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Importance of the functional examination in lower extremities in patients with rheumatoid arthritis

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This paper deals with evaluation of the lower extremity efficiency and balance in rheumatoid arthritis (RA) patients. The authors' own test (LLFT-lower extremities functional test) and balance tests during normal standing and tandem positions with eyes opened or closed were used. Twelve patients with RA and fifteen controls for comparison were examined. Center feet of pressure dislocation on platform in normal standing with eyes open, normal standing with eyes closed, tandem left foot in front and tandem right foot in front positions and further dynamic balance tests on three different boards were analyzed. Visual Analogue Scale monitored the level of pain after each LLFT task. There was found a relation between the intensity of pain and overloading of joints in particular tasks, resulting in lower extremities dysfunction. A significant disbalance in medio-lateral direction during normal standing with eyes closed and tandem right foot in front positions and also in anterior-posterior direction in tandem right foot in front position during static balance tests was found. Correlations showed that patient's age, disease duration and Steinbrocker Functional Classes have an influence on parameters of balance tests. Results indicate that complex dysfunction of lower extremities causes disbalance of posture in static conditions.

Key words: *rheumatoid arthritis, lower extremities dysfunction, postural instability*

1. Introduction

Rheumatoid arthritis (RA) is a chronic disease characterized by joints inflammation, stiffness and pain. Disease process leads to cartilage damage and also to destructions and deformities of joints. First symptoms are manifested in small joints of hands and feet. Although changes in ankle and knee joints occur in latest period of disease, they cause deterioration of lower extremities efficiency and reduction in quality of life [1].

Few researchers have analyzed relation between lower extremity dysfunction and balance disturbances in RA group [2]–[5]. According to data from literature many factors may have impact on worsening static and dynamic balance [3], [6].

This study presents results of the lower extremity functional test with evaluation of the pain level which occurred after each task. Results of the static balance tests during normal standing and tandem positions with eyes opened or closed as well as dynamic tests performed on the balance platform are presented.

2. Materials and methods

2.1. Patients and study design

The research was conducted from November 2011 to April 2012 on Out-Patient Rehabilitation Ward of Department and Clinic of Physiotherapy, Rheumatol-

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ogy and Rehabilitation of Karol Marcinkowski University of Medical Sciences in Poznań. The study included 27 participants, 12 patients with rheumatoid arthritis (7 women and 5 men) and 15 control healthy subjects (11 women and 4 men). Mean (SD) age of patients was 54 (9.8) years (range from 33 to 69 years) and mean age to control participants was 50.7 (6.9 ± SD) years (range from 33 to 58 years). They approximately matched patients with an age. Mean duration of patients disease was 8.3 years (7.9 ± SD), range from 1 to 25 years. Group of patients was different regarding the disease advancement measured by DAS28-Disease Activity Score (remission – 2 patients, little or medium level – 7 patients, high disease activity – 3 patients). The joint destruction was evaluated with Steinbrocker Functional Class (2nd period – 4 individuals, 3rd period – 5 individuals, 4th period – 3 individuals). Participants with RA were included in the research group if they were moving without orthopedic equipment and could independently maintain a stable position. The criteria for exclusion were age above 70 years, replacement of lower extremity joints and coexistence of other diseases which may have negative impact on results. The criteria for exclusion were chronic and neurological diseases and degenerative joints of lower extremities. Healthy volunteers were recruited from the Hospital workers.

2.2. Clinical evaluation methods

Subjective examination included questions concerning age, duration of disease, pharmacological treatment, pain at rest, pain during movement and earlier episodes of swelling in lower extremity joints. Lower extremities function was evaluated using the authors' own test (LLFT-lower extremities functional test). This test included 5 tasks in which one could score up to 30 points (Table 1). The last task allowed measurements of each extremity activity expressed in percentages.

Pain occurrence in lower extremities after each task was measured by Visual Analogue Scale (VAS). The basic score evaluated the possibility to carry out the required activities. The supplementary score evaluated the possibility to apply additional loading for patients who independently performed squats (with or without hold by hands) and patients who raised a chair without hands assistance. Evaluation of body balance was performed in static and dynamic

Table 1. Lower extremities functional test (LLFT)

Test	Performance	Basic score	Additional load and % of both extremities activity	Supplementary score
I. Stairs ascending on second flour	Patient could not ascend	0		
	Patient ascended with assistance of 2nd person	1		
	Patient ascended but held on the banister or used orthopedic equipment	2		
	Patient ascended by side shuffle	3		
	Patient ascended with alternating step	4		
II. Stairs descending from second flour	Patient could not descend	0		
	Patient descend with assistance of 2nd person	1		
	Patient descended but held on the banister or used orthopedic equipment	2		
	Patient descended by side shuffle	3		
	Patient descended with alternating step	4		
III. Squats	Patient could not perform	0	Patient performed 1 squat	0
	Patient performed with assistance of 2nd person	1	Patient performed 2–4 squats	1
	Patient performed with hold by hands	2	Patient performed 5–8 squats	2
	Patient performed with hold by hand	3	Patient performed 9 squats	3
	Patient performed independently	4		
IV. Rising from chair	Patient could not rise from a chair	0	Patients performed 1 repetition	0
	Patient rose with assistance of other person	1	Patient performed 2 repetitions	1
	Patient rose with hold by hands	2	Patient performed 3–4 repetitions	2
	Patient rose with hold by hand	3	Patient performed 5 repetitions	3
	Patient rose independently	4		
V. Riding on the rotor	Patient drove < 0.4 km	0	Load of extremitys < 42%–58% >	0
	Patient drove 0.6–0.4 km	1	Load of extremitys 42%–58%	1
	Patient drove 0.9–0.7 km	2	Load of extremitys 44%–56%	2
	Patient drove 1.2–1 km	3	Load of extremitys 46%–54 %	3
	Patient drove > 1.2 km	4	Load of extremitys 48%–52%	4

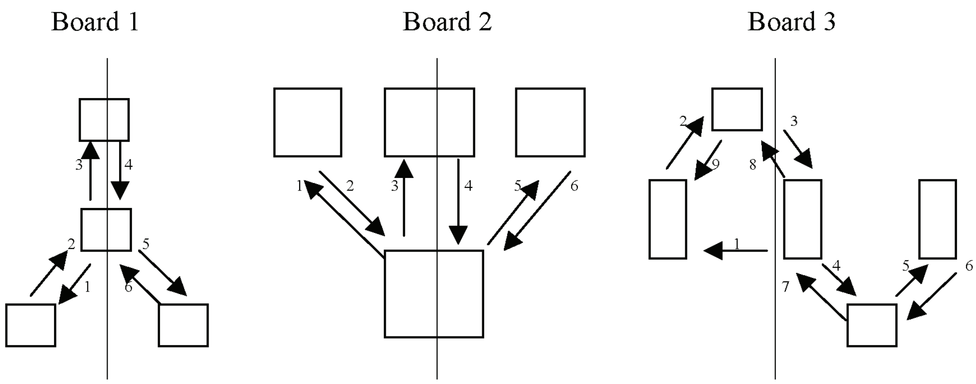

Fig. 1. Boards (variants to COP displacement) used during dynamic tests.
Numbers indicate vectors of the body displacements

conditions on balance platform. Evaluation of percentage weight-bearing symmetry of lower extremities was a supplementary score for rotor riding.

The postural balance tests were performed on the Metitur God Balance platform. Standing balance tests were carried out in normal standing positions with eyes open (NS EO) and eyes closed (NS EC) and in tandem with left foot in front (LF) and in tandem with right foot in front (RF) positions. Measurements in normal standing positions were performed for 30 s in an upright position with feet placed in parallel 20 cm apart. Tandem tests lasted 20 s, alternately left or right foot was put to the front with a line dividing platform to two parts tangent to the medial edge of feet. Participants were asked to maintain the motionless position. Static balance measurements included the average center of feet pressure (COP) sway velocity in millimeters per second in frontal (X, mm/s) and saggital (Y, mm/s) planes. The value of the middle of spectrum in millimeters (mm) in the same planes was also analyzed.

The dynamic test on balance platform was performed on 3 boards (including paths), with the same sensitivity of platform for all "paths". Each board showed different "paths" to displacement of center of feet pressure (Fig. 1). The subject's position during dynamic tests was identical as in normal standing tests. Before measuring the participants were acquainted with the methodology of tests by performing training on each board. The study was based on the principle of biofeedback. Participants could observe certain position of the center of feet pressure (COP). It was visualized as a cursor on recorder's screen and the tasks were to achieve the targets that successively occurred on the screen during displacement of the body. Before investigation volunteers were informed that velocity (time) and accuracy (distance) were equally important in the tests performed.

2.3. Statistical analysis

For evaluation of differences between results obtained during static and dynamic balance tests in RA patients and a control group of healthy volunteers the non-parametric U-Mann–Whitney test for independent variables was used. The value $P < 0.05$ was accepted as statistically significant. Non-parametrical Spearman's rank correlation coefficient (r_s) was used to demonstrate correlations between results obtained in tests performed on balance platform and Steinbrocker Functional Class and DAS 28 results. Linear Pearson's coefficient (r) was used to demonstrate correlations between age and disease duration and the outcomes of static and dynamic balance tests. Level of $P < 0.05$ has been assumed as statistically significant for both correlation tests.

3. Results

Data on pain evaluation at rest, pain during movement and swelling obtained from the subjective part of clinical examination are presented in Table 2.

The greatest pain in lower extremity joints was induced by squats, while the lowest level of pain was measured after riding on the rotor. Few patients might not perform tasks with additional loading (Table 3).

During the static balance tests in frontal plane (X) the average COP sway velocities in tandem RF position and the value of middle of spectrum in normal standing EC position differed significantly from values obtained in healthy volunteers. In sagittal plane (Y) the only significant difference detected between patients and healthy group was the parameter of middle of spectrum measured in tandem RF position (Table 4).

Table 2. Scores of pain at rest, pain during movement and swelling in lower extremities joints in RA patients

	Hip joint		Knee joint		Ankle joint		Metatarsophalangeal I joint	
	left	right	left	right	left	right	left	right
Pain at rest	2	2	2	3	3	3	1	1
Pain during movement	4	3	4	6	6	5	2	2
Swelling	–	–	1	4	4	3	–	–
Total	6	5	7	13	13	11	3	3

Table 3. Scores obtained in each tasks of lower extremity functional test by RA patients and average pain score reported after tasks

Task	0 points	1 point	2 points	3 points	4 points	Average pain
	n					mean value (SD)
Stair ascending	0	0	3	0	9	40 (27)
Stair descending	0	0	2	0	10	43 (31)
Squat	0	0	1	1	10	47 (30)
Squats (0–9)	4	0	0	0	8	
Rising from a chair	0	0	1	0	11	32 (23)
Rising from a chair (0–5)	3	0	0	0	9	
Rotor of the lower extremity-distance	1	0	1	2	8	31 (19)
Rotor of the lower extremity-load	3	2	1	1	5	

Table 4. Comparison of the mean center of feet pressure (COP) sway velocity values (mm/s) and middle of spectrum (mm) in medio-lateral (*X*) and anterior-posterior (*Y*) directions in RA group and control group

Position	Control group (n = 15) mean value (SD)		RA group (n = 12) mean value (SD)	
	X (mm/s)	*Y* (mm/s)	*X* (mm/s)	*Y* (mm/s)
Normal standing EO	2.6 (1.2)	5.3 (1.8)	3.2 (1.3)	6.2 (2.5)
Normal standing EC	3.3 (1.2)	8.2 (2.8)	4.7 (2.2)	12.6 (8.2)
Tandem LP	11.4 (2.6)	10.1 (2.3)	13.4 (5.8)	13.5 (6.4)
Tandem PP	11.4 (2.7)*	10.9 (3.2)	14.4 (5.2)*	13.3 (5.9)
	Spectrum: *X* (mm)	Spectrum: *Y* (mm)	Spectrum: *X* (mm)	Spectrum: *Y* (mm)
Normal standing EO	0.086 (0.025)	0.327 (0.046)	0.112 (0.059)	0.351 (0.052)
Normal standing EC	0.104 (0.067)*	0.395 (0.072)	0.143 (0.060)*	0.466 (0.129)
Tandem LP	0.360 (0.067)	0.382 (0.083)	0.447 (0.177)	0.474 (0.185)
Tandem PP	0.367 (0.083)	0.377 (0.085)*	0.429 (0.134)	0.464 (0.107)*

*Level of statistical significance at $P < 0.05$.

Table 5. Comparison of results obtained during dynamic balance tests on three boards in RA group and control group

Parameter	Control group (n = 15) mean value (SD)			RA group (n = 12) mean value (SD)		
	Board 1	Board 2	Board 3	Board 1	Board 2	Board 3
Time of task	18.76 (7.62)	15.33 (4.42)	18.24 (3.50)	22.74 (7.88)	18.34 (6.78)	21.06 (4.02)
Distance	834.7 (282.0)	1150.6 (457.8)	1164.7 (406.6)	981.4 (302.8)	1099.2 (252.5)	1187.5 (335.6)
Distance: a-p	534.5 (180.3)	784.1 (276.9)	699.0 (232.0)	568 (139.2)	764.8 (200.6)	703.9 (190.1)
Distance: m-l	491.8 (171.0)	699.0 (361.8)	760.1 (295.6)	632.7 (272.6)	619.3 (127.1)	782.0 (265.9)

* Level of statistical significance at $P < 0.05$.

No significant differences in values of measured parameters were found during dynamic tests in both groups of subjects (Table 5).

In this study, there were found significant correlations at $P < 0.05$ between the patients age and the average COP sway velocities and between patients age and values of middle of spectrum as well as between the disease duration and the average COP sway velocities. They were detected only for tandem (LF and RF) position in medio-lateral direction (Table 6). However results of Disease Activity Score (DAS 28) and Steinbrocker Functional Class did not correlate with the results of static balance tests.

Correlations between the time of task performed and patients age (on boards 2 and 3), the time of task performed and disease duration (on boards 1 and 3), the time of task performed and Steinbrocker Functional Class score (on boards 1 and 2) during the dynamic balance tests were significant at $P < 0.05$. These results are presented in Table 7.

4. Discussion

The LLF test was used to evaluate functional ability of the lower extremities and also to assess the intensity of pain which occurred after each task. Deficiency of maximum results in tests demonstrates limitation of function of the lower extremities. Patients sensed higher intensity of pain after stair descend than ascend. Higher risk of muscle

Table 6. Linear Pearson's correlations coefficients (*r*) and levels of statistical significance between age and disease's duration and the average COP sway velocities and middle of spectrum in saggital (*X*) and frontal (*Y*) planes

Position	RA group (n = 12)							
	r	$P < 0.05$*	*r*	$P < 0.05$*	*r*	$P < 0.05$*	*r*	$P < 0.05$*
	Age				Disease's duration			
	X (mm/s)		*Y* (mm/s)		*X* (mm/s)		*Y* (mm/s)	
NS EO	0.242	0.449	0.412	0.183	0.125	0.699	0.252	0.429
NS EC	0.143	0.658	0.418	0.177	–0.127	0.694	0.207	0.518
Tandem LP	0.775*	0.003*	0.350	0.265	0.680*	0.015*	0.353	0.260
Tandem PP	0.651*	0.022*	0.425	0.168	0.590*	0.044*	0.435	0.157
	Spectrum: *X* (mm)		Spectrum: *Y* (mm)		Spectrum: *X* (mm)		Spectrum: *Y* (mm)	
NS EO	0.249	0.436	0.404	0.192	0.545	0.067	–0.292	0.357
NS EC	0.296	0.351	0.387	0.214	0.190	0.555	0.183	0.569
Tandem LP	0.737*	0.006*	0.431	0.162	0.409	0.187	0.385	0.217
Tandem PP	0.645*	0.024*	0.573	0.052	0.535	0.073	0.508	0.092

Table 7. Linear Pearson's correlations coefficients (*r*) and levels of statistical significance between results obtained during dynamic balance tests as well as age and disease's duration and also Spearman's rank correlation coefficients (r_s) and levels of statistical significance between results obtained during dynamic balance tests and Steinbrocker Functional Class (SFC) and DAS28

	RA group (n = 12)							
	r	$P < 0.05$*	*r*	$P < 0.05$*	r_s	$P < 0.05$*	r_s	$P < 0.05$*
	Age		Disease's duration		SFC		DAS 28	
	Board 1		Board 1		Board 1		Board 1	
Time of task	0.422	0.172	0.745*	0.005*	0.846*	0.000*	0.042	0.897
Distance	0.044	0.891	0.062	0.849	–0.197	0.539	–0.119	0.713
Distance: a-p	0.303	0.338	0.334	0.288	–0.104	0.747	–0.322	0.308
Distance: m-l	–0.065	0.842	–0.100	0.768	–0.127	0.695	–0.035	0.914
	Board 2		Board 2		Board 2		Board 2	
Time of task	0.660*	0.019*	0.486	0.109	0.596*	0.041*	0.154	0.633
Distance	0.501	0.097	0.450	0.142	0.015	0.963	0.231	0.471
Distance: a-p	0.459	0.133	0.462	0.131	0.045	0.890	0.343	0.276
Distance: m-l	0.534	0.074	0.454	0.138	0.242	0.448	0.126	0.697
	Board 3		Board 3		Board 3		Board 3	
Time of task	0.603*	0.038*	0.591*	0.043*	0.183	0.570	0.077	0.812
Distance	–0.179	0.579	-0.048	0.883	–0.257	0.420	0.161	0.618
Distance: a-p	–0.009	0.997	0.205	0.524	–0.231	0.470	0.308	0.331
Distance: m-l	–0.283	0.372	–0.164	0.610	–0.291	0.360	0.154	0.633

fatigue or strains during stair descend may result from longer loading period and eccentric muscles contractions required in lower extremity for this activity [7].

The tests such as rising from a chair and squats brought similar information about lower extremity dysfunction in RA group, however, the highest level of pain was reported after having carried out the squats. The lowest level of pain appeared after riding the rotor. It is noteworthy that this was the only test performed in unloading conditions. This observation indicates significant dependence between the level of pain and degree of joints loading coming from the muscle weakness. Therefore, tests used in the study which evaluated the pain intensity in response to the degree of joint loadings can be used in monitoring the rehabilitation process and indirectly in evaluation of the degree of joint destruction.

Weakness of the lower extremities muscles, especially the quadriceps muscles, has already been observed in patients with RA [8]–[10]. Muscle weakness has a complex character and can arise from several causes. Because of pain, inflammation and damage of joints, patients normal activities are impeded, because they avoid movement. The result of it is a muscle weakness as a consequence of disuse atrophy [8]. Another reason may be incomplete voluntary activation of muscles crossing inflamed, painful or damaged joints which have been reported following osteoarthritis [11], [12]. The quadriceps weakness and reduced proprioceptive activity in patients with knee osteoarthritis may result from reduced motoneurones excitability which in turn results in decreased voluntary quadriceps activation [12]. In RA patients with sensorimotor deficits of quadriceps muscles there exists the lower extremity disability [8]. Additionally, the RA patients have been observed with weakness of the muscles antagonistically acting on the knee joint [10], [13].

During static balance tests in both groups of subjects the average value of COP sway velocities obtained in normal standing position with eyes closed were higher than in normal standing position with eyes open. Tjon et al. observed that stability was deteriorated substantially more in RA than control group when deprived of visual information. This was associated with the degree of knee destruction and may arise from impaired sensory feedback from the lower extremities [5]. Another study has demonstrated a significantly larger COP excursion in sagittal plane during the eyes open and closed tasks suggesting the impeded postural control mechanisms by the ankle strategy in RA patients [4]. There are not many studies which demonstrate the impact of factors which are directly or indirectly associated with rheumatoid arthritis influencing balance dysfunction [3], [6]. In RA patients the postural control in normal standing position (looking straight ahead) is highly related not only to sex and age but also to isokinetic endurance and to anxiety. On the other hand, the abnormal level of C-reactive protein and decreased joint mobility which are characteristic of the RA disease have little impact on the postural control [3].

Significant changes (the average of COP sway velocities in frontal plane and the value of middle spectrum in sagittal plane) obtained in tandem RF position during static balance condition could result from more frequent occurrence of left ankle joint dysfunction in RA patients. The left ankle joint during the measurements in tandem RF position was more loaded, so this may explain the higher displacement of COP. Joint effusion which occurs in the course of rheumatoid arthritis causes destruction of the cartilage and distends ligaments and capsules and additionally causes destruction and insufficiency of the medial and lateral ankle tendons [14].

Dynamic tests were performed to complement the evaluation of balance in our study. Aydoğ et al. searched for relation between the results of dynamic balance tests and characteristics of the RA disease such as Disease Activity Score, Health Assessment Questionnaire (HAQ) and Steinbrocker Functional Class [6]. The authors showed that HAQ influences dynamic balance more than disease activity. They also demonstrated that the age and BMI in RA patients and healthy controls were the most important factors influencing the postural dynamic balance. Our findings of dynamic balance tests were not significantly different in RA group in comparison to healthy volunteers. This may result from many factors such as limited ability of participants to learn, fatigue, level of pain, limitation of the range of motion and lack of attention. In our opinion the main factor was a short time for the contact of damaged articular surfaces resulting from constantly joint movements (mainly at ankle joints). It did not significantly disturb afferent impulses from proprioceptors of damaged joint structures as is the case of static balance tests lasting 20 to 30 seconds. Taking into consideration the results of static and dynamic balance tests we suppose that time is a decisive factor influencing the disclosure of balance dysfunction. It is worth emphasizing that results of the lower extremities tests also indicate the dependence on the intensity of pain and correctly performed functional tests since time in which they were carried out (the number of repetitions of squats and rising from chair). In patients with RA the dynamic tests on balance platform have not been commonly used. The study indicates that RA has a negative effect on dynamic postural stability [6]. These results are disputable with our observations.

We found a significant correlation between the age and some parameters of the static balance tests (see Table 6). The increase of body sway in some positions may be explained by disturbances in postural stability which is detected from the fourth decade onwards [15]. However, in balance tests during dynamic conditions there were detected correlations (on some boards) between time of the tasks performed both with age, disease duration and Steinbrocker Functional Class. Perhaps there occur greater dysfunctions of some balance components and impairments of locomotor system in RA patients with increasing age and disease duration. Maybe this leads to the development of poorer movement skill, which is normally associated with old age indexed by reduced speed and accuracy of movement [16]. An indirect proof of its occurrence is slower mean walking velocity manifested by the RA patients in comparison to the healthy group of subjects what was shown in other research [4], [17].

The limit of the present research is the relatively small number of patients with rheumatoid arthritis and large diversity of the degree of structural damage in knee joints. In this aspect our findings should be interpreted as a preliminary report. Moreover, after carrying out the study and analysis of results we consider that positions during tests on balance platform, especially in tandem arrangement should be modified. The reduction supporting quadrilateral is more likely to show a static balance dysfunction in RA patients, so tandem position with one foot directly in front of the other foot is recommended. Additionally, focusing the dynamic test on velocity (time) or accuracy (distance) will make it more precise and the results more objective.

Ogrodzka et al. [18] showed that degenerative knee joint disease disturbed the gait stereotype. We observed that patients with RA presented also abnormalities in performance of LLTE tasks. Additionally, RA located in knee joints disturbed a balance control, which may bring the effect of frequent patients' falls.

Although RA regards mainly tiny joints of the hand, this process also involves a range of large joints of lower extremities. Taking into account the locomotor disability prevention, the important issue seems to be introducing a standardized functional assessment protocol for lower extremities with particular emphasis on the influence of inflammation on the postural control and movement coordination. This paper provides the diagnostic model of functional and postural tests which have not been presented in the literature yet.

Summarizing, the evaluation of the lower extremities function in RA patients should be based on analysis of the results from both functional and postural tests. Because pain is the main clinical symptom in RA, the tests used to evaluate function of the lower extremity should be characterized by different level of difficultly. This assumption can be realized by modification of the units of load, the number of repetitions and/or duration of the test. Both the results of this study and other authors' observations indicate occurrence of balance disturbance in patients with RA. Therefore we think that the balance tests should be the permanent part of monitoring the rehabilitation process.

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