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CHARACTERISTICS OF ADULT FLATFOOT

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Abstract: *Flatfoot impact quality of life and posture. Using RSScan platform 42 FF subjects (mean age ± 58,05), showed significant contact area (CA) differences between left and right feet (Toe 1: 24%, metatarsal 5: 29%, midfoot: 9%). There is a progressive increase in the CA of both legs when comparing group 40-49 years vs group 70-80 years. In this study only CA on the right foot that shows a "decrease" is the Midfoot area (8%). At the level of the left foot, we find significant increases in* the CA. *With age, FFT exhibit increasing static foot deformation (especially in metatarsal 1-3, midfoot, heel) and CA changes.*

Key words: *flatfoot, biomechanical parameters, arthritis, bunion, elderly foot.*

1. Introduction

Flat foot (FFT) has a collapsed medial longitudinal arch, with the hindfoot in valgus and the forefoot in abduction [13], [30], caused by differences in the structure and biomechanics of the foot that lead to discomfort and gait impairment [8], [32], [33]. Age, sex and obesity have a clear effect on the stiffness and structure of the longitudinal plantar arch [35]. The pressure distribution at the plantar level is influenced by: pain, abnormal gait and walking difficulties, by the impairment of muscle tension and especially the triceps surae muscle, obesity and ligamentous laxity [23], [28], [16], [30].

The various etiologies of acquired flatfoot in adults include arthritis, neuromuscular and traumatic conditions, but tibial tendon dysfunction remains the most common [31]. FFT causes subluxation of the subtalar joint in the medial direction, presenting as forefoot abduction, talus valgus, and calcaneal eversion. An altered damping effect of the ground reaction force on the medial longitudinal arch results in stiffening of the plantar soft tissues and Achilles tendon, accompanied by increased tension in plantar fascia [12], [15].

Regarding the incidence of FFT, studies from America and India show that it is higher among young adult women (over 10.3%) than in male populations [2], [26]. Acquired FFT in adults (AFFT) is a common problem in daily practice and affects mainly middle-aged women, the prevalence is 5%-14% among the adult population [1].

The cause of FFT higher incidence in women may be the anatomy of the foot (women have shorter legs and a higher longitudinal plantar arch), the type of footwear (high-heeled shoes), hormonal changes during pregnancy (leading to relaxation of the ankle ligaments and the arch complex of the foot).

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2. Clinic Presentation

AFFT is usually asymptomatic, over time it can cause heels, calf and midfoot pain and is associated with deformity and functional loss. Treatment depends on symptoms, age and activity level [7]. In adults is a common clinical condition with a complex pathology - posterior tibial tendon insufficiency and ligamentous insufficiency and can affect the capsular structures of the foot. The association between flatfoot and reduced gait efficiency is correlated with factors such as: height, age, weight, foot progression angle and joint laxity [19], also an increased ankle stiffness and reduced ankle motion [29].

Current classification systems organize adult FFT into normal, flexible, or rigid, and separately quantify posterior tibial tendon dysfunction [20], involves 4 stages [31]:

1. No deformity (pre-existing flatfoot often present)
2. Flexible deformity:
   A. Moderate (minimal talonavicular joint abduction, talonavicular subluxation <30%)
   B. Severe (talonavicular joint abduction deformity (>30%-40% talonavicular subluxation) or subtalar impaction)
3. Fixed deformity (involving talonavicular, subtalar, and calcaneocuboid joints)
4. Hindfoot valgus
   A. Flexible ankle valgus without significant ankle arthritis
   B. Rigid ankle valgus or flexible ankle valgus with significant ankle arthritis

Regarding the evaluation of FFT, we find several studies that correlate the longitudinal arch deformity of the foot and navicular drop, indicating that during walking, plantar force, medial pressure and CA are higher in FFT compared to the normal foot [10], [16], [34].

3. Therapeutic Management

Diagnosis of flatfoot is generally made clinically, and MRI imaging is used on proportion of 46.55% [22] performed only before surgery intervention [14]

The heel raising test~~,~~ used in the studies by Alvarez and Lin for pre- and post-treatment evaluation, and the staging of disease severity was done according to the Johnson and Strom classification [14], [3] Alvarez et al. [3] included patients with AFFT stage I and II, Lin et al [18] stage II, Bek et al. [5] stage I, II, and III, and Jari et al. [14] included all four stages in their study.

In the evaluation of intervention types, we also find the foot function index used by Budiman et al, [6] which include three subscales: foot pain, disability and activity limitation and demonstrates that after 6 weeks of using orthoses, pain and disability decrease by up to 50% [5]. The prognosis of most patients with AFFT in adults is favourable with conservative treatment, and most of them may not need surgery. Recent studies in the literature regard mostly conservative management using orthoses with or without physiotherapy [3], nonsteroidal anti-inflammatory and corticosteroids drugs [22], also prevention of medial longitudinal arch deformity and plantar pressure, involves physiotherapy, orthotics and taping [4], [11], [25].

In long-term treatment, several types of orthoses: foot orthoses with correction for the arch and ankle or ankle-foot orthoses with low articulation are used to modify gait being applicated in shoes. Dual therapy: orthosis and physiotherapy for the management of flat foot has been studied, generally patients with AFFT in stage I or II are referred to physiotherapy [5], [14].

Conservative management is considered as initial treatment, with surgery being offered only when these measures fail. Surgical options are increasing, but some patients cannot undergo surgery due to comorbidities or socioeconomic concerns.

It is very important to evaluate the functional results of all treatments; there are insufficient publications.

4. Objectives. Material and Methods

This study was conducted between 10 September and 15 November 2024 and aimed to perform a comparative analysis of the biomechanical parameters of the FFT, for a group of 42 FFT subjects, aged between 42 and 82 years (± 58,05), divided into 3 experimental groups (G1 - 42-49 years (±45.64); G2 - 50-63 years (±54.79); G3 - 70-82 years (±73.93)). The objective was to identify the incidence and complexity of deformities according to age.

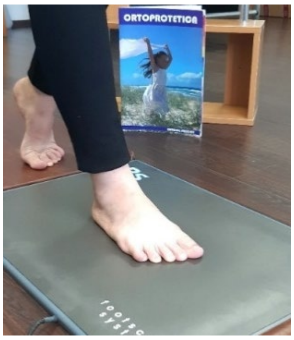


Fig. 1. *RSSCAN platform*

The evaluation of the biomechanical parameters of the flat foot was performed with the RS Scan pressure platform (Figure 1) and consisted of the evaluation in static stance (Figure 2) and dynamic gait (Figure 3), the platform providing complex data for the active contact area (CA) and of the maximum force (Fmax) for 10 areas of the foot (Figure 3) found in the following regions: medial heel, lateral heel, midfoot, toes, hallux, metatarsals.

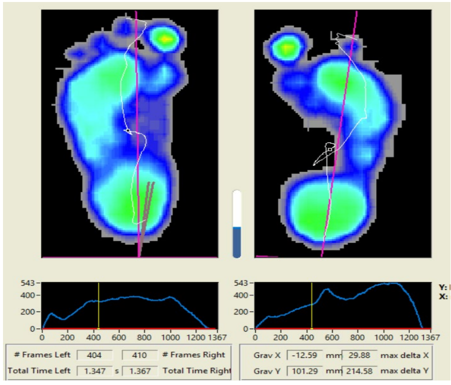


Fig. 2. *RSSCAN platform, static data*

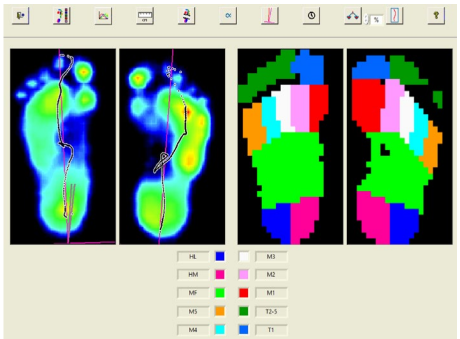


Fig. 3. *RSSCAN platform, dynamic data*

5. Results

Results show high values in all age groups for contact area (CA): midfoot, heel, metatarsal 1-5. An increase in contact surfaces can be observed on both the left and right foot (Figures 4 and 5) from the young group G1 to the old group G3, especially in the area: Midfoot and toe (metatarsals 1, 5 and toes 2-5).

The analysis of contact areas (CA) left foot, between age groups is presented below (Fig.6), thus between G2 and G1 we observe that G2 compared to Gr1 has an increase in the areas: Midfoot (9%) Meta 1 (4%) Meta 2 (1%) and a decrease in the areas Toe 2-5 (31%) Toe 1 (9%) Meta 5 (5%) Meta 4 (2%) Heel Med (2%) Heel Lateral (3%). G3 vs G2: G3 shows increases in CA compared to G2 in the areas Midfoot (3%) Meta 4(4%) Meta 3 (2%) Meta 2 (4%) Meta 1 (6%).

Areas with G3 decrease compared to G2 we have: Heel Medial (3%) Heel Lateral (3%) Toe 2-5 (12%). G2 vs G4: Gr4 shows an increase compared to G2 in the Midfoot areas (12%) Meta 1 (10%) Meta 2 (5%) Meta 3,4 (2%) and a decrease compared to G2 in the areas: Heel Medial (5%) Heel Lateral (6%) Meta 5(6%) Toe 2-5(40%) Toe 1 (6%).

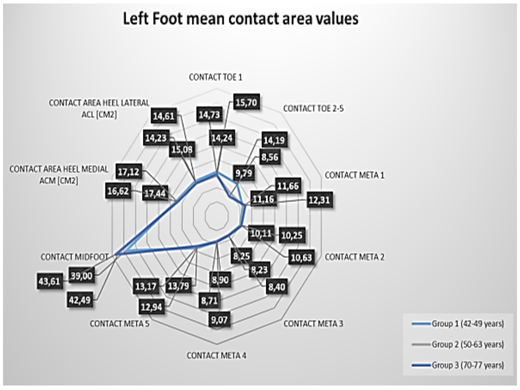


Fig. 4. *Left foot mean contact area*

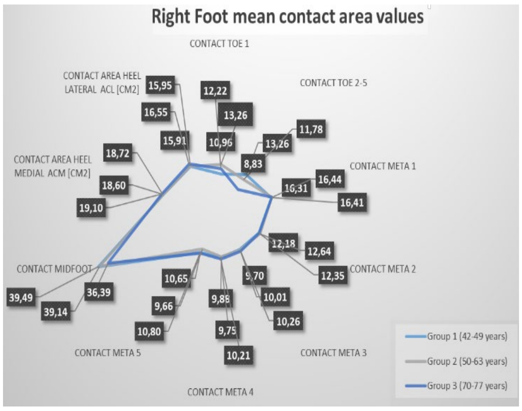


Fig.5. *Right foot means contact area*

The analysis of contact surfaces (CA) right foot, between age groups is presented below (Figure 7), thus between G2 and G1 we observe that G2 has an increase in the areas: Toe1(21%), Meta 2 (4%), Meta 3 (3%) Heel Medial (1%) and a decrease compared to G1 in the areas Meta 5(9%) Midfoot (1%) Toe 2-5 (11%). Between G3 and G2, G3 shows an increase compared to G2 in the areas: Meta1(7%) Meta 2 (4%) Meta 4 (3%) Meta 5 (16%) Midfoot (11%), a decrease in contact surfaces is found in the area Toe 1(22%) Toe 2-5 (29%).

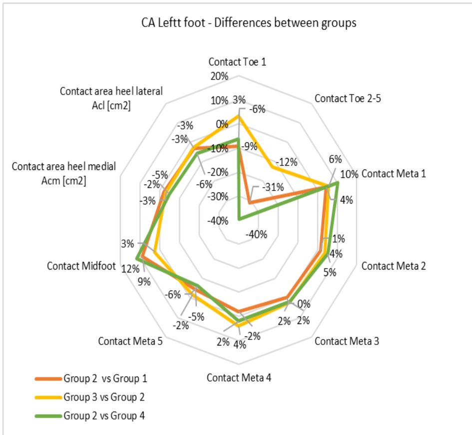


Fig. 6. *CA Left foot differences between groups*

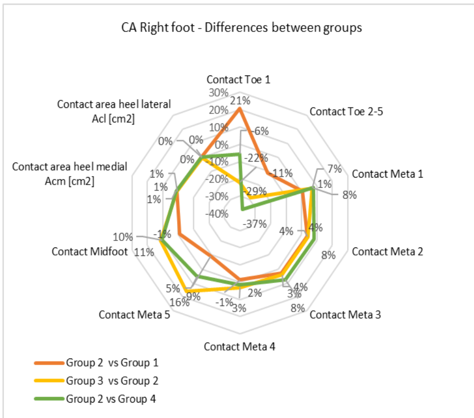
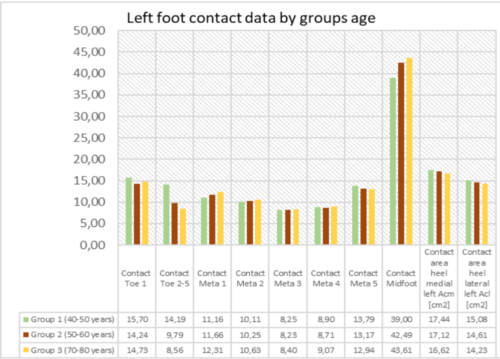


Fig. 7. *CA Right foot differences between groups*

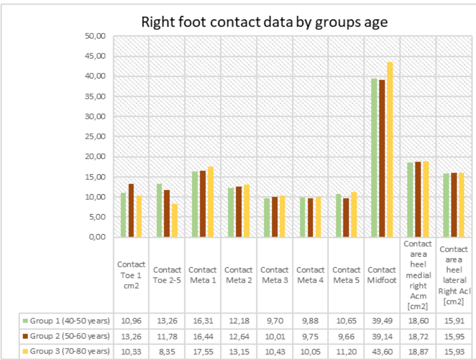
Between G4 and G2, G4 shows a decrease in contact surfaces in the areas: Toe 1 (22%) and Toe 2-5(29%) and an increase in the areas: Midfoot (10%) Meta 5 (5%) Meta 1, 2, 3 (8%). The analysis of contact surfaces by age group for the left and right foot is found below. Left foot (Figure 8): the areas with the largest contact surface for all age groups are: Midfoot, Heel Medial, Meta 5 and Toe 1.



	Contact Toe 1	Contact Toe 2-5	Contact Meta 1	Contact Meta 2	Contact Meta 3	Contact Meta 4	Contact Meta 5	Contact Midfoot	Contact area heel medial left Acm [cm2]	Contact area heel lateral left Acl [cm2]
Group 1 (40-50 years)	15,70	14,19	11,16	10,11	8,25	8,90	13,79	39,00	17,44	15,08
Group 2 (50-60 years)	14,24	9,79	11,66	10,25	8,23	8,71	13,17	42,49	17,12	14,61
Group 3 (70-80 years)	14,73	8,56	12,31	10,63	8,40	9,07	12,94	43,61	16,62	14,23

Fig. 8. *Left foot contact data by groups age*

We observe a progressive increase in contact surfaces from the G1 group (40-50 years) to the G3 age group (70-80 years) for the areas: Midfoot, Meta 4 and 1. We observe a progressive decrease from G1 to G3 for the areas: Heel lateral, Meta5, Toe 1-5, the area that will take over this pressure difference is the Midfoot area, the area loaded anyway for all age groups.



	Contact Toe 1 cm2	Contact Toe 2-5	Contact Meta 1	Contact Meta 2	Contact Meta 3	Contact Meta 4	Contact Meta 5	Contact Midfoot	Contact area heel medial right Acm [cm2]	Contact area heel lateral Right Acl [cm2]
Group 1 (40-50 years)	10,96	13,26	16,31	12,18	9,70	9,88	10,65	39,49	18,60	15,91
Group 2 (50-60 years)	13,26	11,78	16,44	12,64	10,01	9,75	9,66	39,14	18,72	15,95
Group 3 (70-80 years)	10,33	8,35	17,55	13,15	10,43	10,05	11,20	43,60	18,87	15,93

Fig. 9. *Right foot contact data by groups age*

In the Right foot (Figure 9) the areas with the largest contact surface for all age groups are: Midfoot, Heel medial, Meta 1, 2. A progressive decrease from G1 to the G3 age group is observed only for the Toe 2-5 areas. It should be noted that in both the Right foot and the Left foot the Meta2-4 area increases progressively from the younger G1 group to the older G3 group.

4. Discussions

FFT is a common clinical condition that can progress to more severe stages requiring extensive treatment in adults. An early diagnosis for some patients will be helpful in avoiding surgery, but there are no tests to predict the onset or nature, or symptoms develop. The gait kinematics of adults with FFT have been investigated in numerous studies, with significant differences found in lower limb segments by age and sex [21], [27]. The results of our study are in according with the results of different authors [3], correlations are demonstrated between increasing age and a decrease in height of the longitudinal plantar arch, this can be considered a normal aging change [24], [9], [17]. Studies measuring the dynamic function of the foot by assessing plantar pressure during walking have shown a large medial displacement of the center of pressure for the elderly [32], [33], [8], this aspect is also in according with our results about the importance of a complete evaluation and monitoring the evolution of flat foot for development the prevention program [14], [3], [18]. There is a gradual decrease in the medial longitudinal arch starting at age 40, evidenced by an increase in the contact surface of the medial foot when walking. The cause of the medial longitudinal arch decrease is insufficiently known, it is correlated with posterior tibialis muscle dysfunction [19], and the existence of a degenerative process of gradual weakening, elongation and rupture of the posterior tibialis muscle tendon, all of which are common causes in the acquisition of flat foot in the elderly.

5. Conclusions

The results demonstrate that in the case of a flat foot, the complex assessment, monitoring its evolution associated with early therapeutic intervention, complex, personalized allows prevention of the development of associated pathologies and segmental deformities given by vicious static of the flat foot. The analysis of the results indicates a progressive static deformation of the foot, particularly in the metatarsal area 1, 2, 5, midfoot area and medial and lateral heel area (in the case of the heel, the total contact surface increases progressively from the young age group to the elderly). In adult flat foot, it is recommended a permanent management of this pathology, the use of corrective orthoses and kinetotherapy as essential elements in the treatment scheme.

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All authors made equal contributions.

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