Risk factors and associated factors for calcaneal apophysitis (Sever’s disease): a systematic review

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ABSTRACT

Objectives The aim of this review was to identify the potential intrinsic and extrinsic risk factors (RFs), associated factors (AFs) and consequences of developing calcaneal apophysitis (CA).

Design Systematic review.

Data sources Cochrane Library, Embase, Medline Ovid, PubMed, Web of Science and Evidence, searched from inception to April 2021.

Eligibility criteria We included cohort, case–control and cross-sectional studies that were conducted in patients younger than 18 years who were exposed to RFs or who presented with factors associated with developing CA. Studies in languages other than English or Spanish were excluded.

Data extraction and synthesis Two reviewers worked independently to evaluate the risk of bias of included studies. The Newcastle–Ottawa Scale (adapted version) was used.

Results A total of 736 studies were identified and 11 observational studies fully met the inclusion criteria, including 1265 participants with a mean age of 10.72 years. Four studies identified extrinsic factors, 10 identified intrinsic factors and three identified both. The extrinsic and intrinsic RFs, AFs and consequences of CA include limitation of ankle dorsiflexion, foot alignment, stiffness and mobility of the midfoot, plantar pressures and ground reaction force, body mass index, age, gender, presence of other osteochondroses and practice of sport. The risk of bias varied, being either moderate or low.

Conclusions Regarding the factors and consequences associated with CA (Sever’s disease), ankle dorsiflexion limitation is the most frequent intrinsic factor studied, followed by peak plantar pressures and foot malalignment. However, disagreements between the investigators of the included studies were found; in some cases, there is a lack of unanimity between different studies as to which factors are considered to be RFs, AFs and consequences.

PROSPERO registration number CRD42021246366.

INTRODUCTION

Calcaneal apophysitis (CA) or Sever’s disease is the most common cause of heel pain in children and young people, showing an incidence of 3.7 per 1000 patients.1 2 It is a common musculoskeletal disease, representing between 2% and 16% of the consultations in sports clinics3 4 and 5.8%–22.7% of repetitive stress injuries in children.5–7 The condition is most common in girls between 7 and 12 years of age and in boys between 8 and 15 years of age,8 showing a peak in both genders between 10 and 12 years of age.9 10

CA was described by Dr Sever in 1912, due to sporadic continuous pain in the posterior area of the calcaneus bone in paediatric patients.11 Histological studies define CA as inflammation or bone oedema due to a stress fracture in the secondary growth centre of the calcaneus, which is not related to necrosis.9

The inflammation is due to the traction forces from the triceps surae muscle on the CA, which is composed of hyaline cartilage.5 6 9 The repetition of these traction forces, combined with the vertical ground reaction force on the calcaneus, generates bending forces on the medial side of the CA. Because the number of chondrocytes is increased in the CA during the development of children, the CA is not able to tolerate these bending forces.12

The gender incidence of this condition is controversial. A previous study by Orava and Virtanen13 concluded that the CA incidence ratio was 10:1, being more common in boys than girls. However, Micheli and Ireland,14 McKenzie et al9 and Kvist and Heinonen10 concluded that the ratio was 3:1, 2:1 and 1:1 in their respective studies.
CA is a unilateral condition in most cases, which may be related to the dominant leg. However, it has also been described as a bilateral condition in some cases. The diagnosis of CA is mainly based on its signs and symptoms, but it can also be confirmed with complementary tests, such as X-ray imaging. The pain is mainly located in the posterior and plantar side of the CA or in the Achilles tendon insertion.

Various treatments have been described in the literature and the most frequently used include: stretching and lengthening of the triceps surae muscle, application of ice, restriction or limitation of physical activity, rest, topical non-steroidal anti-inflammatory drugs, taping, and the use of foot orthoses and heel pads.

Among the causes of CA, a rapid period of maturation due to accelerated growth that causes muscle–tendon imbalances has been described. Muscle development is slower than bone development, which causes muscular tension. Obesity is considered a cause of a valgus deformity of the knees and ankles, which increases the risk of CA. The distribution of body weight between the right and left feet in children with CA is higher on the affected lower limb, maintaining the highest peaks of pressure in the feet. Another cause is overuse due to repetitive impacts that generate repetitive micro-traumas, in movements such as jumping or running. This repetitive impact that generates repetitive micro-traumas is located in the Achilles tendon insertion.

Eligibility criteria
The included studies were conducted in accordance with the following PECOS statement (P=population; E=exposure; C=comparator; O=outcome; S=study type), which is based on the P=population; I=intervention; C=comparator; O=outcome statement:

- P: patients under 18 years with CA.
- E: exposure to RFs, presenting with the associated factors (AFs) or suffering the consequences of CA.
- C: non-exposure to RFs presenting with the AFs or suffering the consequences of CA.
- O: identify the causes of RFs, AFs and consequences of developing CA, without considering the evolution time for exclusion.
- S: cohort, case–control and cross-sectional studies.

The review was restricted to the following types of studies: case reports, reviews, atlases and guides. No publication status restrictions or publication dates were imposed. Participants were not excluded by weight, height or ethnicity. Exclusion criteria were as follows:

- Studies focused on treatments of CA, such as surgery, foot orthoses, stretching exercises, laser treatment, heel pads or kinesiotherapy.
- Studies focused on animals, fasciitis, ankle instability, Achilles tendinopathy, fractures, rheumatic diseases, cancer or Chopart osteochondrosis.
- Studies focused on areas other than the foot and ankle.
- Studies in languages other than English or Spanish.

Information sources and search strategy
A previous scoping search was carried out in PROSPERO and the Cochrane Library to ensure that this aim had not been addressed by previous studies. JGC and GGN designed the search strategy and carried out the search from inception to October 2022 using optimised search strategies using the following databases: Cochrane Library, Embase, Medline Ovid, PubMed, Web of Science and Evidence search. A sensitive search strategy was performed on 21 October 2022 using relevant search terms that were developed from Medical Subject Headings (MeSH), collecting free-text terms (TIAB) and keywords generated from the subject headings (online supplemental appendix): “Osteochondritis” [Mesh], “Osteochondrosis” [Mesh], “Apophysitis” [TIAB], “Sever’s disease” [TIAB], “Calcaneus” [Mesh], “Calcaneus*” [TIAB], “Humans” [Mesh], “Intrinsic factors” [Mesh], “Extrinsic factors” [Mesh]. Also, a manual search through the reference list of the included articles was performed.

Selection process
All studies identified by the search strategy were screened using the eligibility criteria. The search was made by two independent reviewers (PN-G and JM-L) to determine whether each item met the requirements for inclusion. The final decision was made by a consensus, or when necessary, a third reviewer evaluated the text and decided
upon its inclusion or otherwise (JG-C). The inclusion and exclusion criteria were applied for selection or rejection. First, duplicates were removed. The second step involved the screening of titles and abstracts by two independent reviewers, and the next step was to perform screening based on the full text.

Data collection process
The following information was extracted from each study independently by two reviewers: study details (first author, country and year of publication), type of study, sample size, mean age, percentage of boys and girls, and intrinsic and extrinsic factors related to CA. When necessary, the original authors were contacted to obtain further information. Due to the significant heterogeneity of the included studies, it was not possible to combine the studies in a meta-analysis, so the authors have limited themselves to performing a narrative synthesis of the results as a systematic review.

Risk of bias in individual studies
Two reviewers worked independently to evaluate the risk of bias of included studies. To resolve cases in which the two reviewers’ decisions differed, a third reviewer evaluated the text and decided upon its inclusion or otherwise. The Newcastle–Ottawa Scale (NOS) adapted version was used to evaluate observational studies. The modified version of NOS evaluates bias in terms of selection, performance, detection and information. These four domains are composed of seven items and each one is scored from 0 (high risk) to 3 (low risk). Studies with a score of 14–21 are considered to have a low risk of bias, with a score of 7–13 indicating moderate risk of bias and of 0–6 indicating a high risk of bias.32

Patient and public involvement
None.

RESULTS
A total of 736 studies were identified from the electronic databases and reduced to 437 after duplication was removed. These were screened by title and abstract, and 346 were excluded. Therefore, 91 full-text articles were assessed for eligibility. Eleven studies fully met the inclusion criteria and were the basis of our review (figure 1): two cohort studies, four case–control studies and five cross-sectional studies.

Study characteristics
All selected studies were observational, including cross-sectional studies (n=5),8 9 15 26 33 cohort studies (n=2)34 35 and case–control studies (n=4).7 36–38

The sample size varied from n=148 to n=43035 with the total sample size being n=1265, of which only 22.25% were female. The mean age of the whole sample was 10.72 years, but one study did not mention the participants’ ages.8

Six studies specified whether the CA was unilateral or bilateral,7 9 26 35 36 37 being unilateral in the majority of cases.

Four studies8 9 35 38 identified extrinsic factors, 10 studies identified intrinsic associations and three studies identified both.9 35 38

Regarding extrinsic factors, some authors concluded that greater frequency and intensity of activity leads to a higher risk of CA8 9; on the other hand, other authors state that the level of activity does not affect the risk,38 and even low activity levels increase the risk of CA.35

Ankle dorsiflexion limitation was the most frequent intrinsic factor studied,7 15 26 33 37 followed by peak plantar pressures7 37 and foot malalignment.26 38 These factors are presented in more detail in online supplemental table 1.

Risk of bias
The risk of bias of the included studies varied, with 45.45% of the included studies8 9 15 34 36 showing a moderate risk of bias and 54.54% of the included studies7 26 33 35 37 38 showing a low risk of bias, as assessed using the NOS adapted version. The study by Scharfbillig et al38 showed the best results using this scale. The risk of bias assessment of all included studies is presented in table 1.
Alfaro Santafé et al.15 demonstrated the relationship between the results of the lunge test and the presence of CA, also rejecting the association with the Jack test. The stress exerted by the gastrocnemius and soleus muscles is a factor commonly reported as a limitation that reduces the range of motion. This agrees with accelerated bone growth, which is much faster than muscle development, causing an excessive increase in the stress of the traction forces and muscle–tendon imbalances. Therefore, CA is a result of stress forces.14 15 40

**Foot alignment**

Alterations in foot alignment have been described as another extrinsic AF36 38 demonstrating that children with CA presented higher scores in the Foot Posture Index than asymptomatic children. This suggests that pronated feet present higher levels of stress on the fascia and Achilles tendon.

**Stiffness and mobility of the midfoot**

Children with and without CA presented similar results in terms of stiffness and mobility of the midfoot assessed by the Foot Mobility Magnitude41 in load bearing conditions (p=0.045). In this AF, the authors did not find statistically significant differences in midfoot mobility between children with and without CA.33

**Plantar pressures and ground reaction force**

It is necessary to highlight the maximum plantar pressures as one of the consequences of the condition described in this systematic review; however, the conclusions of previous studies disagree.7 36 Statistically significant differences in maximum plantar pressures in different areas of the feet while running or walking were not found between children with and

### DISCUSSION

The objectives were to conduct a systematic review to identify potentially intrinsic and extrinsic RFs, AFs and consequences of developing CA, and to describe the evidence. The factors identified have generated great controversy in the literature, as since the first description of the disease in 1908,11 there have been no sufficiently rigorous studies aiming to establish these factors.39 The data from these studies were obtained through observations or from expert opinions, in terms of the characteristics, causes and treatment of CA.

According to the risk of bias analysis, only the following studies related to the topic are considered high-quality studies: Martinelli et al., Rodríguez-Sanz et al and Scharfbillig et al.35 37 38 These studies presented a score above 15 points on the NOS, which is considered high quality. The rest of the included studies had a score between 7 and 15 points, which is considered acceptable quality. Therefore, due to the quality of the included studies, the results of the present study should be taken into consideration.

### Limitation of ankle dorsiflexion

The most frequent intrinsic AF for CA demonstrated in this systematic review was the limitation of ankle dorsiflexion. This has previously been shown in studies from Scharfbillig et al.35 Becerro-de-Bengoa-Vallejo et al7 and Alfaro Santafé et al.15 However, the study of James et al.86 concluded that patients with CA presented a great range of movement of the ankle joint. The authors explained that the different results may be due to the heterogeneous methods that were employed to assess the range of movement. Furthermore, the rest of the foot joints compensate for the lack of movement during walking and in sports practice under load.

### Table 1 Risk of bias assessment of included studies (Newcastle–Ottawa Scale, adapted version)

<table>
<thead>
<tr>
<th>Study</th>
<th>Selection bias</th>
<th>Performance bias</th>
<th>Detection bias</th>
<th>Information bias</th>
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<td>A B C</td>
<td>D E</td>
<td>F G</td>
<td>Total score</td>
<td></td>
</tr>
<tr>
<td>McSweeney et al36</td>
<td>1 2 1</td>
<td>2 3</td>
<td>2 2 13</td>
<td></td>
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<td>2 3 2</td>
<td>2 3</td>
<td>1 2 15</td>
<td></td>
</tr>
<tr>
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<td>1 2 1</td>
<td>2 3</td>
<td>3 2 14</td>
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<tr>
<td>Rodríguez-Sanz et al27</td>
<td>2 3 2</td>
<td>2 3</td>
<td>2 2 16</td>
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<tr>
<td>James et al86</td>
<td>2 3 1</td>
<td>1 2</td>
<td>2 3 14</td>
<td></td>
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<tr>
<td>Becerro-de-Bengoa-Vallejo et al7</td>
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<tr>
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<td>Scharfbillig et al38</td>
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<td>Ogden et al8</td>
<td>1 1 1</td>
<td>0 2</td>
<td>1 2 8</td>
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<td>Alfaro Santafé et al15</td>
<td>2 2 1</td>
<td>1 2</td>
<td>2 2 12</td>
<td></td>
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<tr>
<td>Kvist and Heinonen3</td>
<td>1 1 1</td>
<td>1 2</td>
<td>1 1 8</td>
<td></td>
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</tbody>
</table>

A=Is the source population appropriate and representative of the population of interest?; B=Is the sample size adequate, and is there sufficient power to detect a meaningful difference in the outcome of interest?; C=Did the study identify and adjust for any variables or confounders that may influence the outcome?; D=Did the study use appropriate statistical analysis methods relative to the outcome of interest?; E=Are there little missing data, and did the study handle them accordingly?; F=Is the methodology of the outcome measurement explicitly stated, and is it appropriate?; G=Is there an objective assessment of the outcome of interest?.
Body mass index

Body mass index (BMI) was not an RF in the studies of Martinelli et al.35 and Scharfbillig et al.38 with no statistically significant differences found between the groups. However, the study by James et al.42 concluded that vertical ground forces were not an RF for CA. These results may be due to the relationship between CA and an increase in tension in the calf musculature.14 15

Age

The age of children from all included studies ranged from 6 to 15 years (as an RF). Some studies9 35 44 concluded that CA appeared earlier in girls (11 years) than in boys (12 years).

Gender

Previous studies have generated disagreements in terms of the gender distribution of CA.9 13 14 as an AF, but statistically significant differences were not found in this systematic review. The study of Ceylan and Caypinar44 included 20,000 participants, most of them boys. The gender distribution may be influenced by sport and sports practice habits among boys and girls.9 44

Osgood-Schlatter disease

Osgood-Schlatter disease leads to the appearance of CA according to the study of Watanabe et al.34 The causes associated with this disease are similar to the AFs described in this systematic review: age of onset, joint limitation, muscle imbalance, pronated feet and microtrauma, among others. In addition, a high level of sports specialisation and overtraining contribute to its appearance.45

Sport

The studies by Odgen et al.35 and Kvist and Heinonen9 included high frequency and intensity of activity as an AF. However, Scharfbillig et al.38 concluded the opposite. Martinelli et al.35 concluded that fewer training sessions per week and a lower activity level per session (<60 min) represent RF for CA. This may be explained by the fact that patients who are less trained and active may have a low pain threshold. However, differences between the type of sport and the kinds of surfaces were not found.

Strengths and limitations

One of the strengths of this review is the use of a protocol registered on PROSPERO. Also, the present review followed the current items of the PRISMA checklist. Finally, the use of specific checklists to evaluate the risk of bias (the NOS adapted version) is another strength of the present study.

To the best of our knowledge, this is the first systematic review that addresses the RFs, AFs and consequences of CA, including intrinsic and extrinsic factors. Previously, one literature review was published, but from a general point of view of the disease.39

The main limitation of the present systematic review is the number of included studies. Due to the nature of the review, only studies focused on the RFs, AFs and consequences of CA were included. All included studies were observational. The sample sizes were very heterogeneous and sometimes small, from 14 to 430 participants. In total, 1265 participants were included in the systematic review. Most of them were boys and three of the included studies only had male participants.7 13 37

Clinical implications

Precisely determining the intrinsic and extrinsic RFs, AFs and consequences of CA will allow clinicians to identify the disease early as well as prevent and treat it in its early stages.

Future research

Due to the diversity within the included studies, a larger number of more rigorous, prospective and cohort-type studies are needed. Studies must present an accurate methodology, including larger and more homogeneous sample sizes, in terms of age and gender, low risk of bias and uniform diagnostic criteria.

CONCLUSIONS

Regarding the factors and consequences associated with CA (Sever’s disease), ankle dorsiflexion limitation is the most frequent intrinsic factor studied, followed by peak plantar pressures and foot malalignment. However, disagreements between investigators of the included studies were found; in some cases, there is a lack of unanimity between different studies as to which factors are considered to be RFs, AFs and consequences. Higher-quality studies are necessary, with appropriate designs and adequate sample sizes.

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including detecting and correcting any spelling mistakes and errors in the English grammar. PN-G is responsible for the overall content as the guarantor. All authors drafted the initial manuscript, and have read, contributed to and approved the final version of the manuscript.

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**Patient consent for publication**  Not required.

**Ethics approval**  No human participants were involved; thus, no institutional board approval was required.

**Provenance and peer review**  Not commissioned; externally peer reviewed.

**Data availability statement**  Data sharing not applicable as no datasets generated and/or analysed for this study. Not applicable.

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6

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Appendix

MEDLINE Ovid

(Osteochondritis.sh. or Osteochondritis.ab. or Osteochondritis.ti. or Osteochondrosis.sh. or Osteochondrosis.ab. or Osteochondrosis.ti. or Apophysitis.ab. or Apophysitis.ti. or Sever's disease.ab. or sever's disease.ti.) and (Calcaneus.sh. or Calcaneus.ab. or Calcaneus.ti. or Calcane*.ab. or Calcane*.ti.) and Humans.sh.

PubMed


EMBASE

'osteochondritis'/exp OR 'osteochondritis':ab,ti OR 'osteochondrosis'/exp OR 'osteochondrosis':ab,ti OR 'apophysitis'/exp OR 'apophysitis':ab,ti OR 'severs disease':ab,ti AND 'calcaneus'/exp OR 'calcaneus':ab,ti OR 'calcane*':ab,ti AND 'human'/exp

Cochrane Library

(Osteochondritis OR Osteochondrosis OR Apophysitis OR Sever's disease) AND (Calcaneus OR Calcane*) AND Humans

Web of Science

(TI=(Osteochondritis OR Osteochondrosis OR Apophysitis OR Sever's disease) OR AB=(Osteochondritis OR Osteochondrosis OR Apophysitis OR Sever's disease)) AND (TI=(Calcaneus OR Calcane*) OR AB=(Calcaneus OR Calcane*))
Evidence Search

(Osteochondritis OR Osteochondrosis OR Apophysitis OR Sever's disease) AND
(Calcaneus OR Calcane*)
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<th>Intrinsic Factor</th>
<th>Extrinsic Factor</th>
<th>Type analysis</th>
<th>Results</th>
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<tr>
<td>McSweeney SC et al. (2019)</td>
<td>C-CS</td>
<td>n=28</td>
<td>M= 22</td>
<td>8-14</td>
<td>3/11</td>
<td>Rejected: peak vertical ground reaction force or peak plantar pressures</td>
<td>-</td>
<td>Chi-square</td>
<td>Chi-square analysis revealed there were no significant differences in the frequency of foot strike patterns in children with (RFS 10; FFS 2; MFS 1; VFS 1) and without calcaneal apophysitis (RFS 11; FFS 0; VFS 2) during running (P = .549).</td>
</tr>
<tr>
<td>Martinelli N et al. (2019)</td>
<td>CoS Prospective</td>
<td>n=430</td>
<td>M= 328</td>
<td>6-14</td>
<td>-</td>
<td>Rejected: sex, FPI, BMI, Fewer minutes of sport activity, Rejected: terrain type, sports discipline</td>
<td>-</td>
<td>Odd ratio</td>
<td>The symptomatic children were younger (P &lt; .01) compared with the asymptomatic children OR(IC 95%) 0.7 (0.6–0.8). A positive squeeze test was present in 15.5% of the children playing basketball, 18.9% (IC 95%) (0.7–2.1) playing soccer OR(IC 95%) 1.5 (0.8–2.6), and 6.3% playing volleyball OR(IC 95%) 0.3 (0.1–0.7).</td>
</tr>
<tr>
<td>McSweeney SC et al. (2018)</td>
<td>CSS</td>
<td>n=41</td>
<td>M= 19</td>
<td>8-14</td>
<td>100%/0%</td>
<td>Rejected: foot mobility or stiffness</td>
<td>-</td>
<td>ANOVA model and MDC.</td>
<td>There was no significant difference in FS in children with and without calcaneal apophysitis (P = .459). FMM was significantly greater (+19%) in children with calcaneal apophysitis than in those without (P = .045). The mean difference in FMM between groups (1.4 mm), however, did not exceed the minimum detectable change at the 95% confidence level (MDC95%) for the measurement (±2.5 mm).</td>
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<td>Rodriguez-Sanz D et al. (2018)</td>
<td>C-CS</td>
<td>n=106</td>
<td>M=106</td>
<td>9-14</td>
<td>100%/0%</td>
<td>High heel plantar pressure and low velocity of COP: factor or result? Gastrocnemius equinus</td>
<td>-</td>
<td>Cohen’s d (standardized mean difference) and a student’s t-test</td>
<td>Participants with Sever’s condition had significantly higher BMI and peak plantar-pressures (maximum and average) at the heel (Cohen’s d &gt; 3 for pressures) than the controls. Those with Sever’s disease also had significantly slower velocity of the COP (Cohen’s d &gt; 3). Boys with Sever’s disease were also 8 times more likely to have bilateral gastrocnemius equinus than disease controls.</td>
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<tr>
<td>Alfaro-Santafé I et al. (2017)</td>
<td>CSS</td>
<td>n=60</td>
<td>M= 60</td>
<td>7-14</td>
<td>-</td>
<td>Restriction of ankle</td>
<td>-</td>
<td>ANOVA test</td>
<td>The results show a positive Jack’s test of the right foot in 26.7% of the children with Sever’s disease</td>
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<td>Study</td>
<td>Design</td>
<td>n</td>
<td>M (F)</td>
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<td>Sex</td>
<td>Activity</td>
<td>Findings</td>
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<tr>
<td>James AM et al. (2015)</td>
<td>CSS</td>
<td>124</td>
<td>72 (33)</td>
<td>8-14</td>
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<td>dorsiflexion (Lunge test) Rejected: Jack Test compared to 10% of the children without Sever’s disease (p=0.181). Lunge test for the right foot shows a significant difference (p&lt;0.01) between children with Sever’s disease (32.2±3.6) and children without Sever’s disease (40.5±4.1).</td>
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<td>Becerro-de-Bengoa-Vallejo R et al. (2014)</td>
<td>C-CS</td>
<td>56-28</td>
<td>56 (0)</td>
<td>8-15</td>
<td>20/8</td>
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<td>Greater BMI and waist circumference, increased weight and height, increased ankle range of motion, foot posture (pronation), lengthy period of pain</td>
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<td>CoS Prospective</td>
<td>36</td>
<td>36 (0)</td>
<td>9-10</td>
<td></td>
<td></td>
<td>Univariate regression analysis The children within had a higher mean body mass index (P &lt; .001), increased weight (P &lt; .001), and were taller (P &lt; .001) compared with normative values. The children also demonstrated differences in foot posture and ankle joint range of motion. Multivariable regression analyses identified that older participants (P = .046) and those who had experienced pain for longer (P = 0.043) reported higher pain severity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scharbillig RW et al. (2011)</td>
<td>C-CS</td>
<td>303</td>
<td>54 (0)</td>
<td>8-14</td>
<td></td>
<td></td>
<td>Odd ratio There was no statistically significant difference between the groups in the prevalence of gastrocnemius ankle equinus (P = 0.05), There was no difference between groups in total, heel, or forefoot surface contact area (p= 0.81 and 0.47).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogden JA et al. (2004)</td>
<td>CSS</td>
<td>14</td>
<td>11 (3)</td>
<td>-</td>
<td></td>
<td></td>
<td>Odd ratio There was no statistically significant difference between body mass index values when examined in whole groups (OR 0.961 (0.875–1.055; p=0.407). Similar result with FPI (OR 0.922 (0.821–1.036; p= .174) or Total activity hours OR 1.076 (0.994–1.166 p=0.072).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kvist MH et al. (1991)</td>
<td>CSS</td>
<td>67</td>
<td>36 (31)</td>
<td>12.2</td>
<td>85%/15%</td>
<td></td>
<td>Percentage The main sports causing Sever’s disease were running and track and field (73%). Middle- and long-distance running events represented 90% of the cases in runners. The onset of the disease was associated with external trauma in only 5% of the cases.</td>
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</tr>
</tbody>
</table>

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Before the outcome of Sever’s disease, only 1 patient had been active in sports for less than 1 year, 38% for 1-3 years, 36% for 3-5 years and 25% for over 5 years (n = 64). For the 2 months preceding the onset of pain, 24% of the patients had been engaged in physical activity (school, sports and recreation) for less than 5 weeks, 44% had been active for 5-10 h, 13 (21%) for 10-15 h and 6 (11%) for over 15 h (n= 61).

**Supplementary Table 1. Structural Characteristics of the Studies Included.**

<table>
<thead>
<tr>
<th>Note: year (Year of publication); SD (Standard Deviation); CoS (Cohort study); C-CS (Case-control study); CSS (Cross-sectional study); M (Male); F (Female); EG: experimental group; CG: control, rearfoot foot strike (RFS), forefoot foot strike (FFS), midfoot foot strike (MFS); calcaneal apophysitis (CA)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>and intense sports activity</td>
<td>Before the outcome of Sever’s disease, only 1 patient had been active in sports for less than 1 year, 38% for 1-3 years, 36% for 3-5 years and 25% for over 5 years (n = 64). For the 2 months preceding the onset of pain, 24% of the patients had been engaged in physical activity (school, sports and recreation) for less than 5 weeks, 44% had been active for 5-10 h, 13 (21%) for 10-15 h and 6 (11%) for over 15 h (n= 61).</td>
</tr>
</tbody>
</table>