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RESEARCH

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Gait in children and adolescents with idiopathic musculoskeletal pain

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Abstract

Introduction: Musculoskeletal pain is a constant complaint in pediatric practice. The pain may be related to a number of organic diseases and / or be part of the *amplified* musculoskeletal *pain syndromes*. Idiopathic musculoskeletal pain (IMSP) is defined as the presence of intermittent pain in three or more body regions for at least three months, excluding organic diseases that could explain the symptoms.

Objective: To study the gait of children and adolescents with IMSP by dynamic baropodometry.

Methodology: Thirty-two patients with IMSP and 32 healthy controls, matched by age, sex, social class, and body mass index (BMI) were enrolled. All were evaluated for pain intensity through the visual analogue scale (VAS) and gait evaluation using dynamic baropodometry.

Results: The mean age of the IMSP group was 13.6 years (SD = 2.1, range 9.8–16.9) and of the control group was 13.5 years (SD = 2.0, range 9.6–16.5). The mean pain scale was 5.4 cm in the IMSP group and 0 cm in the control group ($p < 0.001$). In gait, the mean right foot velocity of the IMSP group was significantly lower ($p = 0.034$), the time of the step of the IMSP group was significantly higher ($p = 0.003$) and the pace of the IMSP group was significantly lower ($p = 0.001$).

Conclusion: In our study we observed differences between the gait of children with IMSP and healthy controls according to the dynamic baropodometry. This finding indicates the need for individualized attention to the gait of children with musculoskeletal pain.

Keywords: Musculoskeletal pain, Children, Adolescents, Gait, Baropodometry

Introduction

Musculoskeletal pain is a constant complaint in pediatric practice, being a frequent reason for outpatient and emergency appointments [1]. Pain may be related to a number of organic diseases and / or may be part of *amplified* musculoskeletal *pain syndromes*,.

The main condition related to diffuse pain is the idiopathic musculoskeletal pain (IMSP), defined as the presence of intermittent pain in three or more body regions for at least three months, excluding organic diseases that could explain the symptoms, such as inflammatory, neoplastic and infectious diseases, among others [2].

The etiopathogenesis of *amplified* musculoskeletal *pain syndromes* is multifactorial and includes physical factors such as lower central pain threshold, increased nociceptive receptor sensitivity, autonomic nervous system disorders [3], emotional factors such as increased stress and anxiety and environmental aspects [4]. In some patients, there may be other clinical findings related to pain, such as joint hypermobility and obesity, among others [5–8]. Some points of the etiopathogenesis of IMSP are still unknown, among them, gait disorders.

Gait can be evaluated by subjective or objective methods. Muro-de-la-Herran et al. [9] carried out a review of the methods used in the recognition and analysis of human gait from three different approaches: image processing, floor sensors and body sensors.

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In a study using body sensors of adults with fibromyalgia and controls (Locomotrix, Centaure Metrix, France), Auvinet et al. observed that gait may be slowed and the number of strides may be decreased in patients with pain [10]. These aspects should be taken into account in the daily clinical approach, since aerobic physical activities are part of the therapeutic arsenal [11]. However, according to our knowledge, there are no published studies on possible gait changes in children with IMSP.

Dynamic baropodometry is an objective method of gait evaluation and allows the identification of a series of abnormalities, since it automatically recognizes the right and left feet, records all steps, and stipulates the closest average step. It also allows you to view all recorded steps and force curves overlapping. Its use is not associated with any discomfort for patients. Although used for the evaluation of the gait of patients with musculoskeletal disorders, such as rheumatoid arthritis [12] and plantar fasciitis [13], this method has not yet been used for gait evaluation in patients with *amplified* musculoskeletal *pain syndromes*, whether adults or children.

Therefore, our proposal was to carry out a study on the characteristics of the gait of children and adolescents with IMSP, through dynamic baropodometry, a modern method capable of providing information still unknown up to this date.

Material and methods

Study design

Cross-sectional and observational study.

Patients

The sample consisted of patients with diffuse IMSP between the ages of 10 and 16, of both genders, consecutively selected in the outpatient clinic of musculoskeletal pain, of which 164 patients with IMSP were followed regularly. Inclusion criteria were: 1) diagnosis of IMSP according to the Malleson criteria [2], which include the presence of three or more episodes of musculoskeletal pain in a period of three months; and 2) outpatient follow-up time of at least six months. The exclusion criterion was: 1) presence of scoliosis or organic disease in which pain could be a symptom.

The control group consisted of apparently healthy children and adolescents, with no complaint of musculoskeletal pain. Controls were family members and / or friends of patients, or those enrolled in a recreation center for children and adolescents, matched by age, gender, nutritional status, socioeconomic level [14] and school level with patients. The controls were invited through direct or telephone contact with their parents / legal guardians.

This study was approved by the Research Ethics Committee of the local institution. All subjects or parents signed an informed consent form.

Study procedures

All subjects underwent a three-step process: clinical evaluation, performed by a qualified pediatric rheumatologist, to verify the inclusion and exclusion criteria, questionnaire completion, and gait evaluation.

Demographics

We collected demographic data from individuals who were weighed and measured, without shoes and with the least amount of clothing.

Pain measurement

To measure pain, a Visual Analogue Scale (VAS) was used, ranging from 0 (no pain) to 10 cm (maximum intensity pain), according to the last 30 days before the evaluation.

Evaluation of gait by dynamic baropodometry

The FootWork Pro, AM cube®, Gargas, France marching track, with four platforms (A, B, C, and D), was used for a 196 cm path by 49 cm of active dimension, with a thickness of 4 mm / 5 mm of rubber, polycarbonate coated, weighing 18 kg. This track has two sensors per 2 cm^2, totaling approximately 16,384 sensors automatically calibrated. The device contains a Footwork Pro software (IST Informatique - Intelligence Service et Technique, France), which automatically recognizes the right and left feet, records all steps and stipulates the closest step to the average. It allows to visualize all the registered steps and the overlap of force curves. This assessment was performed within 30 days after a medical appointment.

In the test, patients and controls walked once for six minutes on the equipment's digital mat.

Statistical analysis

The SPSS software version 22.0 was used to perform the statistical analysis of the data. Descriptive statistics (mean, standard deviation, 95% confidence interval) was used to characterize patients and controls. The continuous variables of the two groups were compared by the Student's t-test for variables with normal distribution, and the Mann-Whitney test for variables with a distribution not considered normal. Categorical variables were assessed using the chi-square test.

The level of statistical significance adopted was 5%.

Results

Thirty-four patients with diffuse IMSP were initially recruited. Two patients refused to participate in the study and were excluded. In the control group 33 individuals were initially recruited included, but one individual was excluded for complaint of musculoskeletal pain. Therefore, 32 IMSP and 32 controls were enrolled in the study. Demographic and clinical data are presented in Table 1. It was observed that the sample is homogeneous with respect to age, gender, and body mass index (BMI). The mean age in the IMSP group was 13.6 (SD = 2.1) and in the control group was 13.5 (SD = 2.0) ($p = 0.880$). There was a prevalence of the female gender (84.4%).

Statistically significant dynamic baropodometry results are shown in Figs. 1, 2 and 3.

There was a statistically significant difference in the following baropodometry parameters: 1) mean right foot velocity with the IMSP group values lower than those in the control group ($p = 0.034$), 2) step time with IMSP values higher than those of the control group ($p = 0.003$), 3) pace with IMSP values lower than those of the control group ($p = 0.001$). No differences were observed in the following variables: mean left foot velocity(mm/s), mean static right foot pressure (kpa), mean static left foot pressure (kpa), body strength surface on right foot (cm^2), body strength surface on left foot (cm^2), right forefoot load distribution (%); left forefoot load distribution (%); load distribution in the right hindfoot (%); load distribution in the left hindfoot (%); center of force on the left foot (cm^2); center of force on the right foot (cm^2), and center of force of the body (cm^2) (Table 2).

Discussion

Our data show that the gait of children and adolescents with IMSP, evaluated by dynamic baropodometry, is different when compared to healthy children in relation to the mean velocity of the right foot, time of the step, and pace. These results were achieved based on a technology in which sensors are located on a platform that records several aspects of the gait. Since IMSP has a multifactorial etiology, we believe that these changes are part of a complex gear whose final result is a decrease in the patients' quality of life [4].

The methods used in human gait recognition and analysis are based on image processing and can be classified according to two different approaches: 1) non-portable sensors (NWS) and 2) portable sensors (WS) [10]. NWS systems require the use of controlled research facilities and rely on sensors that pick up gait data while the patient walks on a catwalk. In contrast, in WS systems, data analysis is performed outside the laboratory, capturing information about human gait during the individual's daily activities. In this specific case, the sensors are coupled in various locations of the locomotor apparatus. There is also a third group of hybrid systems that uses a combination of both methods.

Children and adolescents with gait disorders may experience musculoskeletal pain [12]. However, it is not possible to know if alterations in walking lead to pain or if the presence of pain alters gait.

Wassmer et al. [13] evaluated 103 children with gait disorders; in eight there was no apparent cause for this disorder. In these cases, pain was significant, as there was functional impairment and school absenteeism. Thus, it is known that in a considerable number of children without apparent locomotor disorders, they present impairment in quality of life. In our non-inflammatory musculoskeletal pain outpatient clinic, we observed that many patients present changes in posture and sedentary lifestyle. We know that walking may be altered in these cases, but there are no studies specifically conducted in children with IMSP.

Dynamic baropodometry, NWS system, allows precise identification of a series of gait abnormalities. For this reason, it has been used in the evaluation of patients with varied diseases, such as neurological, orthopedic, rheumatic, and even physiological, as in the case of longevity [9, 15–21]. However, some authors have evaluated the gait of individuals with musculoskeletal pain with other reliable methods, especially fibromyalgia patients. In these evaluations, the gait was altered [21], which justifies its detailed study in the *amplified* musculoskeletal *pain syndromes*. Dynamic baropodometry is an useful tool for the physiotherapist, since it helps in the diagnosis and treatment of gait disorders.

Auvinet et al. [5] analyzed the gait of 14 adult females with fibromyalgia and 14 healthy controls by means of equipment specially developed to measure walking speed, size, laterality, and regularity of the step (LocometrixTM Centaure Metrix, France). The gait of patients with fibromyalgia was altered, with a decrease in gait velocity in relation to the decrease in step size and pace. In other words, gait was irregular in patients when compared to controls regardless of age. In our study, although we used the technology of dynamic baropodometry to evaluate gait, we observed similar results, for example, gait slowing in patients with pain.

Sil et al. [22] evaluated gait biomechanics in juvenile fibromyalgia using a 10-camera 3D analysis device (Raptor-E, Motion Analysis Corp, Santa Rosa, CA). In this

Table 1 Demographic and clinical data

	Study (n = 32)		Control (n = 32)		p Value
Age (years) (Mean and SD)	13.6	2.1	13.5	2.0	0.880[a]
Female Gender (n and %)	27	84.4	27	84.4	1.000[b]
Weight (kg) (Mean and SD)	49.9	10.8	51.2	14.4	0.689[a]
Height (cm) (Mean and SD)	156.0	8.9	155.3	10.8	0.772[a]
BMI (kg/m^2) (Mean and SD)	20.43	3.82	21.05	4.72	0.568[a]
Pain (cm) (Mean and SD)	5.42	2.60	–	–	–

[a]– Student's t-test; [b] – chi-square test

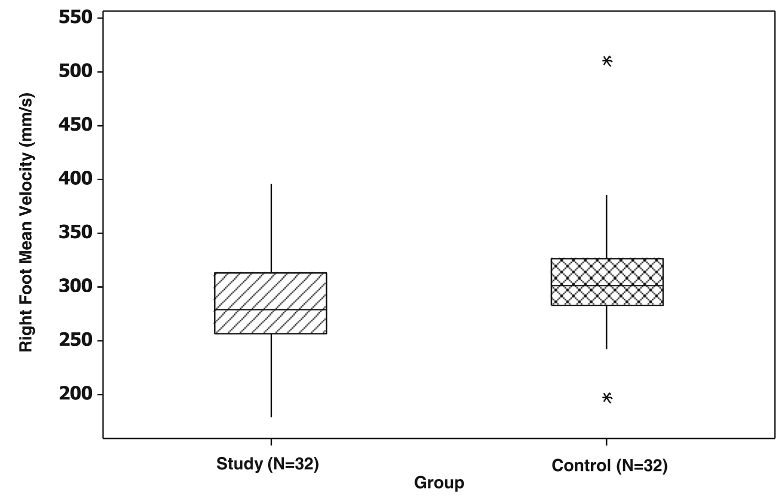

Fig. 1 *Box-plot* of the mean velocity of the right foot (mm/s - millimeters per Second

study, functional gait deficits were observed in 17 female adolescents with juvenile fibromyalgia when compared to 14 healthy controls. In addition, these authors measured isometric strength in lower limbs (Biodex System II equipment, Shirley, NY). Differently from our results, they observed no difference in gait velocity between patients and controls. On the other hand, they observed that the strides were significantly lower in the patient group. The isometric strength in the lower limbs was lower in the patient group, especially in knee flexion and extension and hip adduction. In our study, we did not assess muscle strength. We believe that a specific strength assessment would complement our findings.

Since the prescription of regular physical exercises and aerobic physical activities is part of the treatment of children and adolescents with IMSP [6], a deeper understanding of gait is necessary so that these guidelines are more accurate and appropriate to the characteristics of each patient.

Pain often leads to inertia and slower movement. The antalgic postures are common, with muscular compensations and with the inadequate use of the joints in the movement, generating tiredness and fatigue. These compensations manifest themselves as abnormal gait patterns and are invariably less efficient and more expensive in energy expenditure than normal mechanisms [23].

However, the prescription of physical activities for patients with musculoskeletal pain is consecrated in current literature [6, 24]. In our daily practice, we follow these guidelines and we also encourage patients.

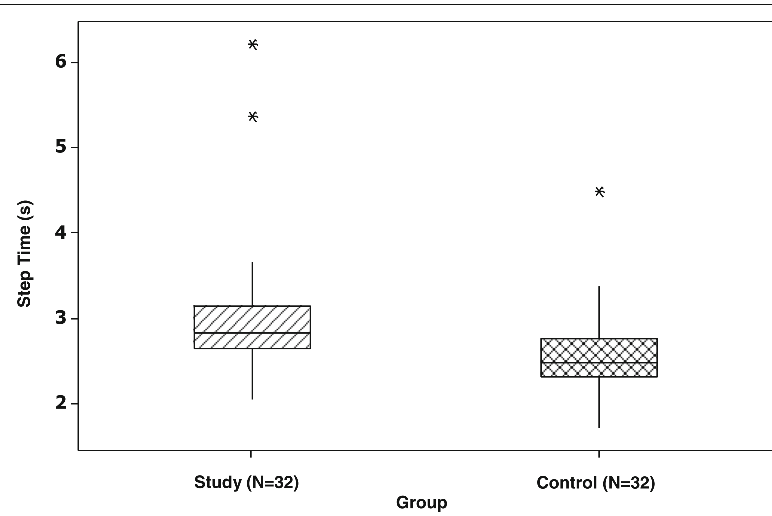

Fig. 2 *Box-plot* of the step time (s=seconds)

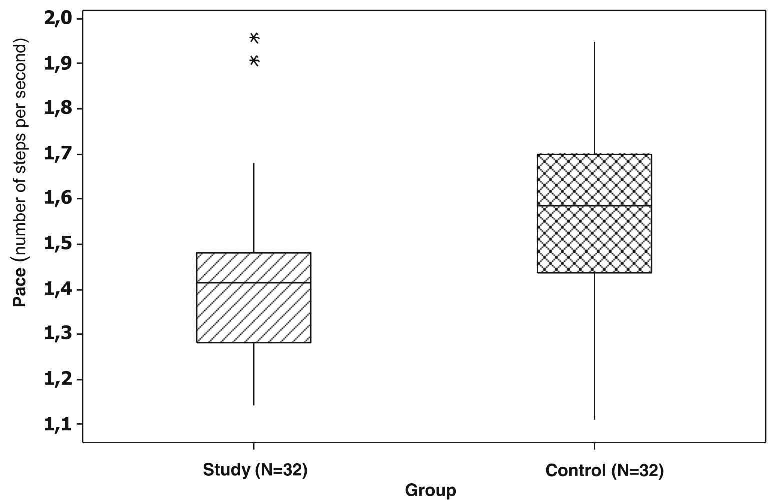

Fig. 3 *Box-plot* of the pace (number of steps per second)

Table 2 Mean baropodometry parameters of patients with idiopathic musculoskeletal pain and healthy controls

Variables	Study ($n = 32$)		Control ($n = 32$)		*P value*
Mean velocity of the right foot (# mm/s)	284.40	54.1	311.10	54.5	**0.034***
Mean velocity of the left foot (# mm/s)	286.10	44.8	309.50	53.3	0.063
Step time (# s)	3.00	0.83	2.56	0.51	**0.003***
Pace (# steps/second)	1.41	0.19	1.56	0.2	**0.001***
Right static mean pressure (# kpa)	37.30	12.4	35.30	12.1	0.517
Left static mean pressure (# kpa)	40.10	8.1	38.60	10.5	0.519
Right body strength surface (# cm^2)	81.50	17.5	87.40	13.9	0.135
Left body strength surface (# cm^2)	84.20	16.4	87.10	16.7	0.478
Right forefoot load distribution (%)	19.20	5.1	20.20	5.2	0.432
Left forefoot load distribution (%)	21.80	5.1	20.30	4.9	0.250
Load distribution in the right hindfoot (%)	27.30	5.9	27.30	7.8	0.999
Load distribution in the left hindfoot (%)	31.70	7.8	32.10	7.2	0.826
Center of force of the right foot (# cm^2)	2.03	2.89	3.61	5.09	0.888
Center of force of the left foot (# cm^2)	1.52	2.04	3.09	5.44	0.417
Mean center of force of the body (# cm^2)	4.68	4.04	5.99	6.57	0.727

mm/s millimeters per second, *s* seconds, *Kpa* kilopascoal, *cm^2* square centimeter
Mann-Whitney test, #
* $p < 0.05$

However, before prescribing physical activity, we firstly have as a therapeutic exercise the subjective evaluation of gait, followed by a training, motivating the adequacy and distribution of body weight on the lower limbs, in addition to the proper positioning of the head, so that the body is sustained against the action of gravity, thus seeking balance.

To the best of our knowledge, this is the first study to study the gait in children and adolescentes with musculoskeletal pain. The main limitation of our study was the reduced number of patients. To minimize this problem, we selected healthy controls matched by age, gender, nutritional status, school level, and socioeconomic level.

Conclusions

In our study we observed differences between the gait of children with IMSP and healthy controls according to the dynamic baropodometry. This finding indicates the need for individualized attention to the gait of children with musculoskeletal pain.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions
MCC: design of the project, main responsible by ethics approval and data collection. MCC also participated in the data interpretation and writing of the manuscript. JN: design of the project. JN also participated in the data interpretation and writing of the manuscript. HAVO: was co-responsible by data collection and participated in the writing of the manuscript. MTT participated in the data interpretation and writing of the manuscript. CAL participated in the study design, data interpretation, writing of the manuscript and paper submission. All authors read and approved the final manuscript.

Ethics approval and consent to participate
This study was submitted to the local Ethics Committee, "Comitê de Ética da Universidade Federal de São Paulo – Plataforma Brasil", number: 940.191. The principals/coordinators and the parents were informed about the study, and their participation was voluntary.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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