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ORIGINAL ARTICLE

Comparison of the mechanical properties of hand and wrist muscles at rest and during activity in patients with rheumatoid arthritis and their healthy peers

Romatoid artritli hastalarda sağlıklı akranlarına göre el ve el bileği kaslarının mekanik özelliklerinin istirahat ve aktivite halinde karşılaştırılması

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Abstract

Purpose: The aim of this study is to evaluate the mechanical properties of the hand and wrist muscles in patients diagnosed with Rheumatoid Arthritis (RA) both at rest and during contraction.

Methods: A total of 83 individuals, including 42 Rheumatoid Arthritis (RA) patients and 41 healthy individuals, were included in the study. Hand and wrist functionality was assessed using the Duru Öz Hand Index, and the mechanical properties of the muscles were evaluated using the MyotonPro® device during both during contraction and rest.

Results: The tone and stiffness values of the flexor muscle in the left and right wrists of healthy individuals (except for the right wrist at rest) during both rest and during contraction were higher compared to RA patients (p<0.05), while the scores for the extensor muscle were similar (p>0.05).In RA patients, the tone and stiffness values of the muscle in the right and left thenar region, measured at rest, were higher compared to healthy individuals (p<0.05), whereas the mechanical properties of the muscle in the hypothenar region were similar (p>0.05). The Duru Öz Hand Index scores of RA patients were lower than those of healthy individuals (p<0.05).

Conclusion: The mechanical properties (stiffness and tone) of the flexor and thenar muscles in RA primarily affect the wrist and hand regions. Rehabilitation programs for the hands and wrists in these patients should prioritize specific exercises targeting the flexor and thenar muscle groups (e.g., relaxation, stretching, functional exercises) and include approaches aimed at improving overall hand functionality.

Keywords: Elasticity, Hand and wrist, Rheumatoid arthritis, Stiffness.

Öz

Amaç: *Bu çalışmanın amacı, Romatoid Artrit tanısı almış hastalarda el ve el bileği bölgesindeki kasların mekaniksel özelliklerinin istirahat ve aktivite halinde değerlendirmekti.*

Yöntem: *Çalışmaya 42 Romatoid Artrit (RA) hastası, 41 sağlıklı birey olmak üzere toplam 83 birey dahil edildi. El ve el bileği fonksiyonelliği DuruÖz El İndeksi, kasların mekaniksel özellikleri MyotonPro® cihazı ile aktivite ve dinlenme halinde değerlendirildi.*

Bulgular: *Sağlıklı bireylerin sol ve sağ el bileği ölçülen fleksör kasın (sağ istirahat hariç) istirahat ve aktivite halindeki tonus ve sertlik değerleri RA'lı hastalara göre daha yüksek iken (p<0,05), ekstansör kasın skorları benzerdi (p>0,05). RA'lı hastaların sağ ve sol tenar bölge istirahat halinde ölçülen kasın tonus ve sertlik değerleri sağlıklılara göre yüksek iken (p<0,05), hipotenar bölgedeki kasın tüm mekanik özellikleri benzerdi (p>0,05). RA'lı hastaların duru öz el indeksi skorları sağlıklara göre daha düşüktü (p<0,05).*

Sonuç: *RA'de fleksör ve tenar bölge kasların mekanik özellikleri (sertlik ve tonus), bölgesel olarak ta önce el bileği ve el olmak üzere etkilendiği görülmektedir. Bu hastaların el-el bileği rehabilitasyonunda öncelikli olarak fleksör ve tenar kas gruplarına yönelik spesifik egzersizler (gevşeme, germe, fonksiyonel egzersizler, vb.) içermeli ve genel el fonksiyonlarını geliştirmeye yönelik yaklaşımlar belirlenmelidir.*

Anahtar Kelimeler: *Elastisite, El ve el bileği, Romatoid artrit, Sertlik.*

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INTRODUCTION

Rheumatoid Arthritis (RA) is an autoimmune, chronic inflammatory, progressive, and systemic disease that affects 0.5% to 1% of the adult population, particularly those with genetic predisposition.[1,2] The disease progresses through periods of activity and remission.[3] With increased disease duration and activity, the joints and the surrounding muscles and ligaments become affected.[4] The joints most commonly involved in RA are the hand and wrist joints.[5] RA impacts six anatomical regions of the hand: the skin, muscles, nerves, joints, tendons, and blood vessels.[6] Involvement of the hand and wrist leads to a reduction in functional grip strength and a two-thirds decrease in lateral and tip pinch strength performed with the thumb.[7] The effects of RA on body functions manifest as restrictions in daily living activities. These restrictions are attributed to pain, decreased range of motion, muscle weakness, and reduced aerobic capacity. Notably, muscle strength decline can be observed even in the early stages of RA.[8]

Hand functions include components such as mobility, muscle strength, coordination, and sensory integration. Since the hand is involved in numerous daily activities, hand functionality is critical for individual independence.[9] Effective hand use depends on factors such as anatomical integrity, joint mobility, adequate muscle strength, proper sensory input, motor coordination, and the absence of pain. In individuals with RA, pathological changes such as joint swelling, pain, deformities, and reduced joint mobility lead to decreased grip strength and impaired hand function. These impairments are further exacerbated by factors like fear of pain, reflex inhibition, disuse atrophy, and joint instability.[10-11] Additionally, the coordinated activity of the thenar and hypothenar muscles is essential for maintaining muscular balance required for proper hand and wrist function. [12] A review of the literature reveals that in two separate studies, RA patients demonstrated lower wrist flexor and extensor muscle strength scores compared to healthy individuals, with joint position sense and proprioception negatively affected.[9,10] However, no specific study was found investigating the impact of RA on the viscoelastic properties of hand and wrist muscles. Existing studies suggest that muscle tone may either increase or decrease.[11-14] Prolonged inflammation and joint damage in RA are associated with muscle weakness and deterioration, while factors such as morning stiffness and inactivity may also affect muscle tone and function.[11,12] Inflammation in RA may influence the viscoelastic properties of joints and periarticular muscles. Clinical features such as morning stiffness and prolonged immobility have been associated with changes in muscle function, including increased perceived stiffness.[13,14]

The literature indicates a lack of sufficient studies examining the wrist and hand muscles in RA patients. Given the frequent hand involvement in RA and its impact on hand functions, we hypothesize that the hand and wrist muscles of RA patients, particularly the thenar and hypothenar muscles, may exhibit differences in mechanical properties during rest and activity compared to their healthy peers due to changes in muscle activation. Evaluating muscle mechanical properties both at rest and during contraction provides valuable insight into the passive and active behavior of muscle tissues. While resting measurements reflect baseline viscoelasticity and muscle tone, contraction-based assessments reveal how muscle properties change under load, which is more functionally relevant to daily activities. Considering that individuals with RA often experience both rest-related stiffness and activity-related limitations, analyzing both states is essential for a comprehensive understanding of muscle dysfunction.

This study aimed to compare the mechanical properties of specific hand and wrist muscles (particularly focusing on thenar and hypothenar muscles) between patients with RA and their age-matched healthy peers and evaluate these properties under two conditions: at rest and during controlled muscle activity.

METHODS

This study was conducted as a collaboration between the Department of Physiotherapy and Rehabilitation and the Department of Rheumatology at Sanko University. The study was designed as a cross-sectional research project. All participants who met the inclusion criteria were informed face-to-face about the study, and voluntary consent forms were signed to confirm their participation. The study adhered to the ethical principles outlined in the Declaration of Helsinki and received ethical approval from the Non-Interventional Clinical Research Ethics Committee of SANKO University during its meeting dated November 20, 2024, with protocol number 2024/11.

Participants

The study included 42 patients diagnosed with RA based on the 2010 ACR/EULAR criteria, who were being monitored at the Rheumatology Clinic of Sanko University, as well as 41 healthy volunteers with similar average ages. The inclusion criteria were being diagnosed with rheumatoid arthritis according to the 2010 ACR diagnostic criteria, willingness to participate in the study, being aged between 18 and 70 years, being able to speak Turkish and comprehend written text, having stable medication usage for at least three months or longer, no history of orthopedic surgery within the last three years, not undergoing physiotherapy, being right-handed as the dominant hand. As an additional inclusion criterion, participants were required to have clinically low-to-moderate disease activity and to be under stable medical treatment for at least the past three months. This criterion aimed to reduce variability in muscle mechanical properties due to acute disease exacerbations. Individuals with clinical signs of median or ulnar nerve entrapment neuropathies (e.g., carpal tunnel syndrome or cubital tunnel syndrome), trapeziometacarpal joint osteoarthritis, or local tendon inflammation affecting the thenar or hypothenar muscles were excluded from the study based on clinical examination. Neurological assessment and palpation were performed to rule out such conditions.

Study design

Demographic information such as age, gender, marital status, occupation, and disease duration of the participants was recorded. Measurements for individuals who met the inclusion criteria and agreed to participate in the study were conducted face-to-face by the same physiotherapist. Hand and wrist functionality of the participants was assessed using the Duru Öz Hand Index, while the mechanical properties of the hand and wrist muscles were evaluated using the MyotonPro® device. The mechanical properties of the muscles were measured both at rest and during contraction. For contraction measurements, participants were asked to perform a submaximal isometric contraction of the target muscle (flexor or extensor for wrist; thenar or hypothenar for hand) while the MyotonPro® probe was applied perpendicularly to the muscle belly. For the hand, measurements of the thenar and hypothenar muscles were performed using a pinch meter. Only individuals with a dominant right extremity were included in the study. Dominant extremity preference was determined using the Edinburgh Handedness Inventory.[15]

Demographic information form

This form is designed to assess participants' demographic information, contact details, and general background. It includes questions about the participants' disease duration, medications used, age, contact information, gender, height, body weight, marital status, education level, and occupation.

MyotonPro®

The MyotonPro® is a portable digital device that objectively and non-invasively measures the tone or tension state, biomechanical, and viscoelastic properties of muscles and other soft biological tissues. The device's probe (3 mm in diameter, made of polycarbonate) is placed perpendicularly on the skin projection of the target muscle. A constant pre-pressure (0.18 N) is applied to the skin surface to compress the subcutaneous superficial tissues. Beneath these compressed tissues, the device delivers rapid, mechanical impulses (0.4 N) with a brief duration (15 ms) to the target muscle using a stable mechanical force. These mechanical impulses from the probe create local and elastic deformation in the measured muscle. After this deformation, the muscle returns to its original state, responding with natural damped oscillations. These oscillations are recorded as an acceleration graph by frictionless and highly sensitive accelerometers located at the opposite end of the probe. The device simultaneously calculates the muscle's tone (characterized by natural oscillation frequency; Hz), stiffness (N/m), and elasticity (characterized by logarithmic decrement of natural oscillations), along with the tissue's tension state, biomechanical, and viscoelastic property parameters. During the measurement, the probe of the device is placed perpendicularly on the muscle surface, targeting the motor point of the relevant muscle. The assessment position and points for each muscle are determined according to the criteria published on the official website of MyotonPro®.[16]

The Extensor Carpi Radialis (ECR) muscle and the Flexor Carpi Ulnaris muscle were used as reference points for wrist measurements.[17] For measurements in the thenar and hypothenar regions, the Abductor Pollicis Brevis muscle was used as the reference for the thenar muscle, and the Abductor Digiti Minimi muscle was used as the reference for the hypothenar muscle.[18] For myotone assessments; participants were asked to rest for a while (3-5 minutes) while sitting on a chair. The participant was asked to sit upright on the edge of the table and extend their arms comfortably on the table. For Flexor Carpi Ulnaris (FCU); 1/3 of the distance between the proximal medial epicondyle and the ulna styloid, the point where the muscle is most bulging, for ECR, 1/3 of the distance between the lateral epicondyle and the radius styloid process was taken as reference.[19,20] The hypothenar region is a thick soft tissue mass on the ulnar side of the palm. The pisiform is located on the palmar aspect of the fifth metacarpal bones and the proximal part of the proximal phalanx of the fifth finger. The reference point for the hypothenar region was determined as the midpoint of one-third the distance between the ulnar styloid process and the head of the fifth proximal phalanx, measured with a tape measure, as previously described.[21] For the thenar region, the reference point was identified as the most prominent part of the abductor pollicis brevis muscle, which lies between the radial styloid process and the base of the thumb. This location was selected based on anatomical palpation and surface anatomy guidelines.[22] In the evaluation of both the thenar and hypothenar regions, the appropriate L-shaped probe of the MyotonPro device was used in accordance with manufacturer instructions. Since the use of this probe was not specified in the cited anatomical studies, reference to the device manual was applied for methodological standardization. The selection of the FCU and ECR muscles for wrist measurements was based on their anatomical accessibility and relevance in wrist flexion and extension. These muscles are more superficial and easier to isolate for mechanical property assessment using the MyotonPro®. In contrast, Flexor Carpi Radialis (FCR) and Extensor Carpi Ulnaris (ECU) were not included due to their deeper location or overlapping muscle structures, which may hinder accurate measurement with surface-based devices.

Hydraulic Hand Dynamometer

This dynamometer (Hand-grip, Jamar dynamometer) is capable of measuring force values ranging from 0 kg-f (kilogram-force) to 90 kg-f. The device has two parallel handles and can be adjusted to five different grip span settings (ranging from 3.5 cm to 8.5 cm in 1.3 cm increments) to accommodate individuals with varying hand sizes.[23] During the hand grip strength assessment, the participant was seated in a chair with back support, feet flat on the ground, hips and knees at 90-degree flexion, the forearm in a neutral position, and the wrist in 0–30 degrees of extension and 0-5 degrees of ulnar deviation. The dynamometer was set to the "0" position before each trial. Participants were instructed to apply maximum grip strength for approximately 3-5 seconds, and the test was repeated three times with 30 seconds of rest between trials. The highest value among the three trials was recorded for analysis. During each trial, standardized verbal encouragement was provided to ensure maximal effort.[24]

Pinch Meter

The pinch meter is a type of dynamometer used to assess peripheral muscle strength and measure hand grip strength. Measurements were performed in the standard position recommended by the American Society of Hand Therapists (ASHT): the participant was seated with the shoulder in adduction and neutral rotation, elbow in 90-degree flexion, forearm in mid-rotation and supported, and wrist in a neutral position. A one-minute rest period was provided between each measurement, and the average of three measurements was recorded.[25] Each pinch trial lasted approximately 3-5 seconds, during which participants were instructed to apply maximum force. Standardized verbal encouragement was provided during each attempt to promote maximal effort.

Lateral pinch (key pinch) force was assessed using the pinch meter. Participants were instructed to perform a lateral pinch between the thumb pad and the radial side of the index finger, as per the American Society of Hand Therapists protocol.

Duru Öz Hand Index

The Duru Öz Hand Index is an 18-item questionnaire designed to assess activity limitations related to hand function. It was first developed in 1996 by Duruöz et al. to evaluate rheumatoid hand functions. The 18 questions are divided into five categories: kitchen tasks, dressing, personal hygiene, workplace activities, and other activities. Possible responses, along with their corresponding scores, are as follows: No difficulty (= 0), very little difficulty (= 1), some difficulty (= 2), quite difficult (= 3), almost impossible (= 4), ımpossible (= 5). The total score is the sum of the scores from all 18 questions (ranging from 0 to 90), with higher scores indicating greater impairment in hand function.[26]

Statistical analysis

Descriptive statistics included means and standard deviations for continuous variables and frequencies and percentages for categorical variables. The normality of data distribution was assessed using the Kolmogorov-Smirnov test. For independent group comparisons: The *t-test* was used for continuous variables when parametric test assumptions were met. The *Mann-Whitney U test* was used when parametric test assumptions were not met. A significance level of $p<0.05$ was considered statistically significant. Data analysis was conducted using the IBM SPSS Statistics 23 software package. The study sample size was calculated using the G-power program, based on primary assessments considering stiffness as the key variable. Assuming a power of 80% (ß=0.20), α=0.05, the minimum sample size was determined to be 21 participants per group, with a total of 42 participants.[27] Considering potential dropouts (20%), it was decided to include a total of 51 individuals in the study.

RESULTS

The study included a total of 83 participants: 42 patients diagnosed with RA and 41 healthy individuals with no chronic illnesses. The mean ages of the participants were 49.86 ± 11.27 years in the RA group and 48.56 ± 9.86 years in the control group, with no statistically significant difference between the groups ($p>0.05$). In terms of gender distribution, the RA group consisted of 85.7% women and 14.3% men, while the control group comprised 80.5% women and 19.5% men. The physical and sociodemographic characteristics of the participants are presented in Table 1. The disease duration of the patients with rheumatoid arthritis included in the study was 87.80 (3-360) months

The tone and stiffness parameters of the right wrist during contraction. as well as the tone and stiffness parameters of the left wrist during rest and activity, were statistically higher in the healthy group compared to the RA group ($p<0.05$). The elasticity values of the left wrist during contraction were statistically lower ($p<0.05$). No statistically significant differences were found in the other evaluated parameters ($p>0.05$) (Table 2).

No statistically significant differences were observed in the tone, stiffness, and elasticity parameters of the wrist extensor muscle groups during contraction and rest ($p>0.05$) (Table 2). When examining the myotonometric properties of the thenar muscle groups during contraction and rest, the tone and stiffness parameters of the right and left extremities in the RA group were statistically higher than those in the healthy group at rest ($p<0.05$) (Table 2).

No statistically significant differences were observed in the tone, stiffness, and elasticity parameters of the hypothenar muscle groups during contraction and rest ($p>0.05$). However, when comparing the Duru Öz Hand Index scores between the groups, the RA group had statistically higher scores than the control group ($p<0.05$).

DISCUSSION

This study aimed to compare hand and wrist muscle mechanical properties between RA patients and healthy controls, revealing significantly lower muscle tone and stiffness in the RA group, particularly in flexor muscles during contraction and the left wrist at rest, compared to their healthy peers.

Although the patient and control groups were homogeneous in terms of age and gender, our findings revealed that the flexor muscle tone

Table 1.Physical and sociodemographic characteristics of the participants.

	Rheumatoid Arthritis(n=42)	Healthy Group (n=41)	
	X±SD	X±SD	p
Age	49.9±11.3	48.6±9.9	
Duru Öz Hand Index (Score)	23.1±22.0	0.9±2.2	<0.001
Disease Duration (Months)	87.8 (3–360)	-	
	n (%)	n (%)	
Gender (Female/Male)	36/6 (86/14)	33/8 (80.5/19.5)	

Table 2. Myotonometric properties of wrist flexor muscle groups, wrist extensor muscle groups, thenar muscle groups and hypothenar muscle groups during contraction and rest.

		Rheumatoid Arthritis (n=42)	HealthyGroup (n=41)	
		X±SD	X±SD	p
Wrist Flexors				
Right				
Tone (Hz)	Rest	20.4±6.0	21.6±5.3	0.340
Tone (Hz)	During Contraction	25.2±12.9	30.1±10.6	0.010*
Stiffness (N/m)	Rest	432±202	480±161	0.060
Stiffness (N/m)	During Contraction	533±324	779±261	0.001*
Elasticity (log)	Rest	1.24±0.3	1.12±0.2	0.045*
Elasticity (log)	During Contraction	1.2±0.5	1.11±0.5	0.383
Left				
Tone (Hz)	Rest	19.31±5.2	22.2±5.1	0.012*
Tone (Hz)	During Contraction	23.4±10.0	31.8±10.9	0.001*
Stiffness (N/m)	Rest	39±161	468±152	0.020*
Stiffness (N/m)	During Contraction	538±271	777±230	0.001*
Elasticity (log)	Rest	1.23±0.2	1.13±0.2	0.047*
Elasticity (log)	During Contraction	1.2±0.4	1±0.3	0.012*
Wrist Extensors				
Right				
Tone (Hz)	Rest	25.7±10.8	23.2±7.4	0.639
Tone (Hz)	During Contraction	25.5±8.9	24±6.7	0.831
Stiffness (N/m)	Rest	554±259	566.±206	0.466
Stiffness (N/m)	During Contraction	618±233	628±205	0.834
Elasticity (log)	Rest	1.27±0.3	1.32±0.3	0.413
Elasticity (log)	During Contraction	1.26±0.4	1.18±0.3	0.318
Left				
Tone (Hz)	Rest	24.4±10.3	21.8±6.4	0.689
Tone (Hz)	During Contraction	25.8±9.8	24.1±8.1	0.441
Stiffness (N/m)	Rest	541±294	530.±181	0.503
Stiffness (N/m)	During Contraction	623±264	664±296	0.511
Elasticity (log)	Rest	1.3±0.3	1.3±0.3	0.946
Elasticity (log)	During Contraction	1.2±0.4	1.3±0.5	0.355

* p<0.05 log: Logarithmic.

Table 2 *(Contd.).* Myotonometric properties of wrist flexor muscle groups, wrist extensor muscle groups, thenar muscle groups and hypothenar muscle groups during contraction and rest.

		Rheumatoid Arthritis (n=42) X±SD	HealthyGroup (n=41) X±SD	p
Thenar Region				
Right				
Tone (Hz)	Rest	25.5±4.4	23.2±3.6	0.007*
Tone (Hz)	During Contraction	31±4.7	32.8±5.7	0.122
Stiffness (N/m)	Rest	519±124	436±98	0.002*
Stiffness (N/m)	During Contraction	747±150	798±124	0.094
Elasticity (log)	Rest	1.4±0.2	1.3±0.2	0.009*
Elasticity (log)	During Contraction	1.2±0.3	1.2±0.2	0.331
Left				
Tone (Hz)	Rest	25.±5.	23.9±4.5	0.033*
Tone (Hz)	During Contraction	30.7±5.6	30.6±5.3	0.892
Stiffness (N/m)	Rest	519±129	453±108	0.014*
Stiffness (N/m)	During Contraction	727±168	737±137	0.767
Elasticity (log)	Rest	1.4±0.3	1.3±0.2	0.103
Elasticity (log)	During Contraction	1.3±0.3	1.3±0.1	0.701
Hypothenar Region				
Right				
Tone (Hz)	Rest	23.5±4.1	22.9±2.4	0.795
Tone (Hz)	During Contraction	26.1±5.1	24.9±3.7	0.239
Stiffness (N/m)	Rest	468±108	452±77	0.695
Stiffness (N/m)	During Contraction	530±158	493±95	0.303
Elasticity (log)	Rest	1.5±0.2	1.5±0.2	0.698
Elasticity (log)	During Contraction	1.4±0.3	1.5±0.2	0.662
Left				
Tone (Hz)	Rest	22.6±3.3	22.5±2.2	0.851
Tone (Hz)	During Contraction	30.4±33	32.1±51.5	0.188
Stiffness (N/m)	Rest	442±87	439±60	0.871
Stiffness (N/m)	During Contraction	525±122	476±103	0.068
Elasticity (log)	Rest	1.5±0.2	1.5±0.2	0.902
Elasticity (log)	During Contraction	1.5±0.3	1.5±0,1	0.335

* p<0.05 log: Logarithmic.

and stiffness values during contraction were significantly lower in individuals with RA compared to healthy controls. This may reflect disease-related alterations in neuromuscular control or structural muscle changes; however, these interpretations remain speculative and require further investigation with direct assessments such as EMG or imaging techniques. Additionally, the absence of consistent effects across all muscles or both sides of the body suggests that local factors - such as hand dominance, joint protection behaviors, or subclinical inflammation - may contribute to the variability in muscle response.

The lack of significant differences in the extensor group, and the observed asymmetry in left versus right wrist measurements, may reflect disease-related variability in joint protection strategies, hand dominance, or subclinical inflammation. Clinically, these results emphasize the importance of early detection and rehabilitation of dynamic muscle dysfunction in RA patients, particularly in the wrist flexors, to prevent functional decline and enhance hand use in daily life.

The higher tone and stiffness scores in the Rheumatoid Arthritis group suggest that the flexor muscles are more affected by the disease's pathophysiological process compared to the healthy group. Smith et al. stated that inflammation in the joints, synovial hypertrophy, and decreased range of motion observed in RA patients are associated with changes in muscle tone.[28] Stamm et al. suggested that the flexor muscles of the hand play a greater role than the extensor group during daily living activities, which may result in more pronounced viscoelastic changes in the flexor muscle group.[29]

Tone can be classified into two forms: neural and non-neural.[30] Inflammation observed in RA can lead to adverse outcomes such as motor neuron loss, synaptic degeneration, and muscle atrophy as a result of microglial activation.[31] In the peripheral nervous system, a reduction in axon caliber may be accompanied by a decrease in conduction velocity.[32] This neurodegenerative process may explain why muscle tone in the RA group is lower compared to the healthy group. The decrease in tone and stiffness parameters of the flexor muscles during contraction may result from the negative impact on neuromuscular control mechanisms.

One of the key findings of this study is the difference between passive (at rest) and active (during contraction) muscle properties in individuals with RA. Passive measurements reflect the intrinsic viscoelastic structure of the muscle, which may be altered by chronic inflammation, fibrosis, or disuse. In contrast, contraction-based assessments depend on active neuromuscular control and voluntary muscle recruitment. In RA, pain, joint damage, and inflammation can impair central and peripheral neuromuscular pathways, leading to reduced activation capacity during contraction even when passive properties appear relatively preserved.

This discrepancy is clinically relevant as it suggests that muscle dysfunction in RA may not always be visible at rest but becomes evident during functional use. Therefore, evaluation and rehabilitation strategies should include assessments under both conditions to accurately detect dynamic impairments and guide targeted interventions. Pain avoidance behavior and reduced muscle usage in RA patients could also contribute to this decline when compared to healthy individuals. Köprülüoğlu et al. highlighted the relationship between decreased flexor muscle tone and joint dysfunction in their study involving RA patients, emphasizing that this should be a key consideration during the rehabilitation process.[33]

Although increased tone and stiffness in flexor and thenar muscles were initially interpreted as targets for relaxation strategies, it is also possible that these changes represent a compensatory neuromuscular mechanism to stabilize joints affected by ligamentous laxity in RA. Since joint stability was not specifically assessed in this study, caution should be exercised when recommending generalized relaxation exercises. Instead, individualized rehabilitation programs that include functional exercises such as grip strengthening, object manipulation, and wrist stabilization should be considered, based on clinical evaluation of joint integrity. In particular, targeted stabilization exercises for the wrist flexor muscles - especially eccentric training - may be beneficial to counteract the observed reductions in tone and stiffness. Similarly, neuromuscular retraining focused on dynamic activation of the thenar muscle group may help improve grip efficiency. For patients with increased tone in thenar muscles, stretching or soft tissue release techniques could be considered to reduce compensatory overactivity.

The lack of significant differences in extensor muscle groups during rest and activity has also been observed in some studies in the literature. Chung et al. discussed the functional differences between muscle groups in RA patients, noting that extensor muscles play a lesser role in stabilization and tension control of the wrist compared to the flexor group. They highlighted that the absence of changes in tone and stiffness in the extensor muscles is an expected finding.[34] Our study findings were consistent with the limited studies available in the literature. We believe that the changes in the viscoelastic properties (tone, stiffness, and elasticity) of the wrist flexor and extensor muscle groups are not solely related to the nature of the disease but are also influenced by usage patterns and compensation mechanisms. From a clinical standpoint, decreased stiffness and tone in the wrist flexor muscles during contraction may indicate a need for strength-based interventions under load, whereas preserved passive properties suggest that passive stretching may be of limited value. In contrast, the lack of change in the extensor group may reflect underutilization rather than pathology, and thus controlled activation strategies - such as resisted extension movements - could be beneficial.

Further investigation into the lack of changes in the extensor muscle group through more detailed biomechanical analyses and larger patient cohorts would be valuable. The RA group had statistically higher tone and stiffness scores in the thenar muscle groups of both extremities during contraction and rest compared to the healthy group, whereas no differences were observed in tone, stiffness, or elasticity in the hypothenar region. The Duru Öz Hand Index scores were also higher in the RA group than in the control group. Smith et al. noted that the presence of inflammation, fibrotic changes, and compensatory mechanisms are associated with increased tone and stiffness in the RA group.[35]

Compared to the hypothenar region, the thenar muscles play a more significant role in grip strength and fine motor skills, making it expected for RA to have a more pronounced impact on these muscles. We also believe this may be associated with clinical findings and symptoms such as muscle spasms and increased muscle activity. Brorsson et al. reported that changes in neuromuscular control mechanisms can lead to clinical problems such as hypertonia and rigidity.[36] Izod et al. stated that the hypothenar muscles are used less frequently in daily living activities compared to the thenar region, and this reduced usage leads to less impact from disease-related degeneration.

As a result, no changes were observed in the tone, stiffness, and elasticity parameters of the hypothenar region.[37] The higher Duru Öz Hand Index scores in the RA group indicate limitations in hand functions. Joint deformities and muscle dysfunction not only negatively impact hand functions but also suggest adverse effects on the mechanical properties of the muscles. Therefore, rehabilitation planning should consider both passive and active muscle properties. For example, reduced contraction stiffness in the thenar group highlights the need for resistance-based precision grip training. On the other hand, the absence of hypothenar changes may not require direct intervention, but should be monitored in case of compensatory overuse. By "functional exercises," we refer to clinically oriented movements such as grip strengthening, fine motor coordination tasks, object transfer, and activities mimicking daily hand use. These exercises are intended to improve practical hand function in RA patients and should be selected based on the patient's individual joint integrity and muscle performance.

Limitations

This study has some limitations. Although our study was conducted in a single center and our sample size calculation was appropriate for our study, clinicians should be careful when interpreting our results obtained in a small sample to the general RA population. Our second limitation is that submaximal contraction was asked from the participants in the measurements during activity. However, how homogeneous this contraction level is realized may vary between participants and may affect the reliability of the measurement. Our third limitation is that the pain felt by RA patients during contraction may limit muscle activation. However, in this study, pain levels during the measurement were not recorded. Occupational information, pinc and grip strength measurements were not questioned.

Conclusion

In RA, the mechanical properties (stiffness and tone) of the flexor and thenar muscles appear to be primarily affected, with the impact observed regionally, starting with the wrist and hand. While hand and wrist functionality decreases, strength may remain unaffected. Rehabilitation programs for the hands and wrists of these patients should prioritize specific exercises targeting the flexor and thenar muscle groups (e.g., relaxation, stretching, and functional exercises) and incorporate approaches aimed at improving overall hand functionality.

Clinically, these findings suggest that decreased hand function in RA may be linked to altered mechanical properties (increased stiffness/tone) in specific muscles like flexors and thenar groups, even if overall strength is maintained. Therefore, rehabilitation strategies should extend beyond general strengthening to include targeted interventions such as stretching, relaxation techniques, and functional exercises specifically for these affected muscle groups to effectively improve hand functionality.

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