Intrinsic predictive factors for acute and recurrent lateral ankle sprain in active and athlete population: A systematic review

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Received: October 2020; Accepted November 2020; Published: December 1, 2020.
Citation: Hanaa I. Alkuwari et al.. Intrinsic predictive factors for acute and recurrent lateral ankle sprain in active and athlete population: A systematic review. World Family Medicine. 2020; 18(12): 228-236 DOI: 10.5742/MEWFM.2020.93934

Abstract

Background: Acute and recurrent lateral ankle sprain are two of the most frequently reported lower limb injuries in the athlete population. Identifying the causative and etiological factors contributing to lateral ankle injury is challenging and it is mostly lagging behind. Understanding the intrinsic factors for lateral ankle injury is crucial for developing preventive measures.

Objective: To identify intrinsic predictors that are associated with increased risk of initial and lateral ankle sprain.

Data source and synthesis: MEDLINE, Web of Science and Google scholar entries electronic from 1970 through to 2015 were searched using the terms ankle sprain, predictors, intrinsic and risk factors. Five relevant studies were identified to fit the inclusion criteria and 19 studies were excluded after reviewing the full text for the following main reasons: subjects recruited from military, age under 15 years, study follow up periods below 3 months and retrospective study design.

Study selection/eligibility: Only prospective (with follow up period of 3 months) studies in English language that were assessing intrinsic factors for lateral ankle sprain in athletes and physically active individuals were included.

Data extraction: Data on research design, study duration, participants, lateral ankle diagnosis, investigated risk factors, odds ratio, confidence interval and other relevant data were assessed.

Result: Five studies were identified with three potential intrinsic factors of ankle sprain; previous ankle sprain and ankle plantar flexion range of motion and with conflicting findings on dorsiflexion range of motion. All of the aforementioned variables were found to increase the risk of lateral ankle sprain with one study reporting increased ankle dorsiflexion range of motion positively influencing the incidence of future ankle injury, while another study contradicted this result and revealed that decreased ankle dorsiflexion range of motion raises the possibility of future ankle sprain.

Limitation: Most studies were not sufficiently powered, with fair to poor quality and with not adequately mentioning concealment and blindness from the outcome measure. Different equipment was used to investigate the variables.

Conclusion: A previous history of ankle sprain as well as ankle plantar flexion strength puts athletes and physically active individuals at risk for initial and recurrent ankle sprain.

Key words: Lateral ankle sprain, Predictors and intrinsic.

Introduction

Initial and recurrent lateral ankle sprain are two of the most frequently reported injuries in both the physically active and athletes. One of the recent descriptive epidemiological studies reported that ankle ligament sprain was the second most common body location of injury in amateur soccer players (1). Bruno et al stated that the incidence of ankle ligament injury in handball, volleyball and basketball players was 52 %. He also found that ankle ligament injury is more prevalent in women volleyball players 13.6% (22). Another study stated that the rate of anterior talofibular ligament injuries was 85.3% of the total ankle sprain that resulted in approximately 50% loss of participation in high school sport matches (2). More than half of injuries were recurrent (3). Carlos and Joao defined lateral ankle sprain as an inversion injury of the ankle (21). Many intrinsic and extrinsic factors have been addressed as a link with lateral ankle injuries such as age, previous injuries, range of motion, dynamic balance and player's position (3,4,5,6). For example V. Hadzic et al's study hypothesised a link between higher plantar-flexion strength and the decrease of active range of dorsiflexion with lateral ankle sprain in male volleyball players. The backdrop of this study was the sample size of participants was too small to generalise the finding (7). Another study conducted by Willems et al concluded that increased dorsiflexion muscle strength, higher extension range of motion at the first metatarsophalangeal joint and less coordination were risk factors for an ankle sprain in female physical education students (8).

Evaluating these variables is critical to develop and implement an effective strategy to prevent and reduce the prevalence of acute and recurrent lateral ankle sprain (3). In addition, it will emphasize on introducing a rehabilitation programme and preventive exercises that will target these variables (4-8). The Evert Verhang paper indicated the importance of pursuing through a transitional research cycle describing seven distinct steps. The first is identifying the burden of disease, the second is describing the theory for causation and aetiology of ankle sprain which is mostly lagging behind. This part is important to be addressed in ankle sprain and would assist in pursuing step six which is implementing an effective preventive program of acute ankle sprain and re-sprain (9). Reviewing systematically the intrinsic factors of lateral ankle sprain is useful to update the sport therapist with recent study results; this would help in appropriately approaching the athlete by using certain indicators (history and examination) to predict the occurrences of lateral ankle sprain.

The aim of this review was to study potential intrinsic risk factors in a systematic fashion and determine what factors contribute to the occurrence of acute and recurrent lateral ankle sprain.

Therefore; prospective studies are needed with a proper study design and sufficientsample size to approach the conclusion.

Method

Protocol:
PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) statement was utilized as a protocol to develop the outline of the study (11).

Eligibility (Inclusion and Exclusion) criteria:
PICOS was the tool strategy to formulate the research question with a huge consideration of FINER criteria (10). Tables 1A and 1B:

Table1 A:

P	Patient	Athletes/Physically active population
I	Intervention	Intrinsic risk factors
C	Comparison	Non
O	Outcome	Ankle sprain or recurrent sprain
S	Studies design	Prospective studies (Cohort and case-control)

Strategy tool used to develop a research question.

Table 1 B:

F	Feasibility	Using adequate study design with adequate sample size
I	Interesting	Interesting as a researcher (Interesting in predictors for ankle sprain)
N	Novel	Updating previous systematic review finding (Not new)
E	Ethical	Approved from Institutional review board (All studies were approved)
R	Relevant	Could influence the clinical practice (Implementation of preventive program)

Considering criteria to develop the research question.

Literature search strategy and data source:
Publications were retrieved by a search of the following electronic database using phrases and search terms that are explained in Table 2:
• MEDLINE
• Web of Science and
• Google scholar

Table 2:

Data base name	Search words used	Date of search	Years covered
Web of Science	Boolean method: 1-Ankle sprain AND Predictors 2-Ankle Sprain AND Risk Factors	9/April/2015	1970-2015
MEDLINE	Boolean method: 1-Ankle sprain AND intrinsic OR predictor	20/April/2015	Past 10 years
Google scholar	1-Lateral ankle sprain + intrinsic risk factors + prospective studies + 2009 - 2015	20/April/2015	Unable to tightly restrict the years

Summary of the electronic database names, terms used, date of search and years covered.

Study selection:
1-Type of studies:
Our search started from March to April 2015 and the studies were included if they met the following inclusion criteria:
• Status and date of publication: we chose published studies from 2009 to 2015.
• Language of the studies: the studies included were only in English language.
• Prospective observational studies (Cohort and case-control)
• Follow up period of at least 3 months (12 weeks)
• Measuring at least one potential intrinsic risk factor for lateral ankle sprain and re-sprain

2-Participants characteristics:
• Gender: participants of any gender (Male, Female)
• Age: adult (above 18 years)
• Physically active or athletes
• Medical problem: subjects without history of lateral ankle sprain or with a previous history of ankle sprain.

3-Type of outcome measure:
• Measuring the occurrences of acute and recurrent ankle sprain.

A definition of initial ankle sprain and re-sprain was made based on mechanism of injury, symptoms with or without physical examination Table 3.

Table 3 explains the definition of initial, recurrent ankle sprain and chronic ankle instability

Term	Definition
Initial ankle sprain (4,5,14,17)	Non-contact inversion injury of ankle that produced more than one day hematoma, pain and swelling and forced the player to be absent from at least one scheduled game or practice
Recurrent ankle sprain (4,5,7,14,17)	History of previous one ankle sprain

Any studies that described ankle sprain in general terms, use of cadaveric and animal models and analytic design were rejected. Unpublished papers and papers from other languages were excluded from the study. Also, ongoing studies, review articles and abstracts from conference meetings were rejected. Studies with participant numbers below 25 and with no clear primary outcome were excluded.

The following predictors, identified from previous studies as potential risk factors for lateral ankle sprain and re-sprain were history of previous ankle sprain, questionnaires (CAIT and FAOS), anthropometric (Height, Weight, BMI), clinical exam (Anterior drawer test, foot type, rearfoot deformities and hallux position), postural balance test, ankle range of motion (dorsiflexion and plantar flexion), ankle strength (dorsiflexion and plantar flexion), foot lift test, leg heel angle, foot internal rotation angle in plantar flexion, mortis test, Navicular Medial Maleollous distance and mortis test.

Data Extraction:
Data on research design, study duration, participation, lateral ankle sprain diagnosis, investigated risk factors, odds ratio (ORs), confidence interval (CI 95%) and any other data that the reviewer deemed relevant were extracted and summarised in Tables 5, 6, 7. The data from the included studies were extracted by one reviewer and verified by the second reviewer. Any disagreements were resolved by meeting and if necessary; a third party was involved.

Quality assessment:
Modified Downs and Black checklist was used to assess the methodological quality of all non-randomised (observational) studies (12). This checklist was created by Downs S and Black N 1998 who showed how to produce a non-randomised studies checklist for their quality assessment. It consists of 32 items (13). Janice J ENG et al made some modification in the checklist because they found the last question in the checklist was ambiguous and difficult to score (Power of the sample size) and decided to score it as 0 if the sample size was not present and 1 if the power calculated. Therefore; after this modification the score range became between 0 to 28 with four quality levels (12,18), Table 4. This methodological quality assessment was used to reduce the number of researchers bias during the data collection stage. Level of evidence was evaluated using Oxford CEBM (Centre of Evidence Based Medicine) recommendation (20). Tables 4a and 4b:

Table 4a:

Modified Downs and Black	
Quality levels-Qualitative	Quantitative
Excellent	26-28
Good	20-25
Fair	15-19
Poor	Less than 14

Table 4b:

CEBM of Oxford–Level of evidence (March 2009)	
Level of evidence	Characteristic of study
1a	SR (heterogeneity) of RCT
1b	Individual RCT (with narrow CI)
1c	All or none RCT
2a	SR (heterogeneity) of cohort studies
2b	Individual cohort study or low quality RCT <80% follow up
2c	Outcome research; ecological study
3a	SR (homogeneity) of case-control studies
3b	Individual case-control study
4	Case series and (poor quality cohort and case control)
5	Expert opinion

Result

Study selection:
The search strategy identified 1,663 titles. Following title and abstract screening, 24 relevant articles were found. Only 5 met the inclusion criteria (Figure 1). All of the included studies were prospective (Cohort and case-control) (4,5,7,14,17). The five included studies had follow up periods that varied between 6-13 months (4,5,7,17). Participants were adolescents in one study (7), and adults in the remaining four studies (4,5,7,14,17). In all studies the inclusion criteria were index with no history as well as with previous history of one or multiple lateral ankle sprains (4,5,7,14,17). Participants were recruited from various settings; university (5), college (4), Norwegian 1st,2nd and 3rd divisions soccer teams (14), Slovenian 1st and 2nd division volleyball teams (7) and fourth division professional soccer teams (17). The predictors of initial and recurrent ankle sprains measured were ankle dorsiflexion (DF) range of motion (4,5,7,17), ankle plantar-flexion (PF) range of motion (7,17), ankle DF and PF strength (7,17), postural dynamic balance (5,7), static balance (5,14), questionnaires; CAIT (5) and FAOS (14), history of ankle sprain (5,14,17), anthropometricdata (Height, weight and BMI) (14,17), Mechanical stability of ankle with anterior drawer test (14,17), foot and first toe biomechanics (14) and angles of; leg-heel, plantar-flexion, mortis test and NMMD (4).

Study characteristics:
Study characteristics (Author's name, years of publication, type of the study, location of the study, follow up period, total participants number, inclusion and exclusion criteria, predictors, outcome measure and the conclusion) are summarized in tables 5, 6 and 7 from all included studies.

Table 5: Study characteristics

Author /year	Type of study/Location	Follow up period	Participants	In /Exclusion criteria
Verdan et al (2009) (7)	-Prospective; Observational study -Slovenia	6 months	-Total 38 -Only male -Age:15-34 years -Two groups: injured and controlled	-Inclusion: male playing volleyball -Exclusion: not clear
De Noronhan (2013) (5)	-Prospective study -Brazil	13 months	-Total 125 -Male +Female -Age:18.2-23.6 -Two groups: injured and controlled	Inclusion: physically active university students Exclusion: no neurological, *MSK, vestibular and ankle sprain less than a month.
Takumi Kobayashi et al (2013) (4)	-Case-Control -Japan	12 months	-Total 191 -Male +Female -Age:18-21 -Two groups: injured and uninjured	Inclusion: Intercollegiate athletes who participate in jumping and cutting motions (badminton, baseball, basketball, volleyball and soccer) Exclusion criteria: Not daily training or who were training for personal reasons, injuries, illness, medical risk, communication disability, mental disturbance
A. H. Engebretsen et al (2009) (14)	-Prospective cohort study -Norway	3 to 6 months	-Not clearly mentioned	-Inclusion: amateur soccer player -Exclusion: those who did not speak Norwegian and injuries were not recorded by physiotherapists
Konstantinos Fousekis (2012) (17)	-Prospective Cohort study -Greece	-10 months	-Total of 115 -Gender not clearly mentioned -Two groups: with and without sprain	-Inclusion: professional soccer players were training regimen (6-7 days of training per week) with one game per week with no ankle injury before 6 months and contact ankle sprain

*MSK: musculoskeletal,

Table 6: Study characteristics

Author	Predictors	Main outcome measure	Conclusion / Quality Assessment score (QAS)/Level of evidence (CEBM –Oxford)
Verdan et al (2009) (7)	-Postural dynamic balance *(BBS in the following axis *MLSI, *APSI and *OSI) with bilateral stance and opened eyes (20 *sec) -*DF and *PF concentric strength using (BBS, dynamometer) -DF and PF *ROM using sitting position and (goniometer)	-Acute lateral ankle sprain -Lateral ankle re-sprain -Knee injury -Navicular bone fracture	-High PF strength and decrease in DFROM were important predictors of lower limb injury including ankle sprain. -(QAS 12). -(CEBM:4)
De Noronhan et al (2013) (5)	-*CAIT - Ankle DF ROM with weight bearing lunge test (trigonometry) -Postural dynamic balance *SEBT (*A, *PL and *PM direction) -Motor imagery using (computer program) -*HX/O ankle sprain -Foot lift test with eyes closed (30 sec)	-Acute lateral ankle sprain -Lateral ankle Re-sprain	-DFROM were not confirmed as predictors for ankle sprain -H/XO of previous ankle sprain is a predictor of future ankle sprain -Better performance on the SEBT in the PL direction was considered as a protective against ankle sprain. -(QAS 18). -(CEBM:2b)
Takumi Kobayashi et al (2013) (4)	-DF ROM with weight bearing lunge test (inclinometer) -Leg heel angle (goniometer) -Foot internal rotation angle in plantar flexion (goniometer) -Mortis test -Navicular Medial Malleolus Distance (NMMD) (digital caliper)	-Lateral ankle sprain -Lateral ankle re-sprain	-Ankle ROM with maximal dorsiflexion (>49.5 degrees) could participate in future re-sprain -Abnormal talocrural kinematic (NMMD) was a predictor factor for an initial lateral ankle sprain. -(QAS 14). -(CEBM:4)
A. H. Engebretsen et al (2009) (14)	-Previous ankle sprain -*FAOS questionnaire -Single leg balance test (on floor and mat) with opened eyes 60 sec and closed eyes 15 secs -Clinical examination: Foot type Rearfoot deformity Halluxs position Anterior drawer test ROM (in supine and prone) -Also height, weight, *BMI	-Lateral ankle re-sprain	-Previous ankle sprain and FAOS sub score were found to be significant risk factors for new acute ankle sprain. -(QAS 14). -(CEBM:4).
Konstantinos Fousekis et al (2012) (17)	-Anthropometric data (Weight, height, BMI) -Isokinetic (eccentric and concentric) muscle strength of ankle DF and PF (Biodex system dynamometer) -Ankle flexibility: DF and PF ROM (goniometer) -Proprioception using (kinesthetic stabilometer) -Lower limb length (from greater trochanter to the ground) -*ADT	- Acute lateral ankle sprain	-3 significant predictors of lateral ankle sprain were revealed from the study: asymmetry in the eccentric strength of both ankle DF and PF, increase in the BMI and increased in the body weight -(QAI 17). -(CEBM:2b).

(Table 6) *BBS: Biodex Balance System, MLSI: medial-lateral stability index, APSI: anterior –posterior stability index, OSI: overall stability index, sec: second, DF: dorsiflexion, PF: plantar-flexion, ROM: Range Of Motion, CAIT: Cumberland Ankle Instability Tools, SEBT: Star Excursion Balance Test, A: Anterior, PL: Posterolateral, PM: Posteromedial, H/XO: history of, FAOS: Foot Ankle Outcome Score, BMI: body mass index and ADT: Anterior Drawer Test.

Table 7:

Study name	Variables	OR/coefficient	CI (95%)	P-Value
de Noronhan et al (5)	1-Hx/O previous ankle sprain	0.795	1.07-4.57	0.03
	2-SEBT PL	-0.432	0.92-0.99	0.03
Verdan et al (7)	1- PF strength	1.2	1.04-1.43	0.05
	2-Active ankle DFROM	0.63	0.41-0.97	0.07
Engebretsen et al (14)	Previous ankle injury	1.95	0.99-3.84	0.05
Konstantinos et al (17)	1-Eccentric ankle DF and PF strength asymmetry	8.88	1.95-40.36	0.005
	2-BMI	8.16	1.42-46.63	0.018
	3-Weight	5.72	1.37-23.95	0.17
Kobayashi et al (4)	1-NMMD	1.419	1.12-14.30	0.025
	2-Ankle DFROM	0.115	1.05-1.20	0.000

Table illustrates study name, variable measured by regression model, OR: odd ratio, CI: confidence interval and the P-value. No study was rated as having excellent methodological quality. Two studies had fair methodological quality with score 17 and 18 (5,17). Methodological quality was poor in three studies; less than 14 (4,7,14). No study was rated as having excellent methodological quality. Only one poor quality study concluded an association between increase in NMMD and lateral ankle sprain (4).

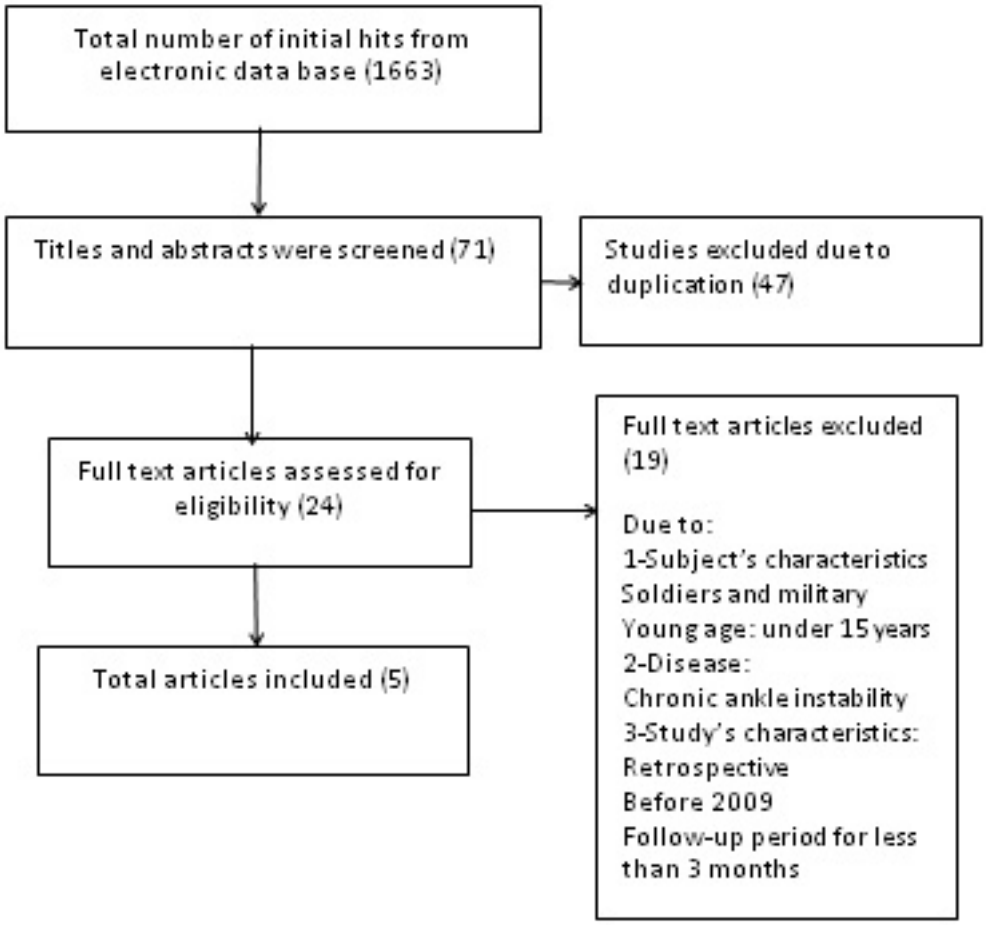

Figure 1:QUOROM (Quality Of Reporting of metanalysis) flow chart diagram of the review process

Discussion

This systematic review presents a observational studies concerning intrinsic risk factors (personal-related) that could identify players at increased risk of initial and recurrent lateral ankle sprain. Most of the studies were conducted between 2009 to 2014.

Previous history of ankle sprain:
Despite using different statistical tools to analyse the result; two prospective studies showed a significant relation between previous lateral ankle injury and future ankle sprain(5,14). Engebresten et al added in their study that this risk increases with the number of previous ankle injuries and decreases with the time since the last injury (14). Rachel and Todd 2011; investigated the effect of previous ankle sprains on predicting future ankle sprain on athletes. They concluded from 3 studies that athletes were at high risk of ankle sprain if they have a history of ankle injury (15).

Niyonsenga and Philips 2013 also found a link in their retrospective study between previous was not eligible for our systematic review because the authors chose to conduct less reliable study design (retrospective) with no follow up period.

The aforementioned results further support our findings that a previous history of lateral ankle sprain increases the risk of future ankle sprain.

Tropp et al's study showed that players with previous history of ankle sprain did not run ahigher risk of future ankle sprain compared to players without previous injury. They explained that if ankle with previous ankle injury that did not impair the functional stability it will not put the athletes at risk for ankle injury (23).

Dorsiflexion range of motion:
From the studies there were conflicting results regarding ankle dorsiflexion range of Motion (DFROM). One study did not confirm that ankle DFROM as a risk factor for acute and recurrent ankle sprain (5). While Kobayashi 2013; found that athletes with increased ankle DFROM with a cut point of 49.5 degrees exhibited more risk for recurrent lateral ankle sprain (4). This similar result was reported by Niyonsenga and Phillips 2013, but by using different procedure (subjects were sitting and goniometer was used) (16). Both Kobayashi 2013 and de Norhan's 2013 studies utilized K. Bennell et al's method to measure ankle DFROM (19).
Verdan et al indicated the decreased active ankle DFROM below 16 degrees associated with recurrent lateral ankle sprain; this finding was not statistically significant (p value: 0.07). In addition it used a different protocol to measure DFROM; subjects were in sitting position (7).

One systematic review reported conflicting evidence on ankle DFROM as a proportion of initial and recurrent ankle sprain in a mixed population (athletes, students, patients and infantry and army recruits) (20).

Ankle strength:
Two authors reported an association between ankle strength with ankle injuries. Both utilized Biodex system and dynamometer with ankle Dorsi-Flexion (DF) and Plantar-Flexion (PF) (7,17).

Konstantions et al concluded that more than or equal to 15% asymmetries of dorsiflexion and plantar-flexion eccentric strength in the ankle joint had 8.8 times to sustain noncontact ankle sprain (17). Verdan et 2009; suggested that bilateral concentric strength differences in both PF and DF was higher in previously injured athletes. Both were clinically significant, but with low statistical value (p: 0.068 for PF differences and p: 0.092 for DFdifferences) (7). This study did not measure eccentric strength as done in Konstantinos study.

Postural dynamic balance:
Only two studies evaluated postural dynamic balance using different equipment (5,7). One study examined the balance by utilising Biodex Balance system and platform and it found no relation between balance deficiency and ankle injury (5). While the other study measured the balance manually by the Star Excursion Balance Test in 3 directions and revealed a protection effect of better reach in posterolateral direction and future ankle sprain (7).

BMI and weight:
Two studies provided valuable information regarding body weight and BMI in relation to the occurrence of future ankle sprain (14,17). They were conflicting each other; one reported that the higher BMI and weight (23.1 and 72.6 kg) respectively have been recognized as potential risk for ankle joint injury (17). While the other did not find a relation between weight and BMI and ankle injury (14).

Other variables:
Studies did not confirm the following variables as predictors for initial and recurrent lateral ankle sprain:
- CAIT questionnaires and central programming (motor imagery) (5)
- Active ankle plantar-flexion range of motion (5,7)
- Single leg stance-balance test (14)
- Height (4,14)
- Angles: leg to heel and foot internal rotation and mortis test (4)
- Postural dynamic balance
- Static balance (5,14)
- Foot type, rearfoot alignment and hallux position (14)
- Anterior drawer test (14,17)

Limitation:
Limitations of review process included: there were differences in studies' quality and restriction to English-language publication. There was heterogeneity in an index and case definition across the study. Most studies were not sufficiently powered, with fair to poor quality and no adequately mentioned concealment and blindness from the outcome measure.

Different equipment was used to investigate the variables.

Conclusion

In athletes and the physically active population, the primary factors that appear to put individuals at risk for acute and recurrent ankle sprain are previous history of ankle injuries,asymmetry in ankle plantar flexion strength and change in ankle dorsiflexion range of motion. Therefore; addressing these risks is crucial in order to develop and implement an effective preventive (screening) and intervention program in the clinical practice. There is a requirement for high quality prospective studies with more homogenous subjects and consistent definitions of acute and recurrent lateral ankle sprain. This will allow others to conduct meta-analyses that would pool the results of multiple primary studies to explore how the presence of combined factors affects ankle sprain risk.

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