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Isokinetic assessment of ankles in patients with rheumatoid arthritis

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ABSTRACT

Introduction: The foot and ankle in rheumatoid arthritis undergo highly destructive synovitis with loss of muscle strength.
Objective: To evaluate the muscle strength of ankles in patients with rheumatoid arthritis based on isokinetic dynamometry parameters.
Materials and methods: Thirty patients with a diagnosis of rheumatoid arthritis involving the ankle(s) and 30 healthy subjects (control group) matched for age, gender, race, body mass index and lower limb dominance were studied. Dorsiflexion, plantar flexion, inversion and eversion were evaluated in all subjects on an isokinetic Cybex Norm dynamometer. The variables were compared between the rheumatoid arthritis and control groups and between the right and left ankles, and the dorsiflexor/plantar flexor and invertor/evertor muscle strength ratio was determined.
Results: Patients with rheumatoid arthritis performed statistically worse in the isokinetic dynamometry test for all ankle movements. The muscle strength ratio between dorsiflexors and plantar flexors was different in the two groups. No significant differences were observed in the invertor and evertor ratios. In the two groups the plantar flexor musculature was statistically stronger than dorsiflexors.
Conclusion: We conclude that patients with rheumatoid arthritis perform worse in isokinetic dynamometry regarding all ankle movements than control subjects, with similar isokinetic test results being observed for the right and left side in both groups, with few exceptions. Isokinetic evaluation posed no additional risk such as important pain or inflammatory activity to patients with rheumatoid arthritis.

Avaliação isocinética do tornozelo de pacientes com artrite reumatoide

Palavras-chave:
Tornozelo

RESUMO

Introdução: O pé e o tornozelo na artrite reumatoide passam por sinovite altamente destrutiva, com perda de força muscular.

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Avaliação isocinética
Pico de torque
Artrite reumatoide

Objetivo: Avaliar a força muscular do tornozelo de pacientes com artrite reumatoide com base em parâmetros da dinamometria isocinética.
Materiais e métodos: Foram estudados 30 pacientes com diagnóstico de artrite reumatoide. O estudo envolveu 30 indivíduos saudáveis (grupo controle) pareados por idade, sexo, etnia, índice de massa corporal e dominância de membro inferior. Todos os indivíduos foram submetidos a avaliação da flexão dorsal, flexão plantar, inversão e eversão com o dinamômetro isocinético Cybex Norm. As variáveis foram comparadas entre os grupos artrite reumatoide e controle e entre os tornozelos direito e esquerdo. Foi determinada a relação de força muscular flexores dorsais/flexores plantares e inversores/eversores.
Resultados: Os pacientes com artrite reumatoide tiveram resultados estatisticamente piores no teste de dinamometria isocinética para todos os movimentos do tornozelo. A relação de força muscular entre flexores dorsais e flexores plantares foi diferente nos dois grupos. Não foram observadas diferenças significativas na relação entre inversores e eversores. Nos dois grupos, os músculos flexores plantares eram estatisticamente mais fortes do que os flexores dorsais.
Conclusão: Os pacientes com artrite reumatoide têm pior desempenho na dinamometria isocinética em todos os movimentos do tornozelo do que os indivíduos do grupo controle. Foram observados resultados semelhantes no teste isocinético para o lado direito e esquerdo, em ambos os grupos, com poucas exceções. A avaliação isocinética não representou risco adicional, como dor importante ou atividade inflamatória, em pacientes com artrite reumatoide.

Introduction

Rheumatoid arthritis (RA) is a chronic inflammatory disease that particularly involves the synovial joints in a symmetric, generally progressive manner.[1,2] The ankle complex and feet are commonly affected. In the latter case, the metatarsophalangeal joints are most frequently involved. Rheumatoid feet and ankles undergo episodes of highly destructive synovitis, which may lead to tendon rupture, subluxation, flatfoot, hallux valgus, etc. With the progression of RA, patients may experience limitations and disabilities in the activities of daily living, mainly due to pain, gait abnormalities and self-care difficulties.[3]

The exact quantification of muscle performance has always been a concern of health care professionals. During rehabilitation, the objective is to assess the patient and evaluate the effectiveness of therapeutic exercises designed to help the patient regain muscle strength. The isokinetic concept of exercise was developed by Perrin in 1960 and is used as an assessment method of muscle strength providing measurement to therapeutic effectiveness and it is also of help in recovering strength after injuries to the musculoskeletal system. One of the advantages of isokinetic exercise over other types is that it allows the assessment of the maximum muscle potential throughout the range of motion.[4]

RA causes muscle strength loss in patients stemming from joint inflammation, pain and edema as well as disuse and a loss of function.[5–7]

The aim of the present study was to assess ankle muscle strength in patients with RA using isokinetic dynamometry. The main isokinetic dynamometer parameters were correlated with overall functional capacity and, specifically, the functional capacity of the ankle and foot joints.

Materials and methods

Thirty patients with RA who fulfilled criteria of classification according to the American College of Rheumatology – ACR[8] – and had involvement of the ankle(s) were included in the study. Patients were consecutively selected from the outpatient clinics of the Federal University of Sao Paulo (UNIFESP). Thirty adults with no lower limb disease, paired for gender, age, race, lower limb dominance and BMI with patients from the RA group, were selected to the control group.

Exclusion criteria were any other type of lower limb disease or injury, a history of joint surgery in the lower limbs, ankle infiltrations over the previous 3 months, pregnancy, heart disease, uncontrolled hypertension, coagulopathies, anticoagulant therapy, severe joint instability or fibromyalgia and inability to perform the complete test. The study was approved by the Ethics Committee of UNIFESP and all subjects signed a term of informed consent.

All patients were submitted to an isokinetic test on a Cybex Norm isokinetic dynamometer (Cybex International, Inc., Ronkonkoma, NY), which had been previously calibrated by a trained physiotherapist. The isokinetic test protocol followed the instructions suggested by Perrin.[5] Before the test, a warm up for 5 min on an ergometric bicycle (Metabolic System Bike, Cybex – Division of Lumex, Ronkonkoma, NY) at a speed of 60 rpm was performed. The procedure was then explained to the patient, who practiced the movements to be tested at the same angular velocities in order to become familiar with the test. The sequence of movements was randomized for each subject. Both limbs were analyzed and the test was standardized to start with the right lower limb.

For the dorsiflexion/plantar flexion test, the subject was placed in the supine position on the bench, with the hip and knee flexed at 80° and 30°, respectively. The knee was

supported in the popliteal region. The knee, the ankle to be tested and the lumbar region were fixed with a resistant pad. The contralateral foot remained on a support. The subject's hands were placed on the armrests. Dorsiflexion/plantar flexion was tested at angular velocities of 30°/s and 60°/s. Each movement was repeated five times at the two velocities, with rest intervals of 30 s between each angular velocity. For the inversion/eversion test, the subject was positioned in the same manner as described for the previous test and the position of the dynamometer was changed. These movements were tested at angular velocities of 30°/s and 60°/s, with each movement being repeated five times at each velocity. The isokinetic dynamometer parameters evaluated for the different movements were peak torque (PT) and peak torque angle (PTA).

The following parameters were evaluated:

- Pain in the ankles and/or feet – using visual analog scales (VAS) ranging from 0 to 10 cm to evaluate pain at rest and during gait.[9]
- Functional capacity – assessed using the Health Assessment Questionnaire – HAQ.[10,11]
- Functional capacity of the ankle–foot complex – the Foot Functional Index (FFI) is a specific questionnaire on the foot.[12,13]
- Range of motion – using the EPM-ROM scale that is a specific questionnaire on range of motion,[14] and the ROM for ankle was measured using a goniometer.

Statistical analysis

Average quantitative variables were compared between the two groups by the Student's *t*-test for two independent samples. The Mann–Whitney test was only used for the isokinetic data. The correlation between quantitative variables was determined using Pearson's correlation coefficient.[15] A significance level of $\alpha < 0.05$ or 5% was accepted for all tests.

Results

In the RA group the participants were 2 men and 28 women (23 Caucasians and 7 non-Caucasians) with an average age of 50.6 ± 1.8 years and body mass index (BMI) of 26.87 ± 0.93 kg/m^2 and the control group was composed by 2 men and 28 women (24 Caucasians and 6 non-Caucasians) with an average age of 50.5 ± 2.1 years and BMI of 27.17 ± 0.75.

Table 1 displays the sample characteristics. The groups were homogenous in terms of age, gender, race, weight, height, BMI and lower limb dominance. However, statistically significant differences between groups were observed in the scores of VAS for ankle and/or foot pain, HAQ, EPM-ROM and FFI.

Regarding the ankle ROM we found a statistically difference between groups with the RA group showing a decrease in the ROM of ankles for all movements (Table 2).

Isokinetic assessment of dorsiflexion and plantar flexion of the two ankles at angular velocities of 30 and 60°/s revealed significantly lower PT values in the RA group for practically all parameters analyzed. In the isokinetic assessment of inversion, significantly higher PT values were observed in the control group for nearly all variables tested (Table 3).

Comparison of the right and left sides in each group revealed similar PT values for all movements studied, except for eversion at 30°/s, which was higher on the left side in the RA group, and plantar flexion at 30°/s, which was higher on the right side in the control group (Table 3).

No significant difference in PTA was observed between the RA and control groups.

Weak to moderate correlations were observed between PT and the HAQ, VAS (rest and gait) and FFI scores. In contrast, no satisfactory correlations were observed between PT of ankle movements and age, disease duration, BMI or EPM-ROM scores (Table 4).

None of the patients reported experiencing pain during or after the isokinetic test.

Table 1 – Characteristics of the patients and control subjects.

	RA group	Control group
Gender (female/male)	28/2	28/2
Race (Caucasian/non-Caucasian)	23/7	24/6
Lower limb dominance (right/left)	27/3	28/2
Age (years)	50 (23–65)	51 (25–64)
BMI (kg/m^2)	26 (19–31)	27 (20–33)
Disease duration (years)	11.2 (1.2–27)	–
VAS at rest (cm)	3 (0.5–7)	0[a]
VAS during gait (cm)	5 (0.5–9)	0[a]
HAQ	1 (0.25–2.75)	0[a]
EPM-ROM	9.5 (4–14)	0[a]
FFI (pain)	53 (2.8–88.7)	0[a]
FFI (difficulty)	50 (0.9–95.8)	0[a]
FFI (limitation of ADL)	26 (2.5–93.7)	0[a]
Total FFI	41 (1.8–90.3)	0[a]

Data were presented as median (minimum–maximum); RA, rheumatoid arthritis; VAS, visual analog scale for pain; HAQ, Health Assessment Questionnaire; EPM-ROM, goniometry scale; FFI, Foot Functional Index; ADL, activities of daily living.

[a] *p* statistically significant.

Discussion

Previous studies have demonstrated that isokinetic dynamometry is a safe and reproducible procedure for

Table 2 – Range of motion for ankle movements.

	RA group	Control group	*p*
Dorsiflexion R	15.53 (0.83)	19.6 (0.3)	<0.001[a]
Dorsiflexion L	15.13 (0.90)	19.6 (0.3)	<0.001[a]
Plantar flexion R	37.46 (2.08)	42.1 (0.3)	0.03[a]
Plantar flexion L	36.13 (2.04)	44.2 (0.7)	<0.001[a]
Inversion R	22.73 (1.54)	37.9 (2.0)	<0.001[a]
Inversion L	21.66 (1.33)	40.5 (1.0)	<0.001[a]
Eversion R	18.06 (1.12)	21.4 (1.0)	0.01[a]
Eversion L	18.26 (1.12)	22.0 (0.9)	0.01[a]

Data were presented as mean (standard error); RA, rheumatoid arthritis; R, right; L, left.

[a] *p* statistically significant.

Table 3 – Peak torque for ankles.

	PT right side			PT left side		
	RA group	Control group	*p*	RA group	Control group	*p*
Dorsiflexion 30°/s	14.2 (2.4)	20.9 (2.1)	0.005[a]	12.0 (1.9)	20.6 (2.1)	<0.001[a]
Dorsiflexion 60°/s	10.4 (1.8)	17.7 (1.8)	0.001[a]	8.3 (1.4)	18.0 (1.9)	<0.001[a]
Plantar flexion 30°/s	20.3 (2.19)	47.7 (4.43)	<0.001[a]	17.9 (2.47)	43.0 (3.99)	<0.001[a]
Plantar flexion 60°/s	13.1 (1.41)	36.9 (3.81)	<0.001[a]	10.8 (1.80)	34.7 (3.24)	<0.001[a]
Inversion 30°/s	8.5 (0.8)	17.8 (1.2)	<0.001[a]	8.4 (0.7)	17.9 (1.4)	<0.001[a]
Inversion 60°/s	6.5 (0.7)	13.4 (1.1)	<0.001[a]	7.1 (0.6)	14.8 (1.1)	<0.001[a]
Eversion 30°/s	9.4 (0.7)	16.2 (0.9)	<0.001[a]	7.1 (0.7)	16.3 (1.1)	<0.001[a]
Eversion 60°/s	7.6 (0.6)	13.3 (0.7)	<0.001[a]	6.2 (0.6)	13.2 (0.8)	<0.001[a]

Data were presented as mean (standard error); PT, peak torque; RA, rheumatoid arthritis.
[a] *p* statistically significant.

the assessment of knees, shoulders and ankles in patients with RA and juvenile rheumatoid arthritis.[6,7,16,17] The safety of this procedure was confirmed in the present study, as none of the patients reported experiencing pain during or after the isokinetic test.

The results found for ROM for ankle show that there is a difference between RA patients and health controls and the moderate correlation found between this parameter and the PT for all movements shows the direct influence between ROM and the strength of ankle muscles.

No standardization for the isokinetic assessment of ankle strength is available. Differences in positions, angular velocities, populations and the isokinetic parameters analyzed hinder the comparison of our results with those obtained in other studies. Functional standardization of ankle isokinetic tests is generally difficult.[18–21] Furthermore, in clinical practice, the extended-knee position is contraindicated in patients presenting involvement of other lower limb joints with poor stretch in the hamstrings, or in cases of involvement of the sciatic nerve. Therefore, we used a supine position in the present study with 80° hip flexion and 30° knee flexion. As this position was indicated by the manufacturer of the dynamometer, it provides maximum comfort to the patient.

In the present study, PT of all movements was significantly lower in the RA group. For the right lower limb (dominant side), highest PT at angular velocities of 30 and 60°/s was observed for plantar flexion, followed by dorsiflexion, eversion and inversion, whereas for the left lower limb (non-dominant side) the highest values were obtained for plantar flexion, followed by dorsiflexion, inversion and eversion. In the control group, highest PT was observed for plantar flexion followed by dorsiflexion, inversion and eversion in both lower limbs. All patients had stronger plantar flexor than dorsiflexor musculature in both ankles. Regarding inversion and eversion in the RA group, the evertors were stronger than the invertors in the dominant leg and the invertors were stronger than the evertors in the non-dominant limb. In contrast, in the control

Table 4 – Correlation between peak torque and other variables in the RA group.

	VAS at rest	*p*	VAS during gait	*p*	HAQ	*p*	Ankle ROM	*p*	Total FFI	*p*
PT right side										
Dorsiflexion 30°/s	−0.09	0.633	−0.108	0.569	−0.266	0.154	−0.514	0.003[a]	−0.256	0.171
Dorsiflexion 60°/s	−0.026	0.891	−0.08	0.671	−0.161	0.394	−0.435	0.016[a]	−0.258	0.168
Plantar flexion 30°/s	0.057	0.764	−0.189	0.315	0.057	0.764	−0.399	0.028[a]	−0.325	0.079
Plantar flexion 60°/s	0.068	0.718	−194	0.302	0.068	0.718	−0.367	0.045[a]	−0.329	0.075
Inversion 30°/s	−0.365	0.047[a]	−0.347	0.059	−0.4	0.028[a]	−0.421	0.020[a]	−0.407	0.025[a]
Inversion 60°/s	−0.237	0.02	−0.287	0.123	−0.035	0.055	−0.392	0.032[a]	−0.367	0.045[a]
Eversion 30°/s	−0.284	0.127	−0.439	0.015[a]	−0.333	0.071	−0.351	0.046[a]	−0.41	0.024[a]
Eversion 60°/s	−0.091	0.63	−0.279	0.134	−0.273	0.143	−0.282	0.013[a]	−0.324	0.08
PT left side										
Dorsiflexion 30°/s	0.135	0.475	−0.224	0.234	−0.301	0.104	−0.373	0.041[a]	−0.208	0.131
Dorsiflexion 60°/s	0.114	0.547	−0.051	0.788	0.114	0.547	−0.423	0.019[a]	−0.248	0.184
Plantar flexion 30°/s	−0.178	0.344	−0.29	0.119	−0.426	0.018[a]	−0.373	0.041[a]	−0.406	0.025[a]
Plantar flexion 60°/s	−0.057	0.762	−0.224	0.233	−0.361	0.049[a]	−0.36	0.050[a]	−0.348	0.059
Inversion 30°/s	−0.362	0.048[a]	−495	0.005[a]	−0.531	0.002[a]	−0.633	<0.001[a]	−0.594	<0.001[a]
Inversion 60°/s	−0.477	0.007[a]	−0.405	0.026[a]	−546	0.001	−0.41	0.024[a]	−0.403	0.027[a]
Eversion 30°/s	−0.609	<0.001[a]	−0.633	<0.001	−0.581	<0.001[a]	−0.571	<0.001[a]	−0.627	<0.001[a]
Eversion 60°/s	−0.433	0.016[a]	−0.478	0.008[a]	−0.462	0.01	−0.478	0.002[a]	−0.048	0.801

RA, rheumatoid arthritis; PT, peak torque; VAS, visual analog scale for pain; HAQ, Health Assessment Questionnaire; ROM, range of motion; FFI, Foot Functional Index.
[a] *p* statistically significant.

group, the invertors were stronger than the evertors in both legs.

Studying normal subjects, some authors reported higher PT values for plantar flexion and dorsiflexion[22,23] than those observed in the present study for the control group, but the plantar flexor/dorsiflexor ratio was similar. Dorsiflexion PT values similar to those obtained here for the control group were reported by Hombäck et al. who used the same knee and hip angles, but with the subject in the sitting position,[19] whereas Suzuki et al. obtained lower values.[20] However, in all these studies cited, especially those evaluating plantar flexion, the subject was positioned with the knee extended. These variations in knee angle may have influenced the differences in dorsiflexor and plantar flexor PT observed between these studies and the present investigation. However we have to be cautious doing this comparison because the sample from these studies were very heterogeneous, for example Homback et al. studied young men and women,[19] Suzuki et al. studied elderly women[20] while Horstmann et al. studied sedentary men.[23]

Wennerberg evaluated dorsiflexion and plantar flexion in athletes using the same position technique used in the present study. On average, athletes presented higher dorsiflexion and plantar flexion PT than that observed among the control subjects. Analysis of the literature demonstrates that normal subjects have exhibited higher invertor and evertor PT than that observed in the control group of our study as well.[24] Studies involving normal subjects and athletes have confirmed that invertors are stronger than evertors.[23,25–27] Our patients with RA had more strength in the evertors than invertors of the right lower limb (dominant). This can be explained by the involvement of the subtalar joint in the dominant leg, which affects the invertor musculature. For both groups, the ankle invertors of the left leg (non-dominant) were stronger than the evertors.

No studies analyzing ankle isokinetic dynamometry in patients with RA have been available until now. Bröstrom et al. studied dorsiflexion and plantar flexion muscle strength in adolescents with polyarticular juvenile rheumatoid arthritis and healthy age-matched controls, using pronation with extension of the knees as the position for assessment. Concentric PT of the two movements was significantly lower in the arthritis group compared to the control group. Moreover, the plantar flexor musculature was stronger than the dorsiflexor musculature. The authors suggested that a decrease in muscle strength may affect functions in daily activities, such as gait, and reduce levels of physical activity, but they did not use any instrument to verify these correlations.[16]

The variations in PT values reported in different studies may be attributed to differences in positions, angular velocities and number of repetitions used for isokinetic dynamometry. We have to take into account too that RA patients have presence of inflammation, secondary osteoarthritis, limited ROM, involvement of multiple joints and all of these can influence the results in the isokinetic test. Standardization of the isokinetic testing method for patients with diseases that affect the ankle–foot complex, normal subjects and athletes is necessary for comparisons of such studies.

Muscle strength asymmetry for some movements, which did not necessarily coincide with lower limb dominance, was observed in both the RA and control groups. Most of the patients with RA and controls were right-footed, with no significant difference between groups. However, a significant difference was observed when comparing evertor PT, which was higher on the left side in the RA group at 30°/s. In the control group, plantar flexor PT was higher on the right at 30°/s. A study involving normal subjects with right lower limb dominance demonstrated significantly greater isometric plantar strength in this leg compared to the non-dominant (left) leg.[25] In the present study, we tested isokinetic PT, which does not appear to be related to limb dominance, i.e., muscle strength is the same, although a predominant involvement of one or the other side is observed in some patients, which is in agreement with some studies.[6,7,28,29]

In the present study, no significant difference in PTA was observed between the RA and control groups. Studying dorsiflexion and plantar flexion PTA in normal subjects, Horstmann et al. reported higher values than those observed in the present control group. However, torque acceleration time was significantly higher in the control group for all movements and angular velocities tested.[23] Thus, patients with RA require more time to reach PTA, which is the same as that of normal subjects, and once reached, PT is lower.

Muscle weakness next to an inflamed joint is the result of muscle inactivity, as atrophy has a direct effect on the patient's muscle strength.[30,31] Patients with RA treated with corticosteroids for long periods may present atrophy due to inactivity and the use of these drugs, which cause a reduction in the volume of type II muscle fibers.[32,33]

In the present study, most patients (76.6%) concomitantly used corticosteroids. As the number of patients who did not use these drugs was very low, no statistical analysis was possible. These findings agree with some studies that conducted isometric and isokinetic assessments of the joints of patients with RA or JRA and found that these patients in fact lose up to 75% of their muscle strength.[6,7,29]

We observed only weak to moderate correlations between PT and FFI scores. This suggests that extensive ankle strength is not necessarily required for good functional capacity. Maximum strength is not needed for the execution of daily activities. Specifically regarding the HAQ, no good correlations with the isokinetic ankle variables were observed. This was likely due to the fact that the HAQ is a global questionnaire that involves the joints of the entire body and activities for which other muscle groups of the lower and upper limbs are fundamental. It should be noted that involvement of the ankles and feet as well as limitations and disabilities resulting from the involvement of the knees and hips interfere with lower limb activities in patients with RA. This may explain the lack of satisfactory correlations between the isokinetic assessment and the questionnaires used.

In the present study, moderate and weak correlations were observed between PT and VAS scores at rest and during gait. These correlations may be explained by the muscle reflex inhibition mechanism, in which joint involvement causes a reduction in muscle activity with a consequent weakness of the muscle groups next to joint even in the absence of pain or in the presence of reduced pain.[34]

Although no important correlations between ankle muscle strength and functional disability were observed in the present study, some investigations have reported gait abnormalities in patients with some type of involvement of the ankle–foot complex as that observed in patients with RA. Such abnormalities include a reduction in the propulsion phase and gait velocity, an increase in the number of steps and a reduction in step length, events that markedly increase energy expenditure. Similar to the present study, Shih et al. also observed a decrease in ankle dorsiflexor and plantar flexor torque in traumatic arthritis and concluded that this alteration was responsible for the reduced propulsion phase of gait in patients.[4]

We observed significant differences in the ratio of the ankle dorsiflexor to plantar flexor musculature between the two groups. This finding suggests that the reduction of muscle strength observed in patients with RA is higher in the plantar flexors than dorsiflexors. In contrast, no significant differences were observed in the invertor to evertor ratios, demonstrating a proportional loss of muscle strength in the invertor and evertor musculature in RA. These findings suggest that both dorsiflexors and plantar flexors should be strengthened during ankle and foot rehabilitation of patients with RA, with special emphasis on the plantar flexor musculature and proportional strengthening of the invertor and evertor muscles.

One of the limitations of our study is that we do not evaluate the disease activity and the dosage of the medications used was not evaluated too and both of these parameters could influence our results.

We conclude that patients with RA perform worse in isokinetic dynamometry than control subjects regarding all ankle movements and similar isokinetic test results were observed for the right and left side in both groups, with few exceptions. Weak correlations were found between PT and foot function and pain. The isokinetic assessment caused no additional risk such as excessive pain or inflammatory activity in patients with RA.

Conflict of interest

The authors declare no conflicts of interest.

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