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User Survey of 3 Ankle Braces in Soccer, Volleyball, and Running: Which Brace Fits Best?

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Context: Recurrence rates for ankle sprains are high. Therefore, preventive measures such as ankle bracing during sports are recommended.

Objective: To systematically evaluate the perceived ease of use, quality, comfort, stability, and hindrance of and the overall satisfaction with 3 contemporary brace types in 3 types of sports.

Design: Randomized comparative user survey.

Setting: Recreational sports: soccer, volleyball, and running.

Patients or Other Participants: Young adult recreational athletes (29 soccer players, 26 volleyball players, and 31 runners).

Intervention(s): Compression brace (CB), lace-up brace (LB), and semirigid brace (SB).

Main Outcome Measure(s): Rating of perceived ease of use, quality, comfort, stability, and hindrance of and overall satisfaction with the brace types during sports on a 5-point Likert scale. The secondary outcome measure was participants' willingness to buy the tested brace.

Results: Overall, the 3 brace types received high mean scores for ease of use and quality. Soccer players preferred the CB over both alternatives, considering the higher scores for comfort (CB = 4.0, LB = 3.5, SB = 2.8), hindrance (CB = 3.7, LB = 2.9, SB = 2.8), overall satisfaction (CB = 3.6, LB = 3.0, SB = 2.5), and greatest willingness to buy this brace. Volleyball players preferred the LB over both alternatives, considering the higher scores for stability (LB = 4.2, CB = 3.2, SB = 3.3), overall satisfaction (LB = 3.8, CB = 3.0, SB = 3.0), and greatest willingness to buy this brace. Runners preferred the CB over both alternatives considering the better score for hindrance (CB = 3.6, LB = 2.8, SB = 2.9) and greatest willingness to buy this brace.

Conclusions: All 3 ankle-brace types scored high on perceived ease of use and quality. Regarding the brace types, soccer players, volleyball players, and runners differed in their assessments of subjective evaluation of comfort, stability, hindrance, overall satisfaction, and willingness to buy the brace. Soccer players and runners preferred the CB, whereas volleyball players preferred the LB.

Key Words: ankle sprains, injury prevention, subjective evaluation, sports, athletes

Key Points

- Compared with a semirigid brace, a compression brace was preferred by soccer players and runners, whereas a lace-up brace was preferred by volleyball players.
- Future authors should investigate subjective or perceived comfort, stability, hindrance, and satisfaction in their evaluation of preventive ankle braces in athletes.
- If we better understand subjective factors of brace use, we can influence behavior and eventually compliance to prevent more ankle sprains.

Ankle injuries are the most frequently occurring sport-related injuries,[1–3] of which about 85% are ankle sprains.[4] This common injury is associated with short- and long-term burdens to the athlete as well as with a societal burden in the form of injury-related costs. Additionally, recurrence rates for ankle sprains are high, even after paramedical or medical treatment, due to an increased injury risk after an initial injury.[5] Therefore, primary and secondary preventive measures against ankle sprains are recommended. Although taping is still a widely used preventive measure,[6] most evidence in the past 2 decades has supported the effectiveness of neuromuscular training and bracing.[5,7–11]

In a recent trial by Janssen et al,[9] bracing provided more cost-effective secondary preventive intervention than neuromuscular training.[12] Other authors confirmed the strong preventive effect of lace-up braces and semirigid braces in basketball and football players, respectively.[7,8] Despite the substantial evidence that bracing is an effective measure against ankle sprains, surveys of athletes in high-risk sports, such as recreational soccer and basketball, showed that only 27% and 33% of athletes, respectively, wore ankle braces.[6] This raises questions regarding the implementation of and barriers to brace use. Important barriers to brace use are a lack of public knowledge about effectiveness and inadequate perceived comfort.[6,13,14] Other subjective factors influencing brace use have also been

proposed, among them perceived stability and perceived hindrance of performance during sports.[15–17] Such subjective factors need to be addressed when the use of ankle braces is promoted.

A recent survey of sports physical therapists[18] demonstrated that evidence of effectiveness was their primary consideration when prescribing a specific brace. Comfort was a secondary consideration; practitioners seem to be implicitly aware of the importance of subjective barriers to brace use. Nonetheless, to our knowledge, no formal evaluation has been conducted of subjective factors in the use of different types of braces. Such an evaluation could quantify the importance of subjective factors to athletes, eventually allowing clinicians and athletic trainers to provide advice on a more specific, better-adopted, and better-maintained brace. Therefore, the objective of our study was to systematically evaluate athletes' perceived ease of use, quality, comfort, stability, and hindrance of and overall satisfaction with 3 types of braces (ie, compression brace [CB], lace-up brace [LB], and semirigid brace [SB]) in 3 types of sports (ie, soccer, volleyball, and running).

METHODS

Participants

We recruited participants by posting flyers at various universities and sport clubs in Amsterdam and by e-mailing the flyer to local sports clubs and physical therapy students. Information on the study design and a call for participation were available to potential volunteers on a dedicated Web site. No relevant information on subjective factors was available to perform a power analysis, so we arbitrarily decided to include 5 participants per factor per sport. We planned to investigate 6 factors, leading to the goal of including 30 participants per sport. Recreational athletes, with or without a history of ankle sprain, aged 18 years or older, who were actively involved at least once a week in soccer, volleyball, or running were eligible to participate. Volunteers with a recent ankle injury (ie, within 2 months of the survey) were excluded, as any swelling or pain due to a recent injury could influence the subjective evaluation. This user survey is a substudy of the main randomized controlled trial that was approved by the Medical Ethics Committee of the VU University Medical Center, Amsterdam, Netherlands (protocol number 31785.029.10; trial registry number NTR 2157). All athletes gave individual informed consent. The flow chart is shown in Figure 1.

Brace Types

We selected 3 brace types for evaluation: a soft CB with figure-8 strap (Malleotrain S; Bauerfeind, Zeulenroda-Triebes, Thuringia, Germany; Figure 2), an LB (195 Ultralight; McDavid Inc, Fountain Valley, CA; Figure 3), and an SB (Aircast A60 Ankle support; DJO, LLC, Vista, CA; Figure 4). The Bauerfeind Malleotrain S was chosen because it is a new preventive sports version of a model (Malleotrain) that was previously proven effective in treating acute sprains.[19] The McDavid 195 Ultralight was chosen because it was proven effective in preventing ankle ligament injuries in football and basketball players.[7,8] The DJO Aircast A60 Ankle support was chosen because it was the brace used in our recent trial on measures to prevent ankle ligament injuries.[9] All braces were provided free of cost by their respective manufacturers or national distributors.

Study Procedure

The order in which the brace types were worn was assigned at random for each participant. This ensured that the order in which the braces were evaluated could not influence the results. Each participant was asked to use the 3 braces during sport participation for 3 consecutive weeks per brace, with a minimum of 3 sport sessions in total. This resulted in 3 rounds of brace evaluation. After every 3-week round, the athlete was asked to complete a questionnaire to evaluate the respective brace (Table 1). We sent each brace only once, and the subsequent brace was not sent until the previous one was returned, to rule out overlapping brace use. At the end of the test period, participants were mailed the brace they preferred, if available.

Questionnaire

At baseline, participants completed an online questionnaire on demographics (height, body weight, and mean hours of sport participation per week), ankle-sprain history, and previous experience with braces. In online follow-up questionnaires, participants were asked to evaluate the following constructs related to the brace: perceived ease of use, perceived quality, perceived comfort, perceived stability, perceived hindrance during sports, and overall satisfaction. Each construct consisted of multiple 5-point Likert-scale items, where 1 was the *most negative* and 5 the *most positive* feedback score. At random, items were phrased in an opposite positive or negative formulation to prevent scoring bias. Finally, participants were asked if they would be willing to buy the tested brace type for personal use to prevent ankle sprains (*yes*/*no*).

Statistical Analyses

We exported the data from the completed questionnaires into SPSS (version 20; IBM Corp, Armonk, NY). The scores of items with opposite formulations were converted before analysis. To assess the construct validity and therefore have the option of providing summation scores per construct within the questionnaire, an exploratory factor analysis with varimax rotation was performed. The scores within each construct were then combined into a mean score for each construct. Mean scores and 95% confidence intervals (CIs) for each construct were calculated and compared using 1-way analysis of variance. Homoscedasticity was verified for the analyses of variance. A Tukey post hoc test was used to determine if between-groups differences were significant ($P < .05$). Cell frequencies of athletes willing to buy the tested brace types were compared using the χ^2 test for independence.

RESULTS

A total of 29 soccer players, 26 volleyball players, and 31 runners participated in the study. Five participants (2 soccer players, 2 runners, and 1 volleyball player) did not receive the first brace according to the protocol and therefore never

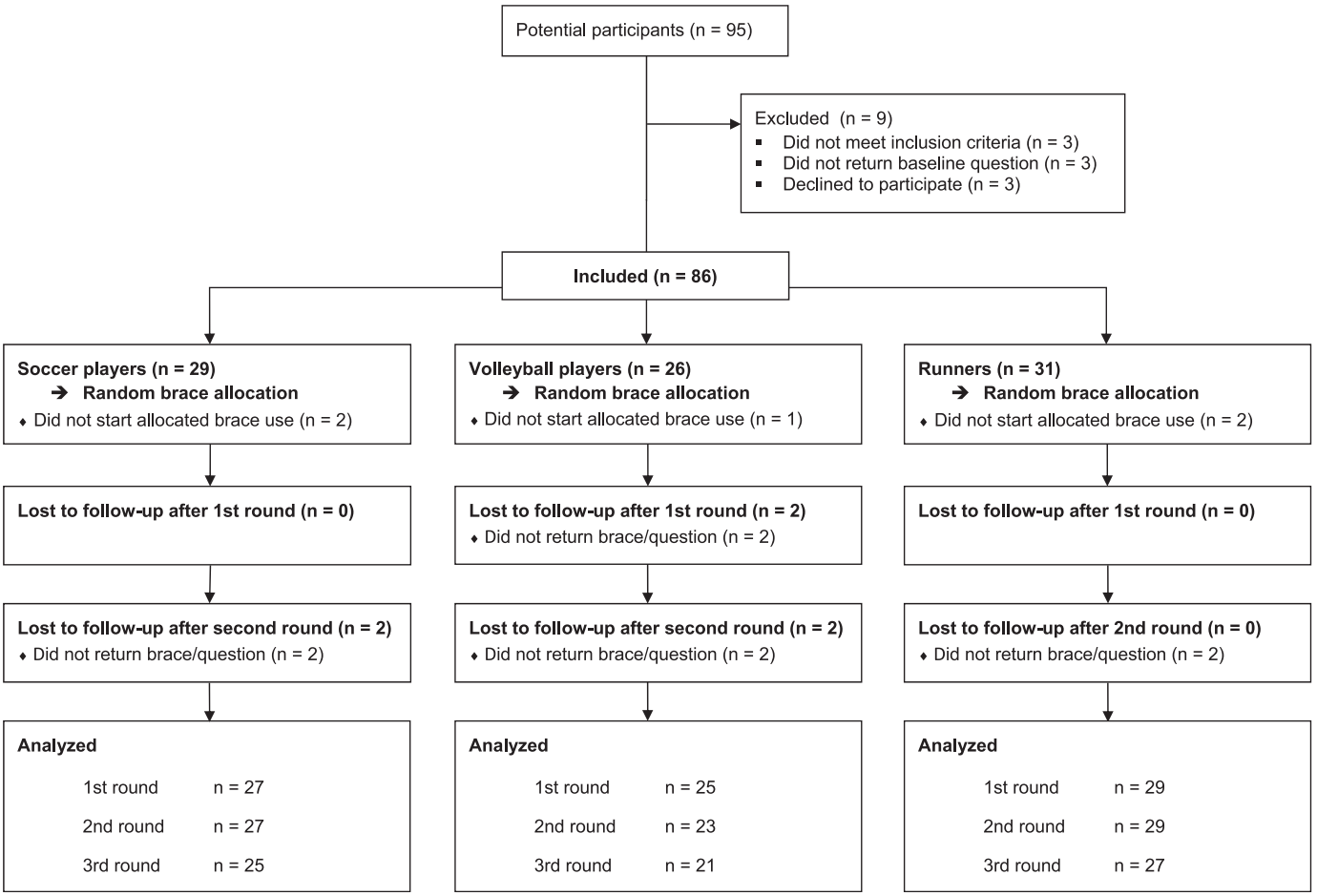

Figure 1. Flow diagram of the participants.

started the study. They were excluded from the analysis. Eight participants were lost to follow-up and, thus, did not test all brace types. However, available data from these participants were included in the analyses for those brace types for which a response was received (Figure 1). Participants in the different sports were comparable with

Figure 2. Compression and figure-8 strap ankle brace (model Malleotrain S; Bauerfeind, Thuringin, Germany).

Figure 3. Lace-up and Velcro strap ankle brace (model 195 Ultralight; McDavid Inc, Fountain Valley, CA).

Figure 4. Semirigid and Velcro strap ankle brace (model Aircast A60 Ankle support; DJO, LLC, Vista, CA).

respect to percentage of women, mean age, mean height, and mean body weight per group. The runners had less sport activity per week, and a lower percentage of them were experienced in brace use compared with the other 2 athlete groups (Table 2).

The exploratory factor analysis demonstrated that the questionnaire constructs (ie, perceived ease of use, quality, comfort, stability, hindrance, and overall satisfaction) were valid; that is, the items within each construct all loaded on 1 factor. The scores for questions within each construct were therefore combined into a single summation score for each construct.

Perceived Ease of Use and Perceived Quality

The mean scores for perceived ease of use of the 3 brace types (application and adjustment) are given in Table 3. The perceived ease of use was better for the CB (4.1 points; 95% CI = 3.9, 4.3) compared with the LB (3.7 points; 95% CI = 3.5, 3.8). Scores were diverse for perceived quality (look and feel), with a mean of 3.6 points (95% CI = 3.4, 3.8) for the SB brace as opposed to 4.1 (95% CI = 3.9, 4.3) for the CB. The perceived quality of the CB was higher than for the SB ($P = .002$).

Sport-Specific Perceived Ease of Use and Quality

For both soccer players and runners, the ease of use of the CB was significantly higher than for the LB. We found no sport-specific differences for the SB. In volleyball players, no differences were evident between brace types for ease of use. Regarding quality, we only found a difference between the CB (4.2 points; 95% CI = 4.0, 4.5) and the SB (3.5 points; 95% CI = 3.2, 3.9; $P = .002$) for soccer players.

Perceived Comfort, Stability, Hindrance, and Satisfaction of the 3 Brace Types per Sport

The differences between the mean scores of the various constructs for the CB and the LB relative to the SB are shown in Figure 5. The scores for the SB act as a baseline because this brace scored close to 3 (range, 1 to 5) on all constructs. Soccer players gave the CB significantly higher scores than the SB for perceived comfort, perceived hindrance, and overall satisfaction. For soccer players, even for perceived stability, the CB and the LB scored significantly higher compared with the SB. Volleyball players gave the LB significantly higher scores over the SB for perceived comfort, perceived stability, and overall satisfaction. Runners rated the CB significantly higher than the SB for perceived comfort, perceived stability, perceived hindrance, and overall satisfaction.

Table 1. Constructs of Subjective Factors of Brace Use[a]

Use
It was clear how the brace had to be applied.
The brace was easy to apply.
I understand the way the brace works.
Quality
The brace looks attractive.
The materials of the brace are of good quality.
Comfort
The brace is comfortable to wear at rest.
The brace is comfortable to wear during training.
The brace fits well around the ankle.
I do not notice that I'm wearing the brace.
The brace stays in place during training.
The brace hurts when worn at rest.
The brace hurts when worn during specific movements.
Stability
The brace provides sufficient support to my ankle.
My ankle feels stable while wearing the brace during sports.
My ankle feels more stable while wearing the brace than without the brace.
Hindrance
The brace makes my ankle feel less flexible.
The brace negatively affects the mobility of my ankle.
The brace hinders use of my ankle during sports.
The brace negatively affects my ability to participate in sports.
Satisfaction
The brace makes me feel secure about my ankle.
I encourage other athletes to wear this brace.
I want to wear the brace during a match.
If suffering from an ankle injury, I have fewer problems with my injury by wearing the brace.
I found it annoying to wear this brace.
I prefer to use tape instead of wearing this brace.
I consider the brace suitable for use in my sport.
Value for money
This brace can be bought for between 40 and 60 euros.
Are you willing to buy this brace for preventive use after sustaining an ankle sprain for the above amount?

[a] Constructs are presented in their original form.

Willingness to Buy the Tested Brace

After testing all braces, a larger proportion (χ^2 $P = .01$) of the soccer players (56%) were willing to buy the CB for ankle-sprain prevention versus the LB (27%) and SB (13%). More than half of the volleyball players (58%) were willing to buy the LB versus the CB (21%) and SB (33%; χ^2 $P = .04$). A comparable portion of the runners were willing to buy the CB (57%) compared with LB (39%) and SB (22%; χ^2 $P = .03$).

DISCUSSION

Our objective was to systematically evaluate subjective factors of brace use in 3 types of braces among athletes in 3

Table 2. Characteristics of Athletes Per Sport

Characteristic	All (n = 86)	Sport		
		Soccer (n = 29)	Volleyball (n = 26)	Running (n = 31)
No. of women (%)	45 (52)	12 (41)	16 (62)	17 (55)
			Mean ± SD	
Age, y	26	23 ± 4	27 ± 11	28 ± 12
Height, cm	180	179 ± 10	182 ± 9	178 ± 9
Weight, kg	73	70 ± 8	77 ± 10	73 ± 13
Exposure, h/wk	5	6 ± 3	5 ± 3	3 ± 2[a]
History of ankle sprain, No. (%)	71 (83)	26 (90)	22 (85)	23 (74)
Experience in ankle-brace use, No. (%)	25 (29)	10 (35)	12 (46)	3 (10)[a]

[a] Difference compared with other groups ($P < .05$).

types of sports to allow clinicians and athletic trainers to provide advice regarding a more specific, better adopted, and better maintained brace.

Overall, the 3 brace types received high (>3.5; range, 1 to 5) mean scores for perceived ease of use (ie, application and adjustment) and quality (ie, look and feel). The CB scored highest: the mean score for perceived ease of use was higher compared with the LB, and the mean score for perceived quality was higher than for the SB.

The CB scored highest for perceived comfort, perceived hindrance, and overall satisfaction compared with the alternatives. The exception was perceived stability; on this factor, the LB scored higher than the CB. Remarkably, the CB scored higher for perceived stability versus the SB, the former standard in preventive bracing.[20]

Brace Scores by Sport

Soccer players gave the CB higher scores than the SB. The LB was not a real alternative for soccer players, as reflected by lower scores for perceived comfort and perceived hindrance compared with the CB. Volleyball players gave the LB higher scores than the SB.

The CB was not a real alternative option for volleyball players, as reflected by lower scores for perceived stability and overall satisfaction compared with the LB. Runners gave the CB higher scores than the semirigid brace (only for perceived comfort). The LB might be an alternative option for runners given the comparable scores for perceived stability versus the CB, but when considering the lower scores for perceived hindrance compared with the CB, this might not be the case.

Although we designed the study to identify which brace was more acceptable to different sporting groups, it is also important to note that within each group, a minority of people found another brace type more acceptable and would buy a different brace. Thus, different brace types suit different sports, but within each sport, an individual may prefer a different brace type.

Relation to Other Studies

Subjective factors, such as perceived comfort, can be important barriers to active brace use.[6,13,14] However, limited data are available on other subjective factors that may facilitate or hamper active brace use. Most brace studies have been laboratory investigations that focused on the effect of ankle orthoses on functional performance in athletes.[21,22] Because ankle braces resist ankle motion, they can potentially influence athletic performance.[15,17] Yet, it is unlikely that wearing modern ankle braces consistently affects performance.[16,17,21–24] In addition to objective performance-related factors, only 1 group[16] also evaluated subjective factors related to performance comfort and stability. With regard to the objective factors, Rosenbaum et al[16] found no differences among braces, whereas the

Table 3. Scores Per Brace Type: Overall and Per Sport for Subjective Factors, Mean (95% Confidence Interval)[a]

Variable	Brace Type	Overall	Soccer	Volleyball	Running
Ease of use	Compression	4.1 (3.9, 4.3)	4.2 (3.9, 4.5)	3.9 (3.4, 4.4)	4.2 (3.9, 4.4)
	Lace-up	3.7 (3.5, 3.8)	3.5 (3.2, 3.9)	4.0 (3.6, 4.3)	3.5 (3.2, 3.8)
	Semirigid	3.9 (3.7, 4.1)	3.8 (3.4, 4.2)	3.9 (3.6, 4.4)	4.0 (3.7, 4.2)
Quality	Compression	4.1 (3.9, 4.3)	4.2 (4.0, 4.5)	3.9 (3.4, 4.4)	4.1 (3.7, 4.4)
	Lace-up	3.8 (3.6, 4.0)	3.8 (3.5, 4.0)	4.1 (3.7, 4.5)	3.6 (3.2, 4.0)
	Semirigid	3.6 (3.4, 3.8)	3.5 (3.2, 3.9)	3.7 (3.3, 4.1)	3.5 (3.2, 3.8)
Comfort	Compression	4.0 (3.8, 4.1)	4.0 (3.8, 4.3)	4.0 (3.6, 4.4)	3.9 (3.6, 4.2)
	Lace-up	3.7 (3.5, 3.8)	3.5 (3.2, 3.7)	3.9 (3.6, 4.2)	3.6 (3.3, 4.0)
	Semirigid	3.1 (2.9, 3.4)	2.8 (2.4, 3.3)	3.4 (3.0, 3.8)	3.2 (2.9, 3.5)
Stability	Compression	3.6 (3.4, 3.8)	3.8 (3.4, 4.1)	3.2 (2.7, 3.7)	3.7 (3.5, 4.0)
	Lace-up	4.0 (3.8, 4.2)	3.9 (3.7, 4.1)	4.3 (4.0, 4.5)	3.9 (3.5, 4.2)
	Semirigid	3.1 (2.9, 3.4)	2.9 (2.4, 3.5)	3.3 (2.8, 3.7)	3.2 (2.8, 3.6)
Hindrance	Compression	3.7 (3.5, 3.9)	3.7 (3.5, 4.0)	3.7 (3.3, 4.1)	3.6 (3.3, 3.9)
	Lace-up	2.9 (2.8, 3.1)	2.9 (2.6, 3.2)	3.2 (3.0, 3.4)	2.8 (2.4, 3.2)
	Semirigid	3.0 (2.7, 3.2)	2.8 (2.4, 3.2)	3.2 (2.7, 3.6)	2.9 (2.5, 3.3)
Satisfaction	Compression	3.4 (3.1, 3.6)	3.6 (3.2, 4.0)	3.0 (2.5, 3.5)	3.4 (3.0, 3.8)
	Lace-up	3.3 (3.0, 3.5)	3.0 (2.7, 3.4)	3.8 (3.5, 4.2)	3.0 (2.6, 3.5)
	Semirigid	2.7 (2.4, 2.9)	2.5 (2.0, 2.9)	3.0 (2.4, 3.5)	2.6 (2.2, 3.0)

[a] Scores represent the mean group value of each construct on a 1 to 5 scale.

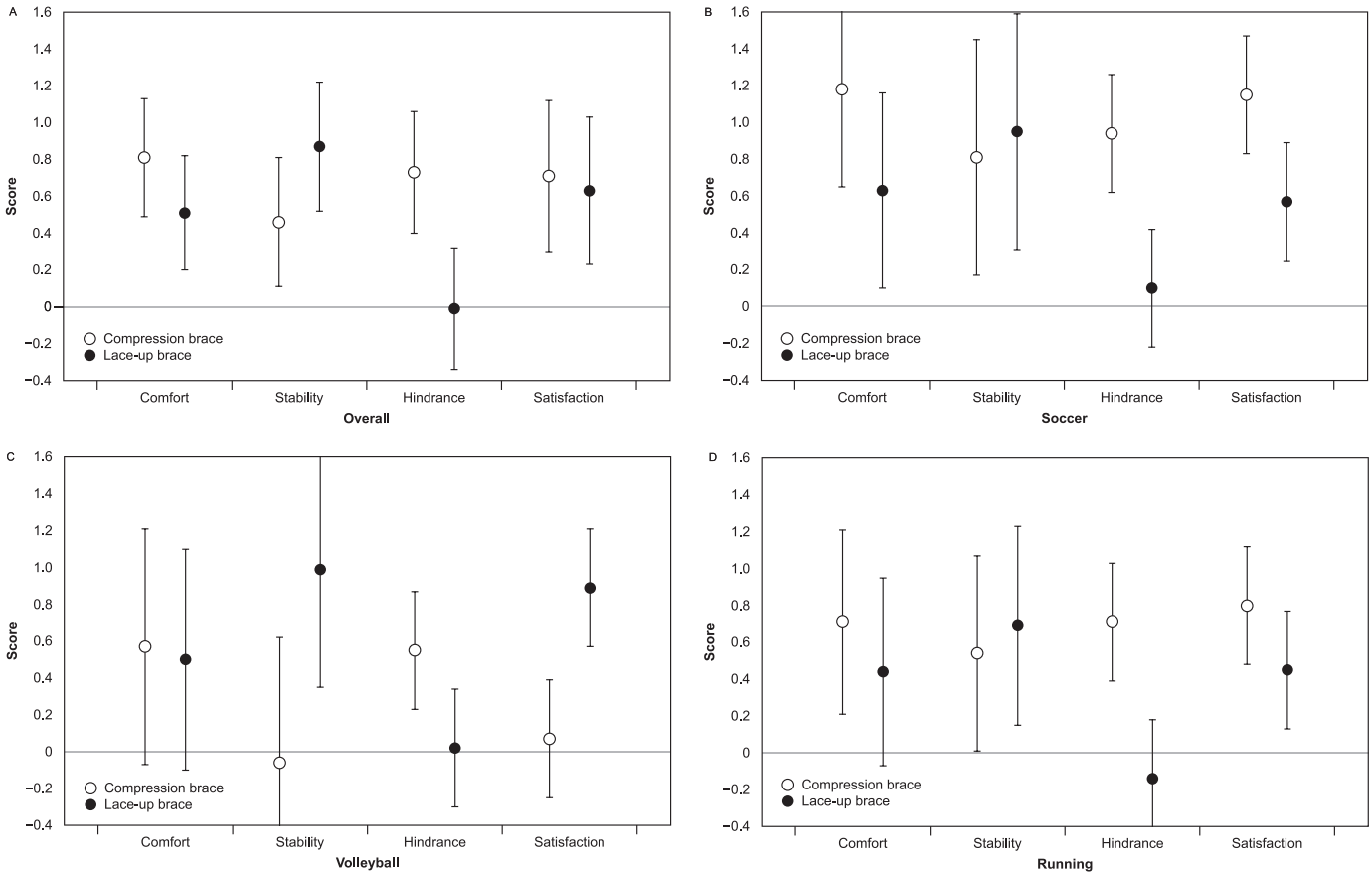

Figure 5. Differences between the mean scores for the various constructs of the compression brace and the lace-up brace relative to the semirigid brace. Error bars indicate 95% confidence intervals of the difference. The x-axis depicts the scores for the semirigid brace and acts as a baseline because this brace scored close to 3 (range, 1 to 5) for all constructs. A positive difference means a higher value for that construct compared with the semirigid brace; a negative difference indicates a lower value. A, Overall. B, Soccer. C, Volleyball. D, Running.

subjective evaluation revealed significant differences in favor of the soft braces (ie, the CB and LB) over the SB. These results are in line with the results of our study. Furthermore, according to Rosenbaum et al,[16] the subjective evaluation of stability among the braces did not differ according to their designs. In addition, we demonstrated that the soft braces (ie, the CB and LB) scored better on perceived stability than the SB. Taking these considerations into account, athletes could be advised to select an appropriate ankle-brace type according to specific subjective properties instead of the objective specifications of the manufacturers.

Mechanical Versus Perceived Instability

Most authors who have examined functional aspects of ankle braces have focused on mechanical properties[25,26] or the influence of brace use on performance[16,17,21–24] instead of on subjective aspects of brace use. Hiller et al[27] proposed a new model for classifying chronic ankle instability (CAI) that stressed the need to account for subjective measures of stability. Following the proposed model, patients with known CAI were classified into subgroups: mechanical instability, functional instability (we prefer the term *perceived instability*), recurrent sprains, and overlapping groups. The investigators found that perceived instability in combination with recurrent sprains characterized the majority of participants. Their conclusion was that specific injury-prevention programs should be developed for these CAI subgroups. These findings further support the need to include the effect of preventive ankle braces on subjective or perceived stability in their evaluation.

Methodologic Considerations

Our study had a high degree of internal validity. The groups of athletes (soccer, volleyball, and running) were comparable with respect to age, body height, body weight, and history of ankle sprain. The percentage of athletes with experience in brace use differed significantly among the groups of athletes, but this may be attributable to the types of sport. Brace use is more common in volleyball and to a lesser extent in soccer but is not considered a common preventive measure against ankle sprains in running due to the nature of the sport. Brace-type scores for perceived ease of use were comparable for all groups of athletes, so we do not believe that bias was a substantial factor due to the differences in brace-use experience. Repeatedly testing different brace types on the same athletes could have introduced some testing effects; by randomly assigning the

brace types to the different athletes, we minimized this type of bias.

Some limitations with respect to the degree of external validity of this study were present. Although 81 players represented 3 sports (ie, soccer, volleyball, and running), our convenience sample mainly consisted of young adults (mean age = 27 years). A larger, more heterogeneous sample of athletes from additional sports and of different ages and competition levels would have allowed for a more in-depth subjective evaluation of the brace types. In this respect, external validity was high for young adults and recreational athletes but lower for athletes in the general population. Following the same argument, we ideally would have tested more brace types, although we would argue that the tested brace types represent the most used brace types in the Netherlands.

Finally, we assessed only if our participants had a history of ankle sprain; stability was not assessed clinically. Recent research has shown that a large percentage of patients with chronic ankle instability had perceived instability. We feel our results are also applicable to this large group of patients[27] but may not be as valid for athletes or patients with mechanical ankle instability.

CLINICAL RELEVANCE AND IMPLICATIONS FOR FUTURE RESEARCH

Future studies of subjective factors in preventive brace use should include a large sample size (current results imply a minimum of 5 participants per factor) with athletes from various sports who are at high risk for ankle sprain and should ideally test various brace types. Subjective factors to be addressed in future studies are perceived comfort, stability, and hindrance, as they could likely assist in selecting the appropriate brace type for individual athletes.

Our study shows that subjective factors in preventive brace use differed considerably among the spectrum of brace types. As discussed, sports physical therapists and athletic trainers consider comfort to be an important factor for the successful adoption of preventive ankle brace by athletes. Although clinicians seem to be implicitly aware of the importance of subjective barriers to brace use, we have shown that these subjective factors can be quantified. Future authors should test if compliance with brace prescription can be enhanced when these subjective factors are accounted for and should preferably include 1 season of follow-up. Self-evidently, increased compliance with brace prescription could lead to greater effectiveness of the intervention.

From a broader perspective, the effectiveness of other preventive interventions, such as neuromuscular training, could also be influenced or enhanced by accounting for subjective factors. We have shown that both a previous ankle injury and participating in a high-risk sport increase overall compliance with neuromuscular training and bracing.[28] A possible explanation is that athletes adapt their behavior due to a higher perception of susceptibility to reinjury. The subjective factors of brace use are actually subjective factors that influence behavior: in this case, adoption or rejection of the intervention. Eventually, if we can better understand these subjective factors, we can influence behavior, which will lead to individualized, better implemented, and finally more efficient interventions for preventing ankle sprains.

CONCLUSIONS

The investigated ankle braces, CB, LB, and SB, scored high on perceived ease of use and perceived quality. They differed significantly with respect to the subjective evaluation of comfort, stability, hindrance, and overall satisfaction among soccer players, volleyball players, and runners. These subjective factors influence the acceptability of brace use by athletes, and consequently, the current results will help athletes, coaches, and practitioners select the optimal ankle brace for each athlete.

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