Injury prevention in team sport athletes

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DYNAMIC POSTURAL STABILITY DIFFERENCES BETWEEN MALE AND FEMALE PLAYERS WITH AND WITHOUT ANKLE SPRAIN.

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ABSTRACT

Objectives To evaluate dynamic stability index (DSI) differences between males and females for different jump directions. To examine both preseason DSI differences between players with and without a history of ankle sprain, and between players with and without an ankle sprain during the subsequent season.

Design Prospective cohort design.

Setting Laboratory.

Participants 47 male (22.9 ± 3.9 y) and 19 female (21.5 ± 2.9 y) sub-elite and elite team sport players.

Main outcome measures Ankle sprain history was collected using an injury history questionnaire. DSI of a single-leg hop-stabilization task measured preseason was collected using force plates and calculated using a Matlab program. Ankle sprains were reported during the subsequent season.

Results Male players demonstrated larger DSI than female players on forward medial/lateral stability index (MLSI) and vertical stability index (VSI), diagonal VSI, and lateral anterior/posterior stability index (APSI) and VSI. Forward, diagonal and lateral dynamic postural stability indices (DPSI) were larger for males ($p < 0.001$). No significant differences were found between players with and without a previous ankle sprain nor between players with and without an ankle sprain during the subsequent season.

Conclusion Male players showed larger DSI scores than female players, indicating lower dynamic stability. Sex-specific training sessions or prevention programs should be developed.

INTRODUCTION

Epidemiological studies have reported high incidence of ankle sprains in team sports such as basketball, football, soccer, softball, volleyball and baseball.[1,2] Most literature has shown that in these indoor and court sports more ankle sprains occur in female players compared to male players.[1] This difference in incidence suggests that mechanisms and risk factors for ankle sprain in males and females should be examined separately. Ankle sprains may have some debilitating consequences for the player. For instance, the risk of reinjury is large[3] and a potential long term consequence is chronic ankle instability (CAI).[4-7] CAI was defined as "an encompassing term used to classify a subject with both mechanical and functional instability of the ankle joint."[5] Moreover, it has been reported that 10–40% of players with long term issues following an ankle sprain still perceive instability and a feeling of giving way,[8-10] even up to three years after recovering from an ankle sprain.[3] Furthermore, CAI could lead to an increased risk of ankle osteoarthrosis.[11] .

The greatest risk factor is a history of ankle sprain.[3] One of the explanations for this increased risk may be a decreased neuromuscular control following an ankle sprain.[4] Balance deficits are a measure of neuromuscular control.[4] A review has shown that athletes who sprained their ankle still show balance deficits during a static balance task after four weeks.[12] These deficits were found not only in the injured ankle, but also in the contralateral ankle that was not injured.

Furthermore, a recent review showed some evidence that postural sway and balance are risk factors for ankle sprains in team sport players.[13] Two studies including male or a combination of male and female basketball players found a higher postural sway being predictive for ankle sprains,[14,15] however one study including male volleyball players did not find this relationship.[16] Those three studies used static balance tasks for measuring postural sway, for instance standing on one leg.[14-16] Furthermore, low odds ratios for postural sway were reported in these studies,[14,15] indicating that ankle sprain risk increased slightly when postural sway increased.

Two main limitations can be addressed in current studies examining the relationship between ankle sprain and stability. At first, in most studies static balance tasks were used to measure stability. Two reviews showed that static balance tasks could not detect stability differences, since they might not be sensitive enough to find small differences in postural control.[6,7,12] Dynamic balance tests, such as landing and stabilizing after a single leg jump, may be more capable to better detect these differences, since they are more challenging and sport specific.[6,7,12,17] The second limitation was that sex differences in stability were not taken into account. For instance, females showed higher dynamic stability scores on a forward jump task compared to males.[18] These findings contribute to the difference in ankle sprain incidence based on sex; female players presented a higher incidence of ankle sprains.[1] Although, it should be mentioned that one study that examined injury rates for different age groups found higher ankle sprain occurrence for male players in the age of 15–24 years.[2] In summary, the strategy for dynamic postural stability might be different for male and female players. Dynamic tasks are recommended to measure differences in postural stability between injured and non-injured players.

In this perspective, a single-leg hop-stabilization task was developed to determine the dynamic stability index (DSI).[19,20] The DSI measures the ability of a player to maintain static balance after a dynamic task. [21] A benefit of the single-leg hop-stabilization task is that it includes jumps in different directions, such as forward, diagonal and lateral. This makes it more sport specific than only performing forward jumps. One of the outcome measures was the dynamic postural stability index (DPSI), a composite score of the medial/lateral, anterior/posterior and vertical DSI.[18] It was suggested that the DPSI could be used for preseason screenings for CAI.[19,20] However, to the authors' knowledge, the relationship between the DPSI and acute ankle sprains has not been examined yet.

Compared with other currently used stability measures, the dynamic, challenging and sport specific aspects of the task used to determine DSI could make it more suitable to detect differences in dynamic stability between male and female players with and without a history of an ankle sprain. It might be suitable to detect preseason dynamic stability differences between players with and without ankle sprain during the subsequent season as well. Moreover, the DSI may assist in determining sex differences. Therefore, the first aim was to determine if sex differences in DSI could be detected for different jump directions. The second aim was to examine whether the DSI measured preseason could discriminate (a) between male and female players who had a history of an ankle sprain and players who did not and (b) between male and female players who sustained an ankle sprain during the subsequent season and players who did not. The first hypothesis was that male players would show lower DSI scores than female players for all directions. The second hypothesis was that players with a history of an ankle sprain and players who sprained their ankle during the season would show higher DSI scores compared to their non-injured counterparts.

METHODS

Design

A prospective cohort design was used to analyze the relationship between the DSI and ankle sprains in male and female team sport players. At the start of the season the DSI was measured during a single-leg hop-stabilization task. In addition, previous injury data were collected in order to provide insight in injury history of players. Ankle sprains were reported during the subsequent season. Written informed consent was obtained from all players and approval was granted in accordance with ethical standards of the local medical ethical committee, conforming to the Helsinki Declaration.

Subjects

Two male basketball teams, three volleyball teams (two male and one female) and one korfball team (mixed) playing at elite and sub-elite level participated in this study. Korfball is a team sport in which 4 males and 4 females play in one team, this sport shares similarities with basketball and netball.[22] More information about this sport can be found in supplementary material provided elsewhere.[22] In total, eighty players were invited to participate in this study. The exclusion criterion was a current injury to the ankle. Eleven players were not able to attend the baseline measurements due to practical reasons. Three players dropped out during the season (2011–2012). One of these three players moved to another city during the season, the other two players stopped playing at the sub-elite or elite level. Therefore, 66 players (47 male (21 volleyball, 10 korfball, 16 basketball) and 19 female (9 volleyball, 10 korfball)) were included (Table 3.1).

Table 3.1. Descriptive statistics of 66 players (mean ± SD).

	Female (n = 19)	Male (n = 47)
Age (years)	21.5 ± 2.9	22.9 ± 3.9
Height (cm)	175.9 ± 7.3	193.5 ± 7.9
Mass (kg)	69.0 ± 11.7	87.1 ± 10.6
BMI (kg/m^2)	22.2 ± 2.8	23.3 ± 2.5

Procedures

At baseline, players completed an injury history questionnaire about location, severity and type of previous injuries experienced during the whole lifetime, injuries experienced in the last 6 months, and injuries at baseline. To estimate severity of an injury, questions regarding duration of injury and time loss due to the injury were included.

Anthropometrics Prior to the test, mass, height and BMI were measured. Height was measured using a measuring tape attached to a wall.

DSI The single-leg hop-stabilization task was used to measure DSI.[21] Prior to testing, the maximal vertical leap was calculated, which was the largest difference between maximal jump height from stance and maximal reaching height out of three trials. A rope was placed at the reaching height plus 50% of maximal vertical leap height.[19,20] Therefore, the jump height was 50% of maximal vertical leap.[21] Jumps were performed in three directions, forward, diagonal and lateral and for each direction the jump distance was 70 cm (see Figure 3.1). Players were instructed to jump, touch the rope, land on one leg and hold their balance for 3 s, while keeping their hands at their hips.[21] In contrast to Wikstrom et al,[21] the player landed on the leg that was most nearby the force plate instead of the dominant or non-dominant leg, since this is more specific for team ball sports.[23] The direction and order of trials was randomized. The player was allowed to practice until the task was executed correctly. After practicing, three successful trials for each direction were recorded. A trial was successful if the player kept balance, touched the rope, did not make an additional hop and did not show excessive sway with the other limb, arms, or trunk.[21] Two force plates (Bertec Corporation, Columbus, Ohio) in combination with a custom made Matlab program (The MathWorks Inc., Natick, MA) were used to collect and calculate DSI. Medial/lateral stability index (MLSI), anterior/posterior stability index (APSI), vertical stability index (VSI) and DPSI were calculated as described by Wikstrom, Naik, et al.[6] and Wikstrom, Tillman, et al.[7] (Table 3.2). These indices stand for fluctuations around a zero point. A smaller deviation from zero means better stability. The MLSI includes fluctuations around the frontal axis, whereas the APSI includes fluctuations around the sagittal axis. The VSI was a measure for fluctuation around the vertical axis and was standardized to body weight. In other words, the VSI includes fluctuations from the subject's body weight.[21] The reliability of the DSI was excellent for the DPSI, APSI and VSI (intraclass correlation (ICC) range: 0.90–0.97), whereas the reliability of the MLSI was poor (ICC = 0.38, 95% CI 0.08–0.66).[19,20] The stability index was corrected for body mass,[6,7] in order to allow better comparison between players and to increase precision of the DPSI measures.[6,7] .

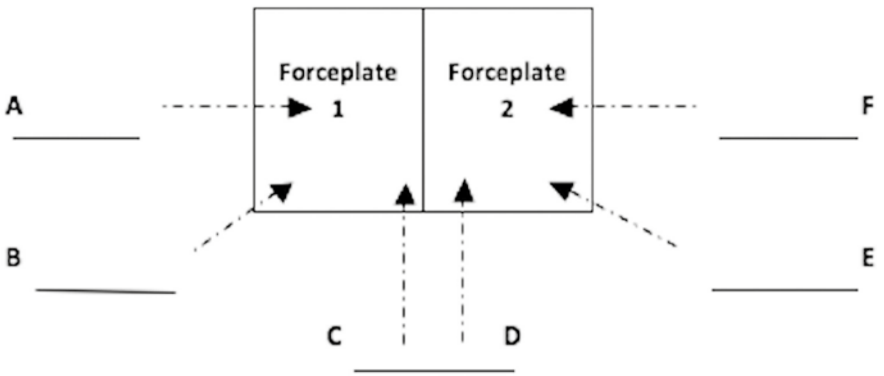

Figure 3.1. Starting positions for single-leg hop-stabilization task. All starting lines were placed 70 cm from the center of the force plate. Right leg landings occurred on center of force plate 1 (A, B, C) and left leg landings on center of force plate 2 (D, E, F). Reproduced and adapted by kind permission of Elsevier from Wikstrom et al. (2008).[21]

Table 3.2. Formulas for Calculating Stability Indices

$$MLSI = \sqrt{\frac{\Sigma\left(\frac{Fx}{weight}\right)^2}{Sample\ frequency}}$$

$$APSI = \sqrt{\frac{\Sigma\left(\frac{Fy}{weight}\right)^2}{Sample\ frequency}}$$

$$VSI = \sqrt{\frac{\Sigma\left(\frac{Fz - weight}{weight}\right)^2}{Sample\ frequency}}$$

$$DPSI = \sqrt{\frac{\Sigma\left(\frac{\Sigma(0 - Fx)^2 + \Sigma(0 - Fy)^2 + \Sigma(weight - Fz)^2}{weight}\right)}{Sample\ frequency}}$$

APSI = anterior/posterior stability index; DPSI = dynamic postural stability index; MLSI = medial/lateral stability index; VSI = vertical stability index. Fx, Fy, and Fz are the ground reaction forces in the different directions; medial/lateral, anterior/posterior, and vertical respectively. Sample frequency is the total number of frames that was collected.

Injury Report Injuries were reported during the season by the team physical therapists by using an injury reporting system based on the recommendations of Fuller et al. (2006).[24] The definition of ankle sprain and a previous ankle sprain was “An injury of the ankle ligaments sustained by an athlete that results from a game or training, irrespective of the need for medical attention or time loss from activities.[24]” Medical attention injuries were registered by team physical therapists. The number of injuries and percentage of injured players were reported.

Power analysis

Since DSI differences between players with and without an ankle sprain have not been examined, the difference between healthy subjects and subjects with CAI was used to calculate the sample size needed to find relevant differences.[6,7] Based on these differences in DPSI scores, the required sample size would be 20 (10 per group) to reach an effect size of 1.35 and a power of 0.80 with alpha set at 0.05. Based on sex differences in DSI shown in a previous study,[18] a sample size calculation was performed for an independent t-test. To reach an effect size of 1.00 with a power of 0.80 and alpha set at 0.05, the required sample size was 34 (17 per group).[25]

Statistical analyses

Means and standard deviations (SD) were calculated for all outcome variables. Independent t-tests were performed to analyze DSI differences between players who sustained an ankle sprain during the season and players who did not. In addition, independent t-tests were used to calculate differences on the DSI subscales between players with and without a history of an ankle sprain. Furthermore, sex differences on the subscales of the DSI were calculated with independent t-tests. Sex differences in DSI have been reported,[18] therefore the unequal number of injured male and female players would give a distorted picture, that cannot be generalized. Since the male group was the largest group and most injuries occurred in males, this group was included in the comparisons between injured and non-injured players. Cohen's d values for each of the variables were calculated and reported as a measure of effect size (ES), where $0.2 \leq d \leq 0.5$, $0.5 \leq d \leq 0.8$ and $d \geq 0.8$ represent a small, moderate and large effect, respectively.[26] In addition, a post-hoc power analysis was performed in order to examine if pre-set power level (0.80) was reached. SPSS 20.0 Statistical Package (SPSS Inc., Chicago) was used to analyze all data. To adjust for multiple t-tests, a Bonferroni correction of the α-value was used. The adjusted α-value was set at 0.0042 a priori.

RESULTS

Body height and mass were significantly higher in males compared to females ($p < 0.0001$). Female volleyball players were taller than female korfball players (179.62 ± 3.63 vs 172.62 ± 8.26, $p = 0.032$). Male basketball players were heavier than male korfball players (92.18 ± 11.47 vs 79.99 ± 8.38, $p = 0.011$) and female volleyball players were heavier than female korfball players (75.04 ± 13.04 vs 63.57 ± 6.72, $p = 0.028$). However, the DSI was controlled for weight, therefore we do not expect that this has influenced the results.

Sex

Figure 3.2 shows the results of the independent t-tests performed to find differences in DSI between male and female players. Specific results of these analyses (i.e. means and SDs) can be found in the appendix. Males scored significantly higher than females on forward MLSI and VSI ($p < 0.001$, ES = 1.32 and 1.08 respectively), diagonal VSI ($p < 0.001$, ES = 1.30), lateral APSI and VSI ($p < 0.001$, ES = 1.14 and 1.21 respectively). In addition, males scored significantly higher on the composite scores: forward ($p = 0.001$, ES = 1.08), diagonal, and lateral DPSI ($p < 0.001$, ES = 1.29 and 1.23 respectively). Post-hoc power analysis showed that for all significant findings, the power was higher than 0.992.

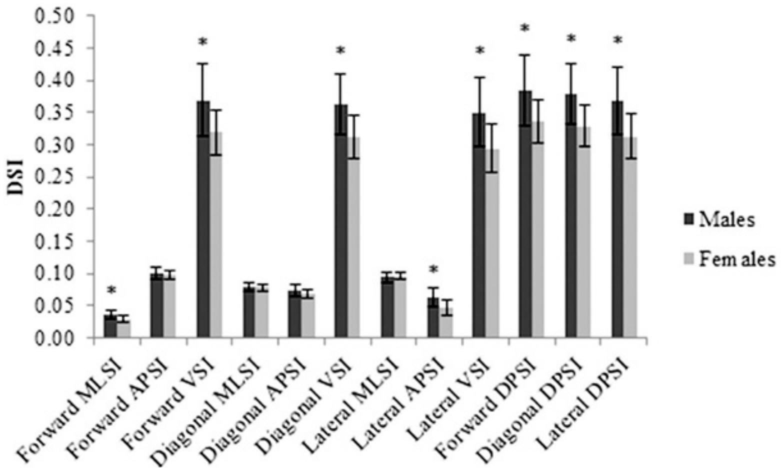

Figure 3.2. Results of DSI of males and females during a single-leg hop-stabilization task. APSI = anterior/posterior stability index; DSI = dynamic stability index; DPSI = dynamic postural stability index; MLSI = medial/lateral stability index; VSI = vertical stability index. *Significantly greater than females.

History of ankle sprain

Because only four ankle sprains occurred in the last six months before screening, the history of ankle sprains during whole lifetime was included. In total, eight male players (17.4%) and 2 female players (10.5%) reported a history of an ankle sprain. No significant differences in DSI were found between male players with and without a previous ankle sprain (Table 3.3).

Ankle sprain during season

Of the male ($n = 33$) and female players ($n = 16$) who did not sustain a previous ankle sprain, six male players (18.2%) and two female players (12.5%) sustained an ankle sprain during the season (Figure 3.3). Table 3.4 shows that no significant differences were reported for preseason DSI scores between male players who developed an ankle sprain during the subsequent season and male players who did not.

Table 3.3. Means and Standard Deviations of Dynamic Stability Index for Male Players With a History of Ankle Sprain (n = 8) and Male Players With no History of Ankle Sprain (n = 38).

Variable	History ankle sprain		No history ankle sprain					
	Mean	SD	Mean	SD	P	95% CI*	Cohen's d	Power
Forward MLSI	0.036	0.005	0.037	0.007	0.995	-0.005, 0.005	0.164	0.070
Forward APSI	0.100	0.010	0.100	0.008	0.973	-0.007, 0.007	0.000	0.050
Forward VSI	0.350	0.037	0.373	0.059	0.169	-0.011, 0.058	0.467	0.217
Diagonal MLSI	0.079	0.009	0.079	0.006	0.849	-0.008, 0.007	0.000	0.050
Diagonal APSI	0.071	0.007	0.074	0.010	0.410	-0.004, 0.011	0.348	0.141
Diagonal VSI	0.348	0.023	0.366	0.049	0.126	-0.005, 0.042	0.470	0.219
Lateral MLSI	0.096	0.011	0.095	0.008	0.715	-0.008, 0.005	0.104	0.058
Lateral APSI	0.056	0.008	0.063	0.016	0.255	-0.005, 0.018	0.553	0.285
Lateral VSI	0.339	0.033	0.352	0.057	0.408	-0.019, 0.044	0.279	0.108
Forward DPSI	0.366	0.036	0.388	0.058	0.171	-0.011, 0.056	0.456	0.209
Diagonal DPSI	0.364	0.022	0.382	0.049	0.120	-0.005, 0.041	0.474	0.222
Lateral DPSI	0.357	0.034	0.370	0.056	0.392	-0.018, 0.045	0.281	0.109

APSI = anterior/posterior stability index; DPSI = dynamic postural stability index; MLSI = medial/lateral stability index; VSI = vertical stability index.

* 95% confidence interval of the difference between players with an ankle sprain and players without an ankle sprain

Table 3.4. Means and Standard Deviations of Dynamic Stability Index for Players Who Sustained an Ankle Sprain During Season (n = 6) and Male Players Who Did Not (n = 33)

	Ankle sprain		No ankle sprain					
	Mean	SD	Mean	SD	P	95% CI*	Cohens'd	Power
Forward MLSI	0.037	0.005	0.037	0.007	0.996	-0.007, 0.007	0.000	0.004
Forward APSI	0.105	0.003	0.099	0.009	0.137	-0.014, 0.002	0.890	0.133
Forward VSI	0.404	0.043	0.369	0.060	0.219	-0.092, 0.022	0.670	0.061
Diagonal MLSI	0.081	0.006	0.078	0.006	0.229	-0.008, 0.002	0.500	0.030
Diagonal APSI	0.083	0.008	0.073	0.009	0.024	-0.020, -0.002	1.174	0.290
Diagonal VSI	0.406	0.034	0.360	0.049	0.051	-0.092, 0.000	1.091	0.237
Lateral MLSI	0.094	0.009	0.095	0.008	0.794	-0.006, 0.008	0.117	0.005
Lateral APSI	0.064	0.016	0.063	0.016	0.902	-0.015, 0.013	0.063	0.005
Lateral VSI	0.358	0.067	0.351	0.056	0.776	-0.059, 0.045	0.113	0.005
Forward DPSI	0.419	0.041	0.384	0.059	0.211	-0.091, 0.021	0.689	0.066
Diagonal DPSI	0.423	0.033	0.376	0.049	0.044	-0.093, -0.001	1.125	0.256
Lateral DPSI	0.376	0.065	0.369	0.056	0.781	-0.058, 0.044	0.115	0.005

APSI = anterior/posterior stability index; DPSI = dynamic postural stability index; MLSI = medial/lateral stability index; VSI = vertical stability index.

* 95% confidence interval of the difference between players with an ankle sprain and players without an ankle sprain

Figure 3.3. Timeline: occurrence of ankle sprains during season 2011/2012. The end of the season is presented per sport.

DISCUSSION

The DSI was originally developed to detect CAI, however the dynamic aspect of the task could make it also suitable for examining the relationship between DSI and acute ankle sprains. To the authors' knowledge, this is the first study that has analyzed this relationship.

The most important finding of this study was that male players demonstrated a larger DSI than female players, indicating that dynamic stability was worse for male players. Moreover, ESs between 1.08 and 1.32 were reported for all significant differences, indicating that the magnitude of the differences was large. These findings showed that the DSI can detect gender differences in dynamic stability. In contrast to the present findings, in a previous study female players demonstrated a worse composite DSI than their male counterparts while performing a forward jump.[18] Two methodological differences need to be taken into account for the interpretation, calculation of the DPSI and type of subjects. Wikstrom et al. (2006)[18] calculated a modified DPSI, which was normalized to vertical potential energy. Furthermore, the present study included elite and sub-elite team sport players, whereas the study of Wikstrom et al. (2006)[18] included healthy subjects. It was not reported if these healthy subjects performed sports. On the other hand, a study including the star excursion balance test (SEBT) found a better dynamic stability for females compared to males during anterior, medial and posterior reaches as in the present study.[27] A larger knee flexion in combination with a better control of the knee while performing the task could have increased the reach distance for the female athletes.[27] Although the SEBT was a measure of dynamic stability, it did not include a landing like the single-leg hop-stabilization task used in the present study.

A connection with studies considering anterior cruciate ligament (ACL) injury prevention may assist in explaining why females demonstrated a better DSI, since dynamic stability plays a role in ACL injury prevention as well.[28-30] One study already tried to examine the link between male and female players with CAI and risk of ACL injury.[30] Literature regarding knee injuries has shown sex differences in landing technique.[31,32] Differences in landing technique may explain why female players showed lower DSI scores than male players. For instance, vertical ground reaction force might have been lower in females,[33] resulting in a lower DSI. Future studies performing biomechanical analysis of the landing task next to dynamic stability measures might help to gain insight in sex differences. Understanding why females score differently compared to males is crucial for coaches and trainers, since that information would allow them to adapt the training programs for each sex more optimally.

The second finding was no difference in DSI between male players with and without a history of an ankle sprain, which was in contrast to the hypothesis. A review has shown that after an ankle sprain, deficits in balance or stability occur.[6,7] On the other hand, another study did not find differences in postural stability between players with and without a history of ankle sprain.[34] It should be noted that the time between ankle sprain occurrence and testing was different, 3.6 months for the study of Huurnink et al. (2013)[34] vs approximately 17.6 months for the present study. A first potential explanation for our results is that the severity of an ankle sprain may have influenced dynamic stability, as suggested by Huurnink et al. (2013).[34] In that study, a diminished dynamic stability after an ankle sprain was found for the players who sustained a severe ankle sprain only.[34] Based on the duration of the previous ankle sprains, no decreased dynamic stability was reported for the more severe sprains (33–74 days) compared to the less severe ones (21–28 days) in the present study. Unfortunately, the answers to the injury history questionnaire did not allow us to collect ankle sprain severity in terms of grade of ankle sprain for each player, but we expect that the grade of the ankle sprain and duration of an ankle sprain are related. A second suggestion that could explain our results is that potentially some of the players with a history of an ankle sprain were able to cope with balance deficits, so called 'copers', whereas other players continued to have problems with ankle stability, so called 'non-copers'.[35] In other words, the decreased stability found for the players with more severe ankle sprains may have been washed out by the results for players with minor ankle sprains without decreased stability. This idea of making a distinction between copers and non-copers has been previously proposed.[35] This distinction was based on measurable factors such as signs of giving way, pain and weakness, return to play and to pre-injury activities.[35] In the present study, these factors were not measured. However, injured players indicated that they have received physical therapy treatment including mobilization of the ankle, balance exercises and functional exercises. Therefore, for future studies it is recommended that questions regarding symptoms after an ankle sprain and return to play after the injury should be added to the injury history questionnaire in order to determine how many of the players with a history of ankle sprain are copers and non-copers.

The third finding of this study was that the DSI could not discriminate between players with and without an ankle sprain during the season following the screening, which did not confirm the hypothesis. In contrary, two reviews have shown some evidence that balance or postural sway was related to a higher risk of an ankle sprain.[13,36] Although no significant differences were found in the present study, it should be noted that moderate ESs were found for differences in three out of twelve subscales and a large ES for four subscales. In addition, injured players demonstrated a trend for higher DSI scores for all subscores except for the forward and lateral MLSI, however these differences did not reach statistical significance. Recent results of our study group found significant differences in preseason DSI between injured and non-injured players for the diagonal APSI, diagonal VSI and lateral APSI.[37] The results seem promising, since they suggest that the DSI has potential to detect dynamic stability differences between players who will and will not sustain an ankle sprain during the season. But the authors acknowledge that a larger sample size would be necessary to confirm that.

Some limitations of this study should be mentioned. The data on previous injuries were collected based on a questionnaire and these injuries had not been confirmed by medical reports. In the present study, athletes were asked to report previous injuries during the whole lifetime. Because this includes a long recall period, some injuries could have been missed or the diagnosis may have been incorrect.[38] Nevertheless, injury recall seemed to be higher when less detailed information was asked.[38] In our study, no specific information was asked, the body region and the number of injuries were the most important items. Therefore, the inaccuracy of incidence rate of previous ankle sprains was expected to be low.

A second limitation of this study was the small sample size. Based on the a priori sample size calculation, we should have included at least 10 players with an ankle sprain during season, while only 8 ankle sprains were reported in our sample. Two of these eight players sustained a previous injury and were therefore removed from the analysis. A higher injury rate was expected based on previous studies including basketball and volleyball players (23.8–42.9%).[15,16,39] Consequently, the study was underpowered. Still, this study is relevant because of its practical impact and based on the present results new studies can be developed.

Based on the current results it is important to keep sex differences in DSI in mind when (preventive) training sessions or prevention programs are being developed for individual players. Potentially for male players more stability exercises after a landing should be included, while for female players other types of exercises might be more helpful. Previous research has shown the benefits of adopting an external focus of attention, which means directing attention to the effect of the movement, for learning a postural control task.[40,41] Therefore, it might be useful to incorporate externally focused instructions in training sessions. Furthermore, it is recommended that studies considering DSI should conduct separate analyses for males and females.

CONCLUSION

Male players showed higher DSI scores than female players for all jump directions, indicating a worse dynamic stability. Players with an ankle sprain during the season did not show higher preseason DSI scores. Furthermore, players with a history of an ankle sprain did not differ in DSI compared to players with no history of ankle sprain. Further research including larger prospective cohort studies that perform regression analyses are needed to determine if a larger DSI can predict the occurrence of an ankle sprain.

CONFLICT OF INTEREST

None declared.

ETHICAL APPROVAL

All athletes filled out an informed consent and procedures were in accordance with the Central Committee on Research Involving Human Subjects.
The procedures of the present study are in accordance with the ethical standards of the Medical Faculty of the University Medical Center Groningen, University of Groningen (approval number: METc 2011/186).

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Appendix.

Results of independent t-tests; differences in dynamic stability index between males (n = 47) and females (n = 19)

Variable	Males		Females					
	Means	SD	Means	SD	P	95% CI	Cohen's d	Power
Forward MLSI	0.037	0.007	0.029	0.005	<0.001[a]	0.004, 0.011	1.315	0.997
Forward APSI	0.100	0.009	0.097	0.007	0.274	-0.002, 0.007	0.372	0.271
Forward VSI	0.369	0.056	0.319	0.034	<0.001[a]	0.027, 0.073	1.079	0.974
Diagonal MLSI	0.079	0.007	0.078	0.006	0.558	-0.002, 0.004	0.153	0.086
Diagonal APSI	0.073	0.010	0.068	0.007	0.018	0.002, 0.010	0.579	0.555
Diagonal VSI	0.363	0.046	0.311	0.033	<0.001[a]	0.028, 0.075	1.299	0.997
Lateral MLSI	0.095	0.008	0.096	0.005	0.429	-0.005, 0.002	0.150	0.150
Lateral APSI	0.062	0.015	0.047	0.011	<0.001[a]	0.008, 0.021	1.140	0.985
Lateral VSI	0.350	0.054	0.294	0.037	<0.001[a]	0.029, 0.082	1.210	0.992
Forward DPSI	0.384	0.055	0.335	0.033	0.001[a]	0.027, 0.072	1.080	0.975
Diagonal DPSI	0.379	0.046	0.328	0.032	<0.001[a]	0.028, 0.074	1.287	0.997
Lateral DPSI	0.368	0.053	0.313	0.035	<0.001[a]	0.032, 0.077	1.225	0.993

APSI = anterior/posterior stability index; DPSI = dynamic postural stability index; MLSI = medial/lateral stability index; VSI = vertical stability index.

[a] Indicates significant differences.