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Relationship between rising motion and trunk function in patients with rheumatoid arthritis

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Abstract

【Study objectives】The present study measured trunk muscle strength in patients with rheumatoid arthritis (RA), compared the results with those of healthy individuals, and investigated factors associated with the rising motion.

【Methods】The study population consisted of 75 female RA outpatients (RA group) and 26 healthy individuals in the control group (HC). A handheld dynamometer (HHD) was used to measure trunk muscle strength, and an RGB-D camera was used to capture images of the rising motion.

【Results】 Time required to perform the rising motion was significantly longer in the RA group (RA: 5.2±2.0 sec, HC: 3.8±1.1 sec; $P<0.01$). In terms of muscle strength in the trunk and shoulders, apart from the trunk flexion muscles, subjects in the RA group had significantly lower muscle strength during right lateral bending ($P<0.01$), left lateral bending ($P<0.05$), and in all shoulder joints ($P<0.01$), including during trunk extension (RA: 10.5%±3.8%, HC: 12.6%±3.2%; $P<0.05$). Furthermore, muscle strength during forward trunk flexion and bilateral bending was lower in Class III patients with RA than in Class I and II patients.

【Conclusion】There was a correlation between diminished activities of daily living and decreased muscle strength in the trunk muscles in patients with RA, and this decrease was a causal factor prolonging rising time.

Keywords

Rheumatoid arthritis, Rising motion, Trunk muscle strength

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Introduction

In rheumatoid arthritis (RA), a number of genetic and environmental factors trigger an autoimmune response that causes chronic inflammation in multiple, symmetrical joints resulting in progressive, destructive joint inflammation. When active arthritis is present, the patient attempts to avoid pain by maintaining a physical position that minimizes intra-articular pressure, thus limiting the patient's movement. This in turn leads to atrophy of the muscles, tendons, and joint capsules, which limits the range of motion (ROM) and causes joint instability and degeneration as well as atrophy of surrounding muscles[1)]. Functional impairment caused by RA is associated with inflammation and subsequent pain, fatigue, decreased muscle strength, muscle atrophy, and decreased ROM due to joint destruction[2)]. Previous studies on exercise therapy to treat the decline in muscle strength caused by RA include a study by Häkkinen et al. on improved trunk muscle strength by directed muscle training[3)], a study by de Jong et al. investigating muscle endurance and knee extensor muscle strength using a bicycle ergometer[4)], and a study by Strasser et al. on increased back muscle strength achieved using bench pull exercises[5)], while in-depth studies focusing on the trunk muscles are limited.

In patients with RA, trunk function has a greater clinical impact on the rising motion than on supine stability, and many patients with RA experience difficulty rising as a result of the decline in whole-body muscle strength caused by disease progression and increasing dysfunction. Patients with RA who have trouble raising their own body maintain their ability to rise with unique methods, such as the use of bed rails or the rebound motion created by swinging both of their legs. However, prolonged reliance on bed rails can contribute to joint deformities in the fingers due to the strong external force that is applied, while the rebounding motion causes hyperflexion of the cervical vertebrae, leading to an increased risk of vertebral instability. Thus, maintaining the rising motion in patients with RA is a perplexing issue for physiotherapists.

In terms of joint destruction in patients with RA, Lindqvist et al. studied the course of radiographic damage over 10 years in a cohort with early RA, and found that the damage arose early in the course of the disease and progressed most rapidly during the first 5 years[6)]. The study found that early erosive changes occurred in the feet in 37% of patients with RA and in the hands in 27%, and that after 10 years, erosions in the hands and feet had occurred in 90% and 87%, respectively. The study findings suggested that erosion in the hands was most common in the wrists (72.6%) and the second metacarpophalangeal joint (MCP II) (51.9%). A study by Courvoisier et al. on the prognostic factors for 10-year radiographic outcome in RA found that the total radiographic Sharp score (a commonly-used indicator of joint destruction) increased from 5.8 ± 9 at baseline to 9.5 ± 14.9, 17.3 ± 22.4, and 35.4 ± 46.1 at 3, 5, and 10 years, respectively[7]. These findings suggest that, as joint destruction progresses with RA duration, patients with progressive RA have difficulty in exerting a strong gripping force when gripping the bed rails to raise their body, and that there is a risk that this motion could exacerbate joint destruction.

The recent aging of society seen in Japan has led to the promotion of care support measures aimed at the elderly, as well as the provision of various insured nursing care services. In a study on the utilization of insured nursing care services by home-based elderly people, Nakagoshi et al. compared the use of various welfare devices among elderly persons who require only a low level of nursing care and those who require a high level of nursing care. The results showed that many high-level nursing care patients used electric beds, suggesting that electric bed use increases with the level of required care in order to prevent bed sores due to the greater amount of time spent in and around the bed and spent lying down [8]. The versatility of these beds has also led to their rapid uptake among patients with RA to the point where the difficulty these patients experience when rising has virtually been eliminated. However, the spread of infrastructure throughout society also gives rise to concerns about a decline in motor function as a result of excessive improvement to living environments, and the adoption of electric beds is also an important issue that needs to be addressed.

Recent research on trunk function includes studies on healthy individuals, as well as spinal cord injury and hemiplegia patients. Ishigami et al. investigated the relationships among back muscle strength, spinal mobility, and quality of life (QOL) among 100 middle-aged and elderly men, and they found that their QOL was associated with sagittal balance, lumbar lordosis angle, spinal range of movement (ROM), and back muscle strength, and that back muscle strength and thoracic spinal ROM both had an effect on improving QOL in the middle-aged and elderly[9]. Granacher et al. conducted core instability strength training in older adults and reported improvements in trunk muscle strength, spinal mobility, and dynamic balance[10]. Moreover, Verheyden et al. found that rehabilitation of stroke patients led to improvements in trunk function, suggesting the importance of a trunk-oriented approach[11]. Monaco et al. showed that sitting and standing balance and trunk function while seated were predictors of function after discharge from rehabilitation and of post-rehabilitation destination[12]. In contrast to these various studies on trunk function, the only study of patients with RA was published by Häkkinen et al., and it compared the neuromuscular capacity (muscle strength, gait, and vertical jump) of healthy females with that of early- or long-term patients with RA, but it did not find any differences among the 3 groups[13].

In light of this lack of published literature on trunk function of patients with RA, the present study focused on the rising motion of patients with RA, examining the association between rising and trunk muscle strength, and it also examined factors related to the rising motion. The objectives of the present study were: (1) to measure trunk muscle strength in patients with RA and compare the results with those of healthy individuals; and (2) to investigate factors associated with the rising motion in patients with RA.

This study was conducted after obtaining written, informed consent from all subjects and with the approval of the ethics review board of Konan Women's University and Konan Kakogawa Hospital.

Materials and Methods

Subjects

The subjects were female patients with RA attending the Rheumatology Department of Konan Kakogawa Hospital who consented to participate in the study and who were able to raise their body without the use of orthopedic devices. Patients with any concurrent serious orthopedic illness other than RA, particularly a previous history of surgery on the trunk, were excluded from the study. Seventy-nine patients consented to participate in the study, but one patient was excluded due to pain from a spinal compression fracture, one patient was excluded due to a history of abdominal surgery to treat colorectal cancer, and two patients were excluded due to an inability to raise their own body. Thus, 75 subjects (RA group) were ultimately selected. Meanwhile, the control group consisted of 26 healthy women (HC group).

Study procedures

General characteristics and disease activity

The height, weight, and body mass index (BMI) of the patients with RA were measured using an automated weight and height scale (THP-SEII; Ogawa Iriki Co., Ltd., Kyoto, Japan). The 12-item short form (SF-12) of the health-related QOL (HRQOL) questionnaire was used to evaluate subjects' QOL. Physical disability was measured and evaluated using the modified Health Assessment Questionnaire (m-HAQ), Visual Analogue Scale (VAS) scores (overall, at rest, and after exercise), swollen joint count (SJC), painful joint count (PJC), and functional impairment classification criteria.

Collection of medical data

Medical data of patients with RA consisting of date of RA onset, red blood cell (RBC) count, hemoglobin (Hb) level, CRP level, and Steinbrocker classification were collected from medical records.

Measurement of muscle strength

Muscle strength was measured using a handheld dynamometer (HHD; microFET2, Hoggan, Salt Lake City, UT). Trunk muscle strength was measured in terms of flexion, extension, and lateral bending. Measurements were performed with the subjects in a seated position in which their pelvis was fixed with 11-cm-wide hook-and-loop fasteners on a bed with a lifting function set at a height at which the subjects' feet did not touch the floor. Using the HHD, trunk flexion was measured in the anterior direction to the mesosternum, trunk extension was measured in the posterior direction to the center of the thoracic spine between the superior and inferior angles of the scapula, and lateral bending was measured from the left and right sides to the lateral aspect of the acromion[14]. Shoulder flexion and extension strengths were measured with the subject in the supine position. Measurement was performed with the HHD at the 90° shoulder flexion position and elbow extension position from the ventral condyle of the humerus. Measurements were performed 3 times after 2 practice attempts, and the maximum value was used for muscle strength. Subjects had a break of at least 15 seconds between each attempt. Muscle strength is expressed as a ratio of body weight.

Measurement of rising motion

Measurement was performed using an RGB-D camera (KINECT, Microsoft, Redmond, WA). The camera consisted of an infrared depth sensor and an image sensor (video camera) capable of calculating the coordinates of joint positions[15]. The sampling frequency was set at 30 Hz.

The rising motion consisted of a movement from the supine position to the upright position on a bed. The method for this movement was the same as that used when waking up in the morning. After confirming that the subject was within view of the camera, the rising motion was recorded with the subject on the bed. The measurement results and the time and pattern of the rising motion were analyzed. The time required to perform the rising motion (rising time) was defined as the time from starting to completing the rising motion.

Statistical analysis

In the comparison of each variable between patients with RA and healthy individuals, the normality of each variable was assessed using the Shapiro-Wilk test, and homoscedasticity was assessed using the Levene test. Normally-distributed continuous variables were then analyzed using an independent sample *t*-test. Variables that were not normally distributed were analyzed using the Wilcoxon rank sum test. Multiple comparisons of each variable in each patient were analyzed using the Kruskal Wallis test. Correlations between variables were analyzed using Pearson's correlation coefficient. Data were analyzed using SPSS (Ver. 2.0) statistical software at a significance level of $P<0.05$.

Results

The characteristics of the RA group and HC group subjects are shown in Table 1. All data are expressed as means ± standard deviation (SD). The height of the RA group was significantly less than that of the HC group ($P<0.05$), but there were no significant differences in age, weight, and BMI. In the SF-12, the physical component summary (PCS; $P<0.05$) and role/social component summary (RCS; $P<0.01$) scores were significantly lower in the RA group than in the HC group, but there were no significant intergroup differences in the mental component summary (MCS) scores.

Table 1 Characteristics of subjects

	RA (n=75)	HC (n=26)
Age (years)	63.1±10.0	59.0±7.4
Height (cm)	153.3±6.7*	157.0±6.2
Weight (kg)	53.1±10.0	53.1±7.0
BMI (kg/m^2)	22.6±4.4	21.5±2.9
SF-12		
PCS	36.6±15.8*	54.1±9.3
MCS	52.5±9.4	52.9±7.0
RCS	43.9±13.2**	50.2±8.1
Time to rise (sec)	5.2±2.0**	3.8±1.1
**: $P<0.01$	*: $P<0.05$	

RA: rheumatoid arthritis; HC: healthy controls; BMI: body mass index; SF-12: Health Related Quality of Life-short form; PCS: physical component summary; MCS: mental component summary; RCS: role/social component summary

In terms of pathology in the RA group, the mean duration of RA was 149.7±128.5 months, and the mean m-HAQ was 0.40±0.53. In terms of RA staging, the most common stage was Stage IV in 38 subjects (50.7%), followed by Stage III in 24 subjects (32.0%). In terms of RA classification, the most common class was Class II in 34 subjects (45.3%), followed by Class I in 23 subjects (19.3%). The swollen joint count (SJC) was 2.0±2.4, and the painful joint count (PJC) was 2.3±3.5. For the mean VAS scores, overall patient VAS was 21.0±2.4 mm, VAS at rest was 15.5±20.9 mm, and VAS at exercise was 30.8±28.3 mm. CRP, indicating systemic disease activity, was 0.54±0.53 mg/dl (Table 2).

In terms of muscle strength in the trunk and shoulders, apart from the trunk flexion muscles, subjects in the RA group had significantly lower muscle strength during trunk extension ($P<0.05$), right lateral bending ($P<0.01$), and left lateral bending ($P<0.05$), and in all shoulder joints ($P<0.01$) (Table 3).

Table 2. Background of RA group

Variable	RA (n=75)	Range
RA duration (months)	149.7±128.5	2 - 604
m-HAQ	0.40±0.53	0 - 2.37
Stage n (%)		
I	4 (5.3)	
II	9 (12.0)	
III	24 (32.0)	
IV	38 (50.7)	
Class n (%)		
1	23 (30.7)	
2	34 (45.3)	
3	18 (24.0)	
4	0 (0)	
Swollen joints	2.0±2.4	0 - 11
Painful joints	2.3±3.5	0 - 13
General Health VAS (mm)	21.0±2.4	0 - 7.7
Pain VAS at rest (mm)	15.5±20.9	0 - 76
Pain VAS at exercise (mm)	30.8±28.3	0 - 100
RBC count (10^6/dl)	4.00±0.37	3.4 - 4.79
Hb (g/dl)	12.5±1.2	8.9 - 15.3
CRP (mg/dl)	0.54±0.53	0.01 - 3.00

m-HAQ: modified health assessment questionnaire; Stage: Steinbrocker's stage classification; Class: Steinbrocker's calss classification; VAS: visual analigue scale; RBC: red blood cell; Hb: hemoglobin; CRP: C-reactive protein

Table 3. Comparison of muscle strength(%) of trunk and shoulder joint between RA and HC groups

Variable	RA (n=75)	HC (n=26)
Trunk		
Flexion	6.4±1.8	7.0±1.9
Extension	10.5±3.8*	12.6±3.2
Lateral bending (right)	8.1±2.4**	9.7±2.8
Lateral bending (left)	8.0±2.5*	9.3±2.4
Shoulder		
Flexion (right)	4.4±2.5**	6.2±1.1
Flexion (left)	4.2±1.6**	6.0±1.0
Extension (right)	5.3±1.6**	7.0±1.5
Extension (left)	5.5±1.9**	6.6±1.1

**: $P<0.01$ *: $P<0.05$

Table 4. Comparison of rising methods between RA and HC groups (n. of patients)

Method	RA (n = 69)		HC (n = 26)	
	n	(%)	n	(%)
1	19	(27.5)	4	(15.4)
2	14	(20.3)	10	(38.5)
3	20	(29.0)	4	(15.4)
4	16	(23.2)	8	(30.7)

Method 1: rising by anterior flexion of the trunk from the supine position without using the arms; Method 2: rotating the trunk to the right and using the right arm to rise; Method 3: rotating the trunk to the left and using the left arm to rise; Method 4: rising by anterior flexion of the trunk with the support of both elbows from the supine position

Rising time was significantly longer in the RA group than in the HC group (RA: 5.2±2.0 sec, HC: 3.8±1.1 sec; P<0.01).

The pattern of rising motion was classified into the following 4 types: (1) rising by anterior flexion of the trunk from the supine position without using the arms (Method 1); (2) rotating the trunk to the right and using the right arm to rise (Method 2); (3) rotating the trunk to the left and using the left arm to rise (Method 3); and (4) rising by anterior flexion of the trunk with the support of both elbows from the supine position (Method 4).

In the HC group, 4 subjects used Method 1, 1 used Method 2, 4 used Method 3, and 8 used Method 4. In the RA group, 19 subjects used Method 1, 14 used Method 2, 20 used

Method 3, and 16 used Method 4. As such, there were no intergroup differences in the method of rising (Table 4). In the RA group, there were differences in rising motion according to the stage and class of RA. However, there were no marked differences in the patients with RA distribution in terms of rising method by stage or class (each stage: P=0.40, class: P=0.23) (Table 5). Examining differences in the method of rising failed to reveal any significant differences in factors such as RA stage, class, or trunk muscle strength (Table 6).

Table 5. Relationship between the rising methods and Stages and Classes in RA group (n. of patients)

Method	Stage (n =69)				Class (n = 69)			
	I	II	III	IV	I	II	III	IV
1	3	1	7	8	3	13	3	0
2	0	1	4	9	6	4	4	0
3	1	4	6	8	7	6	7	0
4	0	1	6	9	4	8	4	0

Method 1: rising by anterior flexion of the trunk from the supine position without using the arms; Method 2: rotating the trunk to the right and using the right arm to rise; Method 3: rotating the trunk to the left and using the left arm to rise; Method 4: rising by anterior flexion of the trunk with the support of both elbows from the supine position

There were no significant differences in the RA patient distribution in terms of rising method by stage or class.

Table 6. Factors associated with rising methods in RA group

	Method 1	Method 2	Method 3	Method 4	
Stage	3.1±1.1	3.6±0.6	3.1±0.9	3.5±0.6	ns
Class	2.0±0.6	1.9±0..9	2.0±0.9	2.0±0.7	ns
RA duration (month)	159.2±158.1	135.0±135.4	136.3±77.9	162.1±145.8	ns
Trunk muscle strength (%)					
flexion	6.5±1.8	7.0±2.2	6.3±2.0	6.1±1.8	ns
extension	10.6±4.1	11.5±4.2	10.5±3.8	10.0±3.7	ns
right lateral bending	7.8±2.1	8.9±2.7	8.2±2.1	7.7±3.0	ns
left lateral bending	7.5±2.6	8.9±2.6	8.3±2.5	7.7±3.1	ns
Shoulder muscle strength (%)					
flexion (right)	4.1±1.8	4.2±1.3	4.6±1.1	5.0±4.6	ns
flexion (left)	4.2±2.0	4.2±1.2	4.4±1.6	4.1±1.3	ns
extension (right)	5.3±1.8	5.8±1.5	5.0±1.7	4.9±1.7	ns
extension (left)	5.5±2.3	5.9±1.7	5.7±1.6	5.3±1.6	ns

Stage: Steinbrocker's stage classification; Class: Steinbrocker's calss classification; Method 1: rising by anterior flexion of the trunk from the supine position without using the arms; Method 2: rotating the trunk to the right and using the right arm to rise; Method 3: rotating the trunk to the left and using the left arm to rise; Method 4: rising by anterior flexion of the trunk with the support of both elbows from the supine position; ns: no significance

There were no significant differences between each methods.

There were moderate positive correlations between rising time and m-HAQ (r=0.562) and RA duration (r = 0.383), and a moderate negative correlation with SF-12 PCS (r = -0.419), indicating a correlation between the trunk muscles and shoulder muscles (Table7). Next, the study looked at SF-12, RA duration, rising time, and trunk and

Table 7. Factors associated with rising time in RA and HC groups (Pearson's correlation coefficient: r)

	RA	HC
Age	0.390**	-0.190
RA duration	0.383**	–
Total patient VAS	0.258*	–
VAS at rest	0.248*	–
VAS at exercise	0.222	–
m-HAQ	0.526**	–
Height	-0.336**	-0.069
Weight	-0.264*	-0.134
SF-12（PCS）	-0.419**	-0.046
Trunk flexion muscle strength	-0.300**	-0.034
Trunk extension strength	-0.277**	-0.382
Trunk right lateral bending strength	-0.295**	-0.288
Trunk left lateral bending strength	-0.344**	-0.159
Right shoulder flexion strength	-0.290**	-0.027
Right shoulder extension strength	-0.229**	-0.24
Left shoulder extension strength	-0.256**	-0.054

**: $P<0.01$, *: $P<0.05$

SF-12（PCS）: Health Related Quality of Life-short form; PCS: physical component summary; VAS: visual analogue scale; m-HAQ: modified health assessment questionnaire

shoulder muscle strength by stage and class. By stage, RA duration was significantly longer in Stage IV than in Stage II (IV: 203.9±145.3 months, II: 52.1±60. 1 months; $P<0.01$) and in Stage IV than in Stage III (IV: 203.9±145.3 months, III: 114.9±79.5 months; $P<0.05$). In terms of muscle strength, left shoulder extension strength was significantly lower in Stage IV than in Stage III (IV: 4.8%±2.1%, III: 6.6%±1.6%; $P<0.01$). However, there were no significant differences in rising time or any of the other variables (Table 8). By class, SF-12 (PCS) was significantly lower in Class II than in Class I (II: 34.7±14.5, I: 47.6±10.4; $P<0.05$) and in Class III than in Class I (III: 26.2±15.1, I: 47.6±10.4; $P<0.01$). Furthermore, RA duration was significantly longer in Class III (251.9±148.5 months) than in Class I (110.8±68.6 months) and Class II (127.6±124.4 months (both $P<0.01$). Rising time was also significantly longer in Class

III (6.5±2.8 sec) than in Class I (4.6±1.7 sec) (P<0.01) and Class II (5.0±1.4 sec) (P<0.05). In terms of trunk muscle strength, strength was significantly lower in the flexors and

Table 8. Comparison of RA duretion and rising time and trunk and shoulder muscle strength by Steinbrocker's stage classification in patients with RA

	stage Ⅰ	stage Ⅱ	stage Ⅲ	stage Ⅳ
	n = 4	n = 9	n = 24	n = 38
SF-12(PCS)	41.9±13.1	33.2±14.8	39.7±16.6	34.9±15.8
RA duration (month)	61.0±61.4	52.1±60.1	114.9±79.5	203.9±145.3** †
Time to rise (sec)	4.3±0.6	4.5±0.8	5.0±1.6	5.7±2.5
Trunk muscle strength (%)				
flexion	5.8±1.0	6.4±1.8	7.2±1.8	6.0±1.8
extension	9.2±1.9	11.4.0±3.2	11.2±3.4	9.9±4.3
lateral bending (right)	8.2±0.7	9.5±2.8	8.6±2.1	7.3±2.4
lateral bending (left)	6.9±2.1	8.3±3.4	7.2±2.9	5.5±3.0
Shoulder muscle strength (%)				
flexion (right)	3.9±0.4	6.2±5.9	4.6±1.2	3.8±1.8
flexion (left)	3.9±0.3	4.8±1.7	4.6±1.2	3.8±1.9
extension (right)	5.2±1.0	5.0±1.2	5.9±1.3	4.8±2.0
extension (left)	5.4±0.6	5.7±1.7	6.6±1.6	4.8±2.1††

**: $P<0.01$: Difference between stage Ⅱ and stage Ⅳ
††: $P<0.01$: Difference between stage Ⅲ and stage Ⅳ
†: $P<0.05$: Difference between stage Ⅲ and stage Ⅳ

Table 9. Comparison of RA duretion and rising time and trunk and shoulder muscle strength by Steinbrocker's class classification in patients with RA

	class Ⅰ	class Ⅱ	class Ⅲ
	n = 23	n = 34	n = 18
SF-12(PCS)	47.6±10.4	34.7±14.5#	26.2±15.1**
RA duration (month)	110.8±68.6	127.6±124.4	251.9±148.5** ††
Time to rise (sec)	4.6±1.7	5.0±1.4	6.5±2.8** †
Trunk muscle strength (%)			
flexion	7.0±2.0	6.6±1.7	5.3±1.6* †
extension	10.7±4.1	11.0±3.9	9.4±3.1
lateral bending (right)	8.7±2.2	8.3±2.4	6.5±2.0** †
lateral bending (left)	7.8±3.2	6.6±2.9	4.2±2.1** †
Shoulder muscle strength (%)			
flexion (right)	4.7±1.3	4.8±3.3	3.3±1.3
flexion (left)	4.6±1.3	4.5±1.6	3.4±1.3* †
extension (right)	5.5±1.6	5.5±1.6	4.6±1.6
extension (left)	5.8±1.7	5.7±1.6	5.2±2.3

**: $P<0.01$: Difference between class I and class Ⅲ
*: $P<0.05$: Difference between class I and class Ⅲ
††: $P<0.01$: Difference between class Ⅱ and class Ⅲ
†: $P<0.05$: Difference between class Ⅱ and class Ⅲ
#: $P<0.05$: Difference between class I and class Ⅱ

right and left lateral flexors in Class III than in Class I (flexors: $P<0.05$, lateral flexors: $P<0.01$) and in Class II ($P<0.05$). In the shoulder muscles, the only significant interclass difference was the decrease in left flexor muscle strength in Class III compared to Classes I and II (both $P<0.05$). However, there were no significant differences in muscle strength between Class I and Class II (Table 9).

Discussion

The rising motion in patients with RA tends to change as the debilitating nature of the disease progresses, from the normal method used by healthy individuals, to the method of using the force of suddenly dropping the legs from a raised position and the method of raising one's upper body by holding the bed rails and bending the arms. Patients are eventually unable to raise themselves and must rely on the use of an electric bed. This change in rising motion is rarely discussed in the medical literature. The present study therefore sought to take the first step by measuring trunk muscle strength in patients with RA and investigating the relationship between rising motion and trunk muscle strength.

The study targeted subjects with a mean RA duration of approximately 12.5 years. Current disease activity was characterized by mild pain, as indicated by a resting VAS score of 15.5 mm, exercise VAS score of 30.8 mm, and total patient VAS of 21.0 mm, although CRP was 0.54 mg/dl, indicating that disease activity was well-controlled. Stage III and IV RA accounted for 62 (82.7%) of the RA group patients, which suggests progressive joint destruction. However, 57 patients (76.0%) in the RA group had Class I and II RA, indicating minimal restriction of daily activities, which suggests that many of the patients were able to maintain a relatively independent lifestyle. The results of performing the rising motion showed that only 2 of the 77 patients with RA used the bed rails, while the remaining 75 patients could raise themselves relatively smoothly. This result could be attributed to the fact that the study recruited ambulatory patients attending our hospital.

Even these patients with RA who maintain an independent lifestyle had clearly diminished muscular strength in the trunk and shoulders (except for trunk flexion) compared to healthy individuals, and they also had lower SF-12 PCS and RCS scores. The reduction in muscle strength compared to the HC group was 12.5% for trunk extension (RA: 10.5±3.8, HC: 12.6±3.2). Right and left lateral bending motions were also 16.5% and 14.0% lower than in the HC group, respectively. This decline was even more pronounced in the shoulders, with a 29% decrease in right flexion, 30% decrease in left flexion, and 25.7% decrease in right extension relative to the HC group.

Mean rising time was 1.4 sec (36.8%) longer in patients with RA than in the HC group. By stage and class, there were no significant differences in mean rising time by stage, but it was significantly longer in Class III patients than in Class I and II patients. One possible explanation for this increase is the decline in strength of the trunk and bilateral trunk flexors, which are primarily responsible for rising motion. Strength in these muscle groups was in fact significantly lower in the Class III patients than in the Class I and II patients. In a study by Ng et al. measuring the muscular activity of isometric contraction of abdominal and back muscles during trunk rotation in healthy males, the authors demonstrated that there was coupling between right trunk rotation and the right flexor muscles, and that the vertebral muscles must act as antagonistic muscles to maintain balance at the moment of flexion[16)]. The rising motion requires both trunk flexion and rotation, so the decline in the strength of these primary muscles seen in patients with RA was believed to have an impact on rising motion. Meanwhile, in a study by Ikezoe et al. using ultrasonography to compare trunk muscle atrophy in healthy young individuals, ambulant elderly individuals, and elderly individuals who were bedridden for a prolonged period, age-induced muscular atrophy of the internal and external abdominal oblique muscles was significantly pronounced in the ambulant elderly individuals compared to the healthy young individuals, and it appeared to be associated with the decline in physical activity accompanying trunk rotation movement in elderly individuals. Compared to the ambulant elderly individuals, the bedridden elderly patients also had severe atrophy in deep trunk muscles including the transverse abdominal muscles and multifidus muscles in the lumbar region[17)]. In the present study, comparison with the HC group showed that patients with RA had severely diminished muscle strength in the trunk flexors (25.3%), right trunk flexors (33.0%), and left trunk flexors (54.8%), suggesting the effects of age-induced changes and decreased activities of daily living. In other words, prolonged disease duration is a factor in worsening disability (class classification), and the decline in trunk muscle strength due to reduced activity leads to an increase in rising time.

It was possible to classify four distinct methods of rising patterns in the patients with RA. The rising methods were those that the patients used in their daily lives to rise from the supine position to the sitting position. Potential correlations between each method and RA stage, class, disease duration, and strength of each muscle group were also investigated, but there were no significant correlations. In light of these findings, we presumed that patients with RA select the rising method not based on factors stemming from their disease state and extent of disability, but rather based on other factors.

The study results revealed a correlation between diminished activities of daily living and decreased muscle strength in the trunk muscles, and this decreased muscular strength was identified as a causal factor in prolonged rising time in patients with RA.

Finally, the relationship between rising motion and trunk muscle strength was examined in patients with RA. However, completing the rising motion is not simply a matter of muscle strength; it also involves the simultaneous functioning of range of motion, coordination, and motor control systems. A limitation of this study was that other factors such as ROM were not evaluated sufficiently. In the future, evaluation of such other factors is needed.

Conclusion

The relationship between rising motion and trunk muscle strength was investigated in patients with RA. Even patients with RA who maintain an independent lifestyle have clearly diminished muscle strength in the trunk and shoulders (except for muscle strength during forward trunk flexion) compared to healthy individuals, and this decrease in muscle strength is thought to be a causal factor in prolonged rising time.

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Abstract

Relationship between rising motion and trunk function in patients with rheumatoid arthritis

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The present study measured trunk muscle strength in patients with rheumatoid arthritis (RA), compared their results with those of healthy individuals, and investigated factors associated with the rising motion.

The subjects were 75 female RA outpatients and 26 healthy female controls. A handheld dynamometer (HHD) was used to measure trunk muscle strength, and an RGB-D camera was used to capture images of the rising motion. Time required to perform the rising motion was significantly longer in the RA group (RA: 5.2±2.0 sec, HC: 3.8±1.1 sec; $P<0.01$). In terms of muscle strength in the trunk and shoulders, apart from the trunk flexion muscles, subjects in the RA group had significantly lower muscle strength during right lateral bending ($P<0.01$), left lateral bending ($P<0.05$), and in all shoulder joints ($P<0.01$), including during trunk extension (RA: 10.5%±3.8%, HC: 12.6%±3.2%; $P<0.05$). Furthermore, muscle strength during forward trunk flexion and bilateral bending was lower in Class III patients with RA than in Class I and II patients with RA.

There was a correlation between diminished activities of daily living and decreased muscle strength in the trunk muscles in patients with RA, and this decrease was a causal factor in prolonged rising time.

Keywords

Rheumatoid arthritis, Rising motion, Trunk muscle strength

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