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Original article

Gait disorders in patients with fibromyalgia

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Abstract

Objectives: The objective of this study was to compare gait in patients with fibromyalgia and in matched controls.

Methods: Measurements must be obtained in patients with fibromyalgia, as the evaluation scales for this disorder are semi-quantitative. We used a patented gait analysis system (Locometrix^{TM} Centaure Metrix, France) developed by the French National Institute for Agricultural Research. Relaxed walking was evaluated in 14 women (mean age 50 ± 5 years; mean height 162 ± 5 cm; and mean body weight 68 ± 13 kg) meeting American College of Rheumatology criteria for fibromyalgia and in 14 controls matched on sex, age, height, and body weight.

Results: Gait during stable walking was severely altered in the patients. Walking speed was significantly diminished ($P < 0.001$) as a result of reductions in stride length ($P < 0.001$) and cycle frequency ($P < 0.001$). The resulting bradykinesia ($P < 0.001$) was the best factor for separating the two groups. Regularity was affected in the patients ($P < 0.01$); this variable is interesting because it is independent of age and sex in healthy, active adults.

Conclusion: Measuring the variables that characterize relaxed walking provides useful quantitative data in patients with fibromyalgia.

Keywords: Fibromyalgia; Accelerometry; Walking

1. Introduction

Fibromyalgia is a condition of chronic musculoskeletal pain accompanied with a broad array of subjective symptoms such as sleep disorders, headaches, tender points, pain threshold lowering, fatigue, gastrointestinal complaints, anxiety, and depression. The diagnosis rests not only on evaluation of American College of Rheumatology criteria [1], but also on the absence of other organic diseases affecting the musculoskeletal system, endocrine glands, nervous system, or metabolism. Once the diagnosis of fibromyalgia is established, the only objective tool available for quantifying the functional impact of the disease is the 6-min walking test, which correlates with the Fibromyalgia Impact Questionnaire (FIQ) score [2].

The objective of the present study was to determine whether gait is abnormal in patients with fibromyalgia. To this end, we conducted a quantitative gait analysis in 14 patients with fibromyalgia and in 14 matched controls.

2. Methods

We studied 14 women who met American College of Rheumatology criteria for fibromyalgia [1]. Mean age was 50 ± 5 years, mean height was 162 ± 5 cm, mean body weight was 68 ± 13 kg, and mean disease duration was 3.4 ± 0.9 years). Controls were recruited among individuals with a negative history for musculoskeletal disease, neurological disorders, and gait abnormalities. The 14 controls were women matched to the patients on age (mean, 50 ± 6 years), height (mean, 163 ± 5 cm), and body weight (mean,

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66 ± 11 kg). Gait analysis was performed in both groups by the same investigator using the same equipment and measurement protocol. Patients and controls gave their oral informed consent prior to study initiation.

The Locometrix^{TM} (Centaure Metrix, France) device used to measure gait variables in this study comprises two accelerometers positioned perpendicularly to each other and placed near the center of gravity of the body, over the middle of the low back, where they are held by a semi-elastic belt. One of the accelerometers records craniocaudal accelerations and the other side-to-side accelerations, at 50 Hz. The data are transferred from the portable recording device to a computer, where they are subjected to statistical analyses.

2.1. The walking test

Each study participant was equipped with the accelerometers and recording device then asked to walk at her normal speed to the end of a straight 40-m-long hospital corridor and back. No visible markers or sounds were available to serve as reference points. Participants wore closed city shoes with flat flexible soles (Fig. 1). The walking distance was sufficient that periods of nonstabilized walking at the beginning and end of the test could be eliminated.

2.2. Study variables

2.2.1. Walking speed

Speed during the walking test was measured in meters per second, using a chronometer.

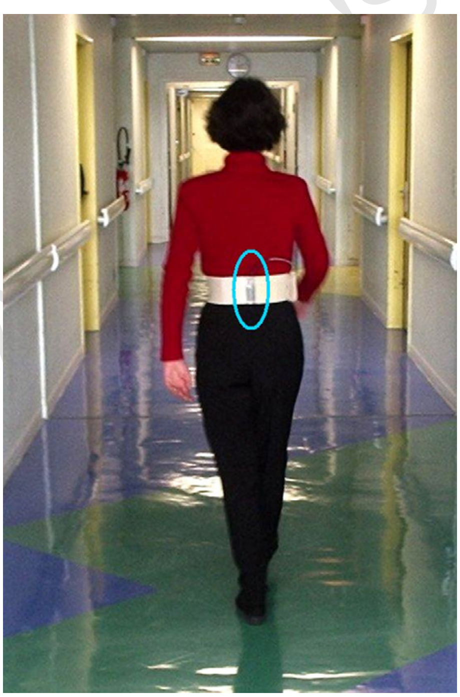

Fig. 1. Walking test in a straight hospital corridor; the two accelerometers are help against the middle of the low back by a semi-elastic belt.

2.2.2. Cycle frequency

Stabilized walking can be viewed as the sum of periodic stationary movements. By applying Fourier fast transform to the cranio-caudal acceleration signal, the fundamental frequency of the periodic movements can be computed and cycle frequency determined.

2.2.3. Stride length

Stride length was obtained in meters by dividing walking speed (m/s) by cycle frequency (Hz).

2.2.4. Side-to-side symmetry and step regularity

These two variables were computed using autocorrelation functions on the cranio-caudal signal. We used two autocorrelation functions, one that expressed the correlation between accelerations corresponding to movements of the right and left limbs and the other expressing the correlation between accelerations corresponding to successive steps. As a result, we were able to compute right-to-left symmetry and step regularity. Z transformation was used to normalize these dimensionless variables [3].

2.2.5. Craniocaudal and side-to-side activity

We used the Fourier transform integral for the craniocaudal acceleration signal. This variable measures the mean mechanical power generated in the craniocaudal and side-to-side directions near the center of gravity of the body (W/kg). Its value depends on both the amplitude and the speed of craniocaudal movements. The results can be taken clinically as reflecting body kinesia [4].

2.3. Statistics

Analysis of variance was used to compare the two groups. Receiver Operating Characteristics (ROC) curves were plotted to evaluate sensitivity and specificity of each variable. For each curve, we determined the area under the curve (AUC) and the significance threshold. AUC can range from 0.5 to 1; values close to 1 are discriminative and informative. The significance threshold indicates the best cutoff for differentiating the two populations. All statistical tests were performed using NCSS 1997 software (Logilab).

3. Results

All gait variables except side-to-side activity were significantly decreased in the group with fibromyalgia, compared to the control group (Table 1). The patients with fibromyalgia walking more slowly, as a result of decreases in both stride length and cycle frequency. Side-to-side symmetry and step regularity were decreased and marked bradykinesia was noted in the patients. The ROC curves are shown in Table 2. AUC values were remarkably high: 1 for craniocaudal activity, 0.98 for walking speed, 0.98 for stride length, 0.94 for cycle frequency, and 0.79 for step regularity; A lower AUC of 0.73 was found for side-to-side symmetry.

Table 1
Gait variables in 14 patients with fibromyalgia and in 14 controls

Variables	Patients Mean ± S.D.	Controls Mean ± S.D.	*P* value
Walking speed (m/s)	1.09 ± 0.24	1.50 ± 0.09	$P < 0.001$
Cycle frequency (Hz)	0.92 ± 0.09	1.05 ± 0.05	$P < 0.001$
Stride length (m)	1.19 ± 0.16	1.43 ± 0.05	$P < 0.001$
Side-to-side symmetry (dimensionless)	205 ± 46	243 ± 33	$P < 0.05$
Step regularity (dimensionless)	273 ± 65	335 ± 46	$P < 0.01$
Craniocaudal activity (W/kg)	1.01 ± 0.78	2.48 ± 0.52	$P < 0.001$
Side-to-side activity (W/kg × 10^{-2})	5.62 ± 4.89	4.08 ± 2.14	NS

Table 2
Sensitivity and specificity of gait variables as assessed using the Receiver–Operating Characteristics method *

Variables	AUC	S.D.	Cutoff
Walking speed (m/s)	0.98	0.02	1.27
Cycle frequency (Hz)	0.94	0.05	1.01
Stride length (m)	0.97	0.04	1.36
Side-to-side symmetry (dimensionless)	0.73	0.09	220
Step regularity (dimensionless)	0.79	0.09	328
Craniocaudal activity (W/kg)	1	0	1.74
Side-to-side activity (W/kg × 10^{-2})	NS		–

4. Discussion

4.1. Patients with fibromyalgia and controls

All 14 patients had documented fibromyalgia without major depression. The only patient with another musculoskeletal disease had mild sciatica. The controls were recruited from our database of 282 healthy active individuals [5].

4.2. Quantitative gait analysis

The introduction of a new generation of accelerometers suitable for biomechanical measurement of low-frequency body accelerations has rekindled interest in studies of gait [3], energy expenditure [6], and walking in elderly individuals [7,8]. The method used in our study has a number of advantages for outpatient gait analysis. Accelerometer position is easy to reproduce in a given individual, as it is based on simple anatomic landmarks. No special experimental setup is needed. The measurements are obtained rapidly and noninvasively. The results reflect overall gait mechanics at a point close to the center of gravity of the body. Finally, mathematical processing of the signals produces simple and robust variables, including walking speed, cycle frequency, stride length, side-to-side symmetry, step regularity, and mechanical power in the craniocaudal and side-to-side directions. Intra- and inter-observer reproducibility has been found satisfactory with this method [3], which is therefore suitable for gait disorder quantification in clinical practice.

4.3. Walking test

Normal walking, or relaxed walking, is the optimal condition for comparative studies [9]. A straight 40-meter long corridor produces a period of stabilized walking that is longer than 20 steps, a condition recognized as improving precision in studies of gait disorders [10].

4.4. Gait disorders in patients with fibromyalgia

Walking speed was severely reduced in our patients with fibromyalgia, in keeping with results obtained by Pankoff et al. [1]. Because walking speed is influenced by overall physical activity, fitness, age, and sex, results in the individual patient are difficult to interpret. Furthermore, walking speed variations can be caused by a variety of mechanisms [11]. In our study, the walking speed decrease was related to both a reduction in stride length and a reduction in cycle frequency.

Bradykinesia was among the main characteristics of gait in our patients with fibromyalgia. Bradykinesia was the best variable for separating patients from controls. Furthermore, bradykinesia is directly related to the amount of movement in the craniocaudal direction and may be suitable for quantifying physical activity in patients with fibromyalgia. A close correlation has been reported between activity measured using accelerometers at the middle low back and oxygen consumption during walking [6,12].

Cycle frequency and step regularity were also fundamental characteristics of gait in our patients. Both variables are dependent on walking speed [13]. They can be altered independently from each other, even when walking speed is normal [14]. The influence of sex and age on cycle frequency should be considered when interpreting results. Regularity is an important characteristic of gait in all age groups and is independent from sex and from age between 20 and 70 years in healthy active adults [5,15]. These characteristics make regularity a valuable clinical tool.

5. Conclusion

This preliminary study confirms that gait analysis is valuable for evaluating motor function in patients with fibromyalgia. Motor function impairment results not only in slower walking, but also in bradykinesia associated with reduced cycle frequency and decreased step regularity. Further studies in larger populations are needed. Furthermore, the possible impact of fatigability on gait in patients with fibromyalgia should be evaluated. Gait analysis could provide objective quantitative data about the impact of fibromyalgia on locomotor function and about the effects of treatment. Finally, studies of correlations between gait disorders and symptom evaluation questionnaires might help to identify subgroups within the overall population of patients with fibromyalgia.

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