Functional Evaluation and Pain Symptomatology of the Foot and Ankle in Individuals with Severe Obesity - Controlled Transversal Study*

Avaliação funcional e de sintomatologia dolorosa do pé e tornozelo em indivíduos com obesidade grave – Estudo controlado transversal

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Abstract

Objective The present study aims to evaluate the prevalence of foot and ankle pain complaints, radiographic parameters, and functional performance in subjects with severe obesity (body mass index [BMI] > 40) who are candidates to bariatric surgery.
Methods Forty severely obese patients were evaluated at a bariatric surgery outpatient facility. These severely obese subjects (BMI > 40) were divided into two subgroups: those with BMI < 50 (n = 24) and BMI > 50 (n = 16). These patients were compared with a control group of 42 volunteers with a mean BMI value of 24. The following parameters were assessed: foot pain (according to the visual analog scale [VAS]), functional performance (according to the American Orthopeadic Foot and Ankle Society [AOFAS] scale, including forefoot, midfoot and hindfoot domains), age, gender, hallux metatarsal-phalangeal angle, hallux intermetatarsal angle, talocalcaneal angle, calcanean pitch angle and Meary angle.
Results Incidence of foot pain was higher in the severely obese group compared with the control group ($p < 0.0001$; odds ratio [OR]: 4.2). Functional performance according

Keywords
► foot
► obesity
► pain
► AOFAS scale

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to the AOFAS scale was lower in obese subjects compared with the control group ($p < 0.0001$; OR for hindfoot, 4.81; OR for midfoot, 3.33).

Conclusion The incidence of foot pain was higher in the group of severely obese patients compared with the control group. According to the AOFAS scale, functional forefoot, midfoot and hindfoot performance was worse in severely obese individuals.

Resumo

Objetivo Avaliar a prevalência de queixas álgicas no pé e tornozelo, parâmetros radiográficos e o desempenho funcional de indivíduos com obesidade grave, Índice de Massa Corpórea (IMC) com valor > 40 e indicação de cirurgia bariátrica.

Métodos Foram avaliados 40 pacientes com obesidade grave acompanhados em ambulatório de cirurgia bariátrica. Este grupo de obesos graves (IMC > 40) foi subdividido em dois subgrupos: obesos com IMC < 50 (n = 24); e outro de obesos com IMC > 50 (n = 16). Foi realizada comparação com grupo controle de 42 indivíduo voluntários com IMC médio de 24. Foram avaliados a presença de dor no pé pela escala visual (EVA), o desempenho funcional pela escala da Associação Americana de Cirurgia do Pé e Tornozelo (AOFAS, na sigla em inglês) (domínios antepé, mediopé e retropé), idade, gênero, ângulo (âng) metatarso-falangeano do hálux, âng intermetatarsal do hálux , âng talocalcaneano, "pitch" calcaneano e âng de Meary.

Resultados Foi observada maior incidência de dor no pé no grupo de obesos graves em relação ao controle ($p < 0{,}0001$, razão de chances [*odds ratio,* OR]: 4,2). O desempenho funcional pela escala AOFAS foi inferior no grupo de obesos em relação ao controle ($p < 0{,}0001$, retropé com OR = 4,81; mediopé com OR = 3,33).

Conclusão Houve maior incidência de dor no pé no grupo de obesos graves em relação ao controle. Houve pior desempenho funcional pela escala AOFAS nas regiões do antepé, mediopé e retropé no grupo de obesos graves.

Palavras-chave
- pé
- obesidade
- dor
- escala AOFAS

Introduction

Today, obesity is one of the most challenging public health problems in modern society. It is estimated that there are currently over one billion overweight people in the world, with 300 million obese people.[1] This condition affects not only developed countries, but also developing countries, where carbohydrates ingestion is widespread due to their low cost.[2]

Population studies have shown that obesity is an independent risk factor for knee pain and arthrosis.[3–5]

In obese patients, feet pain incidence has been less studied in the literature than obesity-related knee pain.[3–5]

Obesity results in feet pain and biomechanical changes secondary to flat foot deformity, plantar fat alterations, decreased muscle strength and gait pattern abnormalities.[6] This process leads to loss of balance and risk of falling, interfering with the mobility of these individuals.[6,7]

Currently, there is a new strand of studies due to the discovery of visceral fat-generate proteins, the so-called adipokines. The best known adipokine is leptin, which plays a role in insulin action and inflammatory cytokines production by chondrocytes.[8] Recent studies have shown a higher incidence of knee pain and osteoarthritis related to high levels of serum adipokines and metabolic syndrome.[9]

The literature on pain incidence, functional performance level and foot and ankle radiographic alignment parameters in severely obese individuals, with a body mass index (BMI) > 40, is scarce. A compilation of these data is required to properly ascertain the importance of this problem. Clinical and imaging parameters that may indicate the need for early intervention are essential to formulate therapeutic and preventive strategies for this growing group of economically active people.

The main objective of the present study is to evaluate the prevalence of pain, determined by a visual analog scale (VAS), in a sample of severely obese individuals (BMI > 40) and compare it to a control group consisting of people with a mean BMI of 24. The secondary objectives are the determination of functional differences according to the American Orthopaedic Foot and Ankle Society (AOFAS) scale[10] and radiographic parameters for morphological evaluation of the foot in both groups. Our initial hypothesis is that a higher prevalence of pain and a lower functional performance are expected in people with severe obesity compared with the control group.

Methodology

The present study complies with the Declaration of Helsinki rules and it was approved by the hospital's Research Ethics Committee (CAAE 69073215.2.0000.5646, opinion 2.127.775). All participants (both from the obese and control groups) signed an informed consent form.

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Table 1 Study group (obese patients)

	GENDER	AGE (years)	WEIGHT (kg)	CLASSIFICATION	HEIGHT (m)	BMI	VAS	SIDE	H	M	F	AMF	AIM°	APC°	ATC
1	Female	61	92	PATIENT	1.5	40.9	9	LEFT	47	79	93	normal	normal	NORMAL	FLAT
2	Female	42	110	PATIENT	1.64	40.9	9	RIGHT	49	60	95	mild	normal	NORMAL	NORMAL
3	Female	64	105	PATIENT	1.6	41	8	RIGHT	28	52	100	normal	normal	NORMAL	FLAT
4	Female	45	108	PATIENT	1.62	41.2	10	LEFT	65	53	74	normal	mild	NORMAL	NORMAL
5	Female	32	99	PATIENT	1.55	41.6	8	RIGHT	50	65	93	normal	moderate	FLAT	NORMAL
6	Male	27	158	PATIENT	1.95	41.6	8	LEFT	85	82	85	normal	normal	NORMAL	NORMAL
7	Female	47	97.5	PATIENT	1.52	42.2	7	RIGHT	67	64	95	normal	normal	NORMAL	NORMAL
8	Male	47	123	PATIENT	1.7	42.6	0	LEFT	80	85	85	normal	normal	NORMAL	NORMAL
9	Male	62	108	PATIENT	1.59	42.7	8	RIGHT	72	76	93	normal	moderate	NORMAL	NORMAL
10	Male	25	143	PATIENT	1.83	42.7	10	RIGHT	67	100	100	moderate	moderate	NORMAL	NORMAL
11	Male	30	128	PATIENT	1.73	42.77	7	RIGHT	82	100	73	normal	mild	NORMAL	NORMAL
12	Male	40	150	PATIENT	1.87	42.9	6	RIGHT	79	85	82	normal	normal	NORMAL	FLAT
13	Female	58	136	PATIENT	1.77	43.4	9	RIGHT	30	32	83	moderate	severe	NORMAL	NORMAL
14	Female	53	102	PATIENT	1.52	44.15	5	RIGHT	67	100	100	moderate	moderate	NORMAL	NORMAL
15	Female	19	109	PATIENT	1.57	44.2	8	RIGHT	67	49	100	moderate	mild	NORMAL	NORMAL
16	Female	38	122	PATIENT	1.66	44.3	9	LEFT	80	82	93	normal	mild	FLAT	NORMAL
17	Female	49	103	PATIENT	1.52	44.58	8	RIGHT	71	56	100	normal	normal	NORMAL	NORMAL
18	Female	47	124	PATIENT	1.65	45.5	7	RIGHT	72	60	77	normal	moderate	NORMAL	CAVUS
19	Female	53	97	PATIENT	152	45.8	0	RIGHT	88	89	90	normal	mild	NORMAL	NORMAL
20	Female	43	126	PATIENT	1.65	46.3	8	RIGHT	68	45	90	normal	normal	NORMAL	CAVUS
21	Female	63	116	PATIENT	1.58	46.5	7	RIGHT	52	87	100	normal	mild	CAVUS	NORMAL
22	Male	50	142	PATIENT	1.72	48	6	RIGHT	60	100	78	moderate	moderate	NORMAL	NORMAL
23	Female	63	115	PATIENT	1.55	48.87	8	LEFT	82	100	73	moderate	mild	FLAT	NORMAL
24	Female	33	140	PATIENT	1.68	49.6	5	RIGHT	67	89	70	mild	moderate	NORMAL	NORMAL
25	Female	52	130	PATIENT	1.61	50.2	3	LEFT	78	75	100	moderate	mild	NORMAL	NORMAL
26	Male	61	146	PATIENT	1.69	51.12	10	LEFT	57	100	57	mild	mild	NORMAL	FLAT
27	Female	45	120	PATIENT	1.53	51.26	3	RIGHT	73	62	100	moderate	moderate	NORMAL	NORMAL
28	Female	41	140	PATIENT	1.65	51.42	8	RIGHT	93	53	100	moderate	mild	NORMAL	NORMAL
29	Female	44	120	PATIENT	1.52	51.94	5	LEFT	84	82	100	mild	mild	FLAT	NORMAL
30	Female	55	116	PATIENT	1.48	52.16	8	LEFT	51	100	100	mild	moderate	NORMAL	NORMAL
31	Female	42	113	PATIENT	1.47	52.29	6	RIGHT	50	45	72	normal	normal	NORMAL	CAVUS
32	Female	36	123	PATIENT	1.53	52.59	5	LEFT	58	100	100	moderate	moderate	NORMAL	NORMAL
33	Female	27	135	PATIENT	1.58	54.08	7	RIGHT	41	61	100	normal	normal	NORMAL	NORMAL
34	Female	37	145	PATIENT	1.62	55.25	7	LEFT	64	100	100	mild	mild	NORMAL	NORMAL
35	Female	51	133	PATIENT	1.55	55.4	10	LEFT	29	39	90	normal	normal	NORMAL	NORMAL
36	Female	40	132	PATIENT	1.54	55.66	8	RIGHT	81	100	83	moderate	moderate	NORMAL	NORMAL
37	Male	40	165	PATIENT	1.72	55.77	5	LEFT	69	100	70	moderate	mild	NORMAL	NORMAL
38	Female	36	162	PATIENT	1.65	59.5	7	LEFT	88	73	95	normal	mild	NORMAL	NORMAL
39	Female	37	153	PATIENT	1.58	61.29	5	RIGHT	55	64	100	normal	normal	NORMAL	NORMAL
40	Male	59	181	PATIENT	1.79	71.6	7	RIGHT	89	100	100	normal	severe	NORMAL	NORMAL

Abbreviations: AIM, hallux intermetatarsal angle; AMF, hallux metatarsal-phalangeal angle; APC, calcanean pitch angle; ATC, talocalcaneal angle; BMI, Body mass index; H, M, F, hindfoot, midfoot, forefoot (respectively) functional performance according to the American Orthopeadic Foot and Ankle Society scale; VAS, visual analogue scale.

This was an observational, cross-sectional study. Data for the present research were collected by orthopedics residents from our service from June 2017 to April 2018.

Forty patients (►**Table 1**) from the bariatric surgery outpatient facility at our hospital were included. The sample consisted of 10 men and 30 women, with an average age of 45.45 years old (range, 25 to 63 years old).

The control group (►**Table 2**) consisted of volunteers (employees, resident physicians, and patients from the general, non-bariatric surgery outpatient facility) from matched gender and age for comparison with the obese group. The control group consisted of 42 people, including 12 men and 30 women, with an average age of 43.9 years old (range, 24 to 61 years old).

The inclusion criteria for the obese group were adult patients with BMI > 40 who were candidates for bariatric surgery and consented to participate in the study. The exclusion criteria were previous performance of surgical

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Table 2 Control group

	GENDER	AGE	WEIGHT (kg)	CLASSIFICATION	HEIGHT (m)	BMI	VAS	SIDE	H	M	F	AMF	AIM	APC	ATC	AM
1	Female	61	80	CONTROL	1.62	30.48	3	LEFT	49	66	100	normal	normal	CAVUS	NORMAL	CAVUS
2	Female	58	61	CONTROL	1.54	25.72	3	LEFT	41	58	100	moderate	mild	NORMAL	NORMAL	NORMAL
3	Female	45	62	CONTROL	1.54	26.14	0	RIGHT	100	100	100	normal	mild	NORMAL	NORMAL	NORMAL
4	Female	44	65	CONTROL	1.68	23.03	0	RIGHT	58	58	100	normal	moderate	FLAT	NORMAL	FLAT
5	Female	38	74	CONTROL	1.74	22.4	0	LEFT	60	90	90	normal	normal	NORMAL	NORMAL	NORMAL
6	Female	54	89	CONTROL	1.7	30.45	3	RIGHT	41	56	100	normal	moderate	FLAT	NORMAL	FLAT
7	Female	27	57	CONTROL	1.71	19.15	0	RIGHT	100	100	100	normal	normal	NORMAL	NORMAL	NORMAL
8	Female	38	59	CONTROL	1.63	22.21	5	LEFT	100	100	100	moderate	mild	NORMAL	NORMAL	NORMAL
9	Female	60	62	CONTROL	1.59	24.52	0	RIGHT	57	53	100	mild	mild	NORMAL	NORMAL	NORMAL
10	Female	35	69	CONTROL	1.71	23.6	0	RIGHT	100	100	100	mild	mild	NORMAL	NORMAL	NORMAL
11	Female	37	72	CONTROL	1.73	24.06	6	LEFT	100	100	100	mild	mild	FLAT	NORMAL	FLAT
12	Female	53	69	CONTROL	1.62	26.29	7	RIGHT	58	66	100	moderate	moderate	FLAT	NORMAL	FLAT
13	Female	41	72	CONTROL	1.7	24.91	4	LEFT	100	100	100	mild	mild	NORMAL	NORMAL	NORMAL
14	Female	20	54	CONTROL	1.59	21.36	0	RIGHT	100	100	100	normal	normal	NORMAL	NORMAL	NORMAL
15	Male	42	87	CONTROL	1.81	26.56	0	RIGHT	100	100	100	normal	normal	NORMAL	NORMAL	NORMAL
16	Male	30	70	CONTROL	1.71	23.66	0	RIGHT	100	100	100	moderate	moderate	NORMAL	NORMAL	NORMAL
17	Male	47	74	CONTROL	1.73	25.01	4	LEFT	100	100	100	normal	mild	NORMAL	NORMAL	NORMAL
18	Male	24	76	CONTROL	1.74	25.1	0	RIGHT	100	100	100	moderate	normal	NORMAL	NORMAL	NORMAL
19	Male	27	78	CONTROL	1.7	26.99	0	RIGHT	100	100	100	normal	normal	NORMAL	NORMAL	NORMAL
20	Male	35	76	CONTROL	1.69	26.61	6	LEFT	100	100	100	moderate	mild	NORMAL	NORMAL	NORMAL
21	Male	61	76	CONTROL	1.72	25.69	0	RIGHT	53	49	100	normal	normal	NORMAL	NORMAL	NORMAL
22	Male	56	92	CONTROL	1.79	28.71	3	RIGHT	100	100	100	mild	mild	NORMAL	NORMAL	NORMAL
23	Female	25	50	CONTROL	1.65	18.4	0	LEFT	100	100	100	normal	mild	NORMAL	NORMAL	NORMAL
24	Female	56	52	CONTROL	1.6	20.3	0	RIGHT	100	100	100	normal	normal	NORMAL	NORMAL	CAVUS
25	Female	35	55	CONTROL	1.53	23.5	0	RIGHT	100	100	75	moderate	normal	NORMAL	NORMAL	NORMAL
26	Female	50	57	CONTROL	1.6	22.3	3	RIGHT	100	90	100	normal	normal	NORMAL	NORMAL	CAVUS
27	Female	33	65	CONTROL	1.68	23	1	RIGHT	100	100	92	normal	mild	NORMAL	NORMAL	NORMAL
28	Male	34	79	CONTROL	1.81	24	0	RIGHT	100	100	100	normal	mild	NORMAL	NORMAL	CAVUS
29	Female	60	60	CONTROL	1.54	25.3	2	LEFT	88	100	100	normal	mild	NORMAL	NORMAL	NORMAL
30	Female	47	575	CONTROL	1.67	20.4	0	RIGHT	100	100	100	normal	normal	NORMAL	NORMAL	NORMAL
31	Female	61	57	CONTROL	1.53	24.3	0	RIGHT	100	100	100	normal	normal	NORMAL	NORMAL	NORMAL
32	Female	51	54	CONTROL	1.55	22.5	0	LEFT	100	100	100	normal	normal	CAVUS	NORMAL	CAVUS
33	Male	58	73	CONTROL	1.7	25.3	0	RIGHT	100	100	100	normal	normal	NORMAL	NORMAL	NORMAL
34	Male	52	83	CONTROL	1.8	25	0	LEFT	100	100	100	normal	normal	NORMAL	NORMAL	CAVUS
35	Female	40	62	CONTROL	1.71	21.2	0	LEFT	100	100	100	normal	mild	NORMAL	NORMAL	NORMAL
36	Female	42	58	CONTROL	1.55	24.1	5	LEFT	90	100	100	normal	normal	NORMAL	NORMAL	NORMAL
37	Female	53	60	CONTROL	1.57	24.3	2	RIGHT	87	92	92	moderate	moderate	NORMAL	FLAT	NORMAL
38	Female	60	49	CONTROL	1.55	20.4	6	LEFT	64	95	100	normal	normal	NORMAL	NORMAL	NORMAL
39	Male	27	82	CONTROL	1.79	25.2	0	RIGHT	100	100	100	normal	moderate	NORMAL	NORMAL	NORMAL
40	Female	43	54	CONTROL	1.53	23.1	0	LEFT	85	85	75	normal	moderate	NORMAL	NORMAL	NORMAL
41	Female	48	63	CONTROL	1.59	24.9	0	LEFT	75	72	75	moderate	severe	NORMAL	NORMAL	NORMAL
42	Female	35	75	CONTROL	1.75	24.5	0	LEFT	100	100	100	normal	mild	NORMAL	NORMAL	NORMAL

Abbreviations: AIM, hallux intermetatarsal angle; AM, Meary Angle; AMF, hallux metatarsal-phalangeal angle; APC, calcanean pitch angle; ATC, talocalcaneal angle; BMI, Body mass index; H, M, F, hindfoot, midfoot, forefoot (respectively) functional performance according to the American Orthopeadic Foot and Ankle Society scale; VAS, visual analogue scale.

procedures (orthopedic, vascular, dermatological, or plastic surgery) in any segment of the lower limbs (hip, knee, ankle, and foot). Individuals with sequelae from lower limb fractures or conditions with surgical indication, whether orthopedic (hip or knee arthrosis, ankle or foot arthrosis) or vascular (arterial or venous insufficiency, ulcers, digital or skin necrosis) were excluded from the research.

Weight and height were measured at the Bariatric Surgery Outpatient Facility. The BMI was calculated by dividing the weight in kilograms (kg) by the square of the height in meters. For classification purposes, a BMI < 20 is considered underweight, whereas values from 20 to 24.9 are normal, and between 25 and 29.9 indicate overweight; BMIs > 30, 40 and 50, respectively, represent obesity, morbid obesity, and superobesity.[7]

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Anteroposterior (AP) and lateral radiographs from both feet from obese and control subjects were taken under load.

The following radiological parameters were measured:

1) hallux metatarsal-phalangeal angle (AMF) measured in AP radiographs: normal, < 15°; mild, 15 to 19°; moderate, 20 to 39°; severe, > 40°;
2) intermetatarsal angle (AIM) measured in AP radiographs: normal, < 9; mild, 9-11; moderate, 12-15; severe, > 16;
3) talocalcaneal angle (ATC) measured in AP radiographs: cavus foot, < 20°; normal, 20 to 30°; flat foot, > 40°;
4) Calcaneal pitch angle (APC) measured in lateral radiographs: flat foot, < 10; normal, 10-30; cavus foot, > 30;
5) Meary angle (AM) or talus-first metatarsal bone angle measured in lateral radiographs. A normal value would be zero. A plantar deviation > 10° indicates a cavus foot, whereas a dorsal deviation > 10° indicates a flat foot.

The AMF and the AIM assess and grade hallux valgus deformity. The ATC, APC and AM assess whether feet are normal or present deformities such as flat or cavus feet.

Pain in daily living activities (walking, going up and down stairs, rest) was assessed in a simple way by the VAS, with values ranging from 0 (no pain) to 10 (most severe pain possible). For a more objective assessment, a score from 1 to 3 was classified as mild pain, from 4 to 6, moderate pain, and from 7 to 10, severe pain. Values > 3 were noted as significant for odds ratio (OR).

The AOFAS scale[10] was used for functional evaluation of the feet. This classification addresses pain, function, use of shoes, distance covered, poor foot alignment and gait pattern. It analyzes the forefoot (hallux and small toes), midfoot and hindfoot/ankle as separate domains. The scale has decreasing values from 100 to zero for each domain (values < 70 are deemed unsatisfactory).

The following parameters from the study and control groups were statistically correlated: VAS, AOFAS scale (forefoot [F], midfoot [M] and hindfoot [H]), AMF, AM, ATC, APC and AIM. The relationship between the VAS and age and the VAS and gender was also assessed.

Visual analogue scale and BMI values were correlated.

Obese subjects were divided in two subgroups: patients with morbid obesity, with a BMI between 40 and 50, and those with superobesity, with a BMI > 50. These subgroups consisted of 24 and 16 subjects, respectively. Visual analogue scale and AOFAS scale parameters were evaluated comparatively between these two subgroups.

Data analysis was performed focusing on the most symptomatic limb (most responsible for VAS score). This methodology aims to avoid compromising the statistical analysis if both limbs (feet) are evaluated as separate statistical units, as previously described by Menz.[11]

Statistical Analysis

The G2 Wilks test was used to assess pain (VAS) in control and obese groups and between obese subgroups; in addition, it was used to determine the relationship between VAS score and gender and VAS score and age. This test was also used to analyze radiographic angles (AMF, AIM, APC, AM and ATC). The Mann-Whitney test was used to analyze AOFAS scale scores. A Pearson correlation matrix was used to ascertain the correlation between VAS and BMI scores. Significance was determined at $p < 0.05$.

Results

Foot pain was reported by 38 out of 40 (95%) obese patients and by 16 out of 42 (38%) control subjects (►**Figure 1**).

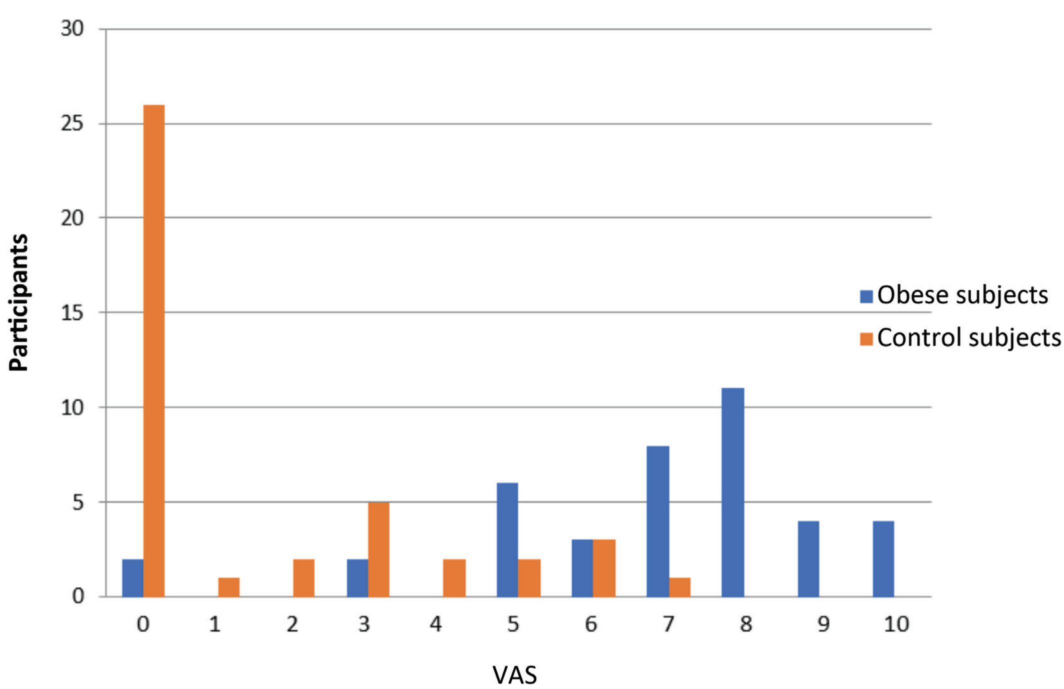

Fig. 1 Two-dimensional representation of visual analog scale (VAS) for pain in obese (*blue*) and control (*red*) subjects.

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Table 3 Correlations in obese and control groups

PARAMETER	OBESE GROUP	CONTROL GROUP	STATISTICAL ANALYSIS
Gender	Male. 25%; Female. 75%	Male. 28.5%; Female. 71.5%	$p = 0.539$
Age	44.85	43.8 (Mean value)	$p = 0.3554$
VAS	95% with pain	40% with pain	$p = 0.0001$
AOFAS H (mean value)	65.87	88.23	$p < 0.0001$
AOFAS M (mean value)	76.1	91.19	$p < 0.0001$
AOFAS F (mean value)	89.59	97.59	$p < 0.0001$
APC	N = 87.5%	N = 85.71%	$p = 0.8585$
	C = 2.5%	C = 4.70%	
	F = 10%	F = 9.52%	
ATC	N = 82.5%	N = 97.6%	$p = 0.031$
	C = 7.5%	C = 0%	
	F = 10%	F = 2.6%	
AM	N = 67.5%	N = 76.2%	$p = 0.743$
	C = 12.5%	C = 14.3%	
	F = 17.5%	F = 9.5%	
AMF	N = 45%	N = 66.6%	$p = 0.743$
AIM	N = 30%	N = 42.85%	$p = 0.54$
Gender x VAS	———————————	———————————	$p = 0.33$ for obese subjects
			$p = 0.6417$ for control subjects
BMI X VAS	———————————	———————————	$p = 0.1407$ for obese subjects
			$p = 0.2343$ for control subjects

Abbreviations: AIM, hallux intermetatarsal angle; AMF, hallux metatarsal-phalangeal angle; APC, calcanean pitch angle; ATC, talocalcaneal angle; BMI, Body mass index; C, cavus; F, flat; H, M, F, hindfoot, midfoot, forefoot (respectively) functional performance according to the American Orthopeadic Foot and Ankle Society scale; N, normal; *p*, p-value, VAS, visual analogue scale.

Among obese patients, there were 19 (47.5%) cases of severe pain, 17 (42.5%) cases of moderate pain, 2 (5%) cases of mild pain, and 2 (5%) subjects referred no pain. In the control group, there were 8 (19.05%) cases of moderate pain, 8 (19.05%) cases of mild pain and 26 (61.90%) subjects referred no pain.

There was no difference between the obese and control groups regarding age and gender, as shown by *t*-student tests ($p = 0.3554$) and difference in proportion test ($p = 0.539$), respectively (►**Table 3**).

The referred pain scale (VAS) showed a higher prevalence of feet pain in the obese group compared with the control group according to the G2-Wilks test ($p = 0.0001$), with an OR value of 4.2.

The AOFAS scale in its three domains, that is, forefoot, midfoot and hindfoot, showed a lower functional performance in the obese group compared with control subjects according to the Mann-Whitney test ($p < 0.0001$) (►**Figure 2**). Odds ratios for hindfoot and midfoot were 4.810 and 3.33, respectively. The OR value for the forefoot could not be determined because no control subject presented a value < 70.

Pain, as assessed by the VAS, was not related to BMI in the obese or control groups, as shown by Pearson tests ($p = -0.1407$ and $p = 0.2343$, respectively.)

The ATC values were higher in the obese group, configuring a higher prevalence of flat feet, as shown by the G2 Wilks test ($p = 0.0317$).

There were no statistical differences between the obese and control groups regarding the remaining evaluated parameters (►**Table 3**).

Comparison between morbidly obese and supermorbidly obese subjects did not show statistical differences regarding the evaluated parameters (►**Table 4**).

Discussion

The present case series agrees with other studies from the literature[2,11] that show an increased prevalence of foot pain in obese individuals in relation to the general population. In this study, there was 95% pain in the obese group and 40% in the control group. Melo et al.[12] described similar data, with 85% pain in lower limbs from morbidly obese patients undergoing reduction gastroplasty. In the general

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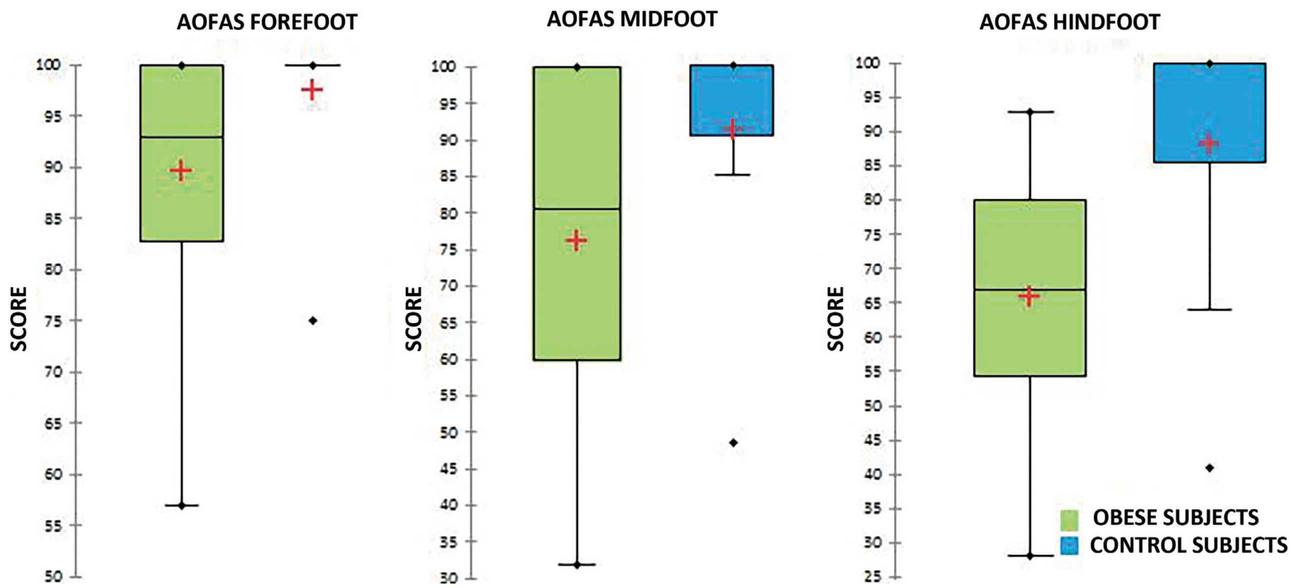

Fig. 2 Box plot graphs showing the American Orthopeadic Foot and Ankle Society (AOFAS) score for forefoot, midfoot and hindfoot domains in obese (*left*) and control (*right*) subjects.

Table 4 Correlations in subgroups with body mass index below or above 50

PARAMETER	OBESE BMI < 50	OBESE BMI > 50	STATISTICAL ANALYSIS
VAS	91.6	100%	$p = 0.075$
	Severe pain = 58%	Severe pain = 31.2%	
AOFAS Hindfoot domain	65.62	66.25	$p = 0.428$
AOFAS Midfoot domain	74.58	78.37	$p = 0.264$

Abbreviations: AOFAS, American Orthopeadic Foot and Ankle Society; BMI, body mass index; *p*, p-value; VAS, visual analogue scale.

population, these rates range from 14% in adolescents to 42% in people > 65 years old.[11] Our study revealed that a severely obese patient (BMI > 40) presents an OR of 4.2 for significant foot pain compared to a control group of people with a mean BMI of 24. In a meta-analysis, Butterworh et al.[2] described an OR of 3.1 for feet pain in obese patients compared with people with a BMI < 25.

All three domains from the AOFAS functional scale[10] were more altered in obese patients than in control subjects. This finding agrees with the higher report of calcaneal posterior pain by obese people,[2] as well as with the greater mechanical overload in the midfoot that result in local pain.[6,13] Compared to the control group, OR values corresponding to the hindfoot and midfoot from severely obese individuals (BMI > 40) of 4.81 and 3.33, respectively, ratify the higher incidence of poor functional performance for daily activities, quality of life and movement.

Even though the interplay between increased body weight and BMI and lower limb pain initially seems to result from biomechanical factors determined by increased load alone, new evidence relates joint pain to systemic metabolic syndrome.[2,14–16]

Visceral adipose tissue, as well as the truncal light fatty tissue, constitute true endocrine organs that secrete cytokines, interleukins, adipokines and leptins.[17] Leptin is reportedly related to pro-inflammatory effects and the destruction of chondrocytes.[14]

Our study showed no statistical relationship between referred pain (VAS) and BMI when comparing obese subjects. Other authors[2,11] reported that BMI would not be independently associated with foot pain. Butterworth et al.[2] emphasized that a high fat mass would be especially related to foot pain. Body mass alone would not be an independent factor for pain.[2,12] These observations suggest the presence of systemic, not just biomechanical, factors determining the onset of foot pain in obese individuals.

Case series[18,19] from the literature described a higher prevalence of flat feet in obese subjects. Our study showed a higher prevalence of increased ATC, consistent with flat feet, in obese individuals. There were no statistical differences between obese and control subjects regarding other studied angles. Some authors[20] reported that there is little relationship between joint pain and radiographic changes. Another factor to consider is that morbidly obese subjects are usually younger.[21] As a result, there was no time to develop radiological arthrosis or secondary deformities, and radiological changes would not be identified despite the pain.[21]

Our research showed no statistical difference regarding angular measurements in radiographs to assess the prevalence of conditions such as hallux valgus. A hallux valgus

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deformity would not be necessarily associated with pain. However, data on its prevalence in obese people are conflicting. For Frey et al.,[22] hallux valgus would be related to normal BMI, and not to obesity. However, Cho et al.[23] correlated hallux valgus to increased BMI values. Nguyen et al.[24] reported that obesity and female gender would be protective factors for hallux valgus. This would be due to the fact that women with BMI < 25 tend to wear high heels, pointed toes shoes, whereas obese females, for having wider feet, wear flat shoes that do not compress the forefoot area.[24]

Menz et al.[25] described a higher prevalence of foot pain in women compared to men (25% versus 19%) in a general population from Framinghan, MA, USA. However, our study revealed no differences between severely obese men and women regarding both the prevalence and severity of feet pain.

Our case series showed no differences in feet functional parameters using the AOFAS scale and in the level of pain (VAS) when comparing morbidly and supermorbidly obese subjects. Our data disagrees from other authors who showed greater functional impairment in superobese individuals.[7] Further studies, including a larger number of individuals, may evidence such differences.

Our study is limited by its cross-sectional design; although the studied parameters may present correlations, it is not possible to determine a cause-effect relationship. Therefore, our statistical analysis cannot affirm that excessive obesity results in pain and low functional level or if these factors would have a reverse causal effect, that is, determining the occurrence of obesity due to the sedentary lifestyle. Another factor worth mentioning is the nondiscrimination of clinical comorbidities such as hypertension, diabetes, and other systemic diseases in obese and control subjects, which may have generated bias in data analysis. In addition, the sample studied was relatively small, which limits the scope of conclusions. However, it should be noted that the study group constitutes a very specific universe of people with extremely severe (morbid) obesity (BMI > 40) and indication for bariatric surgery, while most data from the researched literature[2,12] refer to overweight or mildly obese individuals.

A higher prevalence of foot pain and functional impairment was demonstrated in the studied obese population. The indirect relationship between increased BMI in severely obese patients and pain according to the VAS corroborates the suspicions that systemic mechanisms, not only biomechanical factors, determine pain and functional impairment. These findings reinforce the importance of further studying the involvement of the musculoskeletal system in people with severe obesity.

Our data will help to understand musculoskeletal conditions resulting from obese-related metabolic syndrome and to formulate preventive and therapeutic strategies in this special subgroup of individuals.

Conclusions

Severe obesity (BMI > 40) is related to a higher prevalence of foot pain. Severely obese people have a worse AOFAS functional score in the forefoot, midfoot and hindfoot regions.

Conflict of Interests

The authors have no conflict of interests to declare.

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