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Original research

Subgroup characteristics of patients with chronic ankle instability in primary care

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ABSTRACT

Objectives: To examine clinical and radiological characteristics of participants with an ankle sprain in general practice, classified into subgroups of a previously described chronic ankle instability (CAI) model.
Design: Cross-sectional study.
Methods: 206 participants, who visited their general practitioner with a lateral ankle sprain 6–12 months before inclusion, completed a questionnaire, physical examination, radiography and magnetic resonance imaging. They were classified into three subgroups of the previously described CAI-model: mechanical instability (MI), perceived instability (PI) and recurrent sprains (RS). Regression analyses were applied to evaluate differences in subgroup characteristics.
Results: A total of 192 participants were eligible to be classified into the model. Of these participants, 153 participants were classified into the subgroups and 39 could not be classified. With overlap between the subgroups and patients falling into more than one subgroup, 59 were classified having MI, 145 having PI and 30 having RS. Participants with RS and PI were more often sports participants (OR 6.83;95%CI 1.35–34.56 and OR 4.44;95%CI1.06–18.63 respectively) than participants without RS and PI. Participants with MI more often had a tenderness on palpation of the anterior talofibular ligament (OR 4.09;95%CI 1.91–8.72) and a KL-score ≥ 1 in the talonavicular joint on X-ray (OR 2.24;95%CI 1.09–4.58), compared to participants without MI.
Conclusions: Sports participation, tenderness on palpation of the anterior talofibular ligament and early signs of osteoarthritis were variables that discriminated between subgroups of CAI. However, further research is mandatory in order to examine the usefulness of the CAI model in relation to prognosis and suitable intervention.

Practical implications

- A model for chronic ankle instability (CAI) described by Hiller et al.,[7] with three subgroups including patients with mechanical instability, perceived instability and recurrent sprains, could be useful for clinicians to recognize patients with specific CAI characteristics and consequently apply targeted treatment modalities
- Sports participation, tenderness on palpation of the anterior talofibular ligament and early signs of osteoarthritis (i.e. presence of cartilage loss or osteochondral lesions) are patient characteristics that discriminate between the subgroups of CAI
- There might exist another subgroup of patients with CAI that has not been described before in the literature, since our study found a group of patients in which almost one third reported persistent complaints 6–12 months after an ankle sprain, but could not be classified into the CAI model of Hiller et al.[7]

1. Introduction

Ankle sprains are one of the most frequent traumas of the musculoskeletal system, with an incidence rate of 2.15 per 1000 person-years in the general population of the United States.[1] Almost half of these ankle sprains occur during athletic activities such as basketball, football and soccer.[1] After an initial ankle sprain, about one third of the people experience persistent complaints, including pain, swelling, instability, function loss or feeling of giving way.[2] Additionally, about one third reports a re-sprain within 3

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years after trauma.[2] These persistent complaints are often defined as chronic ankle instability (CAI).[3] In a recent consensus paper, the International Ankle Consortium (IAC) recommended standard definitions to use for patients with CAI, based on history of initial ankle injury, history of episodes of instability and patient-perceived function, measured with validated survey instruments.[4] In addition to these definitions, different models have been proposed to explain the concept of CAI.[5–7] Hertel described two distinct subgroups of CAI patients including those with mechanical instability (MI) and those with functional or perceived instability (PI).[5] According to Hertel, if these subgroups overlap, i.e. patients have both MI and PI, patients will experience a recurrent sprain (RS).[5] However, Hiller et al. stated that patients can both report feelings of instability and can have ankle laxity, but have not experienced a recurrent sprain.[7] Hiller therefore redefined the Hertel model and, based on previous ankle studies, added a subgroup with patients experiencing RS, without reporting MI or PI.[7] This redefined model expands the number of the three subgroups, proposed by Hertel,[5] to seven subgroups, with a possibility of overlap between these subgroups.[7]

The proposed model of Hiller et al.[7] has not yet been evaluated in clinical practice. If this model appears to be applicable in clinical practice in order to identify relevant subgroups of patients with CAI, it may help guide clinicians towards specific intervention strategies and to determine the prognosis. For example, do clinical and radiographic characteristics of patients within the different subgroups differ from each other and can we use possible differences between the subgroups to recognize patients at risk for example MI or RS?[7] Therefore, the aim of this study was to examine the applicability of the CAI model of Hiller among patients with a previous acute lateral ankle sprain in general practice, by describing clinical and radiological characteristics of these subgroups and examining potential differences in characteristics between the subgroups.

2. Methods

Data from a previous cross-sectional study performed in general practice were used for the current study purpose.[8] In this previous study, a total of 206 participants who visited their GP with a lateral ankle sprain 6–12 months before the start of the study were included, through selection from medical records. All were aged between 16 to 65 years and had no reported history of previous fractures of the ankle. All participants provided written informed consent in compliance with the Declaration of Helsinki, 7th version, October 2013.[9] The study was approved by the local Medical Ethics Committee of the Erasmus MC University Medical Center Rotterdam, the Netherlands (2010-026).

All selected participants were approached to fill in a standardized questionnaire, underwent a physical examination and radiography and MRI of the injured ankle. The questionnaire collected data on demographics (*age, gender, body mass index (BMI)*), sports participation before the occurrence of the ankle sprain ('*yes*' *or* '*no*'), perceived recovery (*7-point Likert scale, dichotomized into no persistent complaints: 'completely recovered or strongly improved' (score 1–2) and persistent complaints: 'slightly improved to worse than ever' (score 3–7)*), pain at rest and during exercise (*11-point numeric rating scale (NRS)*), function (*Ankle Function Score(AFS)*[10]*: 0 representing the worst possible and 100 representing the best possible function*), visit to physiotherapist for injured ankle after the occurrence of the sprain('*yes' or 'no'*) and the use of brace or tape after the ankle injury('*yes' or 'no'*).

One trained research assistant performed a standardized physical examination of both the injured and non-injured ankle in all patients. This examination included palpation of the anterior and posterior talofibular ligament (*ATFL and PTFL respectively)* and the calcaneofibular ligament (*CFL*) (*tenderness on palpation 'yes' or 'no' reported by the patient*), and pain at the end of active maximal plantar and/or dorsiflexion ('*yes' or 'no*'). Postural instability was assessed by the one-leg standing (OLS) test.[11] Participants stood on one leg for a maximum of one minute with the eyes open and for a maximum of 30 s with the eyes closed. The time of balance on one leg was measured and the test was defined as positive if the sprained ankle was less stable than the non-sprained ankle. To test for ankle-joint laxity, the talar tilt and the anterior drawer test were performed.[12] For the anterior drawer test, the research assistant stabilized the distal part of the leg with one hand and applied an anterior force to the calcaneus with the other hand. The movement that occurred at the talocrural joint was determined by palpating the movement that occurred between the talus and the malleoli, using the thumb and index finger on the lateral and medial aspects, respectively. The movement was graded from 1 (very hypomobile) to 5 (very hypermobile), with a grade of 5 defined as having laxity and grade <5 as having no laxity. If the research assistant could neither score the test as having laxity nor having no laxity, the test was scored as doubtful.[12] The talar tilt test was performed with the participant sitting and with the ankle in plantarflexion. The thumb of the research assistant was used to detect the amount of inversion by palpating the gap between the lateral malleolus and the talus. The grade of laxity was similar to the grade of the anterior drawer test and scored positive when having laxity.[12]

A standard anterior–posterior and lateral (non-weight-bearing) radiograph of the injured ankle was made, followed by a routine ankle MRI (1.5 T, all on the same machine).[8] All radiographs and MRIs were scored by one musculoskeletal radiologist who was blinded for the clinical characteristics and a standardized scoring form was used. A second blinded musculoskeletal radiologist scored a random subsample of 32 radiographs and MRIs to determine the inter-observer reliability. The inter-observer reliability was calculated using Cohen's kappa (range 0.653–1.00) between the different items. The percentage agreement was 98.8% (5883 of 5952) and 99.1% (1681 of the 1696 scored items) for the MRI and radiography items, respectively. The presence of osteoarthritis (OA) was determined in the talocrural joint and talonavicular joint on radiography using the 0–4 point Kellgren and Lawrence (KL) score (*dichotomized in present (score ≥ 1) or absent (score = 0)*).[13] On MRI the presence of OA was determined by the presence of cartilage loss or osteochondral lesions. Osteophytes (*possibly or evident)* were both scored on radiography and MRI. Furthermore, on MRI the ankle ligaments *ATFL, PTFL and CFL (scored as normal or abnormal in case of thickened, partial or total rupture, or edema of the ligaments*), joint effusion (*present or absent)* and signs of anterolateral impingement (*present or absent)* were examined.

The criteria that were used to define the three subgroups (mechanical instability (MI), perceived instability (PI) and recurrent sprains (RS)) as described by the Hiller model, are described in detail in Supplementary Table S1 in the online version at DOI: 10.1016/j.jsams.2019.02.009.[7] The used definition for the PI subgroup, was not completely similar to the definition used in the Hiller model (i.e. Cumberland Ankle Instability Tool (CAIT)). The AFS was available in our dataset and included an item on PI, with a score lower than 25 indicating PI. Since this item is similar to item 2 of the CAIT, it was used as an alternative to determine the PI subgroup in our study.

A proportional Venn diagram, using an online software EulerAPE,[14] was created visualizing the subgroups of the Hiller model.

Since overlap of participants is expected between the three main subgroups, with patients falling into more than one of the subgroups, differences in characteristics could not be analyzed independently. Therefore, potential differences between the subgroups (*MI, PI and RS*) in patient characteristics (*age, gender, BMI, sports participant),ankle characteristics (persistent complaints, AFS,*

pain at rest and during exercise, visit to physiotherapist and *use of brace or tape after injured ankle*), characteristics from physical examination (*tenderness on ligament palpation, pain end active range of motion (ROM), positive OLS test* and *positive talar tilt test*), radiographic characteristics (*KL-score ≥1 and presence of osteophytes*) and MRI characteristics (*presence of OA, presence of osteophytes, injured ankle ligaments, joint effusion* and *anterolateral impingement*), were evaluated using multivariate regression models. The defined subgroups (i.e. the presence of MI, PI or RS) were used as independent variables in the multivariate regression analyses and patient characteristics, characteristics of physical examination and radiological characteristics with a prevalence of >10% were used separately as dependent outcome variable. For continuous variables linear regression was used and logistic regression was used for dichotomous variables. Multinomial logistic regression analysis was applied for dependent variables consisting of more than two categories. Predictors (e.g. subgroups of the model) with a p-value <0.05 were considered significant. Before performing the statistical analyses, the assumptions were checked and met.

All analyses were performed with the Statistical Package for the Social Sciences V. 21.0. (SPSS, IBM, Armonk, NY).

3. Results

Supplementary Table S2 in the online version at DOI: 10.1016/j.jsams.2019.02.009 shows the patient characteristics of the 206 study participants. The mean age of the study population was 37.3 years (SD 14.7) and 72.3% were sports participants. 6–12 months after the GP visit, about 50% reported persistent complaints and the mean AFS score was 73.5 (SD 20.5). Signs of OA in the talonavicular joint on MRI were present in 20% of the participants. Almost half of the participants had a KL-score ≥1 in the talocrural joint scored on radiography (43.6%).

Of the 206 study participants, 14 participants (6.8%) had missing data on the variables that were used as critiria for classification into the Hiller model and were excluded from further analyses. A total of 192 participants were therefore classified into the Hiller model. With an overlap of participants in the three main subgroups, a total of 59 participants were classified to have MI, 145 PI and 30 RS. A total of 39 participants (20.3%) could not be classified (NC group) following the criteria of the Hiller model. Of the 153 classified participants, 79 (51.6%) had only PI, 36 (23.5%) had both MI and PI and 16 (10.5%) had both PI and RS (Fig. 1). The other four subgroups represented a smaller number of participants; 2 (1.3%) in the RS group, 8 (5.2%) in the MI group, 3 (2.0%) in the group with MI and RS, and 9 (8.9%) in the overlapping group of MI, RS and PI.

Participant characteristics are presented in Supplementary Table S3 in the online version at DOI: 10.1016/j.jsams.2019.02.009 for the three main subgroups (MI, PI and RS) and the NC group separately. Persistent complaints, 6–12 months after their ankle injury were reported by 55.9%, 51.7%, 43.3% and 30.8% respectively for the MI, PI, RS and NC groups, whereas the lowest ankle function (AFS 68.6, SD 26.7) was reported by the RS group. Supplementary Table S5 in the online version at DOI: 10.1016/j.jsams.2019.02.009 presents the characteristics of the individual seven subgroups, without overlap and patients falling solely in one subgroup.

The multivariate regression analyses are shown in Supplementary Table S4 in the online version at DOI: 10.1016/j.jsams.2019.02.009. Participants with PI (OR 4.44; 95%CI 1.06–18.63) and RS (OR 6.83; 95%CI 1.35–34.56) were more likely to be sports participants compared to those without PI and RS respectively. Participants with MI (OR 4.09; 95%CI 1.91–8.72) were more likely to have a tenderness on palpation of the ATFL during physical examination compared to those without MI. Of all radiological findings, only participants with MI (OR 2.24; 95%CI 1.09–4.58) were more likely to have a KL-score ≥ 1 on radiography in the talonavicular joint compared to those without MI.

4. Discussion

In the present study the Hiller model[7] was applied on the data of 192 participants with a previous lateral ankle sprain in general practice. The majority of the participants were classified in the PI group alone (51.6%) or in combination with MI (23.5%) and with RS (5.2%). The other subgroups were represented by a smaller group of participants (<10% of the total population). Participants with RS and PI were more likely to be sports participants than those without RS and PI. Whereas participants with MI were more likely to have a tenderness on palpation of the ATFL during physical examination and a KL-score ≥1 was more often seen in their talonavicular joint, compared to participants without MI.

Characteristics of participants with CAI have been studied before and described in a recent consensus statement.[4,15,16] In contrast to our study, these studies described differences in outcomes between healthy control participants and patients with CAI, such as range of motion of the ankle[16] and subjective disability.[15] A recent study evaluated sensorimotor, mechanical and psychological differences between subgroups of patients with CAI, healthy controls and copers. The authors, however, did not include a MI subgroup and only included a PI subgroup, a RS subgroup and a subgroup with PI in combination with RS. [17] The CAI-model as proposed by Hiller et al. was developed in a study population that included for the most part dancers while we applied this model in a primary care setting including a more varied population.[7] The distribution of our population in the model seems to show some similarities with the distribution of the population in the model of Hiller et al.[7] In both studies, the majority of participants were categorized into the PI subgroup (51.6% and 42.6% respectively).[7] We additionally found that participants in the PI and RS groups are more likely to be sports participants than participants without PI and RS and this seems to be in line with the distribution of the sports participants in the CAI model of Hiller et al.[7]; the majority of the included sports participant were distributed among the PI group (42.6%) and the combination group of PI and RS (30.5%).[7]

Despite the relatively comparable proportional distribution of study participants in the CAI model to Hiller et al.,[7] we found a significant proportion of participants that could not be classified following the criteria of the CAI model as proposed by Hiller. Among all subgroups, including the non-classified group, relatively high percentages of persistent complaints, 6–12 months after patients consulted their GP, were reported. However, no significant differences between the percentages of persistent complaints were found between the subgroups. It was most striking that almost one third (30.8%) of the non-classified participants did report persistent complaints, which was not significantly different from the other subgroups. This unexpected finding may be explained by the applied definition of persistent complaints in our study. The self-reported recovery on a 7-point Likert scale was used for the definition of persistent complaints and significantly differs from the criteria used in the CAI model.[18] As described by van van Ochten et al. there is a large variety in persistent complaints in patients after a lateral ankle sprain, which is also reflected by the scores on the 7-pojnt Likert scale.[8] van Rijn et al. investigated the explanatory variables for reported recovery according to the 7-point Likert scale in patients with acute ankle sprains and found an association between differences in pain intensity and a feeling of 'giving way' during high ankle load activities and reported recovery.[19] Therefore, participants in the NC group may report themselves recovered, but perhaps, when using a different definition of persistent complaints, they were not defined as recovered. However, the fact that

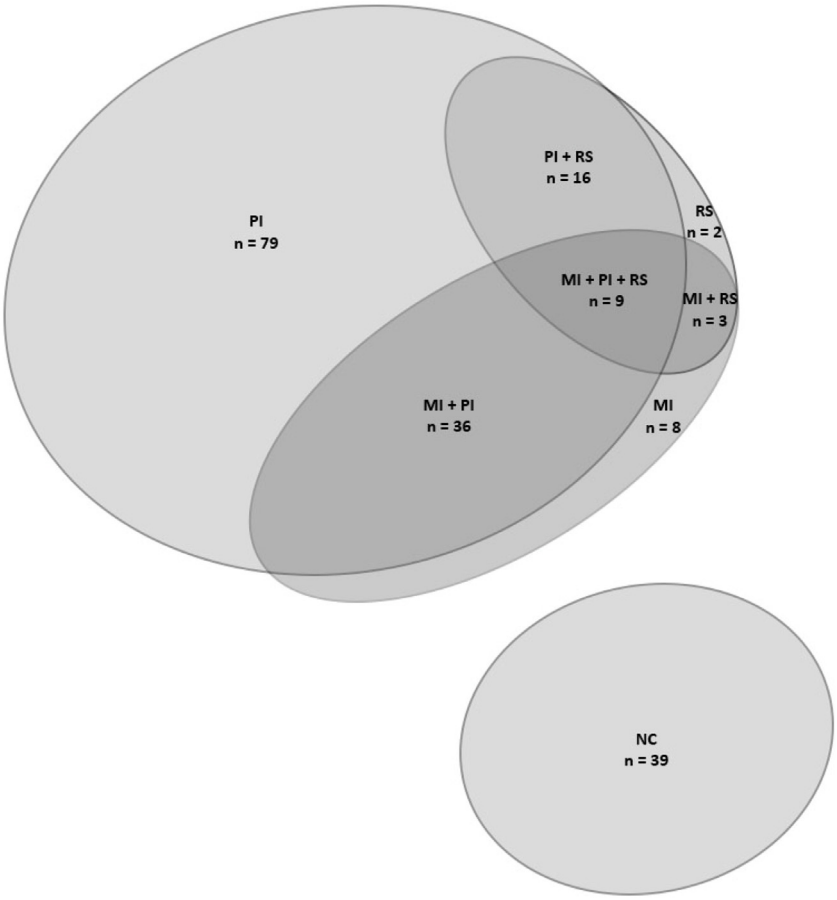

Fig. 1. Proportional Venn diagram of patients with a lateral ankle sprain in general practice classified into the Hiller model (n = 192) (PI: perceived instability; MI: mechanical instability; RS: recurrent sprains; NC: non-classified).

the NC group reported a relatively high AFS score, in contrast to the other subgroups, does seem to indicate that these participants are indeed more recovered compared to participants classified in the other groups. It may be suggested that participants classified into the NC group can be seen as 'copers'. In literature, the term 'copers' is used for individuals with a history of at least one lateral ankle sprain, that occurred at least 12 months ago and do not complain of disability and/or giving way episodes since their injury.[20,21] Unfortunately, this definition could not be applied to the participants in the NC group, since our study population had visited the GP for their ankle sprain 6–12 months prior to inclusion. Still, our study results suggests that another subgroup of patients with CAI may exist and that the use of the CAI consensus criteria [18] may exclude a group of people in clinical practice who do not report complete recovery after their sprain, but do not fit in the model as proposed by Hiller. Therefore, the model of Hiller et al.[7] should be examined further in order to examine possible existence of other subgroups among patients with a previous ankle sprain that do experience persistent complaints but cannot be classified in the Hiller model.

Our findings are supported by Terada et al., who stated that CAI may not consist of homogenous subcategories, but may include a heterogeneous health condition.[17] The heterogeneity within a subgroup may be caused by the fact that only one criteria was used to define the subgroups in the Hiller model[7]. This heterogeneity could be one of the reasons we did not find many significant differences between the subgroups. A CAI model with more homogeneous subgroups may therefore be more useful for clinical practice especially when this would relate to specific treatment indications. Perhaps, more criteria are mandatory in order to create more homogeneous subgroups of CAI. For example, a recent study suggested the use of sensorimotor outcomes in order to define possible subgroups of participants with CAI more accurately.[17] However the use of these measures in clinical practice is questionable.

Several studies have shown that ankle OA can occur after an ankle injury and seems to be related to recurrent ankle sprains.[22–24] Our study results showed that participants with MI are more likely to have early signs of OA in the talonavicular joint (a KL-score ≥ 1) than participants without MI. It has been hypothesized that cartilage degeneration may occur due to changes in ankle mechanics in chronic instable ankles, which may explain the higher prevalence of early OA in the participants with MI.[25,26] However, there is still little evidence for a causal relationship between mechanical instability and the development of ankle OA.[27] Furthermore, in more than half of the patients in the RS group (55.2%) a KL sore >1 was found in the talonavicular joint, meaning that early OA signs are not only prevalent in patients with MI. In particular, in the subgroup with both MI and RS áll participants (n = 3) have a KL score >1 in the talonavicular joint. Also, according to previous literature, MI and RS are not fully independent from each other, since RS is proposed to be an independent consequence of MI.[28] However, the number of participants in the combined MI and RS subgroup in our study was too small to evaluate the relation between MI and RS. Still, early signs of OA (i.e. the presence of cartilage loss or osteochondral lesions) are the most predominant risk factor for developing OA in the longer term.[29,30] Therefore, it is important to recognize patients at risk in order to be able to apply early interventions in the future.

To our knowledge, this is the first study evaluating a CAI model in a group of patients with a previous lateral ankle sprain in gen-

eral practice. Nevertheless, some limitations need to be addressed. To evaluate the Hiller model[7] into our data, we matched the model definitions with our available data. As a consequence, not all definitions of the model could be matched. We used a score of <25 on the instability subscore of the AFS to define PI, instead of the proposed CAIT score. However, we think this subscore is a good alternative, since the AFS is validated as a prognostic instrument for recovery after an ankle injury and is identical to item 2 of the CAIT.[10] Another limitation is the use of the three main subgroups (MI, PI, RS) which includes the overlap of participants in the different subgroups. Our dataset consisted of a relatively small sample size and therefore the seven subgroups of the Hiller model consisted of too small samples to test differences between subgroups (Supplementary Table S4 in the online version at DOI: 10.1016/j.jsams.2019.02.009). Consequently, multiple regression analyses were applied for the three main subgroups only in order to evaluate potential differences between the subgroups. Though, by applying a multivariable approach by including the three main subgroups as independent variables in the regression analysis, the overlap between subroups has been taken into account. Finally, because of the cross-sectional design of our study, we did not follow participants over time. Moreover it should be considered that our subgroups were based on participants that sought care for their ankle sprain and therefore do limit the generalizablity of our findings. Evaluating a CAI model in a clinical setting helped to explore differences in subgroup characteristics of patients with CAI. Although, we do think it is important and useful to consider how such a model may help predict the clinical course of these patients.

5. Conclusion

This is the first study that evaluated the clinical and radiographic characteristics of subgroups of patients with a previous acute lateral ankle sprain in general practice using the proposed CAI model. Sport participation, tenderness on palpation of the ATFL and early signs of osteoarthritis in the talonavicular joint were variables that differed between subgroups. This suggests that the CAI model could be useful for clinicians to recognize patients with specific CAI characteristics and consequently might be able to apply treatments that focuses on the specific characteristics of the patient having MI, PI or RS. However, to evaluate if these CAI characteristics can be useful in clinical practice in order to determine patients prognosis and/or targeted treatment, research in larger populations is necessary.

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