**FACTA UNIVERSITATIS**
Series: **Physical Education and Sport**, Vol. 18, No 3, 2020, pp. 667 - 679
https://doi.org/10.22190/FUPES190715063P

**Review article**

# THE PREVALENCE OF FOOT DEFORMITIES IN ATHLETES WITH VARIOUS SPORTS BACKGROUNDS

*UDC 616.007:611.986:796.071*

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**Abstract**. *Changes and deformities to the feet are frequent among athletes. The aim of this review paper is to determine the prevalence of foot deformities among athletes with various backgrounds, as well as to determine the influence of the deformities on motor task performance. The compiled studies were published between 2002 and 2018. The following electronic databases were used for the search: PubMed, MEDLINE, Google Scholar, EBSCO. The identified studies had to satisfy the following criteria: that they included athletes and that the subject of analysis were the differences in foot deformities in relation to performing motor tasks. Research papers on this topic were reviewed and analyzed. They are clearly organized in tabular form, with a clear outline of the details of the research. The results of 16 research papers are summed up. The most prevalent deformity among athletes is flat feet (pes planus). The studies indicate the various deformities which are prevalent in particular sports, and determine the changes in the feet of the athletes, in particular for the foot which plays a decisive role in certain sports. Individuals with flat feet scored lower results compared to individuals with normal arches in terms of time and reaction speed when performing motor tasks*.

**Key words**: *Foot, Deformities, Athletes, Influence, Frequency*

## INTRODUCTION

The foot is one of the most complicated anatomical segments of the human body. It consists of 26 bones and 32 joints which enable the foot to perform two important functions: standing (static function) and walking (dynamic function) (Jovičić, 2007). Therefore, it must have sound structure in order to endure the forces active during standing, but to also adapt to the surface, function as a shock absorber, and be active during walking. The structure of the foot is such that the functions of three arches maintain stability and the necessary elasticity. Foot deformities lead to a disruption of

Received July 15, 2019 / Accepted December 17, 2020
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static in the foot and affect the knee, which leads to changes in the shape of the foot, that is, the occurrence of a deformity in its internal and external structures. These deformities usually lead to deformities of the knee joint (Jovović, 2008). Furthermore, changes and deformities of the feet lead to a reduction in the physical abilities for the performance of various motor tasks.

An examination of the foot can be performed in several ways and by applying various methods. These include: a plantogram, podoscope, digitalized podography (CDP), etc. They can be used to successfully detect feet deformities, including flat feet (fallen arches, pes planus). There are no clear boundaries that indicate the completion of the formation of the arch, as there are no clear boundaries between normal arches and a deformity (Mosca, 1995). Research has indicated that the longitudinal arch develops spontaneously during the first decade of life and that it slowly rises (Staheli, Chew, & Corbett, 1987).

According to the etiology of emergence, foot deformities can be innate (congenital) and acquired. Feet deformities occur due to a disbalance in limb static and the proper appearance of the feet, a lack of proportion between the active strength of the feet and load. The calcaneus occupies the valgus position and this represents the first stage in the collapse of the longitudinal arch which is referred to as the pes valgus. If this stage is not stopped, it further leads to the collapse of the os naviculare and the os cuboideum and the lowering of the longitudinal and transverse arch which leads to the second stage which is known as the pes planovalgus. Along with the changes in the longitudinal and transverse arch, there is also a distancing of the head of the metatarsal bones and their lowering which represents the third stage of collapsed arches, or the pes transversoplanus. Clawfoot (pes excavatus) is a dynamic deformation which occurs as a consequence of the disrupted balance in the strength of the muscles of the lower leg and feet. Due to muscle insufficiency of the plantar extensors, especially the m. triceps surae, a disbalance between them and the dorsal flexors emerges. The disrupted balance creates a tendency for the front part of the calcaneus to rise, which in turn shortens the plantar aponeurosis, and the longitudinal arch of the foot rises, that is, a denivelation occurs between the ball and heel of the foot. In the case of a foot with normal arches, the difference in height between the ball and heel is approximately 10mm, while in the case of a claw foot it is significantly raised in favor of the heel. Pes equinovarus is one of the most frequent innate deformities. This deformity of the foot is complex and consists of 3 components: ankle equinus (limited upward bending motion), the varus of the foot (an inverted position, especially affecting the heel) and the adduction of the front part of the foot (inward angulation), which gives the foot a specific fallen and twisted look. The foot is in an inverted position, with a pressure point on the outer edge. Pes equinus is a deformity where the foot during contact with the ground is relaxed and most of the pressure is asserted on the tips of the toes, or the upper third of the metatarsus. The foot is in a position of a profound plantar extension. Due to the weakness in the dorsal flexors, the ball of the foot is lowered (Dimeglio, Bensahel, Souchet, Mazeau, & Bonnet, 1995; Živković, 2009).

Physical activity (PA) is encouraged from childhood since it is an important tool in the sedentary habit prevention. From the biomechanical point of view (considering plantar pressure, kinematics, and electromyography), even small alterations in foot and ankle structure or alignment is reflected in sports performance (Arévalo-Mora, Reina-Bueno, & Munuera, 2016). Although sports activities positively affect the reduction of the deformity, the majority of researchers came to the conclusion that a large number of repeated movements in sports and muscle imbalances affect the incidence and development of certain postural disorders (Stošić, Milenković, & Živković, 2011). Also, maintaining unnatural positions for extended periods of time could lead to the development of deformities, which is usually found among professional cyclists (Muyor, Casimiro, Lopez-Minarro, & Alacid, 2012).

The aim of this review paper is to determine the prevalence of foot deformities among athletes with various sports backgrounds, as well as to determine the influence of the deformities on motor task performance.

## METHODS

With the aim of compiling a large number of research papers which dealt with the subject matter of the review paper, the following electronic databases were searched: PubMed, HRCAK, MEDLINE, ERIC, Google Scholar, Kobson, SCIndex and ScienceDirect. Papers published from 2002 to 2018 were reviewed. All of the papers had been published in leading sports science journals, while the main focus of attention was on the papers published from 2005 to 2018. In order for them to be included in the final analysis, they had to meet the following criteria: that the research had to include participants of both sexes, that it included athletes who had no record of foot injury prior to the testing, and that the paper was written either in Serbian or in English. The key words used during the database search included: foot deformities in sports, influence of sport on the foot, and type of foot deformities. The overview and analysis of the research papers was carried out based on: the references (the first author and year of publication), the number of participants, sex, age, type of PA (sport), means of measuring the deformity, type of deformity, and the research results.

Based on the key words, 467 papers were identified. Based on the date of publication, papers published prior to 2002 were excluded from the overview. Other papers were excluded based on their title, abstract, or the subject matter which did not match the subject matter of this paper. Further, papers which focused on participants who had undergone treatment for foot injury were also excluded.

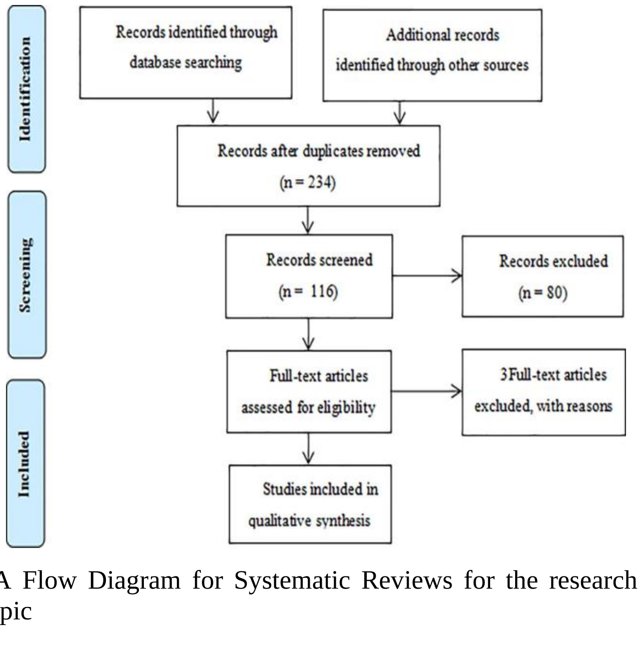


**Fig. 1** PRISMA Flow Diagram for Systematic Reviews for the research related to the given topic

The final analysis included 16 studies which were compiled and analyzed based on the previously mentioned parameters and methods. The studies included male and female participants. All of the studies which were taken into consideration had the following aim: to determine the influence of sport on the arches of the feet, the influence of the shape of the arch on the physical and sports results, and the influence of the arches of the feet on the risk of injury to the lower extremities.

**Table 1** An overview of 16 studies which met the set requirements

| Authors | Participants | | | | Method-Type of deformity | Aim | Results | Conclusion |
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| | n | Gender | Age | PA-Groups | | | | |
| Michelson et al. (2002) | 196 | M 143<br>F 53 | 19-23 | Baseball, basketball athletics, field hockey, American football, lacrosse, football, swimming tennis and volleyball | Pl<br><br>FF | Determining prevalence of foot deformities in various sports and correlation between injuries and deformities | The influence of FF on the injuries to the lower extremities: baseball 5 (15.6%), basketball 1 (0.5%), athletics (long distance) 2 (11.8%), field hockey 1(9.1%), American football 4 (12.1%), lacrosse 2 (9.5%), football 5 (17.9%), swimming 5 (26.3%), tennis 2 (1.0%), volleyball 3 (37.5%). | Athletic population that is representative of collegiate athletics, the existence of FF does not predispose to subsequent lower extremity injury. |
| Ledoux & Hillstrom (2002) | 19 | M 19<br>F x | 21- 38 | E1-11<br>E2-8<br>Recreational PA, walk and run for 10 m. | Pd<br><br>FF and NA | Determining force values at different foot locations among athletes with normal and foot with deformities | 11 NA and 8 FF. ↑ maximal force in the side and ball of the foot for FF compared to NA (p=0.008), ↑ loading amount which is transferred through the side part of the F in FF, (p=0.0064). | Data represent new information on the effect of foot type on foot function and serve as guidelines for further experimental protocols. |
| Aydog et al. (2005) | 146 | M 146<br>F x | 18- 30 | E1-116<br>Football, wrestling, weightlifting, handball, gymnastics<br>C-30 inactive | Pd<br><br>FF and HA | To determine the effect of various sports on sole arch indices | The influence of PA of E and C between the arches of the LF and RF: LF 48.76% and RF 52.42%, 24 wrestlers LF 63.77% and RF 68.22%, 19 weightlifters LF 47.67% and RF | The AI of the gymnasts and wrestlers were significantly different from those of other athletes |

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| | | | | | | | 51.85%, 32 handball players LF 41.99% and RF 44.86%, 22 gymnasts LF 30.56% and RF 30.06% and 30 inactive LF 53.73% and RF 55.77%. | studied, and those of the gymnasts and handball players were significantly different from those of non-athletic controls. |
| Aydog et al. (2005a) | 39 | M 39 F x | 18-30 | E-22 gymnasts and C-17 inactive | Pd FF and HA | To evaluate the relation between muscle strength of the ankle joint and foot structure (deformities) in gymnasts. | The differences between the arch angle of the RF and LF between E and C in r with isokinetic torque of the ankle (%): gymnasts RF 29.1% and LF 34.65% and inactive RF 30.3% and LF 32.27%. | That bilateral foot AI and ankle dorsiflexion muscle strengths are lower in E than C, and there is r between the AI of E and their eversion strengths. |
| Chuckpaiwong et al. (2008) | 50 | x | 20-29 | E1 NA E2 FF Collective and individual sports, walk and run for 10 m (in a neutral gym sneaker). | Pl FF and NA | To determine if FF have altered plantar loading patterns when compared to NA during both walking and running. | 34 NA and 16 FF. interaction between walking and running and FF and NA.↑ normalization of maximal force (medial part) during walking in FF compared to NA ($p=0.001$), ↑ in contact surface ($p<0.001$), maximal force ($p<0.001$) and pressure ($p<0.001$) during the run test compared to the walk test. ↓ r of force and reaction time during the run in the heel of the F ($p<0.001$), ↓ maximal pressure beneath the side of the foot compared to NA ($p = 0.05$). | That participants with FF could be at a lower risk for injury (lateral column metatarsal stress fractures). |

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| Chou et al. (2009) | 18006 | M 8883 F 9123 | 6-12 | E1 E2 (by age and gender) Collective and individual sports | Epd FF, HA, HV, and HE | To determine the overall prevalence and differences between gender of four common foot deformities | Distribution of the deformities: FF 2499 (13.88%), HA 237 (1.32%), HV 252 (1.40%), HE 599 (3.33%). | There are strong association between flexible flatfoot and hindfoot valgus. |
| Queen et al. (2009) | 22 | x | 21 – 29 | E1-12 NA E2-10 FF Cross-cut, side-cut, shuttle run, and landing from a simulated lay-up | Pd FF and NA | To determine if foot type (FF or NA) resulted in loading differences during four sport-specific tasks | ↑ contact surface in FF, cross cut test ($p = 0.001$) and landing from a simulated lay-up ($p = 0.039$), rearfoot ($p = 0.024$), medial midfoot ($p = 0.016$), and lateral midfoot ($p = 0.014$), duration of force acting on inside part is longer ($p = 0.04$) and on outside part of foot ($p = 0.019$), ↑maximal normalization of force on side ($p = 0.027$) and inside of foot ($p = 0.005$). Shuttle test ↑ FF duration of the effect of force in lateral midfoot ($p = 0.037$), both the medial ($p = 0.049$) and lateral ($p = 0.006$) midfoot | That participants with NA could be at a lower risk for medial and lateral midfoot injuries such as metatarsal stress fractures. |
| Schenkel, (2010) | 1 | F 1 | 15 | Basketball | CT Talocalcaneal coalition | Investigation of basketball athlete with activity related chronic bilateral dorsal foot pain and stiffness | 12% of the recorded cases of chronic foot pain occur as a result of this diagnosis. The influence of PA in basketball stimulated the development of Talocalcaneal coalition without any preventive analyses or treatment in the early phases. | In adolescent athletes, delayed diagnosis and inappropriate management may lead to decreased chance of return to competitive activity. |

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| Carson et al. (2012) | 26 | M 26<br>F x | 17 – 18 | E1-16 NA<br>E2-10 HA<br><br>American football, cross over walk and run (barefoot and in sneakers) for 5 m x 12 m | CDP<br><br>FF, NA and HA | To determine if differences in plantar loading in football players occur during both walking and pivoting movements | 16 NA, 6 HA and 4 FF. ↑ HA maximal force in side of F ($p = 0.008$) and inside of F ($p < 0.001$) compared to NA. ↑HA, force duration in side of F ($p = 0.044$), but not in other parts of the F. | That loading patterns differ between football players with NA and HA structure, which could possibly influence injury risk in this population. |
| Đurić et al. (2013) | 35 | M 35<br>F x | 8-15 | Volleyball | Pl<br><br>FF and HA | To detect the presence of the suspended arch of the foot among the students of the volleyball players | The influence of PA in volleyball on the AI (%) is: LF, NA 22.8% RF 20%, stage 1 flat feet 60% RF 62.8%, stage 2 flat feet 5.7%, RF 5,/% and stage 3 flat feet 11.4%, RF 11.4%. | That large number of the volleyball players have deformed arch of the foot, even 88.58%. |
| Mani et al. (2013) | 126 | M 24<br>F 39 | 27-84 | Collective sports and recreation | Pl and Q<br><br>FF | To validate the foot and outcome score for use in evaluating patients with hindfoot deformity, specifically acquired FF. | 39 participants who took part in some form of PA had been diagnosed with FF. | That the foot and outcome score for acquired FF with acceptable construct and content validity and reliability. |
| Nakhostin et al. (2013) | 100 | x | 14-17 | E1-50 NA<br>E2-50 FF<br><br>Moderate PA (collective sports with a ball) | Pl<br><br>FF and NA | To evaluate influence of flexible FF on several PA factors that are necessary for sport performance | The influence of FF and NA on PA, significant difference between E1 and E2, ($p=0.05$) for two tests: the T-test of agility and static balance between the groups with NA and FF. | Presence of a plenty of controversies suggests more works in this domain. |

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| Janković et al. (2014) | 30 | M 30<br>F x | 11-13 | E-30<br>Football | Pl<br><br>FF and HA | To present and analyze the foot status of the participants of football players | The influence of PA in football on AI of F (%): NA 37%, FF stage 1 50%, FF stage 2 10% and FF stage 3, 3.33%. | That large number of participants have the impaired foot arches, even 76,67%. |
| Powell et al. (2014) | 20 | M x F 55 | 18-30 | E1- 10 HA<br>E2- 10 FF<br><br>Recreational PA and moderate intensity barefoot running (3 m/s). | Pl<br><br>FF and HA | To quantify the differences in ankle dynamic joint stiffness, and ankle braking work and ankle propulsive work during stance phase of running | During the run, ↓angle in HA, ↓ duration of movement during contact with the surface and propulsion, ↓ power affecting the ankle among the HA compared to the FF group (p=0.040). | That HA and FF athletes exhibit unique biomechanical patterns during running and may be related to lower extremity injury. |
| Puzović et al. (2015) | 64 | M 43<br>F 21 | 10-12 | E1-43<br>E2-21<br>(by gender)<br><br>Basketball | Pl<br><br>FF | To estimate the prevalence of foot deformities among basketball players, and differences between different gender and age. | The influence of PA in basketball on the changes to the arches of the feet (%) is: M 83.7% and F 23,8%. | Despite basketball training, participants have a high prevalence of deformities, especially boys who stand out with the high prevalence of FF. |
| Arévalo-Mora et al. (2016) | 187 | M 90<br>F 97 | 10-12 | E1-97 NA<br>E2-HA<br>E3-37FF<br><br>Standing depth jump, triple alternate leg jump, vertical jump, 10 m x 5 m run around cones, 20 m sprint, static and dynamic balance and an agility test | Pl<br><br>FF, NA and HA | To determine whether NA, FF, or HA corresponded to better performance of certain motor tests in children | 96 NA, 54 HA and 37 FF. On 8 of the 9 tests the participants with HA scored better results. ↑FF in dynamic balance relative to others. ↑HA relative to FF on static, (p=0.062), ↑NA compared to HA on the agility test, (p=0.048). | Participants with a certain foot type did not achieve better motor performance in the nine trials tested. |

*Legends*: N-Number of Participants; M-Male; F-Female; Pd-Podoscope; Epd-Electronic Podoscope; Pl-Plantogram; CDP-Computerized Digital Podography; CT-Computer Tomography Scan; PA-Physical Activityy; E-Experimental Group; C-Control Group; AI-Arch Index; FF-Flat Feet (Pes Planus); NA-Normal Arch; HA-High Arch (Clawfoot) (Pes Excavatus); HV-Hallux Valgus (Bunions); HE-Heel Eversion (Hindfoot Valgus); F-Foot; Q-Questionnaire; R-Correlation; X-No Data; ↓-Decreasing; ↑-Increasing.

## DISCUSSION

The aim of this systematic review is to collect and analyze research that studied the prevalence of foot deformities among athletes with various sports backgrounds, as well as to determine the influence of the deformities on the motor task performance. Although different motor tasks, in collective or basic sports, lead to different types of foot loading, based on split results from current research results deformities and changes to the foot arch are visible in both cases.

Results indicating greater prevalence of foot deformities in the younger population, with flat feet being the more prevalent, can be found in the research of Chou and associates (2009). Among 18006 elementary school students aged 6 to 12 who took part in obligatory PA and sports games played with a ball, the distribution of foot deformities was analyzed with an electronic podometer: flat feet 2499 (13.88%), clawfoot 237 (1.32%), bunions 252 (1.40%) and Hindfoot valgus 599 (3.33%). Among the boys the distribution was as follows: a flexible flat foot n=1593 (8.85%), clawfoot n=84 (0.47%), bunions n=46 (0.26%) and Hindfoot valgus n=346 (1.92%), and among the girls: flexible flat foot n=2499 (13.88%), clawfoot n=237 (1.32%), bunions n=252 (1.40%) and Hindfoot valgus n=599 (3.33%). Also, it was determined that the condition known as flat foot is more prevalent among boys of all ages than among girls $p<0.5$, and that girls aged 11 and 12 have a higher prevalence of clawfoot compared to boys of the same age, $p<0.074$ and $p<0.063$. Additional results, which further support such findings by studying athletes involved in various sports, can be found in the research of Đurić, Ilić, & Nešić (2013). The authors focused on the influence of volleyball training on the arches of the feet. On a sample of participants (n=35), aged eight to 15, by using a plantogram and the Thompson technique, it was determined that eight of them have normal arches, 21 flat feet stage 1, 2 flat feet stage 2, and 4 have flat feet stage 3. The Russian method also recorded the same distribution results. It was also determined that feet correction was required in 88,58% of the participants. In addition to volleyball players, basketball players also have flat feet, which is shown in the research of Puzović and associates (2015). The authors focused on basketball players aged 10 to 12 in order to determine the prevalence of foot deformities in basketball. Of a sample of 64 participants (43 boys and 21 girls,) using a plantogram, they obtained results that out line differences in terms of gender and the prevalence of the condition known as flat feet, through statistically significant results ($p=0.001$) for the boys (n=36) 83.7% and for the girls (n=5) 23,8%. Also, the results confirm a greater prevalence of flat feet in a younger population of basketball players aged 10, 85.71%, with significant differences in terms of age ($p=0.036$). An interesting observation was presented in a case study by Schenkel (2010), who established the diagnosis of the Talocalcaneal coalition in a female basketball player who had three years of training and reported experiencing pain in her foot. The diagnosis was established by a scanner. Out of all the noted cases with reported foot pain, the aforementioned diagnosis was determined in 12%.

The influence of football training on changes in the arch index (flat foot) was the focus of the research carried by Janković et al. (2014). Although they did not study the correlation of prevalence of foot deformities between the dominant and non-dominant leg among 30 football players aged 11 to 13, the authors indicated the percentage of deformities for each foot separately. Clear differences can be noted in the number of deformities between the legs using the Thompson technique and Russian method. The

Thompson technique provided the following results: 37% of all cases have normal arches, 50% flat feet stage 1, 10% flat feet stage 2, and 3.33% flat feet stage 3. By using the Russian method normal arches were determined in 50% of the cases, flat feet stage 1 in 33.34%, flat feet stage 2 in 13.33% and flat feet stage 3 in 3.33% of the total number of participants (n=30). As many as76.67% of the participants do not have the same arch index of the foot for both legs: in the case of the left foot 11 have normal arches, 15 flat foot stage 1, three flat foot stage 2, and one has flat foot stage 3 according to the Thompson technique; and in the case of the right foot 10 players have normal arches, 18 flat foot stage 1, one flat foot stage 2, and one flat foot stage 3 also according to the Thompson technique.

More complex research that included a greater number of different sports and types of physical training specific for that sport, and control groups with physically non active participants was carried by Aydog and associates (2005). Based on 116 older participants, aged 18 to 30, results were obtained for the left and right foot arch for football players, wrestlers, weightlifters, handball players, and gymnasts. The results indicated changes in the arch index of the right foot among the gymnasts, where the arch was lower compared to that of the football players, wrestlers, and the control group ($p<0.01$). A statistically significant difference was determined in favor of the wrestlers for a high arch of the right foot compared to football players, handball players, weightlifters, gymnasts, and the control group ($p<0.03$). A statistically significant difference for the fallen arch of the left foot was determined in favor of the gymnasts compared to the wrestlers, and control group ($p<0.001$). A statistically significant difference was determined for the high arch of the left foot in favor of gymnasts compared to football players, and handball players ($p<0.007$). A statistically significant difference was determined for the fallen arch of the left and right foot in favor of the handball players compared to the control group ($p<0.049$). The results indicate a weak correlation between the arches of the left and right foot of the football players ($r=0.31$), handball players ($r=0.69$), and wrestlers ($r=0.56$). A high correlation was noted for gymnasts ($r=0.96$), weightlifters ($r=0.88$), and control group ($r=0.80$). The biggest difference between gymnasts and handball players compared to the control group was also noticed, while wrestlers and gymnasts have the most deformities compared to the other athletes. Results that further support these findings are represented in the research of Michelson, Durant, & McFarland (2002).

In addition to the mentioned goal, the authors also expanded the analysis by comparing the degree of risk of injuries among participants with some form of foot deformity. The results pertaining to prevalence among 196 participants, aged 19 to 23 years, were shown by sport, in baseball (total n=32), n=5 (15.6%), basketball (total n=20), n=1 (0.5%), athletics (long distance running) (total n=18), n=2 (11.8%), field hockey (total n=11), n=1 (9.1%), American football (total n=11), n=4 (12.1%), lacrosse(total n=21), n=2 (9.5%), football (total n=28), n=5 (17.9%), swimming (total n=19), n=5 (26.3%), tennis (total n=15), n=2 (1.0%) and volleyball (total n=8), n=3 (37.5%), while cases of flat feet were also determined (a total of 56 participants). The independent risk factor for the lower extremities does not exist for contact sports. Differences in terms of sex have a more significant correlation with injuries to the feet and lower extremities. In the case of women, the factor is greater than in the case of men ($p<0.5$ and $p<0.009$). Out of 99 twisted ankles, 14.1% of the cases also reported the presence of flat feet, and a diagnosed flat foot without a twisted ankle was found in 17.9% of the cases (52 of 291, $p>0.39$).

A research of the influence of different motor tasks on the arch index was carried by Chuckpaiwong, Nunley, Mall, & Queen (2008). A sample of 50 participants was included in an analysis of athletes involved in collective and individual sports, who performed a run and walk test in shoes and barefoot. Using an apparatus installed in the shoes of the participants, and on the surface on which the testing was performed, the researchers could monitor the contact surface, the distribution of the maximal force, pressure on the feet during the PA, and amortization of force during the performance of the motor tasks. A statistically significant difference was noted for the normalization of maximal force in the medial part of the feet during walking, which was higher for the group with flat feet compared to the group of athletes with normal arches ($p=0.001$). There was an increase in surface contact ($p<0.001$), maximal force ($p<0.001$) and pressure ($p<0.001$) during the running test compared to the results of the walking test between the two groups, in favor of the group with normal arches. The relationship between force and reaction time significantly decreased during the running test in the heel ($p<0.001$), and a significant decrease in the maximal pressure below the external part of the foot was noted compared to the group with normal arches ($p=0.05$).

The contact reaction and the amount of force during the propulsion phase during running were compared between a sample of 10 athletes with a diagnosed flat foot deformity and sample of 10 athletes with a clawfoot deformity (Powell, Williams, Windsor, Butler, & Zhang, 2014). The statistically significant difference between the two groups of participants in the amount of static strength which was measured for the ankle was smaller in the case of athletes with a determined flat foot deformity ($p=0.040$).

Furthermore, research carried out by the Arévalo-Mora and associates (2016) focused on the differences in the results of performing the following tests: the standing depth jump, the standing triple alternate leg bound, the vertical jump, the 10 m x 5 m run around cones, a 20 m sprint with a high start, static and dynamic balance, and the test of agility, on a sample of 187 participants with flat feet, high and normal arches. The only test where a statistically significant difference in favor of the participants with flat feet compared to the other athletes was found is the dynamic balance test ($p=0.062$).

Finally, the research of Aydog, Tetik, Demirel, & Doral (2005a) focused on the differences in the muscle strength of the feet (static exercises) between gymnasts and a control group with healthy arches. The results indicate a difference in strength of the dorsal flexion of the feet among gymnasts with flat feet compared to the control group. A correlation between the arch index and strength was not determined for the control group. A statistical significance for the correlation was noted between twisting the ankle outside and inside, and the arch index among gymnasts ($r=0.41$, $p=0.02$). The mean value of the arch index of the left and right foot among the gymnasts and the control group is: 31.4 (29.1), 34.01 (34.65); 60.01 (30.3), 63.75 (32.27).

## CONCLUSION

Based on the results obtained from the studies, it can be concluded that although there are a large number of different studies, the final result of the distribution of foot deformities among different athletes could not be defined. Although the prevalence of flat feet and a clear difference in terms of gender was noted even among the younger population, the impact of various types of training in collective and basic sports was not clearly determined. In the case of girls and women, a greater level of development of bunions was noted (hallux valgus) compared to boys and men, and the aforementioned change to the arches occurs due to inadequate PA and inadequate footwear. Moreover, a diagnosed change in the arch of the foot increases the risk of injuries to the lower extremities in all types of sports. Although foot deformities can be noted among athletes such as wrestlers and gymnasts who have more pronounced flat feet due to barefoot training, certain athletic exercises performed barefoot have a preventive significance against injuries of the lower extremities. The deformity known as clawfoot is noticed in handball players.

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# PREVALENCA DEFORMITETA STOPALA SPORTISTA SA RAZLIČITIM SPORTSKIM ISKUSTVOM

*Promene i deformiteti stopala učestala su pojava kod sportista. Cilj ovog preglednog rada je utvrđivanje rasprostranjenosti deformiteta stopala kod različitih sportista, kao i utvrđivanje uticaja deformiteta na izvođenje motoričkih zadataka. Prikupljanje radova obuhvatalo je period izdavanja između 2002. i 2018. godine. Za pretraživanje literature korišćene su sledeće elektronske baze: PubMed, MEDLINE, Google Scholar, EBSCO. Pronađena istraživanja moraju da zadovolje zadate kriterijume: da su istraživanja vršena na sportistima i da su analizirane razlike kod deformiteta stopala u rezultatima izvođenja motoričkih zadataka. Pregledani i obrađeni su istraživački radovi koji se tiču ove teme i problema rada. Uredno su razvrstani u tabeli koja i prikazuje detalje radova. Sumirani su rezultati iz 16 naučno istraživačka rada. Najzastupljeniji deformitet kod sportista je ravno stopalo (pes planus). Istraživanja pokazuju različite deformitete koji su zastupljeni u određenim sportovima, takođe su ustanovnjene promene na stopalu na nozi sportiste koja ima dominirajuću ulogu u određeneim sportovima. Ravno stopalo ima najslabije vrednosti rezultata u odnosu na normalan tip stopala za vreme i brzinu reakcije pri izvođenju motoričkih zadataka.*

Ključne reči: *stopala, deformiteti, sportisti, uticaj, učestalost*