Universiteit Antwerpen

Faculty of Medicine and Health Sciences
Master of Science in Rehabilitation Sciences and Physiotherapy

The influence of different types of footwear during sport activity on ankle stability.

Jente Wagemans

Promotor: Prof. Dr. Isabel Baert
Co-promotor: Drs. Kevin Kuppens, Ms. Greta Peeters

Masterproef ReVaKi part 2

Academic year 2018-2019

Acknowledgement

I gratefully acknowledge Prof. Dr. Isabel Baert, Drs. Kevin Kuppens and Ms. Greta Peeters of the University of Antwerp for giving me the trust and opportunity to conduct this study. Their support, advice and guidance helped me complete this thesis. I would also like to thank sport clubs Hirano, Perfect team, Bulldogs, VC Kapellen, Basket Willebroek, KFCO Beerschot - Wilrijk and their members for their time and collaboration

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Abbreviations

CAI: Chronic ankle instability

CSA: Cross – sectional area

MOVANT: Movement Antwerp

POMS: Profile of Mood States

CAIT: Cumberland Ankle Instability Tool

VAS: Visual Analogue Scale

MCD: Minimal Clinical Difference

Context

Ankle injuries are the most common sport injuries in the world, with ankle sprains as the most frequently occurring ankle injury(1). Chronic ankle instability (CAI) usually develops following an ankle sprain that has not adequately healed or was not rehabilitated completely. The symptoms of ankle sprains can have adverse effects on the stability mechanisms of the ankle. (2). Trauma, such as an ankle sprain, can cause muscular reflex inhibition and result in significant reduction of the cross – sectional area (CSA) of the muscles (3, 4). The articular afferent information can also be altered due to the symptoms or structural disorders as a result of ankle sprains, causing proprioceptive deficiencies. Reduction of afferent information can change the recruitment order of motor neurons of the low load local stability muscles. This altered recruitment results in increased sense of effort and imbalance between agonist and antagonist. High load global muscles will be recruited for the control of stability of the joint. The final result of this altered recruitment is a dysfunctional development of uncontrolled movement and a loss of functional or dynamic stability (3). The incidence of ankle sprains is highest in sports where practitioners wear shoes, whilst there is no mention of sports with barefoot performance regarding the incidence of ankle sprains (1).

The use of minimal shoe support can give an increased CSA in the intrinsic local muscles, compared to runners using commercial footwear (5). This suggests increased functional and mechanical stability of the ankle joint. When applied to sportsmen performing barefoot, we hypothesise that they have greater ankle stability than sportsmen performing with supporting footwear. Even more than sportsmen performing with minimal shoe support, we hypothesise that sportsmen performing barefoot need more muscle strength, proprioception and recruitment from the intrinsic local muscle as they have no external support for stabilising the ankle whatsoever.

Therefore, this cross-sectional study aimed to compare ankle stability, assessed using different outcome measures between groups who use different types of footwear during sport activity.

This study is the second part of a two – part master thesis off Mr. Jente Wagemans to obtain a Master of Science degree in Rehabilitation sciences and Physiotherapy at the University of Antwerp. In the first part the clinimetric properties of clinical assessments for ankle stability were systematically reviewed. As this systematic review showed, the primary outcome measure for this study is the Multiple Hop Test, which showed to have the best score on validity and reliability for the assessment of ankle stability.

This study is conducted under the supervision of Prof. Dr. Isabel Baert, Drs. Kevin Kuppens and Ms. Greta Peeters. Prof. Dr. Isabel Baert is a tenure track docent at the University of Antwerp with multiple publications in the domain "lower limb". Drs. Kevin Kuppens is a PhD student and assistant at the

University of Antwerp, who is also clinically active. Ms. Greta Peeters works as a lector at the University of Antwerp. This research can be framed within the research themes of the research group MOVANT (Movement Antwerp). This is a research group that bundles research on understanding and improving overall health by using physical activity and rehabilitation, with a clear link to clinical practice.
Subjects for this inquisition were recruited in collaboration with boxing club “The Bulldogs”, volleyball club “VC Kapellen”, MMA club “Perfect Team”, Judo club “Hirano”, basketball club “Basket Willebroek” and football club “KFCO Beerschot - Wilrijk”.

Abstract (Dutch)

Doel van de studie: Onderzoeken of verschillende type schoeisel tijdens sportactiviteiten een mogelijke invloed hebben op enkelstabiliteit

Studieopzet: cross – sectionele studie

Achtergrond: Enkelblessures zijn de meest voorkomende blessures in de sport. Van die enkelblessures zijn enkelverstuikingen het meest voorkomen. Terugkerende enkelverstuikingen kunnen negatieve effecten hebben op de stabiliteitsmechanismen van de enkel, wat uiteindelijk kan leiden tot chronische enkelinstabiliteit. De literatuur toont aan dat enkelverstuikingen het vaakst voorkomen in sporten zoals voetbal, rugby, basketbal en American football. De atleten van deze sporten dragen allemaal schoenen. Er is veel minder vermeld in de literatuur over enkelblessures van kickboksers en andere soortgelijke sporten waarbij er blootvoets gesport wordt.

Methodologie: Eenenvijftig proefpersonen werden opgedeeld in vier groepen aan de hand van type schoeisel tijdens hun sportactiviteiten: blootvoetse sporters, sporters met lage schoenen, sporters met lage schoenen met toppen, sporters met hoge schoenen. Alle proefpersonen werden onderworpen aan vier klinische testen, de Nederlandse versie van de Cumberland Ankle Instability Tool - vragenlijst en de Profile Of Mood States. De testen en vragenlijsten werden op één testmoment afgenomen. Elke klinische test werd twee keer uitgevoerd met elke voet. Het gemiddelde van deze resultaten werd berekend en opgedeeld per dominante en niet – dominante voet voor verdere statistische analyse.

Resultaten: Blootvoetse sporters presteerden beter in tijd (p= 0.047; p= 0.002; p= 0.017) en/ of houdingscorrecties (p= 0.016; p=0.003) bij de multiple hop test dan sporters met schoenen. Er was geen significant verschil in de VAS – scores tussen de verschillende groepen. Sporters die sporten met lage schoenen met toppen hadden significant betere resultaten dan sporters met hoge schoenen op de CAIT – score (p= 0.024; p= 0.030). Proefpersonen die hun sport uitoefenen met lage schoenen met toppen scoorden significant beter dan sporters met hoge schoenen op de side – hop test (p= 0.045). Zij scoorden ook beter dan proefpersonen sportend met lage schoenen op de side – hop test, de figure – of – 8 hop test en de foot – lift test (p= 0.032; p= 0.011; p= 0.019). Proefpersonen die blootvoets sporten waren significant sneller bij de uitvoering van de figure – of – 8 hop test dan proefpersonen die sporten met lage schoenen test (p= 0.019; p= 0.011). Er was geen verschil tussen de verschillende groepen voor resultaten van de POMS.

Conclusie: Blootvoetse sporters presteren het best op de klinische testen voor enkelstabiliteit.

Key words: Ankle stability, footwear, influence of footwear, sports

Abstract (English)

Objective: To compare ankle stability between groups who use different types of footwear during sport activity.

Study design: Cross – sectional study

Background: The prevalence of ankle injuries is high in sports, with ankle sprains as the most common ankle injury. Recurrent ankle sprains can have adverse effects on the stability mechanisms of the ankle, which can eventually lead to chronic ankle instability. Literature shows that the incidence of ankle instability is the highest in sports as football, rugby, basketball and American football. Those are all sports where practitioners wear shoes. Kickboxing and other sports with bare foot performance are not mentioned in literature. The influence of different types of footwear on ankle stability is not yet examined.

Methods: Fifty – one subjects participated in this study. Subjects were distributed in four groups based on the type of footwear they use during their sport activities: shoes with low ankle support, shoes with high ankle support, shoes with low ankle support and studs, and barefoot. All subjects performed 4 clinical assessments for ankle stability, and completed the Dutch version of the Cumberland Ankle Instability Tool and the Profile of Mood States questionnaire. All tests were conducted at one moment, for each group of subjects. All subjects carried out each test twice, with each foot. Results of the clinical tests were averaged and distributed in dominant and non – dominant feet for further statistical analysis.

Results: Barefoot performing subjects scored better in time (p= 0.047; p= 0.002; p= 0.017) and/ or postural corrections (p= 0.016; p=0.003) than subjects performing sports with shoes at the multiple hop test. Subjects performing their sport with low shoe support with studs showed significantly better results than subjects with high shoe support on the CAIT – score (p= 0.024; p= 0.030). Subjects performing their sport with studs executed the side – hop test significantly faster than subjects with high ankle supporting shoes (p= 0.045). They scored also significantly better than subjects with low ankle supporting shoes for the side – hop test, foot – lift test and figure – of – 8 hop test (p= 0.032, p= 0.011; p= 0.019). Subjects performing their sport barefoot were significantly faster than subjects performing their sports with low ankle supporting shoes on the figure – of – 8 hop test (p= 0.019; p= 0.011). There was no significant difference between groups for the results of the CAIT and the POMS.

Conclusion: Subjects performing their sports barefoot show better results for the clinical ankle stability assessments than subjects performing their sports with shoe support.

Key words: Ankle stability, footwear, influence of footwear, sports

Introduction

Ankle sprains are the most common ankle injuries in sports with a prevalence of 76.7% (1). The initial symptoms associated with an ankle sprain are swelling, tenderness of the ankle, and pain with movement and full weightbearing. A severe, not adequately healed or not completely healed ankle sprain usually develops to chronic ankle instability (CAI) (2). The recurrence values of ankle sprains reported in literature go from 19% to 70%. CAI was developed in 19% to 72% of patients sustaining ankle sprains, due to the adverse effects on the stability mechanisms (6-8).

CAI occurs when there is an inefficiency in functional and/ or mechanical stability. Ankle sprain symptoms, such as pain, can affect functional ankle stability by decreasing afferent information. This results in altered recruitment of muscles, dysfunctional development of uncontrolled movement and a loss of joint stability, and eventually in recurrent ankle sprains (3, 6, 8). Mechanical ankle instability occurs when a severe ankle sprain results in anatomical changes, such as pathological laxity, arthrokinematic impairments and synovial changes (2, 9).

Literature shows that the incidence of ankle sprains is the highest in sports as football, rugby, basketball and American football (1). Multiple factors can confound the occurrence rate of ankle sprains in these sports. History of ankle injuries, shoes with air in the heels, absence of stretching before the game, contact, level of competition and BMI are risk factors for ankle sprains in sports (10-13). According to the author, research concerning these contributing factors is exclusively performed in sports where practitioners wear shoes. It is noted that kickboxing and other sports with barefoot performance are not mentioned in literature regarding ankle injuries.

The influence of different types of footwear on the occurrence of ankle stability is not examined either. The role of shoe design among basketball players is examined for ankle sprain rate and prevention. There was no evidence of difference between the different shoe designs for both outcomes (14, 15). The use of minimal support footwear while running contributes to an increase in cross– sectional areas (CSA) of the intrinsic foot muscles and a greater use of the spring– like function of the longitudinal arch of the foot(5). An increase of CSA from the intrinsic foot muscles suggests an increased recruitment of motor neurons, resulting in increased afferent information and therefor greater coordination and proprioception (3). Intrinsic foot muscles are a part of the local muscle system maintaining the functional stability (2). Efficient movement function, postural control of alignment and balance of the dynamic body is maintained by precisely coordinated muscle actions at the correct time, for the correct duration and in the correct combination of forces, within groups of synergistically acting muscles. This also extends to agonist and antagonist muscle interactions (3). Sensory, biomechanical and motor processing strategies are required to achieve this coordinated muscle actions and to achieve joint stability (3). It could be hypothesized that sportsmen performing their sport activities barefoot have more ankle stability than sportsmen performing their sport with shoe support. Barefoot sport performance can cause increased recruitment of motor neurons, increased proprioception and overall area, volume and strength of the local stabilisers of the ankle joint.

Therefore, the aim of this study is to investigate the influence of different types of footwear during sport activities (shoes with high ankle support, shoes with low ankle support, shoes with low ankle support with studs and barefoot) on ankle stability, measured by the multiple hop test as primary outcome. All clinical assessments for ankle stability are performed barefoot.

Methods

Ethics

This study was approved by the ethical committee of the University Hospital Antwerp (ref. number: 18/43/475). All subjects volunteered to participate and were informed about the aim of this study and gave written informed consent. All subjects also gave consent about filming the clinical tests. This consent was written in correspondence with the applicable national and international privacy regulations.

Subjects

Eighty - five subjects were recruited from different local sporting clubs, by visiting and e- mail correspondence. Subjects were enlisted based on our predetermined categories for different types of footwear used during sport activities: shoes with low ankle support, shoes with high ankle support, shoes with low ankle support and studs, and barefoot. Participants were recruited in the following disciplines: Judo, football, basketball, kickboxing and volleyball. To be included in this study, subjects had to be male, between 18 – 35 years old, and had to practice their primary sport for at least 3 years with the same type of footwear and 4 hours per week while practicing their secondary sport for not more than 2 hours per week. Subjects were excluded when they had ankle injuries and/or complaints, a history of severe ankle injuries, which affect ankle stability, injuries and/or complaints at the lower limbs, which affect ankle stability, severe ocular impairment, and subjects with any neurological, cardiac, vascular or metabolic disease. We prepared a questionnaire (appendix 1) for the volunteering subjects to fill in, to distinguish eligible subjects.

Test protocol

All tests were conducted at one moment, for each group of subjects. Order of testing, starting foot to perform each test with and starting test subject were chosen randomly. Subjects carried out each test twice, with each foot.

Outcome measures

Ankle stability

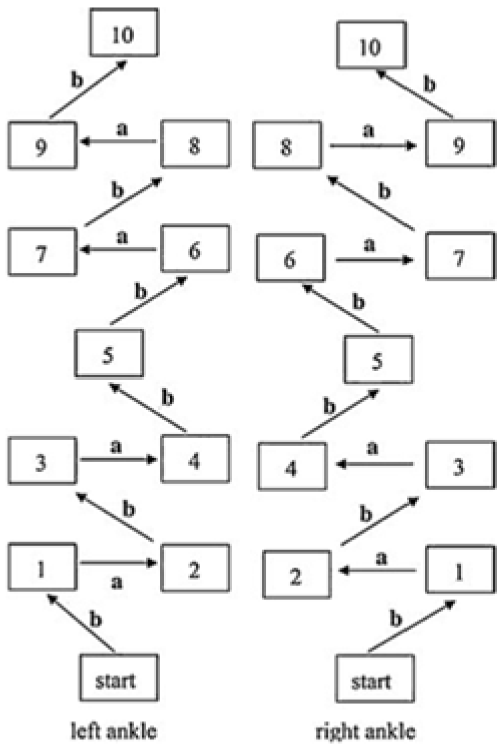
Four ankle stability assessments were performed: Multiple hop test, foot – lift test, side – hop test and figure – of – 8 hop test. Every test was conducted on a firm surface with subjects barefoot. All participants had the opportunity to try out the clinical tests. The average of the two trails for each ankle was used for analysis. All clinical tests were filmed by using GoPro cameras. The conducted CAIT was used complementary to the results of the ankle stability assessments. The multiple hop test was chosen as the primary outcome measure for this study.

Multiple hop test (16)

This is a dynamic balance test where eleven pieces of inelastic tape mark a numbered pattern on the floor. (figure 1) The Intertape distances were adapted to the subject's height. Subjects had to try to maintain balance when hopping over the course, following the numbered pattern and while landing on the ankle. They also had to avoid making any postural corrections. Subjects had the opportunity to have a practice trial with each ankle. The hop course was performed twice with each ankle alternately, with a 30 – second rest between each ankle and 3 minutes between repeats. Choice of ankle to start with was decided randomly and stayed identical for each repeat.

Time interval was measured from the start at the first marker until the subject stands still and stable at the last marker of the course. After each attempt the subjects were asked to rate the difficulty of the multiple hop test by giving a score on a 100 mm visual analogue scale (VAS), where 0 indicates "not difficult at all" and 100 mm indicates "impossible to perform". Postural corrections, such as falling, displacing the supporting foot, touching the ground with the swinging foot and moving the trunk, were also be documented. These outcome measures were averaged and distributed in dominant and non – dominant feet for further statistical analysis.

Figure 1: multiple hop test



Foot – lift test (17)

This test is a static balance test and uses a single – legged stance on a firm surface. Subjects had to hold their non – weight – bearing foot next to the weight – bearing leg at calf level, with the hands supporting the Iliac crests. Individuals had to keep their balance with eyes closed and remain as motionless as possible without moving their arms or the non – weight – bearing leg.

The amount of foot lifts during a 30 – second period were documented. A foot lift is defined as any part of the foot that loses contact with the ground. Each foot lift constituted 1 error. When the non – weight – bearing foot touched the ground, an error was documented. For each second that foot stayed on the ground, an additional error was recorded.

The test will be performed twice on each foot. There will be a 30 – second rest between feet and 1 – minute break between repeats. The total amount of errors was documented for each foot. This was the outcome measure for this test. The results were averaged and distributed in dominant and non – dominant feet for further statistical analysis.

Side – hop test (17)

Subjects had to hop laterally 30 cm and back medially 30 cm for ten repetitions (figure 2). The outcome measure for this dynamic balance test was the total time it takes to complete the 10 repetitions. The time intervals were averaged and distributed in dominant and non – dominant feet for further statistical analysis.

This test was performed twice with each foot, with a 30 – second break between feet and 1-minute break between repeats.

Figure 2: side - hop test

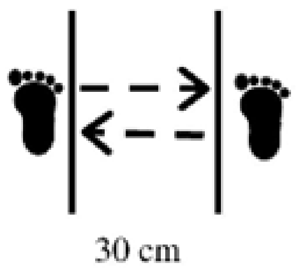
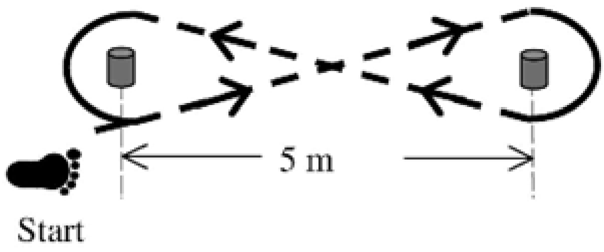


Figure – of – 8 hop test (17)

This test is also a dynamic balance test where subjects had to hop twice in a figure – 8 around two cones, separated 5 meters from each other, as quickly as possible (figure 3). The outcome measure for this test was also the time interval. The test started at the “go” signal and ended when crossing the marker. This test was also performed 2 times with each ankle, with a 30 – second rest between different ankles with at least 1-minute rest between repeats. The time intervals were averaged and distributed in dominant and non – dominant feet for further statistical analysis.

Figure 3: figure – of – 8 hop test



Cumberland Ankle Instability Tool (appendix 2)

The Cumberland Ankle Instability Tool (CAIT) is a questionnaire that assesses specifically symptoms of instability. The Dutch version will be used, which is proven valid and reliable to assess ankle instability (18). This questionnaire contains 30 questions giving a possible maximal score of 30 points. A maximum score means good ankle stability. Subjects had to fill in the CAIT at the same test moment as the clinical tests.

Mood state

Profile of Mood States – Dutch version (appendix 3)

The test indicates for 32 words or statements how the subject were feeling the day of the test. Each statement was scored on a 5 – point scale. The POMS measures five different mood swings: tension, anger, vigor, fatigue and depression. This test was conducted to investigate whether mood states could be a contributing factor to the performance of the test subjects This questionnaire was filled in at the same moment as the clinical tests and the CAIT.

Statistical analysis

Statistical analysis was processed by IBM Statistics version 25. Normal distribution was tested using the Shapiro – Wilk test, complemented by visual inspection of the applicable histograms. All outcome values were normally distributed. Therefore, one – way ANOVA test was used to compare test results between groups, with Bonferroni post – hoc testing.

Results

51 subjects (male, mean age 25 ± 4,4 years, mean body height 1,83 ± 0,08 m, mean body weight 78,2 ± 10,2 kg) met the eligibility criteria and were included in the study. 12 subjects perform sports barefoot, 16 subjects with shoes giving low ankle support with studs, 10 subjects with shoes giving low ankle support without studs and 13 subjects with shoes giving high ankle support.

Primary outcome measure

The comparison between different types of footwear during sport activities for the outcome measures of the multiple hop test are stated in table 1, for both dominant and non – dominant feet. Statistical significant differences in time values and amount of postural corrections were found. There is no significant difference in VAS – scores. Subjects performing sports with high shoe support and low shoe support with studs seem to need more time compared to barefoot performing subjects to execute the multiple hop test. Subjects performing sports with low ankle support and high ankle support appear to need more postural corrections than barefoot sports performing subjects to keep stability. Subjects performing sports with low ankle supporting shoes with studs also turn out to perform better on postural corrections than subjects performing sports with high ankle support.

Secondary outcome measure

Table 2 shows statistical significant differences between the different types of footwear for the stability assessments. There was significant difference between footwear in all clinical tests for either dominant and non – dominant feet. Subjects performing sports barefoot and with low ankle support with studs turn out to have better ankle stability than subjects performing sports with high ankle support shoes and subjects with shoes with low ankle support, according to the side – hop test, the figure – of – 8 hop test and/ or the foot- lift test.

In addition of de clinical tests, participants completed the Dutch version of the Cumberland Ankle Instability Tool (CAIT). The results of the CAIT are also stated in table 2. Significant differences were found in favour of subjects performing with shoes giving low ankle support with studs in comparison with subjects with high ankle supporting shoes, in both dominant and non – dominant feet. This means that subjects performing their sports with shoes with low ankle support with studs seem to have better ankle stability than subjects performing sports with high ankle supporting shoes, according to their own opinion about ankle stability.

Profile Of Mood States

Figure 4 shows the results of the categories of the POMS sorted by type of footwear. Statistical analysis is stated in table 3. All types of footwear score high on vigor while the results of the other categories are lower but differ from one another. There is no significant difference.

Table 1: Ankle stability results of the multiple hop test

Primary outcome: Multiple hop test	**Barefoot** ***n* = 12**	**Low AS with studs** ***n* = 16**	**Low AS** ***n* = 10**	**High AS** ***n = 13***	***P***	***P* barefoot - low AS**	***P* barefoot - low AS with studs**	***P* barefoot - high AS**	***P* low AS with studs - low AS**	***P* low AS - high AS**	***P* low AS with studs - high AS**
Dominant feet											
Time (s)	22.85 (3.11)	26.67 (2.33)	23.12 (3.01)	28.41 (5.33)	0.001†	1.000	0.047†	0.002†	0.110	0.006†	1.000
Postural corrections	4.83 (2.57)	5.81 (2.10)	7.85 (2.97)	8.62 (5.29)	0.030†	0.275	1.000	0.051	0.887	1.000	0.203
VAS	4.27 (0.75)	4.69 (1.47)	4.58 (1.61)	5.15 (1.38)	0.432	1.000	1.000	0.639	1.000	1.000	1.000
Non – dominant feet											
Time (s)	22.55 (2.84)	25.13 (2.22)	23.43 (3.54)	26.57 (4.08)	0.014†	1.000	0.234	0.017†	1.000	0.138	1.000
Postural corrections	3.92 (2.07)	4.88 (2.59)	7.90 (3.29)	8.27 (3.61)	0.001†	0.016†	1.000	0.003†	0.081	1.000	0.019†
VAS	3.77 (1.06)	4.45 (1.48)	4.80 (1.50)	5.11 (1.59)	0.129	0.597	1.000	0.139	1.000	1.000	1.000

AS = ankle support
Data are presented as Mean (SD). The *P* value corresponds to an ANOVA (with post hoc tests) comparing the four groups.
†Significant difference between groups ($P < 0.05$)

Table 2: Ankle stability results of the secondary outcome measures

Secondary outcome	**Barefoot** ***n* = 12**	**Low AS with studs** ***n* = 16**	**Low AS** ***n* = 10**	**High AS** ***n = 13***	***P***	***P* barefoot - low AS**	***P* barefoot - low AS with studs**	***P* barefoot - high AS**	***P* low AS with studs - low AS**	***P* low AS - high AS**	***P* low AS with studs - high AS**
Dominant feet											
Side – hop test (s)	9.61 (1.33)	9.23 (1.55)	10.52 (0.85)	10.58 (1.23)	0.023†	0.669	1.000	0.436	0.108	1.000	0.050†
Figure- of- 8 hop test (s)	12.86 (1.06)	13.20 (1.88)	14.70 (1.37)	13.52 (0.75)	0.019†	0.019†	1.000	1.000	0.057	0.289	1.000
Foot- lift test	14.71 (8,95)	8.28 (6.47)	11.55 (9.68)	13.89 (5.28)	0.116	1.000	0.185	1.000	1.000	1.000	0.319
CAIT	24.83 (4.09)	27.62 (2.75)	24.50 (5.80)	22.31 (6.03)	0.034†	1.000	0.758	1.000	0.633	1.000	0.024†
Non – dominant feet											
Side – hop test (s)	9.22 (0.89)	9.09 (1.61)	10.45 (0.37)	10.30 (1.07)	0.006†	0.097†	1.000	0.145	0.032†	1.000	0.045†
Figure- of- 8 hop test (s)	12.87 (0.94)	12.99 (1.80)	14.73 (1.38)	13.77 (0.69)	0.005†	0.011†	1.000	0.569	0.011†	0.519	0.724
Foot- lift test	12.33 (7.93)	8.53 (6.39)	20.35 (15.68)	15.73 (7.54)	0.022†	0.321	1.000	1.000	0.019†	1.000	0.282
CAIT	25.83 (4.04)	28.00 (2.86)	25.40 (5.28)	22.54 (7.17)	0.044†	1.000	1.000	0.621	1.000	1.000	0.030†

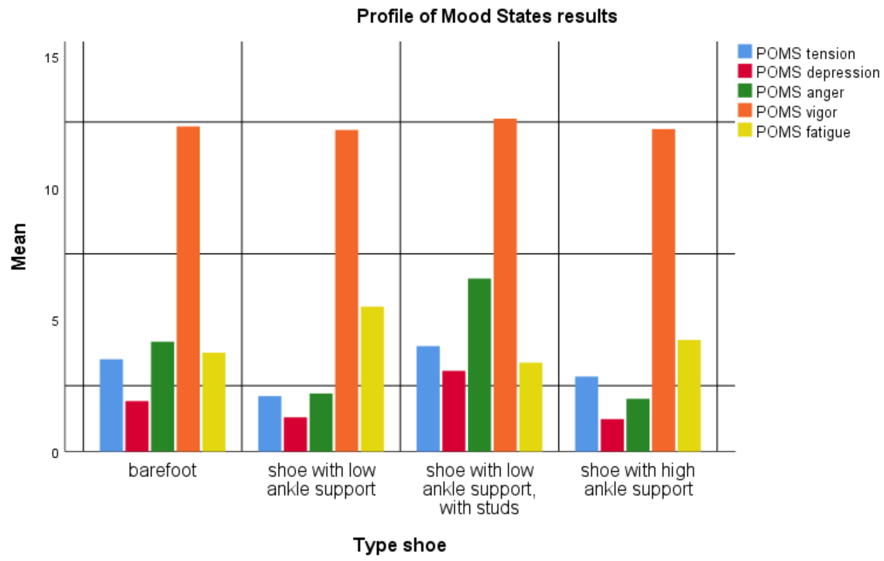
AS = ankle support
Data are presented as Mean (SD). The *P* value corresponds to an ANOVA (with post hoc tests) comparing the four groups.
†Significant difference between groups ($P < 0.05$)

Table 3: mood states results of de POMS

Profile of Mood Stated	Barefoot *n* = 12	Low AS with studs *n* = 16	Low AS *n* = 10	High AS *n = 13*	*P*	*P* barefoot vs low AS	*P* barefoot vs low AS with studs	*P* barefoot vs high AS	*P* low AS vs low AS with studs	*P* low AS vs high AS	*P* low AS with studs vs high AS
Tension	3.50 (3.00)	4.00 (3.92)	2.10 (1.91)	2.85 (3.98)	0.550	1.000	1.000	1.000	1.000	1.000	1.000
Depression	1.92 (2.31)	3.06 (4.51)	1.30 (1.95)	1.23 (3.03)	0.426	1.000	1.000	1.000	1.000	1.000	0.855
Anger	4.17 (5.00)	6.56 (6.56)	2.20 (2.86)	2.00 (2.55)	0.052	1.000	1.000	1.000	0.169	1.000	0.083
Vigor	12.33 (3.17)	12.63 (3.28)	12.20 (2.70)	12.23 (3.61)	0.985	1000	1.000	1.000	1.000	1.000	1.000
Fatigue	3.75 (2.99)	3.38 (3.42)	5.50 (3.81)	4.23 (3.32)	0.867	1.000	1.000	1.000	0.753	1.000	1.000

AS = ankle support
Data are presented as Mean (SD). The *P* value corresponds to an ANOVA (with post hoc tests) comparing the four groups.
†Significant difference between groups ($P < 0.05$)

Figure 4: Graphical presentation POMS



Discussion

The purpose of this cross – sectional study was to investigate whether there is a difference in ankle stability between different types of footwear used during sport activities, such as shoes with low ankle support, shoes with high ankle support, shoes with low ankle support with studs or barefoot. Although there is growing interest in barefoot and minimalistic shoe performance in sports and rehabilitation, to our knowledge, this is the first study that thoroughly investigates the difference in ankle stability between footwear.

To investigate the research hypothesis, there are multiple clinical tests for the assessment of ankle stability. Generally applied clinical tests are the y– balance test, the star– excursion balance test and various types of hop tests. A systematic review investigating clinimetric properties of clinical assessments for ankle stability shows that the multiple hop test came out most reliable and valid (19). Hence, the multiple hop test seemed to be the best available test to assess ankle stability in sportsmen with different types of footwear during sport activities.

Subjects performing barefoot scored significantly better at the multiple hop test than subjects performing sports with low ankle support with and without studs, and subjects performing with shoes giving high ankle support on time interval and/ or postural corrections. They also executed the figure – of – 8 hop test significantly faster than subjects performing their sport with low ankle support. These results partially confirm our hypotheses that sportsmen performing their sport activities barefoot have better ankle stability than sportsmen performing with shoe support. The significantly worse results of subjects performing with high ankle supporting shoes on the multiple hop test and the side – hop test support the findings of Miller et al. with their investigation about the effect of minimal shoes on the arc structure and intrinsic muscle strength, when we apply this to ankle stability (5). These results possibly contradict the studies of Curtis et al. and Barret et al.. when they found no evidence between different shoe designs in the rate and prevention of ankle sprains (14, 15). There is no statistical difference between groups in VAS – scores and in POMS – scores. Although VAS – scores are globally used, it is a subjective measure to rate the difficulty of the test. It does not measure ankle stability itself. We conducted the POMS to objectify the mood states of our participants. The results of the POMS - scores possibly indicate that the results of the clinical assessments for ankle stability are not influenced by mood states of the subjects, since there is a statistical difference between groups for ankle stability. There is no mention in literature of any association between mood states and ankle stability but literature shows that psychological factors have a significant relationship with functional test performance and validated outcome measures after Anterior Cruciate ligament reconstruction. There was no observed difference in knee stability though (20). The Dutch version of the POMS is scored by 5 different categories A conclusive mood state score could help conclude whether the results of the stability tests are influenced by the mood states of the participating subjects.

Although there is a statistical difference in ankle stability results between subjects with different types of footwear used during their sport activities, there can be other factors contributing to the influence of ankle stability. We recruited judoka, kickboxers, footballers, volleyball players and basketball players as subjects for this study. These sports have some difference in characteristics that can possibly influence the results of the ankle stability tests. Even though we excluded possible subjects based on recent history of ankle and/ or lower limb injuries, a long term history of severe ankle and/ or lower limb injuries can also have an adverse effect on the stability mechanisms of the ankle (11). Other possible confounding factors of ankle stability in sports are level of competition, BMI and contact during sport activities (10-12, 21, 22). Further research is warranted about confounding factors influencing ankle stability in sports.

To detect between-group differences with an effect size of 0.25, a minimum number of 45 participants in each group is needed with a power of 80% and an α of 0.05%. This power calculation is based on the minimal clinical difference (MCD) of the multiple hop test: outcomes should, respectively, differ more than 7 errors, 6 seconds and 27 mm before considering it a real difference. (23) Our sample size consisted 16 subjects in the group of sportsmen performing with low ankle support shoes with studs, 12 subjects in the group op barefoot performing sportsmen, 10 subjects in the group of sportsmen performing with shoes with low ankle support without studs and 12 subjects in the group of sportsmen performing with high ankle support shoes. We can conclude that this study is underpowered to detect between- group differences based on the population of this inquiry. Even though this study is underpowered, the results give a first insight about the difference in ankle stability between subjects performing sports with different types of footwear. Research with a larger sample size could give a more conclusive result.

This cross – sectional study is the first study that thoroughly investigates the difference in ankle stability between footwear. All groups of subjects were tested in similar circumstances to obtain standardisation. Since there was no interference with sport activities of the subjects, the results of this study can be considered as valid. Subjects were tested once. To determine whether different types of shoes have influence on ankle stability, a longitudinal study letting different groups perform the same exercises with different types of footwear and conducting ankle stability assessments on multiple test moments could give more conclusive results.

Clinical relevance

If further research would confirm the results this study, sport physiotherapists could possibly have more insight about the prevention of ankle sprains and resulting CAI. Subjects performing their sports with high ankle support scored worst on the clinical tests for ankle stability. By advising sportsmen with their choice of shoes, prevalence of ankle sprains could possibly decrease. This should be further investigated. These results could also be beneficiary for treatment of CAI. Further investigation about barefoot rehabilitation exercises in the treatment of CAI could be useful for sport physiotherapy.

Conclusion

This cross – sectional study investigated the possible influence of different types of footwear during sport activities on ankle stability. After statistical analysis, we determined that sportsmen performing barefoot have best results on the multiple hop test and may have the best ankle stability. We may also conclude that barefoot performing sportsmen, sportsmen performing with low ankle support with and without studs show better results than sportsmen performing with shoes giving high ankle support, based on the results of the other clinical assessments. Although these results are statistically significant, this study is underpowered. Further research is recommended with a greater sample size of subjects to evaluate whether different types of footwear during sport activities have an influence on ankle stability.

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Appendix

1. Eligibility questionnaire

Algemene informatie:

Leeftijd:…………..

Lichaamslengte:………

Lichaamsgewicht:…………

Dominante voet:…………

Sport specifieke informatie:

Primaire sport:…………………………………………..

Uren primaire sport/ week:……………………….

Hoeveel jaar beoefent u reeds deze sport?

…………..

Doet u nog aan andere sporten? Zo ja, welke?

……………………………………………….

Hoeveel uur voert u deze andere sport(en) uit per week?

…………

Welk type schoeisel draagt u hoofdzakelijk tijdens uw primaire sport, de voorbije drie jaar?

☐ Geen, blootvoets

☐ Schoen die steun geeft tot onder de enkelknobbels [1]

☐ Schoen die steun geeft tot onder de enkelknobbels, met noppen [2]

☐ Schoen die steun geeft tot boven de enkelknobbels [3]

Figuur 1

Figuur 2

Figuur 3

Welk type schoeisel draagt u voornamelijk in uw dagelijks leven?

……………………………………………….

In te vullen door proefpersoon:

Medische informatie:

Heeft u momenteel last van klachten en/of instabiliteit aan de enkel?

☐ Ja

☐ Neen

Indien "ja", hoe zou je deze klacht omschrijven?

Licht – matig – ernstig - zeer ernstig

Had u in het verleden last van enkelblessures?

☐ Ja

☐ Neen

Indien "ja", wanneer? ……………….

Heeft u momenteel last van klachten aan de onderste ledematen (heup, knie, voet)?

☐ Ja

☐ Neen

Indien "ja", hoe zou je deze klacht omschrijven?

Licht – matig – ernstig – zeer ernstig

Welke? ....

Had u het voorbije jaar last van klachten aan de onderste ledematen?

☐ Ja

☐ Neen

Indien "ja", welke? ....

Heeft u reeds operaties ondergaan?

☐ Ja

☐ Neen

Indien "ja", welke en wanneer?

……………………………………………….

Lijdt u aan een oogafwijking, die u hindert tijdens uw sportactiviteit?

☐ Ja

☐ Neen

Indien “ja”, welke? ....

Lijdt u aan een neurologische, metabole of hart – en vaataandoening?

☐ Ja

☐ Neen

Indien “ja”, welke? ....

Heeft u een gekende evenwichtsstoornis?

☐ Ja

☐ Neen

Indien “ja”, welke? ....

2. Cumberland ankle instability tool (CAIT)

The Cumberland Ankle Instability Tool: Nederlandse versie

	Links	**Rechts**	**Score**
<u>1. Ik heb pijn in mijn enkel</u>			
Nooit	◻	◻	5
Tijdens sport	◻	◻	4
Bij rennen op oneven ondergrond	◻	◻	3
Bij rennen op vlakke ondergrond	◻	◻	2
Bij lopen op oneven ondergrond	◻	◻	1
Bij lopen op vlakke ondergrond	◻	◻	0
<u>2. Mijn enkel voelt ONSTABIEL</u>			
Nooit	◻	◻	4
Soms tijdens sport (niet elke keer)	◻	◻	3
Vaak tijdens sport (elke keer)	◻	◻	2
Soms tijdens dagelijkse activiteiten	◻	◻	1
Vaak tijdens dagelijkse activiteiten	◻	◻	0
<u>3. Als ik een SCHERPE draai maak, voelt mijn enkel ONSTABIEL</u>			
Nooit	◻	◻	3
Soms tijdens rennen	◻	◻	2
Vaak tijdens rennen	◻	◻	1
Tijdens lopen	◻	◻	0
<u>4. Bij het van de trap af gaan, voelt mijn enkel ONSTABIEL</u>			
Nooit	◻	◻	3
Als ik snel ga	◻	◻	2
Af en toe	◻	◻	1
Altijd	◻	◻	0

<u>5. Mijn enkel voelt ONSTABIEL bij het staan op ÉÉN been</u>			
Nooit	□	□	2
Op de bal van mijn voet	□	□	1
Met mijn voet plat	□	□	0
<u>6. Mijn enkel voelt ONSTABIEL wanneer…</u>			
Nooit	□	□	3
Ik van links naar rechts hop	□	□	2
Ik op de plaats hop	□	□	1
Ik spring	□	□	0
<u>7. Mijn enkel voelt ONSTABIEL als…</u>			
Nooit	□	□	4
Ik ren op oneven ondergrond	□	□	3
Ik jog op oneven ondergrond	□	□	2
Ik loop op oneven ondergrond	□	□	1
Ik loop op vlakke ondergrond	□	□	0
<u>8. TYPISCH, wanneer ik begin met mijn enkel verzwikken (of verstuiken) kan ik dit stoppen…</u>			
Direct	□	□	3
Vaak	□	□	2
Soms	□	□	1
Nooit	□	□	0
Ik heb nog nooit mijn enkel verzwikt	□	□	3
<u>9. Na een TYPISCH geval van mijn enkel verzwikken, wordt mijn enkel weer ‘normaal’…</u>			
Bijna direct	□	□	3
Binnen één dag	□	□	2
1–2 dagen	□	□	1
Meer dan 2 dagen	□	□	0
Ik heb nog nooit mijn enkel verzwikt	□	□	3

3. Profile of Mood States

Profile of mood state: Nederlandse versie

Aanwijzingen :

Op de volgende bladzijde vindt u een lijst met woorden. Deze woorden beschrijven gevoelstoestanden.

Het is de bedoeling dat u aangeeft **in welke mate** de betekenis van het woord past bij uw gemoedstoestand **op dit moment**.

Bijvoorbeeld:

"prettig" 0 – 1 – 2 – 3 – 4

Als het woord **absoluut niet** bij u gevoel past, dus als u zich helemaal niet prettig voelt, dan omcirkelt u het cijfer **0**.
Als het woord **een beetje** bij u gevoel past, dus als u zich weinig prettig voelt, dan omcirkelt u het cijfer **1**.
Als het woord **middelmatig** bij u gevoel past, dus als u zich prettig voelt,
dan omcirkelt u het cijfer **2**
Als het woord **goed** bij u gevoel past, dus als u zich erg prettig voelt,
dan omcirkelt u het cijfer **3**.
Als het woord **heel goed** bij u gevoel past, dus als u zich bijzonder prettig voelt, dan omcirkelt u het cijfer **4**.

Het gaat er dus om hoe u zich **OP DIT MOMENT** voelt.

Denk niet lang na over uw antwoord. Het gaat om uw eerste indruk. Er bestaan geen foute antwoorden. Elk antwoord is goed, als het uw eigen stemming weergeeft. Sla geen woorden over.

<u>In te vullen door proefpersoon</u>

Profile of mood state: Nederlandse versie

De omschrijving past bij mijn gevoel VAN DIT MOMENT

0 = absoluut niet   1 = een beetje   2= middelmatig   3 = goed   4 = heel goed

1. neerslachtig	0 – 1 – 2 – 3 – 4	17. ongelukkig	0 – 1 – 2 – 3 – 4
2. slecht gehumeurd	0 – 1 – 2 – 3 – 4	18. woedend	0 – 1 – 2 – 3 – 4
3. uitgeput	0 – 1 – 2 – 3 – 4	19. lusteloos	0 – 1 – 2 – 3 – 4
4. aktief	0 – 1 – 2 – 3 – 4	20. vol energie	0 – 1 – 2 – 3 – 4
5. zenuwachtig	0 – 1 – 2 – 3 – 4	21. rusteloos	0 – 1 – 2 – 3 – 4
6. hulpeloos	0 – 1 – 2 – 3 – 4	22. onwaardig	0 – 1 – 2 – 3 – 4
7. geërgerd	0 – 1 – 2 – 3 – 4	23. knorrig	0 – 1 – 2 – 3 – 4
8. helder	0 – 1 – 2 – 3 – 4	24. doodop	0 – 1 – 2 – 3 – 4
9. paniekerig	0 – 1 – 2 – 3 – 4	25. opgeruimd	0 – 1 – 2 – 3 – 4
10. droevig	0 – 1 – 2 – 3 – 4	26. angstig	0 – 1 – 2 – 3 – 4
11. opstandig	0 – 1 – 2 – 3 – 4	27. droefgeestig	0 – 1 – 2 – 3 – 4
12. vermoeid	0 – 1 – 2 – 3 – 4	28. kwaad	0 – 1 – 2 – 3 – 4
13. levendig	0 – 1 – 2 – 3 – 4	29. afgemat	0 – 1 – 2 – 3 – 4
14. gespannen	0 – 1 – 2 – 3 – 4	30. onzeker	0 – 1 – 2 – 3 – 4
15. eenzaam	0 – 1 – 2 – 3 – 4	31. wanhopig	0 – 1 – 2 – 3 – 4
16. aan het eind van mijn krachten	0 – 1 – 2 – 3 – 4	32. mopperend	0 – 1 – 2 – 3 – 4

Einde van de vragenlijst

Controleer aub of alle vragen beantwoord zijn. Dank u.

4. Informed Consent

Titel:
De invloed van verschillende types schoeisel tijdens sportactiviteiten op enkelstabiliteit

Hierbij bevestig ik, ondergetekende, ……………………………… dat ik over de studie ben ingelicht en een kopie van de "Informatie voor de Patiënt en Toestemmingsformulier" ontvangen heb.

Ik heb de informatie gelezen en begrepen.

De onderzoeker heeft mij voldoende informatie gegeven met betrekking tot de voorwaarden en de duur van de studie. Bovendien werd mij voldoende tijd gegeven om de informatie te overwegen en om vragen te stellen, waarop ik bevredigende antwoorden gekregen heb.

Deelname aan de studie zal niet worden vergoed.

Ik heb begrepen dat ik mijn deelname aan deze studie op elk ogenblik mag stopzetten nadat ik de onderzoeker hierover heb ingelicht, zonder dat dit mij enig nadeel kan berokkenen.

Mijn medische gegevens zullen strikt vertrouwelijk behandeld worden. Ik ben mij bewust van het doel waarvoor deze gegevens verzameld, verwerkt en gebruikt worden in het kader van deze studie.

Ik ga akkoord met de verzameling, de verwerking en het gebruik van deze medische gegevens, zoals beschreven in het informatieblad voor de patiënt.

Ik stem geheel vrijwillig toe om deel te nemen aan deze studie en om mee te werken aan alle gevraagde onderzoeken. Ik ben bereid informatie te verstrekken i.v.m. mijn medische geschiedenis, mijn geneesmiddelengebruik en eventuele deelname aan andere studies.

Ik ga ermee akkoord dat mijn huisarts/specialist en andere zorgverleners die bij mijn behandeling betrokken zijn, indien nodig, op de hoogte worden gebracht van mijn deelname aan dit onderzoek.

____________________ ____________ ____________________

Naam van de Proefpersoon **Handtekening** **Datum**

____________________ ____________ ____________________

Naam van de Onderzoeker **Handtekening** **Datum**

Prof. Dr. Isabel Baert
isabel.baert@uantwerpen.be
03/2659114
Universiteit Antwerpen
Faculteit Geneeskunde en Gezondheidswetenschappen Vakgroep
Revalidatiewetenschappen en Kinesitherapie Campus Drie Eiken
Universiteitsplein 1
2560 Wilrijk (Antwerpen)

5. Informed consent filming

Titel: ***De invloed van verschillende types schoeisel tijdens sportactiviteiten op enkelstabiliteit***

Geachte heer,

Om gegevens verzameld binnen dit wetenschappelijk onderzoek van de Universiteit Antwerpen correct te kunnen interpreteren, zouden wij, de onderzoekers, de klinische testen uitgevoerd in het kader van deze studie willen filmen. Het resulterende beeldmateriaal zou in eerste instantie dienen voor dit wetenschappelijk onderzoek. Daarnaast kan dit beeldmateriaal tevens gebruikt worden voor educatieve doeleinden binnen de opleiding Revalidatiewetenschappen en Kinesitherapie aan de Universiteit Antwerpen. Bij het filmen van deze testen worden er geen namen genoemd en zal u onherkenbaar gemaakt worden op het videomateriaal, zodat u anoniem blijft voor derden.

Graag zouden wij uw toestemming krijgen voor het filmen van de klinische testen in het kader van dit wetenschappelijk onderzoek. Wij garanderen hierbij om uw persoonsgegevens te behandelen overeenkomstig de geldende nationale en internationale privacyregels. Voor verdere vragen omtrent de verwerking van persoonsgegevens, gelieve contact op te nemen via onderstaande gegevens.

- ☐ Hierbij bevestig ik, ondergetekende, ……………………………………………, dat er gefilmd mag worden door de onderzoeker tijdens het afnemen van de klinische testen in het kader van deze studie, en dat het resulterende beeldmateriaal anoniem gebruikt mag worden voor het wetenschappelijk onderzoek.

- ☐ Hierbij bevestig ik, ondergetekende, ……………………………………………, dat het resulterende beeldmateriaal dat vergaard is door het filmen van de klinische testen van deze studie nadien anoniem gebruikt mag worden voor educatieve doeleinden binnen de opleiding Revalidatiewetenschappen en Kinesitherapie aan de Universiteit Antwerpen.

______________________	______________	______________________
Naam van de proefpersoon	**Handtekening**	**Datum**

______________________	______________	______________________
Naam van de Onderzoeker	**Handtekening**	**Datum**

Prof. Dr. Isabel Baert
isabel.baert@uantwerpen.be
03/2659114
Universiteit Antwerpen
Faculteit Geneeskunde en Gezondheidswetenschappen Vakgroep
Revalidatiewetenschappen en Kinesitherapie Campus Drie Eiken
Universiteitsplein 1
2560 Wilrijk (Antwerpen)