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Is there a relationship between functional flat foot and prevalence of non-insertional achilles tendinopathy in joggers? — a pilot study

Agnieszka Wnuk[1], Ewa Mizia[2], Bartosz Rutowicz[2], Jerzy A. Walocha[2]

[1]Department of Ergonomic and Exercise Physiology, Faculty of Health Sciences
Jagiellonian University Collegium Medicum, Kraków, Poland
[2]Department of Anatomy, Jagiellonian University Medical College, Kraków, Poland

Corresponding author: Agnieszka Wnuk
ul. Szarych Szeregów 1/14, 32-065 Krzeszowice, Poland
Phone: +48 504 002 650; E-mail: agnieszkawnuk90@gmail.com

Abstract: Introduction: Non-insertional Achilles tendinopathy is one of the most common overuse injuries experienced by joggers. The pes planus evaluation is often based only on the visual method without a dynamic test. Functionally inefficiency of longitudinal or transverse arch of the foot may be a significant risk factor affecting the lower limb biomechanics and causing of pain in the Achilles tendon area.
Assumptions and purpose of the study: This study was undertaken to determine and investigate the relationship between the functionally inefficient longitudinal and transverse arch of the foot and the prevalence of non-insertional Achilles tendinopathy.
Materials and methods: The study group consisted of 11 regular joggers at different levels, who were diagnosed with non-insertional Achilles tendinopathy. The clinical evaluation involved pedobarographic analysis using the Footscan pressure plate. Information on loads applied to metatarsal area, the basis of the second and third metatarsal bones were subjected to statistical analysis.
Results: All subjects who were diagnosed with overuse injuries in the Achilles tendon area showed a functionally inefficient transverse arch of the foot. Despite their pain, the individuals subjected to the study did not cease completely their physical activity.
Conclusions: Collapse of the natural arch of the foot can lead to biomechanical disorder in the lower limb joints. This is one of the risk factors for the occurrence of changes due to overuse injuries within the Achilles tendon.

Key words: non-insertion tendinopathy, running, plantar pressure.

Introduction

Non-insertional Achilles tendinopathy is one of the most common types of overuse injuries. The term ‘tendonitis’ was first used by Puddu in 1976 to describe histological degenerative changes [1]. In the past it was believed that inflammatory process is not a key feature of the ongoing change, but in recent years the importance of inflammatory changes has been brought into discussion again [2, 3]. The pathological process has now been described as a combination of degenerative and inflammatory changes. The area of the overuse usually affects the Achilles tendon between 2 and 6 cm from its attachment to the calcaneal tubercle. For the most accurate description of the ongoing changes, the clinicians now use the phrase ‘failed healing response’ [4, 5].

Athletes, both professionals and amateurs, are the most vulnerable group at risk of overuse injuries affecting the Achilles tendon. The occurrence of the problem has been described as 37.3 per 100,000 cases in some European populations [6]. Several important risk factors have been studied and described, including: uneven length of the lower limbs [7], limited ankle dorsiflexion [8], workout errors [9], use of certain medications such as steroids or fluoroquinolones [10]. A typical symptom is pain, which significantly limits the function and, in particular, physical activity. Pain symptoms are the most intense in the first phase of motion after resting. Diagnosis can be made on the basis of clinical evaluation and symptoms. Patients usually indicate the anteromedial side of the tendon as the most painful. To confirm the diagnosis, as in the case of this study, the following additional test can be performed: compression of the area indicated by the patient, which will cause pain and passive evaluation of the dorsiflexion of the foot [11].

Some prospective studies have shown that both cavus foot and pes planus increase the risk of injury in the lower limb [12]. However, subsequent studies pointed to completely different results. The number of publications stating that there is no relationship between the shape of the foot and the occurrence of injuries it is at least equal to the number of publications confirming the aforementioned correlation. The problem also appears in terms of assessment of the pes planus and its classification [13]. There is a substantial body of scholarly literature describing the methodology of tests and indicators applied to assess the foot in a static position. Among others, the following parametres can be distinguished: arch index, arch angle, footprint index. They are used for evaluation of the rebound of the sole of the foot, visual inspection (i.e. collapse of the navicular), or determination of parameters from X-ray images [14]. This research was inspired by the absence of reports that would take into account functionally inefficient foot arches.

Pedobarographic analysis that uses the reactive force of the ground to evaluate specific areas on the sole of the foot in dynamic circumstances, shows the image of changes occurring during the process of walking or running [15]. According to the authors of this study, the foot, which does not retain its natural arches under dynamic conditions, is at potential risk of overuse injuries within the Achilles tendon. As a consequence of the inappropriate load distribution, the whole kinematic chain may be affected.

The aim of the study was a dynamic assessment of the arches of the foot, while running on a pedobarographic plate in patients who jog regularly and who were diagnosed with non-insertional Achilles tendinopathy.

Methods and materials

The study included 11 people who were diagnosed with overuse injuries within the Achilles tendon area. The study group consisted of 5 women (mean age of 28 years) and 6 men (mean age of 31.6 years). The BMI of the patients was calculated, based on the anthropometric data, and 22 was the mean score. The site of the study was a physiotherapeutic practice with an ultrasound laboratory and pedobarographic plate. All participants of the study were familiarized with the informed consent sheet and have signed the relevant documents. The study has been approved by the Bioethics Commission of the Jagiellonian University. Characterisation of participants of the study is shown in Table 1.

Table 1. Characterisation of participants of the study.

Variable		n	%
Gender	Female	5	45.5
	Male	6	54.5
Age	≤25	2	18.1
	25< x ≤30	5	45.5
	>30	4	36.4

The inclusion criterion for participation in the study was a diagnosis of non-insertional Achilles tendinopathy made by an orthopedic physician, based on a clinical examination and an ultrasound scan. The participants also had to be regular joggers who make a minimum of 30 km per week.

The exclusion criteria for participation in the study were past fractures in the lower limbs or spine. Presence of pain in the knee or hip area, neurological disorders, active cancer or suspicion of its presence.

The clinical examination involved in completing a questionnaire which was developed for the study by its authors. The questions referred to basic anthropometric information and intensity of jogging workouts. Some questions were taken directly from the high accuracy VISA-A test, which was developed specifically to assess the pain of Achilles tendon [16]. The next step was an ultrasound scan, performed by an orthopedic expert. Taking into consideration that due to recent studies about Achilles three main types of torsion [17]. The evaluation of soft structures was performed with a 18 MHZ head (MyLab25Gold, manufactured by Esaote, S.p.A). After a clear diagnosis of an overuse injury within Achilles tendon, without any coexisting pathologies, the participant was subjected to a biomechanical test.

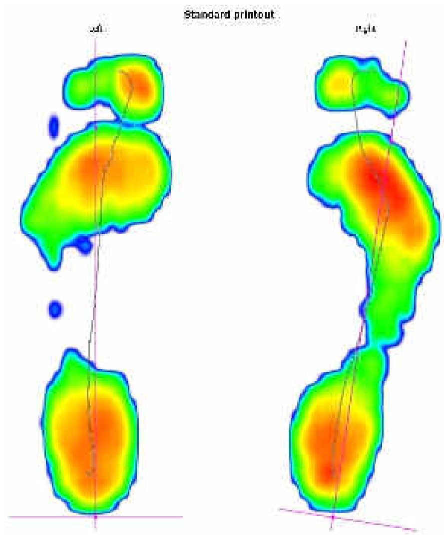

Fig. 1. Results of evaluation of walking on Footscan pedobarographic pressure plate.

Evaluation of biomechanical parameters was made on the basis of a pedobarographic assessment of the feet. The device used for this part of the study was a 0.5 m Footscan®9 pedobarographic pressure plate manufactured by RSscan (4,096 sensors, scanning up to 300 Hz per second) and v9 Essentials software used for the analysis of the results of the test. In order to avoid errors which could result from deliberate stronger impact on the surface of the plate, marking pads were placed and a 2.5 meter track was prepared. Eight anatomical areas are automatically identified by the software, using a special algorithm. These areas are defined as: medial heel (MH), lateral heel (LH), metatarsal heads (M1, M2, M3, M4, M5) and the big toe (Hallux — T1). In terms of load applied to the foot, based on the load indicators, four areas can be distinguished: Heel, Mid Foot medial, Mid Foot lateral and Forefoot. The procedures used for measurement were based on scientific reports [18, 19]. The patients were instructed to inform the person conducting the test about any pain during its course.

Only selected pieces of information, confirming functional inefficiency of longitudinal and transverse arches of the foot have been taken into account in the general report of the test.

The results were subjected to statistical analysis using Statistica 12 PL software. The value of $\alpha = 0.05$ served as the level of statistical significance. For the description of the statistical analysis of quantitative variables, in order to obtain the most transparent results, average values with the standard deviation were applied. To evaluate the relationship between the loads applied to the forefoot and the mid foot, and the presented maximum force, Student's t-test method was used for dependent tests.

Results

In the case of all participants of the study, the diagnosis, based on thorough clinical and radiological examination, was non-insertional Achilles tendinopathy. The pedagarographic assessment shows that during active loading, while in motion, the shape of the foot and its arch, and consequently the results of individual measurements and coefficients, change compared to the static effort. All the participants of the study showed functional longitudinal or transverse pes planus.

The parameters indicating the loads applied to the individual foot areas, allowed to distinguish the maximum loading force for the right and left foot respectively. The maximum load average for the right side was 34.08 N/cm^2 (SD = 6 N/cm^2), and for the left side respectively it was 33.67 N/cm^2 (SD = 5.7 N/cm^2). Table 2 presents the maximum force results for the analysed areas of the foot respectively.

Table 2. Distribution of maximum load applied on selected areas of the right and left foot.

	N	MAX M2	MAX M3	MID FOOT	PEAK POWER
		Mean [N/cm^2]	Mean [N/cm^2]	Mean [N/cm^2]	Mean [N/cm^2]
RIGHT LEG	11	31.9	27.8	6.4	34.1
LEFT LEG	11	30.2	27.2	5.3	33.7

M2,3 — base of the second, third metatarsal bone

The maximum dynamic foot load (M2, M3) and mid foot load during the run were analysed and compared to the peak force. The test showed significant differences between all the variables, both for the right and left foot. The greatest differences have been observed for the mid foot area, whose value was more than 5 times lower than the peak force for the right, and more than 6 times lower for the left foot (Table 3).

Table 3. Distribution of maximum force of the load applied on individual foot areas.

Variable				Peak power			p
	N	Mean	SD	N	Mean	SD	
RIGH FOOT							
Max M2		31.88	6.84				0.04*
Max M3	11	27.75	6.82	11	34.98	6.03	<0.01*
Mid foot		6.42	4.99				<0.01*
LEFT FOOT							
Max M2		30.16	5.97				<0.01*
Max M3	11	27.17	7.56	11	33.68	5.73	<0.01*
Mid foot		5.27	5.27				<0.01*

* p <0.05 statistically significant value

In both groups, during the transfer phase, the width of the feet increases, on average, by 6.9% (0.5 cm), this feature is the most pronounced in the left foot. In this regard, the participants constituted a very homogeneous group, with a standard deviation of 0.06 with respect to the feature in question. The increase of the transverse dimension the foot in regular joggers, during dynamic examination may be associated with poor functional performance of stabilisers of transverse arch of the foot — passive — deep transverse metatarsal ligaments, and active — the tibialis posterior, peroneus longus and adductor hallucis over the load induced in the transfer phase by the participant's body. The results of the dynamic examination showed significant repeatability of the increase of the transverse dimension the foot compared to those obtained during the static examination — the increase occurred in 10 out of 11 subjects. The width of the foot has decreased in the case of just one patient and this value did not exceed 3 mm.

The participants questionnaire assessment of their ankle showed that, despite persistent complaints, 8 out of 11 patients, did not cease their jogging workout. After 10 calf raises on one lower limb, all patients experienced severe pain in the calcaneal tubercle area (on a 10 grade scale the pain was 7 or 8 on average). None of the participants were able to perform more than 12 single leg hops without the occurrence of severe pain (2 patients made 12 hops, 5 patients — 9 hops, and 5 patients — less than 8 hops).

Discussion

Methods of assessment of pes planus in adults in static position show no clear evidence of changes that occur while in motion. According to the British researchers, the only reliable diagnosis is the one, based on evaluation of walking of the patients [20].

The project of this study deliberately assumed to assess the loading of specific areas of the foot only while running. Any prior verification of the parametres in a free standing position could condition the researchers and represent a disturbing factor.

For many years there has been no clear classification of changes within the arches of the foot [21]. According to clinicians, the results of visual and biomechanical examinations are poorly correlated. In the case of a very advanced longitudinal pes planus, the final diagnosis is always based on current X-ray imaging [22, 23], which gives no information about the whole lower limb chain which is involved in the changes related to the collapse of the arch. There are no studies available that would clearly define the correlation between pes planus and the occurrence of overuse injuries within the Achilles tendon. In their study, an Australian team of researchers show a relationship between the rebound of the foot and the thickness of the peroneus muscles, the tibialis anterior, and the calcaneal tendon, based on ultrasound imaging evaluation [24]. The results of their study showed the thickening of the muscles corresponding to the motion of the foot in the transverse plane and the reduction in the size of the Achilles tendon which is responsible for the motion control in the sagittal plane in the foot with a fallen longitudinal arch. In our opinion, it is difficult to relate to the presented data because the study had been performed only under static conditions, omitting other important parameters such as the activity of the indicated muscles.

The literature that provides information about a test group, similar to the test group subjected to the present study, is also very divided. One group of scientists argues that pes planus has become our new natural state, and the adjustment of the footwear to the situation would be the only appropriate method of treatment [25–27]. The authors provide many possible solutions for the sports footwear itself (additional shock absorption for the heel, elastic front of the shoe) as well as the individual adaptation of the insoles — addition of appropriate support in the fallen areas of the longitudinal or transverse arch. According to these studies, the problem of overuse injuries occurring within the Achilles tendon is the result of poorly fitted training shoes. The second group of researchers shares our hypothesis, which assumes that collapsed arches of the foot is not a normal or natural situation. Such a condition requires exercises that would strengthen global and local stabilizers [28–30]. The results of these studies confirm that any disorders within the foot are always followed by biomechanical consequences in other parts of the lower limb. A simple change of the footwear without an individually fitted workout aimed to strengthen weak links — cannot produce lasting results.

Our study confirmed that all the joggers who were diagnosed with non-insertional tendinopathy, also suffer from transverse pes planus. The review of the available literature indicates that no work aiming to analyze this relationship has been done so far. Dynamic studies that use pedagarographic assessment clearly show differences in selected parameters in patients with different foot shape [31]. For the majority of participants, the transverse dimension of the forefoot increased during the motion, which points to inefficiencies of the short muscles of the foot, responsible for local stabilization. In order to draw clear conclusions, such results should be referenced to the control group.

Despite the best understanding of the Achilles tendon structure, problems occurring in its area require a holistic approach that would include disorders within the foot and the entire biokinematic chain. It is important to consider all factors that may limit the success of treatment, including systemic disorders or psychosocial issues [32, 33]. The aim of a physiotherapist is to restore an athlete to his or her expected activity because, as our research reports show, in spite of pain symptoms, only a few runners have limited their workouts. The scopes of physiotherapy should also include the analysis of weak links and preparation of a tailor-made workout [34]. Treatment with eccentric triceps surae exercises should not be the only one recommended and unquestioningly approved gold standard [35].

The pilot study has been conducted in order to identify all possible limitations of the target research project. One of the significant weaknesses of the presented results is that the group of participants was small. The basic assumption, however, was the selection of patients who are active joggers and who have confirmed overuse injuries within the Achilles tendon area. Over a dozen patients were rejected during the selection phase, due to an ongoing inflammatory process and pain symptoms while jog-trotting. The second limitation of the presented studies is the absence of existing standards for pes planus classification in pedagarographic assessment. For this reason, the results presented herein do not have a generally adopted benchmark.

The results of this pilot study indicate the need for further analysis. The further exploration should focus on the prevalence of functional transverse pes planus in patients who indicate no pain symptoms within the Achilles tendon area. Only such a comparison can define this relationship.

Conclusions

- All the patients diagnosed with non-insertional Achilles tendinopathy had abnormalities in the function of the arch of the foot.
- Despite their pain, the participants of the study did not cease completely their physical activity.
- The results of the study buttress the need for further analyses of the phenomenon observed.

Conflict of interest

None declared.

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