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“Foot stabilization through strength training for athletes with flat foot”

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D I S S E R T A T I O N

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ABSTRACT

Objective: to look at the difference of flatfoot development in different gymnastics disciplines: artistic and rhythmic.

Design: Between-groups.

Setting: National Gymnastics Arena

Subjects: twenty healthy subjects appointed to groups by gymnastics disciplines: rhythmic (n=10) and artistic(n=10).

Main Outcome Measures:

Static postural control was checked on a force plate (Alfa Platforma). Calcaneal-tibial angle as determined by calf and hell lines and Clarke angle as a measure of the medial longitudinal arch.

Results:

The artistic gymnasts showed significantly greater medial longitudinal angulation than the rhythmic group athletes.

Conclusions:

The rhythmic gymnasts exhibit significantly more pronounced flexible flatfoot than artistic gymnasts. The present study focalized on the effects of rhythmic gymnastics as a contributor to abnormal foot and ankle anatomy.

Key words: flexible flatfoot, rhythmic gymnasts, artistic gymnasts, medial longitudinal arch.

CONTENTS

INTRODUCTION

1. Flatfoot

Flatfoot (pes planus) is associated with the collapses of the longitudinal arch of foot and the excessive rear foot eversion. Flatfoot may be classified into 2 groups: physiological (flexible) and pathological (rigid) (3). Pathologic is differentiated from physiological with stiffness of the foot, causes disability and requires treatment. The difference between them can be observed by tiptoe test and Jacks test (dorsiflexion of the great toe) (2).

The medial longitudinal arch collapses during weight-bearing and disappears when feet are relieved of the weight-bearing forces. Flatfoot affects all age groups, genders and ethnicities, with a greater incidence observed in women, young patients and children (9).

Flexible flatfoot is a common foot condition in the pediatric and adolescent population (5, 44), and the prevalence of pathological flatfoot that required therapeutic attention was 10,3% in children aged 7 - 14 years (55). Flatfoot is also referred to as pes planus (53) pes planovalgus (60).

2. Etiology

The etiology of this deformity is not fully known, but is most probable multi-factorial in nature. The anatomical varieties, bad biomechanics, occupation -related movement, weight gain, shortening of calf muscles and over-stretched front muscles of shin, over-exertion, bad footwear contribute elements (32).

Risk factors for the deformity may include hypertension, obesity, diabetes, previous trauma, steroid exposure. Posterior tibial tendon dysfunction is the most common cause of acquired flatfoot deformity (30).

Flatfoot is exceptionally prevalent postural defects of children, particularly training in gymnastics. Children admitted gymnastics are at the age 3 years old. At this age the prevalence of calcaneal valgus (overpronation) or varus (abnormal lateral angulation of the foot) is not indicative of lower extremity dysfunction, as these types of deformities imply a pathological and should be treated in later childhood (from 6 years of age).

Moreover, Kasperczyk (26) detected that flatfoot is within the normal range for children below 4 years old and can be disappeared as the decreases of plantar adipose tissue. However, it would not be excessive to point out that many authors like Pfeiffer (52) indicated in his investigation among examined 835 Austrian children aged 3-6 years that 44% with flexible flatfoot and only 1% with rigid flatfoot.

3. Treatment

The are many treatments for painful flexible flatfoot, ranging from physiotherapy, foot orthoses, exercise therapy and surgery (20, 13). Various researches have tested the impact of different insoles on balance. Firstly, McPoil et al. (1989) 43 evaluated the effects of FOs on the COP in 18 females with forefoot deformities (nine with forefoot varus and nine with forefoot valgus).

Orthoses used in this study were determined as “rigid, semi-rigid and soft”. The results showed that in the varus group, only the shoes reduced the COP area to a significant extent. Whereas in the valgus group, the shoes only, and all three types of insoles decreased the COP area compared to the barefoot condition, however, there was no significant difference between the different types of insoles.

Based on the COP excursions data, the authors think that orthoses have no benefit over footwear with good rearfoot stability for women with a forefoot varus deformity. In contrast, those women with a forefoot valgus deformation would improvements from orthoses as well as stable footwear.

Scherer and Sobiesk (1994) 44 also evaluated the effects of ‘functional’ Foot orthoses on the COP in 18 participants. They found the COP shifted laterally in 92% of participants whose COP index (area lateral to the COP divided by the area medial to the COP was initially medially displaced. However, the method to determine the COP index in this study may be quite error-prone — the method involved printing the footprint with the COP marked onto paper then cutting the footprint along the COP line and weighing the medial and lateral sections of the paper.

A further study found a similar lateral shift in the “instant center of force” with “medial arch supports”, however, testing was only performed on five participants (Scranton et al., 1982) (45).

In contrast, Miller et al. (37) found no change in the COP, although they did find “functional” Foot orthotics decreased both vertical and anteroposterior ground reaction forces in the early stages of the stance phase of gait. Analyzing the effect of FOs on COP still appears to be in the experimental stages as the clinical meaning of COP is yet to be determined. However, there is the possibility that once the normal COP has been determined, and if it is deemed important, then FOs may be used to move an abnormal COP towards a normal COP.

Cadaveric studies have also been used in conjunction with mechanical testing tools to demonstrate that the placement of an orthosis had a direct effect on the ankle joint and subtalar joint stability. The study by Tochigi (47) used five fresh-frozen cadaver limbs with simulated ankle-subtalar complex instability created by the transaction of the anterior talofibular ligament and the interosseous talocalcaneal ligaments.

Specimens were subjected to cyclic axial loads ranging from 9.8 to 668 N, and three-dimensional angular displacement measurements were made at the ankle and subtalar joints with electric goniometers. Measurements were made before and after the insertion of an orthosis designed to support the medial longitudinal and transverse arches of the foot. He found that the maximum ankle internal rotation was decreased from a mean (SD) of 3.3° (0.9°) to 2.3° (0.4°) ($P = .028$), but subtalar rotation was not significantly changed. He concluded that the orthosis reduced abnormal ankle internal rotation created by ligamentous resection and that the use of arch support restored some level of stabilization by limiting internal rotation of the ankle joint. Other than COP changes, the effect of FOs on temporal parameters and peak pressures has also been studied. Bennett et al. (1996) 48 assessed the effect of FOs on 22 participants. Using “Root-type” FOs they found the lateral border of the foot reached maximum peak pressure 5% to 7% earlier in the stance phase of gait, and conversely, the medial border reaches maximum peak pressure later.

In contrast to these findings, Cornwall and McPoil (63) assessed the effect of FOs on the initiation of plantar surface loading in 10 healthy volunteers. They used two different types of orthoses: a “rigid” style and an “accommodative” style. The rigid device was a prefabricated orthosis that was modified using a heat gun so as to be comfortable, then forefoot and rearfoot wedges were applied. They found the medial forefoot was loaded significantly earlier with the rigid orthosis compared to the other conditions of shoe only, and soft orthosis.

Unfortunately, Cornwall and McPoil made no reference to the study by Bennett et al. (1996) (48). The differences may be accounted for by the fact that Cornwall and McPoil divided the foot into seven distinct areas to assess plantar pressures. In addition, they used relatively “normal” participants, whereas Bennett et al. used participants with a previous history of foot and leg problems.

Studying 6 examined the effects of simulated golf and orthotic intervention on static balance inexperienced golfers. Nine subjects had static-balance measurements taken on the Cybex® FASTEX system before and after 9 holes of simulated golf. The simulated golf was used to induce a fatigue factor that one would experience during golf activity. Subjects stood on the FASTEX in single-leg stance for 30 seconds, and a stabilization index was calculated. Subjects were then fit with custom-molded orthotics and returned for the same testing protocol after wearing the orthotics for 2 weeks.

Results showed a trend toward a decrease in stabilization time from baseline balance testing to post-golf-simulation balance testing with orthotic use. 6 Although we did not measure stabilization time, our results revealed that after 2 weeks of orthotic intervention, COPV measures decreased significantly in all foot-type groups. This could be attributed to either a learning effect with repeated balance trials or the effects of wearing the orthotics between testing sessions.

CHAPTER I

LITERATURE REVIEW

1.1. Literature Review of Risk Factors

According to Paul W. Knapp, failure of the posterior tibial tendon affects surrounding ligamentous structures and will eventually lead to bony involvement and deformity (30).

According to Saldivar-Ceron H.I., there is an association between obesity and flatfoot. The prevalence of overweight/obesity was 49.1% and of flatfoot was 12.1% (male: 8.1%, female: 4%, p = 0.28). The association between obesity and flatfoot was significant (p <0.001) and there was a 2.5 times higher risk of overweight-obese children compared to those of normal weigh.

Jen-Huei Chang et al. evaluated the relationship between flatfoot and obesity, gender, and age in Taiwan (7). A sample of 2,083 children, between 7 and 12 years of age from public elementary schools in northern Taiwan was analyzed. The results of this study indicate that the prevalence of flexible flatfoot is highest among males who are obese and overweight, particularly in the age range of 7 to 8 years.

Liya Xu et al. pointed out the following risk factors for flatfoot in children and adolescents in China: sex, age, region, shoe shape, joint relaxation, exercise time. The detection rate of flatfoot in girls and boys was different. Compared with girls, the detection rate of flatfoot in boys was higher. The detection rates for flatfoot in children and adolescents were different in different age groups.

The results of this study showed that the detection rate of flatfoot tends to decrease with the increase in age. Joint ligament relaxation was also a critical factor in the occurrence of flatfoot in children and adolescents. Most studies showed that the incidence of joint relaxation was higher in girls than in boys. This may be related to girls' joint flexibility being more significant than that of boys. In children living in a city or in studies in which children were recruited from an urban area, urban area was also a susceptible factor for flatfoot in children. In terms of physical activity, children who exercised less were more likely to have flatfoot. Low levels of physical activity could lead to delayed or uneven muscle strength, resulting in poor arch strength. The exercise was closely related to physical development, weight management, and a healthy lifestyle However, children need to engage in appropriate physical activities.

Adolescents who are not fully developed should avoid taking part in overloaded labor (such as burden-bearing) and sports (such as weight lifting). They could engage in high leg lifting, jumping activities (such as rope skipping, long jump, high jump, vertical take-off, etc.), and climbing activities (such as climbing ladders, using balance beams, rope climbing, pole climbing, etc.) to fully exercise the muscles and ligaments of the arch of the foot.

1.2. Literature Review of Diagnosis methods.

Diagnoses of flexible flat foot is often based on radiographic or clinical measures, yet the validity and reliability of these measures for a pediatric population is not clearly understood (20). Plain film radiographs are considered the reference standard to determine flat foot magnitude; however, this method is costly, involves radiation risk, and is not routinely used in clinical practice (61). Radiographic results of flatfoot include the hindfoot alignment (17). The tibio-calcaneal angle was obtained between the weight- bearing axis of the tibia and the calcaneus from the heel contact point (6). On the lateral weight-bearing view the talo-first metatarsal and calcaneal pitch angles were observed.

According to Weimar, only three measures of flexible flat foot had any published data to support validity and reliability of the measure within a pediatric population (Chippaux-Smirak index, Staheli arch index and FPI-6), each with their own limitations (61).

Based upon the study of Hegazy, FPI-6 and Clarkes angle are both can be utilized as a screening method for flatfoot in adolescents aged 12-18 years with Clarkes angle outperforming FPI-6 (16). Postural control is considered quite seriously in sports medicine as one of the measures of the sensorimotor function of the lower extremity.

Postural control is organized in a hierarchical manner and is influenced by input from the vestibular, visual, and somatosensory systems (20). The somatosensory system is constantly processing information from afferent receptors from the skin, joints, muscles, and tendon (64, 25) and continuously making adjustments to maintain equilibrium and dynamic balance (20). For maintaining standing balance and postural control, afferent information should be obtained from the plantar cutaneous surface of the foot (28, 43).

Efficient postural control is important in maintaining balance and avoiding falls during gait and other activities. The plantar surfaces of the feet serve as an interface between the body and the ground and play an important role in postural control (27). The impact of afferent input from the plantar cutaneous surface of the foot to postural control has been researched based on local anesthesia and ischemic blocking, (35, 36, 12) however others (28, 8) have analyzed the effect of hyper stimulating plantar afferent receptors through stimuli like vibration. The plantar cutaneous receptors contribute substantially to the maintenance of postural control; however, the extent of their contribution is still not clear. In addition, reducing plantar cutaneous afferent input through surface cooling (ice, cryotherapy) impairs postural control (43, 12, 42).

Little is known; however, about how increased plantar cutaneous stimulation affects postural control. Improved postural control through altered afferent information from plantar cutaneous receptors may improve the results with various injured or disabled populations. Postural control is frequently assessed by having subjects stand on 1 leg as still as possible on a force plate; this is often referred to as static postural control. The force plate permits the calculation of variability in the regulation of stance. Greater variability is typically associated with postural instability (59). For instance, static postural control has been observed to be impaired in persons with lateral ankle instability (3, 7, 18).

However, static postural control has been criticized as a measure of sensorimotor function because measurement techniques may not be sufficiently sensitive to disclose deficits in impaired persons (21). Quiet standing in a single-leg stance might be a task that is too easy, which affords subjects the chance to use alternative motor means to properly accomplish the task even in the presence of pathology (57). This has resulted in the development of more complex and dynamic postural-control tasks.

One of such tasks is the Star Excursion Balance Test (SEBT), a series of lower extremity reaching tasks (29, 14). The SEBT has been shown to be sensitive to determining deficits in subjects with chronic ankle instability (48) and patellofemoral pain syndrome (11). Plenty of authors have demonstrated how to investigate and measure foot posture in different age even though there are no universally accepted criteria for diagnosing flatfoot within existing literature. Diagnoses are based on radiographic investigation is considered as a reference standard measure, but have radiological load. Chippaux-Smirak index vestibular and somatosensory systems.

The somatosensory system is constantly processing information from afferent receptions from plantar surfaces of the foot to maintain balance. The plantar cutaneous receptors contribute significantly to the maintenance of postural control, even though the extent of their contribution is unclear. The Star Excursion Balance Test has been shown to determine deficits in ancle instability., the Shaheli arch index, the FPI-6, the Clarkes angle are both valid and diagnostically accurate clinical tests for flatfoot lower extremity and is influenced by input from the visual.

1.3. Literature Review of flatfoot influence on athletes’ injuries

Many authors have demonstrated the relationship existing between the height of the medial longitudinal arch of the foot and athletic injuries. Flatfoot may be considered as a risk factor for development and progression of patellofemoral syndrome (PFPS) (58). Even though, the mechanism remains indistinct as the occurrence of PFPS is multifactorial.

Many factors are considered as allowance of possibility of runners to get injuries, including excessive pronation or foot eversion and foot eversion velocity (41), increased internal tibia rotation (44), higher impact peak and loading rate of the vertical ground reaction force (45), increased ankle invert ion moments (46) and increased knee abduction and external rotation moments (47).

The difference of MLA height between individuals with normal and flat feet has an effect on various kinetic and kinematic parameters of locomotion (63) which might increase the risk of injury (50). On the other hand, there are some studies which have reported no significant difference between normal and flat-footed subjects in their kinetic parameters and susceptibility to injury (45).

Mohammad Ali Sanjari and Sahar Boozari (48) demonstrated in their study, that no significant finding was observed between groups (the independed variables of the study were foot type normal and flatfoot during condition before and after fatigue) in linear CoP measures. This similar response to fatigue in individuals with flat and normal feet indicates the same biomechanical behavior despite their different MLA height. Furthermore, these findings show that linear CoP measures are not able to distinguish the gait behavior difference among individuals with normal and flat feet.

The increased range of motion during training gymnastic practice may increase mobility at the cost of weakened stability, which leads to locomotor dysfunction. While a normal foot development is influenced by numerous factors such as adequate physical activity, sex, footwear, genetics, for normal foot development of children who go in for sport (gymnastics) the number of influencing factors increases. That factors may include excessive, asymmetric training loads starting with the early age, which contribute to biomechanical faults.

METHODS AND MATERIAL

Subjects

Twenty subjects with no visual, vestibular disorders, lower extremity musculoskeletal injury female athletes (10 artistic gymnasts and 10 rhythmic gymnasts) were involved to participate. As the age of athletes is from 12 -15 the consent was obtained from the parent and coach. After reading and signing an informed form, the Ethical Committee of ASAPES approved the study.

The general characteristics were been taken and presented in Table 1. This study was performed among athletes of national team with different training experience. The participants have dissimilar training history from recruitment to the present time. The recruitment occurs at age of 4 - 5 years for both of these disciplines, however the time spending on pre-training practices, including strength training of all the major muscle groups, agility exercises, the multitude of jump-based exercises is inherently different. All of the rhythmic athletes started their competing activity from the age of 6 years, whereas the artistic gymnasts competed at the regional level at the age of 8 - 9 years.

The first study phase started with measurement of body height and body composition to describe weight, fat and muscle masses (inBody). Anthropometry data was taken in morning before training, body mass index was calculated and compared with World Health Organization percentile thresholds for female aged 5-19 years. According the specific demands of each discipline there are some body weight and height deviation.

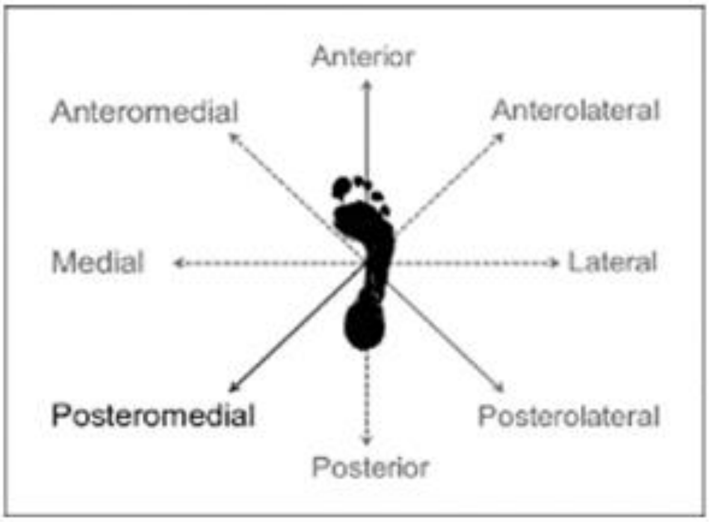
Design

We assess the effects of training 2 various disciplines of gymnastics in development of the flatfoot. Independent variables were at 2 levels (rhythmic and artistic gymnastics) and dependent variables were at 2 levels too (flexible pes planus and normal foot).

Testing procedure:

For definition of the medial longitudinal arch of the foot there are several measurements to obtain quantitative data:

1. Clarke angle
2. Chippaux- Smirak Index (CSI)
3. Staheli arch index
4. Calcaneal- tibial angle



For dynamic postural control perform The Star Excursion Balance Test. The SEBT is one of the functional tests that combine a single -leg stance with maximum reach of the opposite leg. The subject is standing at the center of a grid placed on the floor with 8 lines, extending at 45 degree increments from the center of the grid; anterior, anterolateral, lateral, posterolateral, posterior, posteromedial, medial and anteromedial. Subjects maintained a single- leg stance on the stance leg while reaching with the opposite leg to touch as far as possible along the appropriate line. The examiner marked the touching point along the line and then measured the distance from center to the touch point.

Figure 2. Calcaneal – tibial angle on the photographed lower extremities

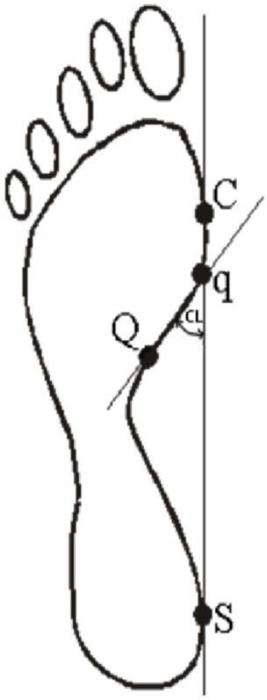


Figure 3. Clarke angle measurement.

Foot pronation was assessed by the Clarke angle, a measure of the medial longitudinal arch. The procedure involved the participant sitting in a stable chair with the tibia set perpendicular to the ground with the feet bare and resting on the podoscope. An image was obtained in this unloaded position in order to determine foot shape in non-weight bearing conditions. Another image was then captured during upright standing.

The digital photographs were examined using computer software to determine the Clarke angle for the right and left foot, which was treated as the angle between the tangent of the medial edge of the foot (running from the peak of the first metatarsal head to the most internal point of the calcaneus) and the tangential line connecting the acme of arch concavity with the most medial point on the forefoot.

Based on the obtained angle, the foot was defined as collapsed arch or pes planus (0–30°), reduced arch (31–41°), neutral arch (42–54°), and high arch or pes cavus (> 55°)

DISCUSSION

The human foot is a very complex structure, which allows it to serve many diverse functions. The evolutionary development of the arch of the foot was coincident with the greater demands placed on the foot as humans began to run.

Patrick O McKeon proposed a novel paradigm for understanding the function of the foot. There is evolutionary evidence that the foot arch architecture and musculature developed in response to the increased demands of load carriage and running. The theoretical basis of lumbopelvic-hip core stability is rooted in the functional interdependence of the passive, active and neural subsystems controlling spinal motion and stability originally proposed by Panjabi (50).

The passive subsystem consists of the bony and articular structures, while the active subsystem consists of the muscles and tendons attaching to and acting on the spine. The neural subsystem consists of sensory receptors in the joint capsules, ligaments, muscles and tendons surrounding the spine.

The functional configuration of the bony anatomy of the foot results in four distinct arches which include the medial and lateral longitudinal arches as well as the anterior and posterior transverse metatarsal arches.

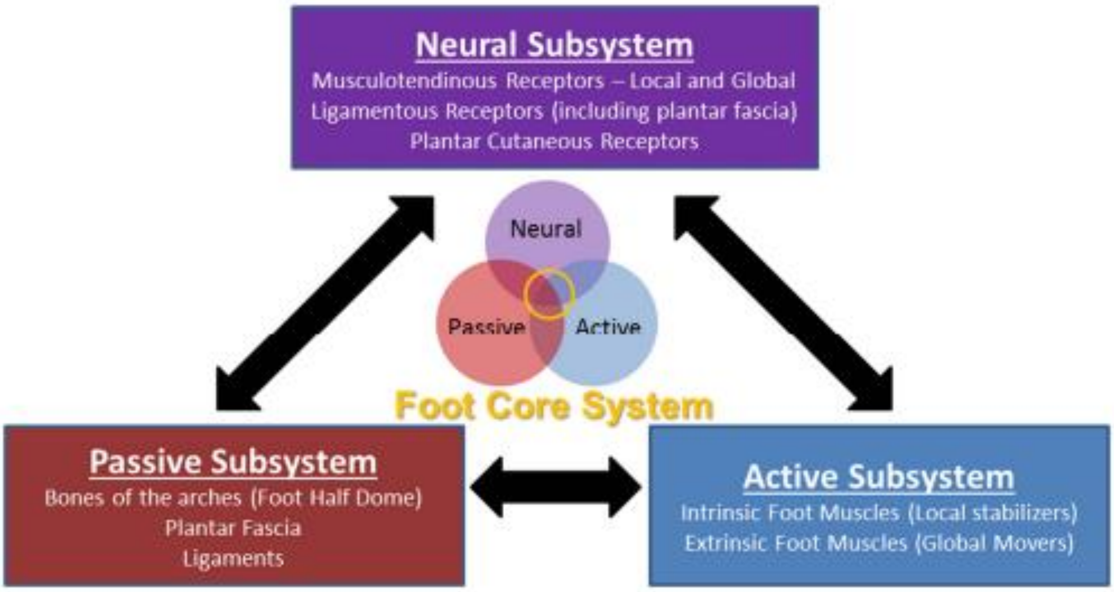


Figure 2. The foot core system. The neural, active and passive subsystems interact to produce the foot core system which provides stability and flexibility to cope with changing foot demands.

McKenzie (38) proposed that these arches coalesce into a functional half dome responsible for flexibly adapting to load changes during dynamic activities.

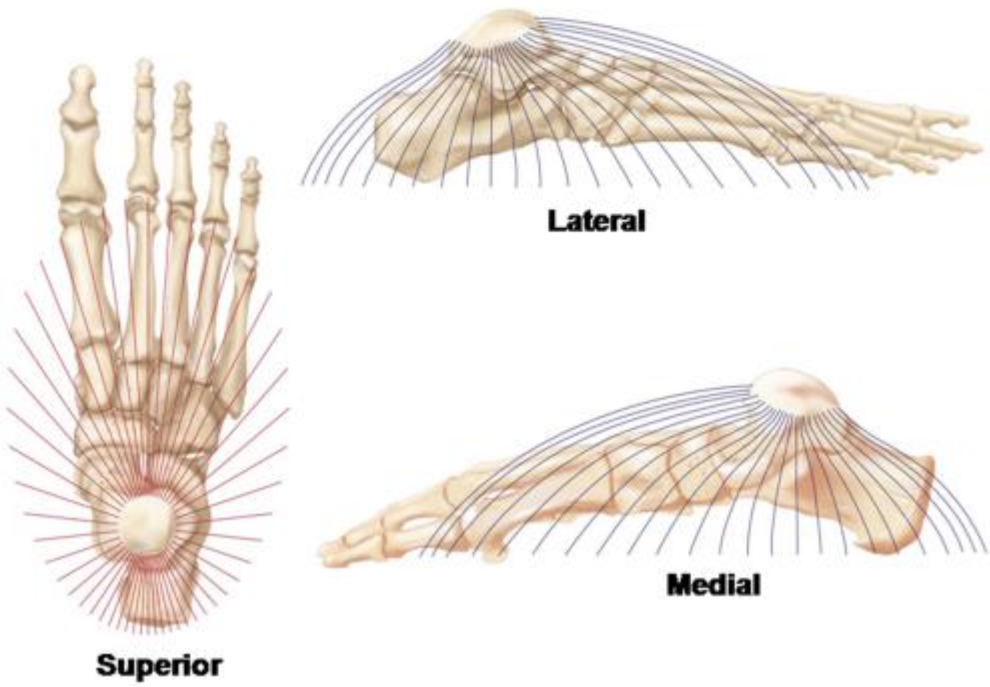


Figure 3. Functional half dome proposed by McKenzie. Note the origin of the dome is considered to be the dome of the talus.

There is increasing evidence to suggest that training the foot core via short foot exercise progressions can improve foot function. For example, 4 weeks of short foot exercise training in healthy individuals reduces arch collapse as assessed by measures of navicular drop and arch height index, and improve balance ability. In another study, healthy individuals who completed 4 weeks of short foot exercises demonstrated improved dynamic balance compared to those who performed 4 weeks of towel curl exercises (33).

However, postural control gains following a 4 - week balance training home exercise program were equivalent between healthy training groups that did and did not perform the short foot positioning during their balance exercises (54). In healthy young adults with pes planus, there were significant increases in great toe flexion strength and the cross-sectional area of the abductor hallucis muscle after 4 weeks of short foot exercises and foot orthotic intervention compared to foot orthotic intervention alone (24).

Functional quality	**Description**
Supportive of the foot arches	Diminished function of the intrinsic foot muscles lead to deleterious alterations in foot posture whereas training the intrinsic foot muscles enhances foot posture
Activity dependent	Intrinsic foot muscles are more active in dynamic activities such as walking compared to standing
Load dependent	As postural demands increase, such as from double to single limb stance, so does the activity of the intrinsic foot muscles

Synergistic	The intrinsic foot muscles work together as a unit to provide dynamic arch support during the propulsive phase of gait
Modulating	The intrinsic foot muscles support the foot in its role as a platform for standing and lever for propelling the body during dynamic activities

Table 1. Functional qualities of the intrinsic foot muscles and their corresponding evidence - based descriptions

Robbins and Hanna61 reported a significant reduction in the foot length (measured radiographically from the anterior aspect of the calcaneus to the first metatarsophalangeal joint) following 4 months of barefoot walking and running. The shortened foot is an indirect measure of foot strengthening as it indicates a raising of the arch. Muscle size has been directly correlated to muscle strength (1).

Using this principle, Brüggemann et al (5). measured the cross-sectional area of some of the core muscles of the foot in runners who trained for 5 months in shoes that lacked any support to the arch and rearfoot. They reported significant increases in the cross-sectional area of many of these muscles. Further studies are needed to determine whether strength and cross-sectional area gains of the foot core muscles lead to a reduction in running-related injuries.

Anna Sobera et al pointed out in the study the prevalence of foot and ankle deformities in trampoline and artistic gymnasts. This study was performed in 2014 and involved 20 healthy female athletes (10 trampoline gymnasts and 10 artistic gymnasts) aged 6 – 14 years attending regular training. The examination revealed that artistic gymnasts present only slightly increased calcaneal-tibial angles with an approximate 8° deviation . It is possible that the more diverse training structure of artistic gymnastics, although also responsible for excessive load, is less detrimental to the foot and ankle joints than trampoline gymnastics.

The results of the study present many evidences that there are significant differences in development flexible flatfoot in young athletes of rhythmic and artistic gymnastics. This was most obvious in the fact that the rhythmic gymnast has significantly larger rearfoot angles than the artistic gymnast. While both of these disciplines may share a number of similarities, but there are many differences in load forces on the musculoskeletal system. The artistic gymnastics involves a greater jumping component in which the vertical load forces on the musculoskeletal system several times greater than that experienced by rhythmic gymnasts, whose training profile is mostly centered on hanging and stand exercises. For this reason, does the present study focalize on the effects of rhythmic as a significant contributor to abnormal foot and ankle anatomy. It is highly probable that the forces induced by rebounding and landing on rhythmic gymnastics are of such magnitude that even the relatively strong tibialis posterior muscles are unable to effectively stabilize the ankle, leading to lower extremity deformity as a result of overuse. While jumping involves similar amplitudes of muscle activation throughout the movement, modifications in the temporal sequence of calf muscle activation may be the cause of insufficient stabilization of the ankle during rebound. This may ultimately lead to overpronation and introduce calcaneal valgus.

The greatest Clarke angles were observed in tumbling gymnasts. This finding was confirmed in another study on elite female acrobatic gymnasts where their training was positively associated with longitudinal arch structure but negatively with transversal arch structure (51). While these findings are of particular interest, it needs to be mentioned that neither of the aforementioned studies involved trampolinists outright.

Aydog et al. (31) reported that elite gymnastics athletes present enlarged longitudinal arch compared with untrained individuals. These researchers found a significant positive correlation between arch indexes and foot eversion strength in gymnasts but not among controls. While lower extremity strength is undoubtedly enhanced by the numerous jump-related exercises that quantify acrobatic and artistic gymnastics practice, the gymnasts recruited in the present study presented deformity by way of a high-arched foot although the prevalence of this defect and its magnitude was greater in the trampoline group.

The present study focalizes on the effects of rhythmic gymnastics as a contributor to abnormal foot and ankle anatomy. A number of evidences was confirmed in the study:

1. The age when gymnasts commence specialized training regimes and enter competition. The prevalence of injury in sport is of particular concern as ever younger athletes are recruited when still at very early stages of motor and musculoskeletal development. The rhythmic gymnast at the age of 4 years, while the artistic only at the age of 7 - 8 years. There is also the difference in the starting age of competition participation; rhythmic is at 6 years, artistic is at 8 years.

2. The training time is one of the first-rate influences, the difference is calculated by daily 3 yours.

3. The difference in the surfaces, the artistic gymnastics requires demanding footwork on a variety of surfaces, from hardwood floors to gymnastics mats of varying densities, landing mats and trampolines, whereas the rhythmic athletes need only a specialized soft carpet.

4. The difference in loads, the artistic gymnastics suggests a variety of loads with a wide range of exercises, which have positively influence on foot shape, while rhythmics suggests a plenty of repetitive exercises, which have unfavorable effects on foot.

5. The artistic gymnasts performed a relatively larger share of bar-based exercises (wall bars, horizontal bar) than the rhythmic gymnasts as well as spending more time on the balance beam.

6. The multiple jump-based exercises, a core component of artistic gymnastics training (particularly in the floor exercise and vault events), can strengthen the lower extremity muscles such as the calf and plantar flexor muscles. While rhythmic gymnasts perform less multiple jump-based exercises during their training.

RESULTS AND ANALYSES

Results of our work we divided into three groups:

1.The largest part of the study was focused on conditions in which both of disciplines train.

2. Results received from measurement of Clarke angle

3. Results received from calcaneal-tibial angle.

4. For rhythmic gymnasts the indicators were 34,1± 2,1 for left foot and 36,5±1,5 for right foot. For artistic gymnasts the indicators were 41,6±2,6 for left foot and 44,6± 3,6 for right foot

5. Calcaneal- tibial angle in in the rhythmic and artistic gymnasts:

N	Rhythmic Right	Rhythmic Left	Artistic Right	Artistic Left
10	15,2±5,2	12,0±2,0	6,0±4,0	5,4±3,4

Table1. Characteristics of the study participants

This difference was statistically significant P<0,05.

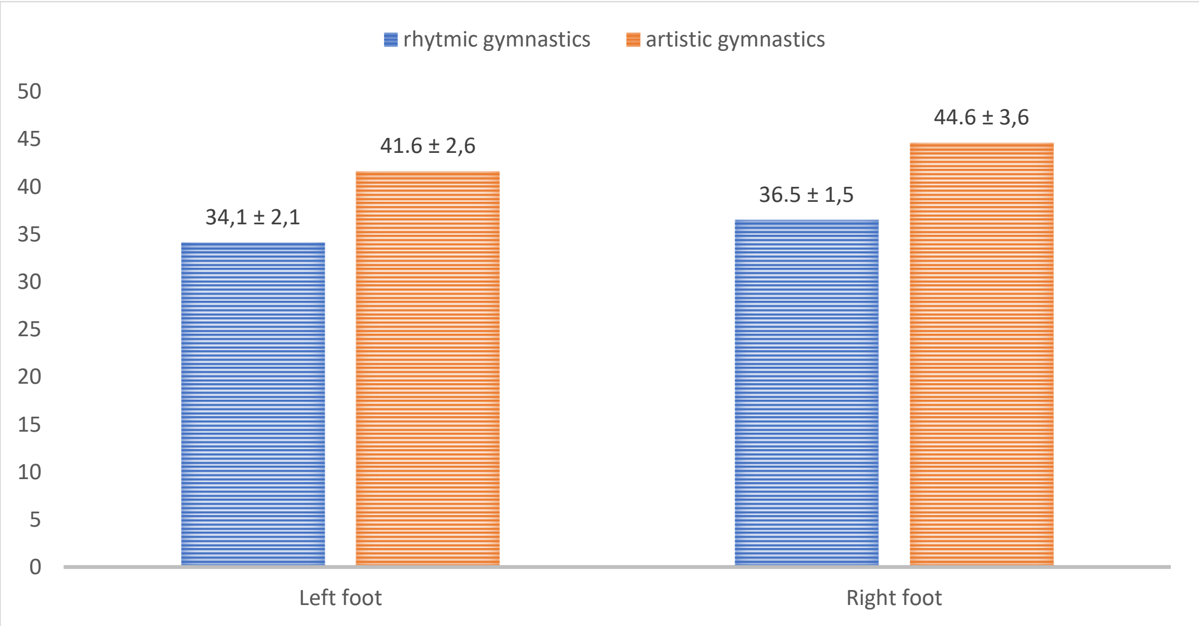


Figure1. Calcaneal-tibial angle in rhythmic and artistic gymnasts

CONCLUSION

The present study focalizes on the effects of rhythmic gymnastics as a contributor to abnormal foot and ankle anatomy. A number of evidences was confirmed in the study:

1.The age when gymnasts commence specialized training regimes and enter in competition regime. The prevalence of injury in sport is of particular concern as ever younger athletes are recruited at very early stages of motor and musculoskeletal development. The rhythmic gymnast is at the age of 4years old, while the artistic one only at the age of 7-8 years old.

2. The training time is one of the first-rate influences, the difference is calculated by daily 3 hours.

3. The difference in the surfaces, the artistic gymnastics requires demanding footwork on a variety of surfaces, from hardwood floors to gymnastics mats of varying densities, landing mats and trampolines, whereas the rhythmic athletes need only a specialized soft carpet.

4. The difference in loads, the artistic gymnastics suggests a variety of loads with a wide range of exercises, which have possibility influence on foot shape, while rhythmics suggests a plenty of repetitive exercises, which have unfavorable effects on foot.

5.The muscular disbalance between the front and back shin muscles in rhythmic gymnastics, as a result of training on tiptoes. Tibialis anterior tendon(overstretched for rhythmic gymnasts) is one of the main support mechanisms of the arch and as a result, with its dysfunction the arch of the foot is no longer supported which can result in a flat foot deformity or the foot slapping. Posterior tibial tendon(shortened for rhythmic gymnasts) dysfunction insufficiency is the most common cause of flatfoot deformity.

6. Ligamentous laxity. Having a wider range of joint motion rhythmic gymnasts after repeated ankle sprains gradually during their training work lose the stability of ankle. This occurs when the connective tissue, or ligaments, are overstretched and not stabilizing the

joint the way it is supposed to. Having loose ligaments in the legs and feet may appear to have flatfeet. While the feet have an arch when not supporting weight, when stood upon, the arch will flatten.

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