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The Effect of Lace-up Ankle Braces on Injury Rates in High School Football Players

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Abstract

Background—Although a nkle injuries occur frequently in high school football players no prospective studies have been performed to determine if wearing lace-up ankle braces will reduce the incidence and severity of ankle and other lower extremity injuries in these athletes.

Purpose—Determine if lace-up ankle braces reduce the incidence and severity of lower extremity injuries sustained by high school football players.

Design—Cluster randomized controlled trial.

Methods—2081 players from 50 high schools were randomly-assigned to braced or control group. Braced group subjects wore lace-up ankle braces during the 2010 football season. Athletic trainers recorded brace compliance, athletic exposures and injuries. Cox Proportional Hazards models were utilized to compare injury rates between groups. Injury severity (days lost) was tested with Wilcoxon Rank Sum.

Results—The rate of acute ankle injury (per 1,000 exposures) was 0.48 in the braced group compared to 1.12 in the control group (Cox Hazard Ratio (HR)=0.39, 95% Confidence Interval [CI] 0.24, 0.65, p<0.001). The severity (median days lost) of acute ankle injuries was the same (5 days) in both groups (p=0.985). The rate of acute knee injury was 0.70 in the braced group compared to 0.69 in the control group, (HR=0.92 [0.57, 1.47], p=0.721). There was no difference (p=0.242) in the severity of knee injuries between the groups (controls 11.5 days, braced =17 days. The rate of other lower extremity injuries was 0.95 in the braced group and 1.32 in the control group, (HR=0.72 [0.48, 1.09], p=0.117) while the severity was similar in both groups (6 days versus 7 days, p=0.295).

Conclusions—Players who used lace-up ankle braces had a lower incidence of acute ankle injuries but no difference in the incidence of acute knee or other lower extremity injuries. Braces did not reduce the severity of ankle, knee or other lower extremity injuries.

Introduction

Football is one of the most popular sports in the U.S. with an estimated 1.1 million high school interscholastic participants.[20] Ankle injuries occur frequently in high school football [3,24] nationally it is estimated that 24% (n = 78,000) of all ankle injuries (n = 327,000) that occur in high school athletes are sustained by football players.[21] equally important is the severe monetary consequences that ankle injuries impose on the US health care system [10, 31] In addition, it is well documented that these injuries can affect athletes long after they are finished playing competitive high school sports with the increased

likelihood for the onset of osteoarthritis, decreased levels of physical activity and lower quality of life.[1,8,12, 31] Despite the morbidity and financial burden that ankle injuries impose, there is still a need for research investigating ankle injury prevention strategies in young athletes.[34]

Lace-up ankle braces are commonly utilized in the US to prevent ankle injuries in adolescent athletes but their use remains controversial. Brace advocates cite anecdotal evidence of their effectiveness and point to the fact that collegiate and professional athletes often wear them so adolescent athletes should do the same. Brace detractors on the other hand often point to the fact that the efficacy of ankle bracing in adolescent athletes has not been determined. In addition, laboratory studies [28, 33] have reported that limiting ankle motion through external support has the potential to influence the transfer of force up through the kinetic chain leading to more acute knee injuries such as ACL tears.

Critical reviews [6,16] have shown that most research using ankle braces to prevent injuries often utilized a semi-rigid (hard plastic) brace, enrolled subjects with a previous history of ankle injury or utilized college age or adult athletes. To date, only a single study has reported on the effect of using lace-up ankle braces prophylactically to prevent a first time ankle injury in adolescent athletes (basketball players).[15]

The primary objectives of this study were 1) to determine whether using lace-up ankle braces reduced the number and severity of acute first-time and recurrent ankle injuries sustained by high school football players; 2) to determine whether using lace-up ankle braces affected the incidence and severity of acute knee or other lower extremity injuries.

METHODS

Design

This was a randomized controlled trial that utilized stratified cluster (school) randomization. Schools were assigned to be in the braced (use ankle braces) or control (no ankle braces provided) group. This study was approved by the XX-XXXXXXX Health Sciences Minimal Risk Institutional Review Board. Data was collected for one football season (August through November, 2010).

Sample size

The base sample size was calculated for the primary outcome to compare the incidence rates of acute ankle injuries by ankle brace versus no brace. Based on previous research [3,14, 20,21] we assumed an injury rate of 5% in controls and hoped to reduce this by 50% in the braced subjects. The alpha level was set at 0.05 with 80% power to detect a difference in injury rates. It was assumed that the within cluster variation [7] would be small (0.001) across schools since each high school was required to conform to Wisconsin Interscholastic Athletic Association (WIAA) regulations regarding the first day of practice, season length, and maximum number of competitions and practices allowed.

It was estimated that we would need a base sample size of 1900 players from 38 schools (950 players from 19 schools in each group). The number of schools in the control group was increased to account for the players who would be predisposed to wear ankle braces. Additional schools were added to the braced group as a precaution for possible school drop-out and or non-compliance.

School recruitment and randomization

Each of the 277 Wisconsin high schools with Licensed / Certified athletic trainer (AT) services was contacted by a combination of phone calls, e-mails and letters to determine if they were interested in participating in the study. To be eligible, each school's administrator and coaches were required to give their permission to enroll their student athletes as research subjects and each school AT was required to complete an online research training tutorial.

A total of 51 eligible schools agreed to participate and were stratified based on their pupil enrollment into three groups (small, medium and large). Schools were randomized (7 braced and 10 control) within each stratification level. One school was randomized to the control group but did not collect any data. A complete description of the school recruitment and randomization is found in Figure 2.

Subjects

Potential subjects included all football players (grades 9–12). Players were made aware of the study through the use of flyers and recruited by the research staff and school ATs during pre-season meetings. To be included in the study, each subject had to be a member of the freshman, sub-varsity or varsity interscholastic football teams and able to fully participate (no disabling injuries) on the first day of practice. All subjects (and their parents if the subjects were < 18yrs. old) signed the research subject consent form.

Ankle Brace

The lace-up ankle brace selected for the study was the Don-Joy Ankle Stabilizing Brace (Don-Joy Inc., Vista CA, USA) The brace is designed to fit the right or left foot constructed of synthetic fabric and laced in the front like a shoe. Two straps wrap around the ankle and are secured with Velcro while another elastic wrap wraps around the top of the ankle. The research staff individually measured each player to insure proper brace fit Subjects were individually instructed to wear the brace over a single pair of socks, apply equal tension throughout the lacing system and secure the Velcro straps. Subjects were told to wear a brace on each ankle for each team organized conditioning session, practice or competition until the season was completed.

Data collection

Prior to participation, subjects completed a self report questionnaire to collect information including: sex, grade level, dominant leg, expected playing position (offense and defense), expected level of competition (freshman, sub-varsity or varsity), previous history of lower extremity injury within the last 12 months, previous surgical history, previous use of ankle tape or braces, the height of shoe they elected to wear (mid-top or low top), the cleat type (molded and detachable) and the Foot and Ankle Ability Measure-Sport (FAAM), which is a self report measure of ankle function validated for use in athlete populations.[13]

During the season, ATs at each school maintained a daily exposure calendar, recorded the onset of injuries, days lost due to injury and the daily use of external ankle support (brace and/or athletic tape) throughout the entire season. An athlete exposure was defined as any coach directed competition, practice or conditioning session [21] and was monitored with the assistance of the football coaching staff. An injury was an event that occurred during a football exposure that forced the athlete to stop participation and prevented the athlete from participating in football activities the following day.[21] ATs evaluated each injury by obtaining an injury history from the athlete, determining the injury mechanism, and performing a physical examination. When warranted, injured athletes were referred to their physician for complete diagnosis and treatment. Control group subjects who injured their

ankle were provided with the same ankle brace as the braced subjects when they returned to competition.

Injury severity was determined by the number of days that an athlete was prohibited from participating in football due to the injury. An injured player was allowed to return to practice or competition under the direction of their AT. In order to return, each injured subject had to demonstrate the ability to perform functional activities (running, cutting, tackling drills) similar to the demands of football. If a player sustained an injury that kept them out until after the season would have ended, the length of time the player would have been unable to participate was estimated by the AT and the physician who treated the injury.

Ankle brace compliance and the use of other external support by control subjects (lace-up brace, hard shell brace, adhesive tape) were monitored by the on-site AT. Players in both groups were encouraged to be compliant with their original group assignment. Players who elected to be non-compliant had their change in compliance status recorded in the exposures calendars so the number of exposures with and without ankle braces could be determined. All of the injury and exposure data for the subjects who dropped out (quit or cut from team for athletic code violations) was included in the analyses through the last day they were a member of their team. Players were allowed to wear their own style of football shoe which was classified as being low-top or mid top height.

Statistical Analyses

All analyses were done based on the intent-to-treat principle. Descriptive statistics were used to characterize individual subjects in each group, and clusters in each group. Acute injury rates and corresponding 95% confidence intervals (CI) were calculated by cluster adjusted Poisson regression with generalized estimating equations and number of exposures as an offset. All injury rates are reported per 1,000 exposures with corresponding 95% confidence intervals (CI).

Time-to-first-event was compared between the braced and control group using a univariate, cluster accounted for, Cox Proportional Hazards (Cox PH) model. A multivariate, cluster accounted for, Cox PH model was utilized to examine the relationship between treatment groups and acute ankle injury survival while controlling for several independent variables (sex, grade, level of competition, BMI, and previous injury history). The assumption of proportionality of the hazards were verified as sufficient for each Cox PH model. The number needed to treat (NNT) for acute ankle injuries was calculated as 1/ARR.

Injury severity was determined by comparing the median days lost due to injury for subjects in the control and braced groups with the Wilcoxon Rank Sums test. All analyses were carried out using R for analysis, version 2.10.1.[2]

RESULTS

A total of 2102 football players initially enrolled in the study. Prior to the start of the regular season, 21 players quit or did not go out for their team, leaving a total of 2081 players (1088 control group and 993 braced group) who served as subjects. The subjects participated in a total of 125,419 football exposures (16% competition and 84% practice). The number of exposures categorized by subjects' external support on both ankles were as follows: wore braces alone 55,298 (44.1%), braces plus ankle tape 160 (0.01%), tape alone 617 (0.05%), and no support 65,338 (52.1%). There were 533 (0.4%) exposures in which subjects had both ankles supported, but one ankle had more support than the other, and there were 3,437 (2.7%) in which subjects had one ankle supported in some fashion and the other ankle had

no support. The demographic characteristics of both the control and braced groups were similar (Table 1).

Five hundred sixty-six subjects (27.2%) sustained a total of 686 injuries for an overall injury rate of 5.47 /1000 exposures. The characteristics of the injuries are found in Table 2. The overall injury rate (per 1000 exposures) and 95% CI was 5.73 (4.82, 6.81) for control subjects and 5.19 (4.07, 6.62) for braced subjects.

Acute Ankle Injuries

A total of 95 (injury rate = 0.77/1000 exp.) first event acute ankle injuries (lateral, medial, syndesmotic sprains, and fractures) were recorded. Sixty one (64%) were treated by the onsite athletic trainer while 34 (36%) of these injuries required referral to a physician or emergency department. A total of 68 injuries were sustained in the control group while 27 were sustained by players in the braced group. The incidence of acute ankle injury per 1000 exposures was significantly lower ($p = 0.003$) for the braced group (0.48) compared to the control group (1.12) As shown in the Kaplan-Meier curves in Figure 3, the control group had lower survival rates for acute ankle injuries beginning with the first exposure. The median number of exposures until an acute ankle injury was 25.5 in the control group and 34.0 exposures in the braced group.

Table 3 summarizes the injury rates and adjusted Cox hazard ratios for specific types of injuries sustained by the subjects. After adjusting for sex, previous ankle injury, grade level, competition level, BMI, shoe height and cleat type, the incidence of acute ankle injury was 61% lower for acute ankle injuries in the braced group. The Number Needed to Treat (NNT) to prevent one first event acute ankle injury was 28.3, (95% CI: 18.6, 59.7). The severity (median days lost) was 5.0 days in both groups ($p = 0.985$) for acute ankle injuries. The severity (median days lost, interquartile range IQR [25^{th}, 75^{th}] and p value) for each type of injury are found in Table 4.

The reduced rate of acute ankle injuries in the braced group was found in players both with and without a previous history of an ankle injury within the previous 12 months. (interaction: $p = 0.642$). The incidence of an acute ankle injury was reduced in the braced group by 70% ($p = 0.004$) for players who reported a previous ankle injury, and 57% ($p = 0.010$) for players with no previous ankle injury. The relative risk of sustaining of an acute ankle injury in the braced group was 0.435 (95% CI: 0.281, 0.674).

Acute Knee Injuries

There were a total of 87 (85 first events) acute knee injuries recorded (42 in braced group, 45 in the control group. The injuries that occurred most often included medial collateral ligament sprains (n = 31), anterior cruciate ligament tears and sprains (n = 20), meniscus tears (n = 9), patellar subluxations / dislocations (n = 8) and lateral collateral ligament sprains (n = 7). There was no difference ($p =0.971$) in the incidence of acute knee injuries per 1000 exposures between the braced (0.70) and control (0.69) groups. The relative risk of sustaining of an acute knee injury in the braced group was 0.974 (95% CI: 0.642, 1.478). The severity (days lost) of the acute knee injuries sustained by the control and braced groups was not statistically different (Table 4, $p = 0.242$).

Other Lower Extremity Injuries

One hundred forty-three other lower extremity injuries were recorded (57 in braced group, 86 in control group). The injury that occurred most often was acute muscle strain (n = 43) of the hamstrings, hip flexors, quadriceps and gastroc muscles followed by contusions (n = 37) of the lower limbs. Fourteen injuries were sustained that were classified as anterior knee

pain (patellar tendonitis, patellar femoral stress syndrome, patellar bursitis, fat pad impingement). An additional 14 injuries were classified as tendonitis that occurred in the foot, lower leg or hip. A total of 9 foot, toe and hip ligament sprains occurred while 8 fractures (4 acute, 4 stress) occurred in the toe, foot or lower leg. There was no difference ($p = 0.099$) in the incidence of other lower extremity injury between the braced group (0.95) and control group (1.32) (Table 3). The relative risk of sustaining other lower extremity injuries in the braced group was 0.743 (95% CI: 0.534, 1.036). Finally, there was no difference ($p = 0.295$) in the severity of other lower extremity injuries in the braced and control groups (Table 4).

DISCUSSION

The primary finding of this study is that using a lace-up ankle brace reduced the incidence of acute ankle injuries by 61% in high school football players, regardless of their age, level of competition, BMI, shoe height or cleat design. In addition this injury reduction was found in braced players both with and without a previous history of an ankle injury. In practical terms, we could assume from the NNT of 28.3 that approximately two to three acute ankle injuries would be prevented during a single season on a high school football squad consisting of 60 players.

The reduction in the incidence of ankle injury is similar to the results of previous prospective studies of other athlete populations that looked at the effectiveness of hard shell braces. Sitler [26] reported that an Air Stirrup orthosis primarily reduced the incidence of ankle sprains in military cadets participating in intramural football. Surve [27] reported that the risk of sustaining an ankle sprain was reduced by 69% in adult male soccer players with a previous injury while no reduction in injury risk was noted for players who did not have a previous injury. Unlike those previous studies however, we found that lace-up braces reduced the incidence of injury in athletes both with and without a previous history of ankle injury. The difference in our results may be explained in part by the fact that our subjects were adolescent rather than adult athletes and that our sample size, number of exposures and injury incidence in our study was substantially larger than Surve's study. Our results are also in contrast to Yang's retrospective study of North Carolina high school athletes [35] which reported higher ankle injury rates in players using ankle braces who had no previous history of ankle injury. This may be due to the fact that Yang's study identified ankle brace use through athlete self report rather than direct observation by AT's, such as in our study, and that numerous sports (other than football) were included in their analysis.

Our findings of a reduced rate of ankle injuries in football players with and without a previous history of ankle injury is consistent with one previous study in high school athletes. McGuine et al[15] utilized a similar research design and found that ankle injuries were reduced for high school basketball players who did not have a history of previous ankle injury.

Acute Knee injuries

Previous authors [28, 33] have postulated through laboratory studies that limiting motion through external support at the ankle with a hard shell brace would influence the transfer of force up through the kinetic chain leading to more acute knee injuries such as ACL tears. However, our results reveal the incidence and severity of knee injuries were not affected by the use of the lace-up braces. We must acknowledge however that this study may not have adequate sample size and statistical power to detect a statistically significant difference. However, the current results are in agreement with data reported in high school basketball players[15] which reported that using a lace-up brace did not increase the risk of an acute knee injury in high school basketball players. This may be due in part to the fact that lace-up

braces offer less ankle motion restriction than hard shell braces [4] and may minimize the transfer of forces from the foot and ankle up to the knee. The limited force transfer is supported in laboratory studies by Di Stefano[5] who reported that a lace-up brace did not cause changes in lower extremity kinematics that may lead to acute knee injuries.

Other Lower extremity Injuries

Our finding of a trend of decreased incidence of lower extremity injuries with the use of lace-up braces stands in contrast to a previous research on basketball players[15] which noted a trend for higher rates of other lower extremity injuries in basketball players who used lace-up braces. The number of injuries (n = 53) in thatstudy was small such that this apparent trend may have occurred by chance. In contrast, our current study reports almost triple the number of other lower extremity injuries. It should be noted that a high number of contusions were recorded which can be argued are not directly or indirectly related to the use of lace-up ankle braces. In addition, the previously cited laboratory studies seem to indicate that there would not be an increased risk for acute injuries like muscle strains or gradual onset injuries such as a stress fracture while wearing ankle braces. However, in the future researchers may want to examine the relationship that lace-up ankle braces and limited ankle motion plays in upper leg, hip or low back kinematics.

The effect of other ankle support

We were concerned that the use of ankle tape (alone or in conjunction with a lace – up brace) would confound our results. Even though all players were constantly encouraged to be compliant with their group assignment, players were allowed to use ankle tape if they desired. To control for this phenomena, we had each AT record all of the instances in which ankle tape was used. In many cases, ankle tape was used by a player in conjunction with the ankle brace immediately following an ankle injury or alone if they forgot their braces for a specific practice or game. While analyzing the results however, we found that the influence of ankle tape was negligible since it was used in less than (1.4 %) of the exposures and only 12 acute ankle injuries were sustained (5 in the braced group and 7 in the control group) by subjects using ankle tape.

Other Injury Prevention Strategies

Published Reviews [9,16, 34] on strategies to prevent lateral ankle sprains have reported that neuromuscular programs reduce the relative risk of ankle sprains of a similar magnitude as bracing (from 0.2 to 0.5), primarily for recurrent ankle sprain. As a result it may be argued that the preferred injury prevention method could be determined by athlete preference. This may be of particular importance in high school athletes, who may be more compliant with consistently wearing a brace rather than consistently participating in a neuromuscular training program. There is good evidence however, that neuromuscular programs are also effective at preventing ankle sprains in high school football [17] as well as basketball and soccer players [14] or reducing other types of injuries such as anterior cruciate ligament tears.[10] Future research is warranted to determine if a combination of prophylactic bracing and neuromuscular training is the optimal strategy to prevent lower extremity injuries.

Comparison to Previous High School Football Research

The rate of acute ankle injury (0.76 /1000) was similar to the previous reported rate of 0.77 / 1000 by Nelson [21] and the distribution of the lower extremity injuries was similar to the study published by Shankar [25] In addition, our finding of an increased incidence of acute ankle injury in players with a previous injury is in agreement with previous research that reported the injury rates were higher in players who had sustained a previous injury. [29, 30]

Our results show that other factors such as shoe height and cleat design were not associated with an increased risk of an acute ankle injury. While shoe style had been studied previously [2] in basketball players, we are not aware of any previous research that examined these possible risk factors in high school football players. We did not find any relationship between the type of surface, (synthetic or natural grass) and the incidence of ankle injuries in our study. Previously, Meyers [18] compared injuries that occurred in competition on FieldTurf and natural grass in high school players; non-contact injuries that were less severe were more likely to occur on FieldTurf while head and neural trauma and injuries that were more severe occurred more often on natural grass. Comparing our results to this work is difficult due to the fact that 40% of the exposures in their study took place on natural grass while 90% of the player exposures took place on natural grass in our study.

Economic Implications

These findings have significant implications beyond the sport of football and extend to the US health care system as a whole. Research[19, 22] has shown that ankle braces offer a low cost alternative to athletic tape ($40 – $60 per ankle per season versus $20 -$30 per ankle brace) brace when providing external support to the ankle. By extrapolating our data to the incidence of acute ankle injuries nationwide, providing lace-up braces has the potential to decrease the number of ankle injuries sustained by high school football players by 39,000 and reduce the number of ankle injuries that require treatment by a physician or in an emergency department by 14,000. The estimated costs ($35 to $40 per player) of providing a pair of lace-up braces for each of the 1.1 million players would be substantial ($36 million to $44 million). However, these costs should be weighed against the direct and indirect financial impact (direct medical costs, loss of future earnings, pain and suffering, impact on quality of life and legal liability) that these injuries have on the US health care system as described by Knowles ($11,925 per injury) or the total comprehensive costs of $581 million for all ankle injuries in high school football reported by the US Consumer Products Safety Commission Directorate of Economic Analysis.[29]

Limitations

First, like numerous high schools across the US, not all schools in Wisconsin have athletic training services for their athletes. Therefore approximately 38% of schools were not eligible for inclusion in this study. Second, we only classified shoes as being one of two styles, low-top or mid top and acknowledge that a specific brand or model of shoe may have played a role in the results. Third, there could have been selection bias for players who enrolled in the study. Most Wisconsin high schools require that potential study participants be made aware of any interventions or lack of interventions prior to study enrollment. Therefore, it is feasible that potential players from control schools did not elect to participate because they would not receive ankle braces prior to the start of the season. It is also possible that players in the braced group did not elect to participate because they did not want to wear ankle braces during the season. Finally, as with similar injury intervention studies, players and the ATs collecting the data were not blinded as to their allocation into the control or braced groups.

Conclusion

The use of a lace-up ankle brace reduced the incidence but not the severity of acute ankle injuries in high school football athletes. This protective effect was observed in players both with and without a previous history of ankle injury. The use of the brace did not increase the incidence or severity of acute knee injuries. or other lower extremity injuries.

Wearing lace-up ankle braces may be a cost effective injury prevention strategy in high school football players. Future research is needed to examine the effect of lace-up ankle

braces on all lower extremity injuries when used in conjunction with a comprehensive neuromuscular training program.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What is known about the subject

The ankle is the most commonly injured body site in high school athletics, particularly in the sport of football. Most previous studies have reported that semi rigid ankle braces reduce the incidence of ankle injuries in older athletes participating in soccer players or subjects with a previous history of ankle injury.

What this study adds

This is the first study to show that lace-up ankle braces (commonly used by adolescent football players) reduce both first-time and recurrent ankle injury in high school football players. The use of ankle braces did not affect the incidence or severity of acute knee or other lower extremity injuries.

Figure 1.
DON JOY Brace Photo (JPEG)

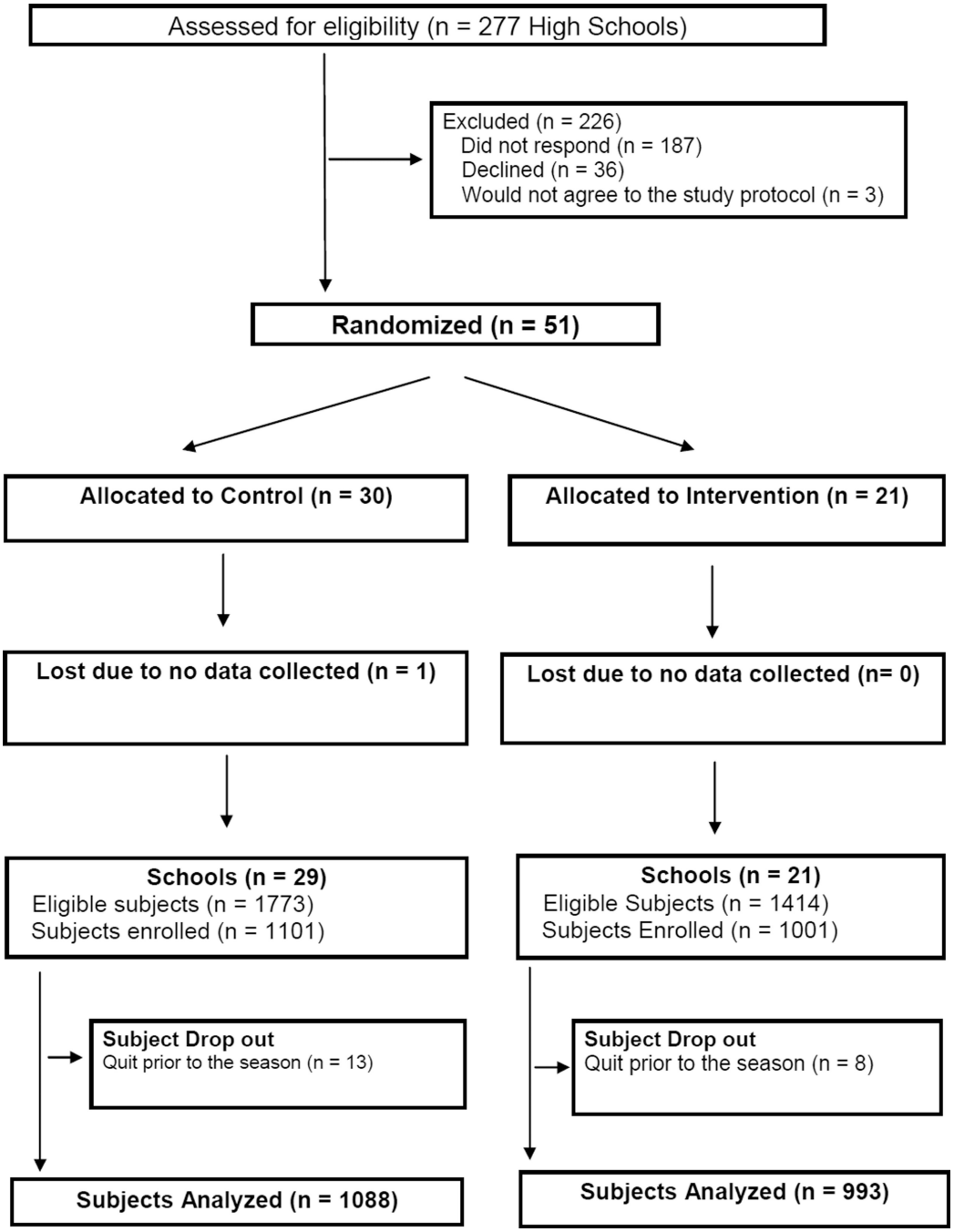

Figure 2.
School recruitment and randomization

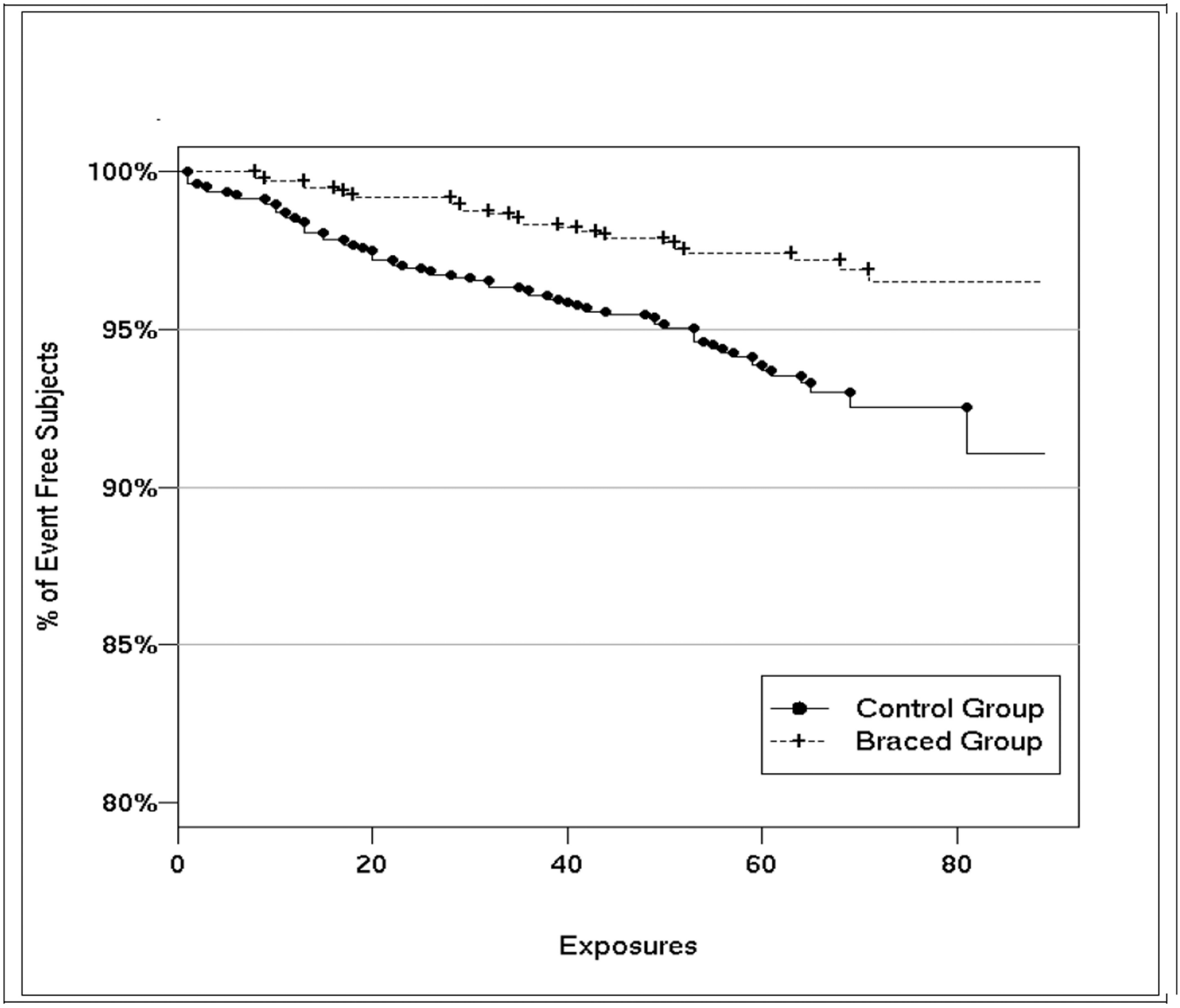

Figure 3.
Percentage of acute ankle injury-free participants over time. (*Kaplan Meier Survival Analysis = $p < 0.001$*)

Table 1

Demographic Summaries of Braced and Control Groups by Individual Participant and by Cluster

Variable	Individually		Per Cluster[1]		
	Controls N = 1088	Braced N = 993	Controls N = 29	Braced N = 21	P-value[2]
Gender					
Male N (%)	1086 (99.8)	991 (99.8)	99.8 ± 0.6	99.8 ± 0.8	0.731
Age (yrs) (mean ± SD)	16.1 ± 1.1	16.2 ± 1.1	16.2 ± 0.3	16.2 ± 0.2	0.914
BMI (kg/m2) (mean ± SD)	24.5 ± 4.4	24.8 ± 4.6	24.5 ± 1.2	24.8 ± 1.0	0.384
Grade					
Freshman N (%)	217 (19.9)	180 (18.1)	18.3 ± 13.1	20.0 ± 15.2	0.674
Sophomore	339 (31.2)	289 (29.1)	31.4 ± 9.7	28.2 ± 12.0	
Junior	264 (24.3)	258 (26.0)	24.6 ± 8.1	24.9 ± 10.3	
Senior	268 (24.6)	266 (26.8)	25.7 ± 9.2	26.9 ± 6.6	
Level of Competition					
Freshman N (%)	202 (18.6)	164 (16.5)	16.0 ± 13.1	17.1 ± 13.7	0.866
Sub-Varsity	325 (29.9)	295 (29.7)	30.0 ± 10.8	30.1 ± 11.1	
Varsity	561 (51.6)	534 (53.8)	54.1 ± 11.5	52.8 ± 9.1	
Offensive Position					
Back N (%)	346 (34.2)	347 (37.6)	32.9 ± 8.4	35.9 ± 9.4	0.240
End	303 (30.0)	259 (28.1)	27.4 ± 7.0	24.8 ± 8.1	
Line	362 (35.8)	316 (34.3)	33.3 ± 7.6	33.1 ± 8.3	
Defensive Position					
Back N (%)	335 (32.6)	328 (35.6)	31.3 ± 9.1	33.0 ± 8.8	0.298
Line	404 (39.3)	344 (37.4)	38.0 ± 8.8	34.2 ± 9.0	
Linebacker	290 (28.2)	249 (27.0)	26.4 ± 7.2	26.0 ± 10.2	
Shoe Height					
Low top N (%)	378 (34.7)	337 (33.9)	35.7 ± 15.4	34.3 ± 15.5	0.757
Mid top	710 (65.3)	656 (66.1)	64.3 ± 15.4	65.7 ± 15.5	
Shoe Cleat					
Detachable N (%)	787 (72.3)	736 (74.1)	72.2 ± 9.9	72.1 ± 19.8	0.992
Molded	301 (27.7)	257 (25.9)	27.8 ± 9.9	27.9 ± 19.8	

Variable	Individually		Per Cluster[1]		
	Controls N = 1088	Braced N = 993	Controls N = 29	Braced N = 21	P-value[2]
Previous Ankle Injury					
Yes N (%)	113 (10.4)	120 (12.1)	10.4 ± 5.3	12.2 ± 7.6	0.377
Leg Dominance					
Right N (%)	1007 (92.6)	913 (91.9)	92.2 ± 5.2	92.0 ± 4.3	0.867
Previous Use of Ankle Tape					
Yes N (%)	184 (16.9)	207 (20.8)	17.0 ± 10.1	21.2 ± 12.0	0.203
Previous Use of Ankle Braces					
Yes N (%)	164 (15.1)	221 (22.3)	16.7 ± 10.8	20.4 ± 12.2	0.272
FAAM Scale (median, range)					
Left	32 (6 – 32)	32 (6 – 32)	31.0 ± 0.4	30.1 ± 1.8	0.041
Right	32 (2 – 32)	32 (2 – 32)	30.9 ± 0.5	30.3 ± 1.8	0.162
Exposures Type (mean ± SD)					
Competition	9.4 ± 3.4	10.0 ± 3.7	351 ± 184	474 ± 195	0.029
Non-competition	50.5 ± 11.7	50.7 ± 50.7	1896 ± 996	2396 ± 1008	0.089
Exposure Surface (mean ± SD)					
Grass	58.3 ± 13.4	56.9 ± 16.6	2187 ± 1100	2689 ± 1180	0.134
Synthetic	1.6 ± 2.7	3.8 ± 10.7	59 ± 131	181 ± 537	0.320

[1] reported as mean average percentage (categorical) or average value (continuous) within each cluster

[2] t-test p-value for comparison of cluster averages between groups

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Table 2

Injury Characteristics in Braced and Control Groups

Variable	Control Group N = 373 Injuries N (%)	Braced Group N = 313 Injuries N (%)
Team Session		
Practice	155 (41.6)	137 (43.8)
Competition	218 (58.4)	176 (56.2)
Field Surface		
Grass	349 (93.6)	280 (89.5)
Synthetic	24 (6.4)	33 (10.5)
Injury Onset		
Acute	348 (93.3)	293 (93.6)
Gradual	25 (6.7)	20 (6.4)
Body Area		
Foot	13 (3.5)	11 (3.5)
Ankle	73 (19.6)	29 (9.3)
Lower Leg	9 (2.4)	12 (3.8)
Knee	59 (15.8)	51 (16.3)
Upper Leg	28 (7.5)	16 (5.1)
Hip / Pelvis	22 (5.9)	9 (2.9)
Trunk / Back	21 (5.6)	34 (10.9)
Shoulder	38 (10.2)	35 (11.2)
Arm / Elbow	9 (2.4)	13 (4.2)
Hand / Wrist / Fingers	30 (8.0)	22 (7.0)
Face	1 (0.3)	1 (0.3)
Head	62 (16.6)	69 (22.0)
Neck	7 (1.9)	8 (2.6)
Other	1 (0.3)	3 (1.0)
Type of Injury		
Ligament Sprains	131 (35.1)	96 (30.7)
Muscle Strains	54 (14.5)	42 (13.4)
Contusion	44 (11.8)	37 (11.8)
Fractures	35 (9.4)	22 (7.0)
Concussion	62 (16.6)	69 (22.0)
Other	47 (12.6)	47 (15.0)
MD or ED Referral		
Yes	196 (52.5)	209 (66.8)
Required Surgery		
Yes	20 (5.4)	18 (5.8)
Injury Severity (days lost)		
Mild (1 – 7)	186 (49.9)	131 (41.9)
Moderate (8 – 21)	108 (29.0)	95 (30.4)

Variable	Control Group N = 373 Injuries N (%)	Braced Group N = 313 Injuries N (%)
Severe (> 21)	79 (21.2)	87 (27.8)
Days Lost (median, range)	8 (1 – 261)	10 (1 – 365)

Table 3

Injury Rates and Cluster-Adjusted Cox Proportional Hazards Ratios Comparing Types of Injury Events in the Braced Group with Injury Events in the Control Group[a]

Injury Type	Group	Injury Rate (95% CI)[b]	Adjusted Hazards Ratio (95% CI)[c]	p-value
All Acute Ankle Injury	Control	1.12 (0.83, 1.52)	reference	
	Braced	0.48 (0.28, 0.84)	0.39 (0.24, 0.65)	< 0.001
Acute Ankle Injury without a previous history of ankle injury	Control	0.91 (0.64, 1.28)	reference	
	Braced	0.40 (0.20, 0.81)	0.43 (0.23, 0.82)	0.010
Acute ankle injury with a previous history of ankle injury	Control	2.91 (1.92, 4.41)	reference	
	Braced	1.05 (0.53, 2.09)	0.30 (0.14, 0.68)	0.004
Acute Knee Injury	Control	0.69 (0.50, 0.96)	reference	
	Braced	0.70 (0.44, 1.11)	0.92 (0.57, 1.47)	0.721
Other Lower Body Injury	Control	1.32 (0.98, 1.79)	reference	
	Braced	0.95 (0.64, 1.40)	0.72 (0.48, 1.09)	0.117
Upper Body Injuries	Control	2.58 (2.09, 3.18)	reference	
	Braced	3.02 (2.22, 4.10)	1.13 (0.82, 1.55)	0.463
All Injuries	Control	5.73 (4.82, 6.81)	reference	
	Braced	5.19 (4.07, 6.12)	0.84 (0.59, 1.21)	0.352

[a] The post hoc analysis showed that the intra-cluster correlation = 0.013

[b] Injury rates per 1000 exposures.

[c] Hazard Ratio analysis adjusted for: Grade Level, Competition Level, BMI, Shoe height and Cleat type.

Table 4

Injury Severity (Days lost) By Injury Type and Treatment Group

Injury Type	Controls Median IQR (25^{th}, 75^{th}) Range	Braced Median, IQR (25^{th}, 75^{th}) Range	P-value
All Injuries	8 (4 – 19) 1 – 261	10 (5 – 28) 1 – 365	0.024
Acute Ankle	5 (4 – 11) 1 – 115	5 (3 – 15) 1 – 97	0.985
Acute Knee	11.5 (11 – 52) 2 – 261	17 (8 – 68.8) 1 – 300	0.242
Other Lower Extremity	6 (3 – 10) 1 – 189	6 (4 – 17) 1 – 345	0.295
Upper Body	10 (5 – 21.3) 1 – 115	10 (5 – 26.8) 1 – 365	0.529