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ORIGINAL REPORT

IMPAIRED POSTURAL CONTROL IS ASSOCIATED WITH WORSE SCORES ON THE HEALTH ASSESSMENT QUESTIONNAIRE DISABILITY INDEX AMONG WOMEN WITH RHEUMATOID ARTHRITIS

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Objective: **To explore the relationship between functional status and different domains of postural control, and to make recommendations about the use of postural control tests in clinical practice among women with rheumatoid arthritis.**
Subjects: **A total of 91 women with rheumatoid arthritis and 110 controls. The patients were grouped according to the total score of the Health Assessment Questionnaire (HAQ): HAQ1 = 0 (good, *n* = 21); HAQ2 = 0.1 to < 1 (impaired, *n* = 44); HAQ3 = 1–3 (severely impaired, *n* = 26).**
Methods: **Postural control tests: timed one-leg stance test (OLST), timed up and go test (TUG), and posturography tests on a force-plate.**
Results: **A poorer performance in the OLST and TUG tests was associated with higher, i.e. worse, HAQ scores. The results of the force-plate measurements were more complex. The results for healthy controls provided some clarifying information, but did not alter the main results.**
Conclusion: **It is recommended that both OLST and TUG tests are included in the postural control assessment design for patients with arthritis. It seems that the force-plate measurements are not as good for screening postural control impairments associated with functional disability, but they may still have their use in, for example, monitoring the effect of intervention or rehabilitation.**

Key words: balance; functional disability; motor control; rheumatoid arthritis.

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INTRODUCTION

Impairments such as limited joint mobility, decreased muscle strength, and reduced oxygen uptake are well documented in patients with chronic rheumatoid arthritis (RA) (1). RA often results in reduced work capacity and permanent work disability, and thus has expensive consequences for society (2). Maintenance or restoration of functional capacity is a major goal of therapy.

The Health Assessment Questionnaire (HAQ) (3) and its modified versions have been used widely to evaluate disability in daily activities, i.e. functional status (4). HAQ has been related to permanent work disability (5), with improvement in HAQ scores associated with an increase in employment (6). A HAQ score ≥ 1 has been found to be a significant independent risk factor for cumulative work disability and for RA-related disability pension (7). In a study by Puolakka et al. (8) the loss of productivity (including RA-related work disability and sick leave) was calculated over a 5-year follow-up in a cohort of patients with recent-onset RA. HAQ at 6 months was linked to the International Classification of Functioning, Disability and health (ICF) components to explore which are the best predictors for loss of productivity. Interestingly, of the items in the HAQ, only the group of questions linked to the ICF subcategory "changing and maintaining body position" was independently associated with loss of productivity.

A significant relationship between HAQ and performance in postural control tests among patients with RA would seem logical. The results concerning this association have, however, been contradictory. The failure of the static double-leg stance test to find any significant correlations between, for example, HAQ and the posturographic variables may indicate that this test does not place sufficient demands upon the integrated systems of standing balance (9, 10). The attempt to evaluate associations between HAQ and the more demanding one-leg stance test was hampered by the fact that more than 60% of the patients with RA failed to perform the test for 30 s (9). Aydog et al. (11) found a significant association between HAQ and impaired postural control in a more "stable" test on a movable balance platform, but not in a more "unstable" test. Many of the patients with RA failed to complete the latter test, which disturbed postural stability to a greater extent.

Postural control is reported to be "a very complex entity that must be measured across different domains and cannot be reflected by any one single measure" (12). Postural control can be assessed under either static or dynamic conditions. Dynamic tests assess postural control during voluntary execution of a movement, such as walking or rising from a chair. Static tests

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assess the ability to maintain an upright position in various situations, such as with the eyes closed or with expected or unexpected perturbance. The tests may also represent different domains of postural control: functional, physiological, and/or the central nervous system integration of visual, vestibular and somatosensory information with final motor output demonstrated by the movement of the centre of force (13).

Norén et al. (14) suggest that, when assessing postural control in patients with RA, a range of different clinical postural control tests are needed. When selecting the test battery the functional status of the subjects should be taken into consideration in order to minimize the number of subjects failing to perform the test.

The main purpose of the present study was to explore, among women with RA, the relationship between HAQ score and the performance in tests assessing different domains of postural control, and to make recommendations for the use of different postural control tests in clinical work. In addition, the relationship between HAQ score and other assembled data (e.g. pain, psychological distress, muscle strength, and cervical radiographs) was evaluated.

METHODS

Subjects

A total of 91 women, who were inpatient-treated or rehabilitated because of RA in the Rheumatism Foundation Hospital (Heinola, Finland), participated in the study (mean age 47 years). The exclusion criteria were: age less than 20 years or more than 60 years; total dependence in daily activities; poor balance because of some specific disease (e.g. vestibular); severe low-back pain or sciatica during the past year; severe injury to lower extremities (e.g. bone fracture, ligament rupture) requiring surgery or cast-treatment during the past 5 years, or such injury earlier but still affecting daily activities; and β-blocker medication. With the same exclusion criteria, 110 women without RA participated as controls (mean age 41 years). These subjects included white- and blue-collar workers from the hospital staff (excluding physiotherapists) and their families and friends, as well as participants from inpatient functional restoration courses. All subjects gave informed consent. The study was approved by the local ethics committee.

Questionnaires

Functional status in activities of daily living was assessed by the Finnish version of the HAQ (15). The HAQ includes 20 questions in 8 subdimensions: dressing and grooming, getting up, eating, walking, hygiene, reach, grip, and common daily activities. The response alternatives were: 0, able without any difficulty; 1, able with some difficulty; 2, able with much difficulty; and 3, unable. The highest response within each subdimension was used as a score for that function. For the total HAQ score, the sum of the highest responses in each subdimension was divided by 8 to form a score with the range 0–3. The patients were grouped according to the total HAQ score: HAQ1 = 0 (good functional status, n = 21); HAQ2 = 0.1 to < 1 (impaired functional status, n = 44); HAQ3 = 1–3 (severely impaired functional status, n = 26).

The patients also completed a questionnaire including visual analogue scales (VAS, 0–100 mm) for pain intensity, self-rated general health, and self-rated postural balance. Rimon's Brief Depression Scale (RBDS) (16) was used to screen for psychological distress (> 6 points indicates psychological distress).

Clinical examination

Physicians performed the clinical examinations and went through the patient records. The recorded data included: presence of swollen or tender joints in the lower extremities or cervical pain at the time of inspection; erythrocyte sedimentation rate (ESR); duration of the disease; and the presence of rheumatoid factor.

Cervical radiography

Lateral-view cervical spine radiographs during flexion and extension were taken using a 150 cm tube-to-plane distance. A diagnosis of anterior atlantoaxial subluxation (AAS) was made if the distance between the anterior aspect of the dens and the posterior aspect of the anterior arch of the atlas was > 3 mm. Atlantoaxial impaction (AAI) was diagnosed using the Sakaguchi-Kauppi method, which has been developed in particular for screening purposes and evaluates the position of the atlas in relation to the axis (17).

Muscle strength

Maximal grip strength (kg) of both hands was measured with a Digitest Force® dynamometer (Newtest Oy, Oulu, Finland). The best result out of 3 attempts was recorded (18). Maximal isometric extension and flexion strength (N) of the knee joint of both legs was measured after 1 practice trial with a Lido® device (Lido Multijoint II, Loredan Biomedical Inc., West Sacramento, CA, USA). Muscle strength of the worse performing limb was used in the analysis (19).

Aerobic capacity

A submaximal bicycle ergometer test (T-Ware®, Tunturi Oy Ltd, Turku, Finland) was used to estimate the maximum oxygen uptake (VO_2max; ml/kg/min) (20).

Postural control tests

The tests used have been reported to be reliable (14). They were selected to represent different domains of postural control (13). During inpatient rehabilitation, the patients with RA did not specifically train in tasks similar to these tests and they did not use the posturography device other than for the purpose of this study. Specifications for the test procedures are described in Appendix I.

Timed up and go test. The timed up and go test (TUG) includes a timed (s) sequence consisting of rising from an armchair, walking 3 m, turning, walking back, and sitting down (21).

Timed one-leg stance test. In the timed one-leg stance test (OLST) the subject was standing on one leg (first the right leg and then the left) with the other slightly flexed from hip and knee, and arms hanging freely beside the body. The goal was to balance on one leg for 60 s. Healthy adults should be able to balance on one leg with their eyes open for 30 s (22, 23). In the present study the results were grouped: good balance (OLST ³ 30 s), impaired balance (OLST < 30 s). The results were analysed separately for the better and worse performing legs; the "worse" leg being the one on which the subject managed to stand for less time.

Posturography. Posturography is used to record the forces actuated by the subject's feet on the supporting surface (24). In the present study, posturography measurements were performed using the In Good Balance® force-plate device (Metitur Ltd, Jyväskylä, Finland).

The test procedure was as follows: double-leg stance test, eyes open; double-leg stance test, eyes closed; single-leg stance test, eyes open (the result was analysed separately for the better and worse performing legs; the "worse" leg being the one with higher velocity moment); dynamic test.

The following parameters were measured: velocity moment (mm^2/s), calculated as the mean area covered by the movement of the centre of force during each second of the test, taking into account both the distance from the geometrical midpoint of the whole test and the speed of movement during the same period; the time needed for completion of the dynamic test (in seconds).

Statistical methods

Values are reported as means (standard deviation, SD) or medians (with interquartile range, IQR). The statistical significance between the groups was evaluated by analysis of variance (ANOVA), Kruskal-Wallis test (Monte Carlo p-value) or Fisher-Freeman-Halton test. The hypothesis of linearity was evaluated by analysis of covariance (ANCOVA) or ordered logistic regression analysis.

RESULTS

Demographic and clinical characteristics

Impaired functional status was associated with more pain, poorer self-rated general health, worse self-rated balance, a higher frequency of psychological distress, higher frequencies of hip and knee pain, radiographic abnormalities in the cervical spine, as well as decreased muscle strength (Table I).

Postural control

In order to obtain more perspective in the postural control test results, the performance of the women with RA in the 3 HAQ groups was compared with that of healthy controls. A significant difference was found between the patients with RA and controls in age (47 years vs 41 years, $p<0.001$) and height (163 cm vs 165 cm, $p<0.001$). Thus, the postural control analyses were adjusted by age and height.

Table II shows that impaired functional status was linearly associated with poorer performance in both the OLST and TUG tests. Localized analyses showed that, in the OLST test, the HAQ3 group performed significantly worse than the HAQ1 group (better leg, $p=0.02$; worse leg, $p=0.017$), and all HAQ groups performed statistically significantly worse than the controls (p = value varied from 0.023 to <0.001). Localized analyses of the TUG test showed that patients in the HAQ3 group performed statistically significantly worse in the test than those in the HAQ1 or HAQ2 groups, and all HAQ groups performed worse than the controls ($p=0.001$).

In the force-plate measurements a significant association was found between HAQ scores and double-leg stance (eyes open). Interestingly, the control group did not differ statistically significantly from any of the HAQ groups. In the single-leg stance test on the force-plate the number of subjects failing to stand on the worse leg for the required 10 s was significantly higher in the HAQ3 group than in the HAQ1 or HAQ2 groups. Because of this high number of failures (drop-outs) the posturographic results for the single-leg stance on the worse leg were not analysed. In the test performed on the better leg, localized analyses showed that patients in the HAQ3 group performed significantly worse than the controls ($p<0.001$). In the dynamic test all HAQ groups performed significantly worse than the controls ($p=0.039$).

Table I. *Demographic and clinical characteristics of the subjects with rheumatoid arthritis*

Variables	HAQ1 $n=21$	HAQ2 $n=44$	HAQ3 $n=26$	p-value
Age, years, mean (SD)	47 (9)	48 (8)	47 (10)	0.85
Height, cm, mean (SD)	164 (7)	163 (6)	161 (5)	0.19
Weight, kg, mean (SD	69 (13)	71 (13)	68 (11)	0.58
Pain (VAS), mm, median (IQR)	15 (5, 22)	24 (8, 36)	49 (17, 61)	0.002
Self-rated general health (VAS), mm, median (IQR)	30 (14, 45)	30 (14, 45)	45 (29, 57)	0.02
Self-rated balance (VAS), mm, median (IQR)	3 (1, 6)	10 (2, 23)	18 (10, 42)	0.01
Duration of disease, years, median (IQR)	2 (1, 6)	2 (1, 5)	14 (1, 20)	0.009
ESR, mm/h, median (IQR)	7 (5, 14)	14 (5, 25)	21 (10, 28)	0.078
Swollen joints in the lower extremities present, *n* (%)				
Knee	0 (0)	7 (16)	3 (12)	0.18
Ankle	1 (5)	4 (9)	6 (23)	0.16
Foot	1 (5)	8 (18)	1 (4)	0.17
Tender joints in the lower extremities present, *n* (%)				
Hip	1 (5)	5 (11)	8 (31)	0.033
Knee	1 (5)	17 (39)	8 (31)	0.012
Ankle	3 (14)	14 (32)	8 (31)	0.32
Foot	10 (48)	21 (48)	10 (38)	0.74
Cervical pain	1 (5)	10 (23)	8 (31)	0.065
AAS present, *n* (%)	1 (5)	6 (15)	8 (32)	0.043
AAI present, *n* (%)	0 (0)	1 (2)	6 (25)	0.002
Physical performance				
Knee extension isometric strength[a], *n*, mean (SD)	127 (45)	115 (26)	93 (30)	0.002
Knee flexion isometric strength[b], *n*, mean (SD)	62 (20)	54 (12)	44 (15)	<0.001
Grip strength[a], kg, mean (SD)	27 (6)	21 (9)	13 (6)	<0.001
VO_2max, ml/kg/min, mean (SD)	28.6 (6.3)	30.6 (4.9)	27.8 (6.1)	0.70
Psychological distress present, *n* (%)	6 (29)	10 (23)	14 (54)	0.029

[a]The worse performing limb.

VAS: visual analogue scale; IQR: interquartile range; ESR: erythrocyte sedimentation rate; AAS: anterior atlantoaxial subluxation; AAI: atlantoaxial impaction; SD: standard deviation.

Table II. *Performance of the women with rheumatoid arthritis and the controls in the postural control tests.* p*-value for linearity is shown for the differences between the Health Assessment Questionnaire (HAQ) groups*

Variables	HAQ1 $n=21$	HAQ2 $n=44$	HAQ3 $n=26$	p-value for linearity[a]	Controls $n=110$
OLST test, n (%)					
Worse performing leg ≥30 s	15 (71)	20 (45)	8 (31)	0.002	108 (98)
Better performing leg ≥30 s	19 (90)	34 (77)	15 (58)	0.011	110 (100)
TUG test, s, mean (SD)	6.8 (1.1)	7.0 (0.9)	8.2 (1.5)	<0.001	5.4 (0.8)
Force-plate measurements					
Double-leg, eyes open, mm^2/s, mean (SD)	5.8 (3.7)	6.6 (2.8)	10.3 (8.3)	<0.001	8.2 (5.0)
Double-leg, eyes closed, mm^2/s, mean (SD)	16.3 (19.0)	13.2 (12.1)	15.9 (10.8)	0.89	10.7 (7.4)
Single-leg, better leg, mm^2/s, mean (SD)	60.8 (25.4)	56.9 (29.3)	75.5 (53.1)	0.053	45.7 (18.1)
Failed on worse leg, n (%)	1 (5)	5 (11)	8 (31)	0.049	0 (0)
Dynamic test, s, mean (SD)	27.7 (7.2)	27.2 (7.5)	27.7 (8.2)	0.85	22.9 (5.9)

[a]Adjusted for age, height.
OLST: one-leg stance test; TUG: timed up and go test.

DISCUSSION

A significant association was found between high, i.e. worse, HAQ score (especially scores ≥1, i.e. HAQ3 group with severely impaired functional status), and poorer performance in the OLST and TUG tests, thus underlining the functional element of these tests. The results for the force-plate measurements were more complex.

It has been suggested previously that more than one test is needed for the evaluation of postural control of patients with RA, and that the tests should be selected with care, taking into consideration the functional status of the patients, in order to minimize drop-outs (14). The somewhat contradictory results in previous studies (9–11) may be because the tests have been either too simple to show the relationship with functional status, or too difficult, resulting in a high number of drop-outs. In the present study only the single-leg stance on the force-plate on the worse leg seemed to be "too difficult". The OLST and TUG tests have previously been used mainly among elderly people, but the present study shows the usefulness of these tests also among "younger" patients with RA.

The results from some previous studies suggest that adults should be able to balance on one leg (OLST test) with their eyes open for at least 30 s (22, 23). This is in accordance with the results of the present study. In a prospective study 50% of patients with RA reported falls during a 1-year period (25). Low OLST scores proved to be a significant risk factor for falls: the mean value for the "fall" group was 18 s and for the "no-fall" group 44 s. In the present study the proportion of subjects failing to stand for 30 s (in the OLST test) or even 10 s (in posturography) was remarkably high, especially in the group with HAQ scores ≥1. We suggest that the focus should be on improving postural control if the result of the OLST test is less than 30 s.

The TUG test has, in previous studies, correlated significantly with, e.g. the patient's ability to go outside alone safely, and with risk of falls among elderly people (21, 26, 27). Normal performance for adults in the TUG test is suggested to be less than 8 s (27). In the present study only those patients with the most impaired functional status (HAQ3), on average, took more than 8 s. We suggest that the focus should be on improving postural control, at least, if the result of the TUG test is more than 8 s among patients with RA.

The only significant association between HAQ scores and the posturographic force-plate measurements was found in the double-leg stance, eyes open measure. However, none of the HAQ groups differed statistically significantly from the controls. This may be due to the high biological inter-individual variation of the measure. It seems that this method is not useful as a screening test for impaired postural control. Intra-individual variance of this test has been reported to be smaller (28), and thus it may still have its use in monitoring, e.g. the effect of intervention or rehabilitation.

Impaired functional status was, in the present study, associated with higher ratings of pain severity, poorer self-rated general health, poorer self-rated balance, and higher rates of psychological distress, as well as weaker muscle strengths, higher frequency of hip and knee pain, and higher frequencies of radiographic abnormalities of the cervical spine. In previous publications, HAQ score has been associated with disease activity, pain, muscle strength, range of movement of joints, swollen and tender joint counts, laboratory tests that reflect inflammatory and, to a lesser extent, with radiographic damage to joints (29–35).

It is probable that the mechanisms behind the association between HAQ and the impaired performance in the postural control tests are multifactorial. Human motor control is extremely complex even without disease-specific effects acting on it. Maintaining posture and balance requires sensory, biomechanical and motor processing strategies, as well as anticipation of events and past experience (36). The main sensory inputs into the postural control system are vision, vestibular end-organs, proprioceptors, and pressoreceptors of the feet. In most circumstances their interaction with one another makes it possible for adequate compensation to occur in case of loss of any one of these modalities (37).

A new model suggests that pain may affect motor control via multiple mechanisms (38). These include inhibition on all motor control levels, from reflexes to cortical motor planning. Pain may also alter the proprioceptive input, resulting in inaccurate "virtual body". In the early phase of pain the problem of motor control impairment may be mostly peripheral. The longer the pain exists the more probable become impairments in central mechanisms, such as motor planning. The central mechanisms also seem to play a role in RA. Patients with RA have been reported to have slower reaction times, and impaired hand coordination compared with healthy controls (39). The involvement of central mechanisms means that postural and motor control impairments cannot be overcome simply by reducing pain. The intervention should involve the rehabilitation of the sensorimotor system as a whole.

Study limitations

The present study had its origin in the clinical need of physiotherapists to understand better how to assess postural control of patients with RA and how to interpret the results. The suggested cut-off values for the OLST and TUG tests are based on the present and some previous studies, but their relevance needs to be confirmed in future studies with a different study design. The RA group in the present study represents female patients treated and rehabilitated at a specialized hospital for rheumatic diseases. At least 50% of the patients have had RA for 2 years or less. As the study group does not represent the general population of patients with RA, the results should be generalized with caution. A further limitation is that the control group was not age-matched.

CONCLUSION

In conclusion, it is recommended that both the OLST and TUG tests are included in postural control assessment design for patients with RA. Force-plate measurements appear to be useless as a screening method, but some of them may still have their use in, for example, monitoring the effect of intervention or rehabilitation. Further research is needed to evaluate the usability of the suggested cut-off points for OLST (30 s) and TUG (8 s) tests in clinical work. At best, the development of successful postural control rehabilitation methods for patients with RA, in addition to adequate drug treatment, might lead to improvements in functional status, decreased risk of falls, and might help patients to maintain their working ability.

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APPENDIX I. *Specifications for postural control test procedures*

Timed Up and Go test

The seating height was 46 cm and the elbow rest height 67 cm. The subject wore her usual footwear. Physical aid was not allowed during the test. At the request to start, the subject rose from the chair, using hands if needed, walked 3 metres forward beyond a line on the floor, turned around, returned to the chair, and sat down again. The timer was started when the subject's back left the chair and stopped when their buttocks touched the seat surface again.

Timed one-leg standing test

The subject was standing without shoes. Compensatory movements of the arms and the lifted leg were allowed. If any of the following events occurred before 60 s had lapsed, the timed trial was stopped and the time noted: (*i*) any displacement of the foot on the floor; (*ii*) any use of the arms for support; (*iii)* the non-weight-bearing leg touched the floor. If the first attempt resulted in less than 10 s the test was repeated and the better result of the 2 trials was recorded.

Posturography

Double-leg stance test, eyes open. The subject was standing still on the force-plate without shoes in a freely chosen stance width. Parameters were calculated during a 30-s period.

Double-leg stance test, eyes closed. Same as above, but eyes closed.

Single-leg stance test, eyes open (first on the right leg and then on left). The subject was standing on one leg in a similar position to the timed one-leg stance test. Postural control parameters were calculated during a 10-s period.

Dynamic test. The subject had to move her centre of force to hit 5 boxes placed on a *Z*-shaped path shown on a computer screen placed in front of the subject. The subjects were standing in a similar position as during the static stance (see number 1).