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Prophylactic Ankle Taping and Bracing: A Numbers-Needed-to-Treat and Cost-Benefit Analysis

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Objective: Taping and bracing are thought to decrease the incidence of ankle sprains; however, few investigators have addressed the effect of preventive measures on the rate of ankle sprains. Our purpose was to examine the effectiveness of ankle taping and bracing in reducing ankle sprains by applying a numbers-needed-to-treat (NNT) analysis to previously published studies.

Data Sources: We searched PubMed, CINAHL, SPORT Discus, and PEDro for original research from 1966 to 2002 with key words *ankle taping, ankle sprains, injury incidence, prevention, ankle bracing, ankle prophylaxis,* and *numbers needed to treat*. We eliminated articles that did not address the effects of ankle taping or bracing on ankle injury rates using an experimental design.

Data Synthesis: The search produced 8 articles, of which 3 permitted calculation of NNT, which addresses the clinical usefulness of an intervention by providing estimates of the number of treatments needed to prevent 1 injury occurrence. In a study of collegiate intramural basketball players, the prevention of 1 ankle sprain required the taping of 26 athletes with a history of ankle sprain and 143 without a prior history. In a military academy intramural basketball program, prevention of 1 sprain required bracing of 18 athletes with a history of ankle sprain and 39 athletes with no history. A study of ankle bracing in competitive soccer players produced an NNT of 5 athletes with a history of previous sprain and 57 without a prior injury. A cost-benefit analysis of ankle taping versus bracing revealed taping to be approximately 3 times more expensive than bracing.

Conclusions/Recommendations: Greater benefit is achieved in applying prophylactic ankle taping or bracing to athletes with a history of ankle sprain, compared with those without previous sprains. The generalizability of these results to other physically active populations is unknown.

Key Words: ankle sprain, ankle prophylaxis, orthoses, injury incidence, injury prevention

Ankle sprains are one of the most common injuries in sports[1–5] and occur nearly 7 times more frequently than all other ankle injuries.[6] The anterior talofibular ligament is injured most often, followed by the calcaneofibular ligament.[7,8] In the United Kingdom, 5000 ankle injuries per day are treated, whereas in the United States, it is estimated that more than 25 000 ankle sprains occur per day.[9] Residual disability is found in 20% to 50% of those suffering an ankle sprain.[10–12] Symptoms related to residual disability after an ankle sprain, such as pain, inflammation, and loss of motion may lead to increased treatment costs and time lost from activity.

Ankle sprain incidence by specific sport has also been studied. The most common injury in soccer is the lateral ankle sprain, accounting for up to 85% of all ankle sprains.[13] In American football, ankle sprains comprise 10% to 15% of all injuries.[4] Smith and Reischl[11] reported that 70% of interscholastic varsity male basketball players have suffered at least 1 ankle sprain. In field hockey, the most common type of injury is a ligament sprain; most ligament sprains are at the ankle.[14] Athletes most susceptible to ankle sprain are those with a previous history of an ankle sprain.[1,12,15–18]

The combination of a high incidence of ankle sprain in sports and residual disability after sprains has led to the implementation of prophylactic measures. Preventive interventions such as taping and bracing are thought to decrease ankle sprain incidence by providing mechanical support and enhanced proprioception to the ankle. Although investigators[19,20] have assessed the effect of taping and bracing, which may be associated with ankle injury, on factors such as range-of-motion restriction and functional performance, few authors[13,15,21–27] have evaluated the effect of preventive measures on reducing the incidence of ankle sprains. Previous researchers reported injury incidence and calculated relative risks or odds ratios to describe the effects of a preventive measure. However, relative risks and odds ratios are not easy to interpret and might give a biased view of the actual treatment effects. For instance, a measure that reduces injury incidence from 1 to 0.5 has a relative risk of 2.0, but a measure that reduces injury incidence from 0.2 to 0.1 has, in this regard, the same effect.

A novel analysis to determine the effect of an intervention that builds upon traditional epidemiologic methods is the num-

Table 1. Studies of Ankle Taping and/or Bracing and Injury Rates

Article	Population	Intervention	Verhagen et al Score[32]	Numbers-Needed-to-Treat Criteria Met
Quigley et al[21]	College athletes‡	Protective wrapping	2†	No*
Tropp et al[13]	450 male Swedish soccer players	Bracing	9	No*
Garrick and Requa[15]	Male intramural basketball players§	1) Taping 2) Bracing	10	Yes
Sharpe et al[22]	38 female collegiate soccer players	1) Bracing 2) Taping 3) Combination	10†	No*
Surve et al[23]	504 male South African senior soccer players	Bracing	9	Yes
Rovere et al[24]	297 male collegiate football players	1) Taping 2) Bracing	9	No*
Sitler et al[25]	1601 male intramural basketball players	Bracing	13	Yes
Simon[26]	148 male collegiate football players	1) Taping 2) Wrapping (Louisiana)	8†	No*

*No control group.
†Rated by authors of current study; all others rated by Verhagen et al.[32]
‡Sport, sex, and sample size not specified.
§Unspecified number of players completed 2562 player-games.

bers needed to treat (NNT). The NNT is a useful statistic when trying to ascertain the clinical benefit of a treatment.[28–31] The NNT is presented as the number of treatments necessary to prevent one injury occurrence[28–31] and is therefore easier to interpret than odds ratios and relative risks.[30] Our purpose was to examine the efficacy of ankle taping and bracing in preventing ankle sprains in athletes by applying an NNT analysis to previous studies of ankle taping and bracing.

METHODS

We searched studies published between 1966 and 2002 on PubMed, CINAHL, SPORT Discus, and PEDro using the key words *ankle taping, ankle sprains, injury incidence prevention, ankle bracing, ankle prophylaxis,* and *numbers needed to treat*. We also reviewed reference lists of the resulting articles to identify additional studies. We then eliminated those articles that did not address the effects of ankle taping or bracing on injury rates using an experimental design. We were left with 9 English-language articles that met these criteria and excluded one article[27] because the choice of activity (parachuting) was not considered relevant to our purpose (Table 1).

Quality Assessment

A critical appraisal scale developed by Verhagen et al[32] was used to rate the 8 articles for their research-design quality on a scale from 0 to 14, with 14 being the highest. Five of the 8 articles were rated for quality by Verhagen et al,[32] and these previously reported scores were used. For the 3 articles[21,22,26] not previously rated using this scale, 3 of the authors (L.C.O, L.I.V, C.R.D.) individually rated them using the same scale, and these scores were then averaged (see Table 1). Articles scoring above 8.4 (greater than 60% of possible points) on the scale of Verhagen et al[32] were then reviewed to determine whether the research design was appropriate and sufficient information was provided to permit the calculation of the NNT. Three articles[15,23,25] scored above the cut-off value and met all the criteria to calculate NNT. One article was eliminated because it scored below the cut-off value, and the remaining 4 were eliminated because they did not include a true control group that received no intervention.

Calculation of Numbers Needed to Treat

The NNT is calculated[28,31] as the inverse of the absolute risk reduction and is expressed as follows:

$$\frac{1}{P2–P1}$$

P1 is the event rate in the treatment group, and P2 is the event rate in the control group. In addition to being easy to understand clinically, NNT can be used to determine the cost-benefit of a treatment.[28–31] To calculate the NNT, a number of criteria must be met. Injury incidence, including the number of injuries in relation to the number of subjects or athlete-exposures in each population, must be reported, and a control group must be available for comparison. The NNT is a valid measure only when the comparison groups are similar at baseline. In the case of ankle sprains, it has been documented that injury risk increases substantially for athletes with a history of ankle sprain.[1,15–18] For groups to be similar at baseline, injury history must be reported so that the NNT can be calculated for each group.[28,30]

Cost-Benefit Analysis

We applied a cost-benefit analysis by using the calculated NNT values to examine the advantages and disadvantages of bracing and taping.[29,33] In a cost-benefit analysis, both costs and benefits are assigned a monetary value.[33] The cost-benefit not only determines the least cost but also places values on effectiveness because the known outcomes are not identical.[33] In doing so, we make the assumption that the preventive effects of taping and bracing are equal between intramural basketball players and competitive soccer players previously studied and athletes who practice 6 days per week. The following assumptions were made in calculating the costs associated with taping and bracing.

Table 2. Numbers-Needed-to-Treat Analysis

Article	(+) History§	Injury Incidence	Numbers Needed to Treat	(−) History	Injury Incidence	Numbers Needed to Treat¶
Garrick and Requa[15]*	Control = 24 sprains/434 AEs‡ Treatment = 13 sprains/794 AEs	Control = .0553 Treatment = .0164	26	Control = 12 sprains/670 AEs Treatment = 4 sprains/367 AEs	Control = .0179 Treatment = .0109	143
Sitler et al[25]†	Control = 6 sprains/90 subjects Treatment = 1 sprain/87 subjects	Control = .067 Treatment = .011	18	Control = 29 sprains/722 subjects Treatment = 10 sprains/702 subjects	Control = .040 Treatment = .014	39
Surve et al[23]†	Control = 42 sprains/131 subjects Treatment = 16 sprains/127 subjects	Control = .321 Treatment = .126	5	Control = 33 sprains/129 subjects Treatment = 32 sprains/117 subjects	Control = .256 Treatment = .274	57

*Ankle taping.
†Semirigid ankle stabilizer.
‡AEs indicates athlete-exposures.
§(+) History indicates athletes with a history of previous ankle sprain. (−) History indicates athletes without a history of previous ankle sprain.
¶NNT indicates 1/(injury incidence for control group − injury incidence for treatment group). Injury incidence is number sprains per number AE or number subjects.

Table 3. Cost-Benefit Analysis of Taping and Bracing Based on the Numbers-Needed-to-Treat Results

	Sitler et al[25]				Surve et al[23]				Garrick and Requa[15]			
	History		No History		History		No History		History		No History	
	Taping	Bracing	Taping	Bracing	Taping	Bracing	Taping	Bracing	Taping	Bracing	Taping	Bracing
Cost of prophylaxis	$1.37	$35.00	$1.37	$35.00	$1.37	$35.00	$1.37	$35.00	$1.37	$35.00	$1.37	$35.00
Number needed to treat	18	18	39	39	5	5	57	57	26	26	143	143
Cost per ankle sprain	$24.66	$630.00	$53.43	$1365.00	$6.85	$175.00	$78.09	$1995.00	$35.62	$910.00	$195.91	$5005.00
Interventions*	78	1	78	1	78	1	78	1	78	1	78	1
Total cost per season	$1923.48	$630.00	$4167.54	$1365.00	$4534.30	$175.00	$6091.02	$1995.00	$2778.36	$910.00	$15280.98	$5005.00

*Number of times needed to tape or brace per season.

Tape Cost. We defined the cost of tape as one roll of Johnson and Johnson Zonas tape (New Brunswick, NJ). The cost of one case (32 rolls) of tape is $43.95; therefore, one roll of tape would cost $1.37 (Medco, Tonawanda, NY, winter 2002). We assumed that it would take one roll of tape to tape one ankle. The cost does not include prewrap, tape adherent, heel and lace pads, or the salary of an athletic trainer.

Brace Cost. We defined the cost of bracing based on the cost of an Air Cast stirrup brace (Summit, NJ). One Air Cast brace costs $35.00 (Medco, winter 2002). The Air Cast brace was chosen because it was the brace used by Sitler et al[25] and Surve et al.[23]

Taping Intervention. The number of interventions was based on a 13-week traditional competitive season (end of preseason to beginning of postseason) with 6 practice and game sessions per week. An individual athlete would thus have each ankle taped 78 times in a 13-week season.

Bracing Intervention. We assumed that one brace per ankle would be used during a 13-week season with 6 practice and game sessions per week.

Cost per Ankle Sprain. The cost to prevent one ankle sprain was estimated by multiplying the cost of the prophylaxis by the NNT for each condition in both studies.

Total Cost per Season. We calculated the total cost per season by multiplying the cost per ankle sprain by the number of interventions per season. For taping, a season is 78 interventions, and for bracing, a season is one intervention.

Ratio. We calculated a ratio of the cost of taping to bracing to better explain the relative cost of taping and bracing.[33]

RESULTS

Numbers Needed to Treat

From the data of Garrick and Requa[15] on collegiate intramural basketball players, we determined that to prevent 1 ankle sprain per game in athletes with a history of sprain, a clinician would need to tape 26 ankles (Table 2). In athletes without a history of ankle sprain, to prevent 1 sprain, a clinician would need to tape 143 ankles. From the data of Sitler et al[25] on military academy intramural basketball players, we calculated that to prevent 1 ankle sprain during an intramural season (participants had a mean of 8.4 sessions per season) in athletes with a history of sprain, a clinician would need to brace 18 ankles. In athletes without a history of ankle sprain, to prevent sprain, a clinician would need to brace 39 ankles. From the data of Surve et al[23] on competitive soccer players over the course of 1 season (participants averaged 278 hours of play per season), NNTs of 5 athletes with a history of previous sprain and 57 of those without a prior injury were determined. Both taping and bracing therefore appear to be more beneficial in preventing ankle sprains in athletes with a history of ankle sprain.

Cost-Benefit Analysis

Our cost-benefit analysis determined that ankle taping would be 3.05 times as expensive as ankle bracing over the course of a competitive season (Table 3). From the results of Garrick and Requa,[15] the cost of taping 26 athletes with a history of sprain all season would be $2778, whereas bracing these athletes would cost $910. To tape 143 athletes with no history of ankle sprain would cost $15 281, whereas bracing would cost $5005. From the results of Sitler et al,[25] the cost of taping 18 athletes with a history of sprain would be $1923, whereas bracing these athletes would cost $630. To tape 39 athletes with no history of ankle sprain would cost approximately $4168, whereas bracing these athletes would cost $1365. From the results of Surve et al,[23] the cost of taping 5 athletes with a history of sprain would be $4534, whereas bracing these athletes would cost $175. To tape 57 athletes with no history of ankle sprain would cost $6091, whereas bracing would cost $1995.

DISCUSSION

Ankle taping and bracing are among the most common interventions associated with athletic trainers, yet very few authors have examined the effectiveness of taping and bracing on the prevention of ankle sprains and have reported injury rates.[13,15,21–26] Most published studies related to ankle taping and bracing have focused on performance measures rather than injury prevention. Although it is important to understand how taping and bracing affect measures of ankle range of motion, strength, proprioception, and neuromuscular control, clinicians ultimately need to know whether taping and bracing actually prevent ankle sprains.

Our literature search produced only 9 studies[13,15,21–27] on the effectiveness of ankle taping or bracing in reducing ankle sprains. What is startling is that very few of these researchers included a true control group that did not receive any intervention.[13,15,22,23,25] Still more troubling is that a prospective study of the effectiveness of ankle taping using a control group and tracking injury rates has not been conducted in 30 years. One would assume that developments related to the quality of athletic tape, shoewear, playing surfaces, and playing styles could affect the ability of ankle taping to reduce ankle sprains.

We were able to apply an NNT analysis to 3 of the 8 studies to determine how many ankles would need to be taped or braced to prevent one sprain. The NNT analysis has not been used previously in the athletic training literature but has been used most often in studies of experimental treatments and procedures in cardiology and pharmacology. The NNT has typically been used when a negative outcome resulted in high morbidity or death. The value of NNT has been established in various disciplines, and it is now commonly taught in epidemiology and evidence-based medicine as a clinically useful analysis.[28,29] The analyses may be applied to injury prevention in sports medicine to determine how many athletes must be treated with a given intervention in order to prevent 1 injury. The results can then be used to determine the cost-benefit of performing the intervention. The ideal NNT of an intervention is 1 because this would indicate that for every patient treated, 1 pathologic event would be prevented; however, this ideal is rarely achieved. Values between 2 and 5 are considered effective in studies of treatment of pathologic conditions, and values of 20 or more may be useful for studies of prophylaxis aimed at preventing pathologic conditions.[34] Because this is the first known NNT analysis assessing the effectiveness of an intervention at preventing sports injuries, we are unable to compare our NNT results with others in similar contexts.

Using the quality assessment scale of Verhagen et al,[32] the 3 studies we used for the NNT analysis were 3 of the highest rated of the 8 studies we examined. The quality assessment provides an indication of the robustness of the experimental design and the completeness in the reporting of the methods

and results of individual studies. The lack of universally accepted standards for performing quality assessment of sports medicine research articles should be noted, however. We found 3 previous systematic reviews involving quality assessment of studies related to ankle-sprain prevention.[32,35,36] All 3 groups used their own assessment scales. We opted for that of Verhagen et al[32] because we felt it was the easiest to use and understand. The previous authors[32,35,36] addressed ankle-sprain prevention methods, such as shoewear and balance training, in addition to prophylactic taping and bracing.

Of the 3 studies subjected to NNT analysis, 2 studies were conducted on collegiate intramural basketball players (one of bracing,[25] one of taping[15]), and the third examined bracing in competitive South African soccer players.[23] Generalizing these results to other athletic populations must be done cautiously. Although there is no minimum number of studies necessary to perform an NNT analysis, more generalizable conclusions can be generated when NNT results from a large number of studies are available. As stated previously, few studies have addressed the effectiveness of ankle taping and bracing on the prevention of ankle sprains.

Although it is more cost effective to tape an athlete 1 time than to brace the same athlete, bracing is approximately 3 times more economical over the entire season. Our conclusion is that bracing is less expensive and less time consuming for the athlete and athletic trainer over the duration of a sports season. These clinical conclusions are supported by a body of laboratory research literature demonstrating that bracing is superior to taping in restricting ankle-inversion range of motion both before and after exercise.[37] Semirigid braces, similar to those used in the studies by Sitler et al[25] and Surve et al,[23] restrict inversion range of motion more than tape and lace-up braces do.[20,37] Ankle taping and bracing have also been hypothesized to prevent ankle sprains via enhanced proprioception and neuromuscular control; however, there is no clear evidence that one intervention is more effective than the other in this regard.[19,20]

Even though bracing is more cost effective, is bracing superior to taping in preventing ankle sprains? The comparison of NNT results across studies of different populations is difficult and must be done with caution. Specifically, injury exposures and length of intervention are not part of the NNT calculation. All the studies we examined used a different length of intervention, and, thus, the NNT calculations are specific to the individual lengths of intervention. The NNT results for Garrick and Requa[15] indicate the number of ankles that need to be taped to prevent 1 ankle sprain in one intramural basketball game. The results for Sitler et al[25] are specific to the number of ankles that need to be braced to prevent 1 sprain over the course of 1 intramural basketball season. The results of Surve et al[23] reflect the number of ankles that need to be braced to prevent 1 sprain over the course of an entire competitive soccer season. The NNT is affected by, and should be interpreted in the context of, the duration of intervention.

Three previous groups[23,24,26] directly examined the preventive effects of ankle taping versus bracing. Ankle bracing was more effective than taping in preventing ankle sprains in collegiate football players[24] and female collegiate soccer players.[23] The third group did not identify significant differences between taping and bracing in preventing ankle sprains in collegiate football players.[26] Based on the results of these studies directly comparing taping and bracing, it appears that bracing may be more effective in preventing ankle sprains.

Large-scale studies of the effectiveness of taping and bracing in male and female athletes of various activity levels are clearly needed. Contemporary studies of ankle taping in this context are especially lacking. In Simon's 1969 article[26] comparing the effectiveness of taping and bracing on ankle-sprain prevention in collegiate football players, he stated that ''as the status of the athletic trainer increases and the true value of his services are fully recognized, it becomes essential that members of the profession recognize the paucity of scientific evidence to support many of its traditional procedures. . . . Today's demands on an athletic trainer's time and budget no longer warrant the retention of practices or procedures which fail to survive the critical scrutiny of a controlled study.'' Despite this apt call for clinically based research of the most common interventions rendered by athletic trainers, no study of the effects of taping in the prevention of ankle sprains in 30 years has included a control group. A well-designed, prospective study of injury-prevention methods should have 3 components. First, large numbers of athletes and exposures are needed. This may be best accomplished by conducting the study across several institutions. Second, 2 groups that are similar at baseline are needed. One group with no history of ankle injury and another group with a history of ankle injury should be included. Random and concealed allocation to a control (no taping or bracing) or treatment group (taping or bracing) is essential. Third, calculation of injury incidence is essential for determining NNT.

CONCLUSIONS

Although ankle taping and bracing are commonplace in athletic training, the time and cost of taping and bracing large numbers of athletes must be considered. Our first conclusion is that taping and bracing appear to be more effective in preventing ankle sprains in athletes with a history of ankle sprain than in those without a history of ankle sprain. Second, when deciding whether athletes should be taped or braced, the increased cost and time of ankle taping, compared with bracing. must be considered. Ankle bracing, therefore, may be a better way to provide the support necessary to prevent ankle sprains. Lastly, our application of the NNT statistic was limited by the number of studies that had both treatment and control groups as well as documentation of injury rates. Even though we were able to calculate NNT for 3 studies, generalizing these results to all sports, ages, and skill levels is not possible. Further proper prospective research is needed to evaluate the effectiveness of taping and bracing in reducing ankle sprains in male and female athletes who participate in interscholastic, collegiate, professional, and recreational sports.

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