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Article *in* Medicine Science | International Medical Journal · December 2019

DOI: 10.5455/medscience.2019.08.9110

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Medicine Science 2019;8(4):986-93

The correlation of muscle strength, flexibility and range of motion with pain in musicians playing string instruments

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Received 20 Febuary 2019; Accepted 02 July 2019
Available online .2019 with doi:10.5455/medscience.2019.08.9110

Abstract
The aim of this study was to determine the correlation of muscle strength, flexibility, and range of motion with pain in musicians playing string instruments. This randomized, controlled trial included 37 in musicians aged range of 19 to 41, including 17 male and 20 female string players. The mean of age, weight, height, and BMI values of musicians playing a string instrument were examined. The amount of pain parameters was measured with the visual analog scale, joints' range of motion measured with universal goniometer and flexibility measured with Beighton Hypermobility Score. Measured variables were analyzed, compared, and correlated. The mean age of participants was 24.97±5.52 years, and the mean body mass index of participants was 21.69±2.46 kg/m2. Regarding the rough grip, pinch grip muscle strength, pain parameter scores between male and female string players, statistically significant differences were observed ($p < 0.05$). There was no difference between male and female musicians in terms of flexibility ($p > 0.05$). A weak positive correlation observed between muscle strength and pain parameters; a weak negative correlation observed between joints' the range of motion and pain parameters. Also, a significantly strong negative relationship observed between flexibility and pain parameters. In conclusion, according to scores between female and male string players, statistically significant differences were noticed in the rough grip, pinch grip muscle strength, pain parameters in contrast with flexibility. This study found that flexibility and joints' range of motion has a negative correlation with pain in musicians playing a string instrument in contrast to muscle strength.

Keywords: Musicians, strength, flexibility, pain, range of motion

Introduction

Musculoskeletal injuries frequently are observed in musicians. Musicians used their musculoskeletal systems for long periods outside their normal position [1,2]. Overusing of specific muscle groups result in musculoskeletal disorders due to overloading. There are many reasons for pain and disability, such as long-term performance, posture disorders, muscle weakness and loss of fitness, and inappropriate instrument selection [3,4]. Overusing extension, flexion muscle of wrist leads to increase rough and pinch grip pain, showing insidious onset and elbow pain, reduced hand functions, decreasing rough and pinching strength [5-7].

Musicians playing string instrument overuse their distal and proximal phalangeals, so they complain wrist and hand muscle strain, pain, disability of daily functions. Keeping the violin on the left hand, repeated and fast hand, wrist and elbow movements cause pain [8,9]. Complex actions lead to overloads of muscles and joints to stand in the same position for a long time. Soft tissue tendons and ligaments injuries are frequently observed. This situation results in pain, lack of strength, and sensory changes. Ideal muscle strength, flexibility, and coordination are needed to prevent this situation [10].

Muscle examination methods are used for evaluation of muscle strength [11]. Age, gender, environmental factors, flexibility play an essential role in muscle strength. Musicians' musculoskeletal systems are affected negatively for long periods outside the normal position. Therefore, muscle strength evaluation of upper and lower extremities is criteria for endurance [12].

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Musicians need to perform the high-speed movement in the normal range of motion. The range of wrist, deviation of radial and ulnar, metacarpophalangeal, interphalangeal joints are more critical for musicians playing string instruments — inadequate flexibility cause not learning through the development and different movements. The development of force, speed, and coordination are adversely affected because of decreased flexibility. Joint structure, tendon, and ligament, age, gender, general body temperature affect flexibility [13].

In the studies, ligaments, and tendons have positive effects on elasticity in contrast to muscle strength. With age, tissue elasticity, flexibility, and physical activity decreases [14]. In the literature, there was no study to examine the correlation between muscular strength, flexibility, range of motion, and pain in musicians playing string instruments. The purpose of this study was to evaluate the relationship of muscle strength, flexibility, and range of motion with pain in musicians playing string instruments.

Material and Methods

This randomized, controlled, clinical trial was performed in compliance with the principles of the Declaration of Helsinki. Approval for the study was granted by the Malatya Clinical Research Ethics Committee (Approval number: 2017/89, dated: 19/07/2017). Informed consent was obtained from all the study participants.

The target population of the study consisted of musicians playing string instruments between July 2017 and February 2018 at the Department of Conservatory, Inonu University. Individuals that met the inclusion criteria were selected from the target population using simple randomized sampling.

With a simple random sampling method, individuals were listed by number, and those to be sampled were selected using a casual number table.

The study included 37 musicians playing a string instrument (17 males, 20 females) aged 19-41 years to determine the effect of muscle strength, flexibility and range of motion on pain in musicians playing string instruments. Musicians who agreed to participate in the study and met the inclusion criteria were selected by a randomized sampling method in the relevant phase. The inclusion criteria were being an advanced musician or student at Inonu University State Conservatory, ability to perform at least one string instrument, aged 19-41 years, a sufficient mental capacity to be able to adapt to the training program.

Exclusion criteria were the presence of orthopedic disease and operation and not being a musician and having the ability to play at least one string instrument.

The demographic information and clinical characteristics of the musicians were recorded including age, gender, height, weight, BMI, and dominant side.

The severity of pain was assessed using a Visual Analog Scale (VAS) ranging from 0 (no pain) to 10 (intolerable pain). The VAS scale is recommended for evaluation because of high reliability [15]. This scale includes resting, activity, and night pain. This study evaluated the pain scores of musicians playing a string instrument after the performance.

With Manual Medical Research Council Muscle Testing, Muscle strength is often rated on a scale of 0/5 to 5/5 as follows; 0/5 means no contraction, 1/5 means muscle flicker, but no movement; 2/5 means movement possible, but not against gravity (test the joint in its horizontal plane), 3/5 means that movement possible against gravity, but not against resistance by the examiner, 4/5 means that movement possible against some resistance by the examiner (this category can be subdivided further into 4–/5, 4/5, and 4+/5), 5/5 means normal strength. Manual Muscle Testing used for evaluation of hand and wrist muscle such as extensor and flexor carpi ulnaris&radialis, extensor and flexor digitorum superficialis, thenar muscle. Rough and pinch grip strength scores were measured using with Jamar hand dynamometer to measure rough grip strength and an electronic pinch meter to measure the pinch finger grip strength [16].

Active Range of motion is used to describe the amount of joint movement. Every joint in the body has a "normal" range of motion. The universal goniometer was used for joints' range of motion. Stiff joints can cause pain when musicians play string instruments. Ulnar deviation, radial deviation, wrist flexion& extension, interphalangeal and metacarpophalangeal joint flexion & extension were evaluated in this study [17].

Beighton Hypermobility Score is used more like a clinical parameter to perform a quick assessment for generalized hypermobility. While musicians playing string instrument made the palm and forearm resting on a flat surface with the elbow flexed at 90°, if the metacarpal-phalangeal joint of the fifth finger can be hyperextended more than 90° concerning the dorsum of the hand, it was considered positive scoring 1 point. When they arms outstretched forward but hand pronated, if the thumb can be moved to touch the ipsilateral forearm, it was regarded as positive scoring 1 point. Their arms outstretched to the side and hand supine, if the elbow extends more than 10°, it was considered positive scoring 1 point. While they standed, with knees locked in genu recurvatum, if the knee extends more than 10°, it was considered positive scoring 1 point. Their knees locked straight and feet together, if the patient can bend forward to place the entire palm of both hands flat on the floor just in front of the feet, it was considered positive scoring 1 point. A low score (0-2 points) means non-hypermobility. Total score (3-4 points) means normal. A higher score [5-9 points) means joint laxity [18].

Data Analysis

Analysis of the data was made in SPSS 22 statistical package program. In the power analysis performed, assuming that the difference 1 unit with $\alpha = 0.05$ and $1-\beta$ (power) = 0.80, at least 32 musicians were required for the sample. The Mann Whitney-U test was used for the comparison of the significance of data that meet non-parametric conditions. Correlation between parameters was made with Spearman Correlation. A value of $p<0.05$ was accepted as statistically significant.

Results

The evaluation was made of 37 participants with musicians playing a string instrument, comprising 17 males and 20 females with a mean age of 24.97±5.52 years (range, 19-41 years). The mean

body mass index (BMI) of participants was found 21.69±2.46 kg/m2 (Table 1). All participants were correlated muscle strength, flexibility, range of motion, and the level of pain. The number of a female with right-sided dominant was 18; while a female with left-sided dominant was two musicians playing string instruments. The number of male with right-sided dominant was 13; while male with left-sided dominant was four musicians.

Table 1. Demographic and clinical characteristics of the musicians

		n	Mean±SD	Minimum	Maximum
Age	1:Female	20	23.95±5.15	19	41
	2:Male	17	26.17±5.85	20	41
Height (m)	1:Female	20	1.64±0.05	1.52	1.75
	2:Male	17	1.76±0.04	1.70	1.85
Weight (kg)	1:Female	20	56.95±7.04	45	70
	2:Male	17	69.64±8.92	58	88
BMI (kg/m^2)	1:Female	20	21.04±2.31	17.30	25.78
	2:Male	17	22.45±2.48	18.52	26.37

BMI body mass index, SD Standart deviation

Table 2 presents the median, min, and max scores of grasping, pinching muscle strength, pain parameters, and flexibility between male and female musicians. There was a difference between male and female musicians in terms of rough grip, pinch grip muscle strength and pain ($p<0.05$), while there was no difference between male and female musicians in terms of flexibility ($p>0.05$).

Table 2. Comprasion between musicians in terms of muscle strength, pain and flexibility

		n	Median (min, max)	p[a]
Rough Grip Right	1: Female	20	38.99(29.00-56.66)	**0.001**
	2: Male	17	61.00(28.66-98.66)	
Rough Grip Left	1: Female	20	37.33(22.66-52.66)	**0.001**
	2: Male	17	64.33(25.33-95.00)	
Pinch GripRight	1: Female	20	5.66(3.00-8.00)	**<0.001**
	2: Male	17	8.00(4.66-14.00)	
Pinch Grip Left	1: Female	20	5.33(4.00-7.00)	**0.001**
	2: Male	17	7.66(4.33-13.00)	
Resting Pain	1: Female	20	3.50(2.00-6.00)	**0.027**
	2: Male	17	5.00(2.00-8.00)	
Active Pain	1: Female	20	5.00(3.00-7.00)	**0.035**
	2: Male	17	6.00(3.00-10.00)	
Night Pain	1: Female	20	3.50(2.00-5.00)	**0.008**
	2: Male	17	5.00(2.00-8.00)	
Flexibility	1: Female	20	2.00(0.00-6.00)	0.405
	2: Male	17	1.00(0.00-6.00)	

a: Mann-Whitney U test

Table 3 presents the correlation of muscle strength, flexibility, and range of motion with pain in female participating. A weak positive correlation was observed mostly between muscle groups (extensor carpi ulnaris&radialis, flexor carpi ulnaris&radialis, flexor & extensor digitorum superficialis) and pain in female musicians.

A weak negative correlation was observed between flexibility and pinched grip muscle strength in contrast to rough grip muscle strength in female musicians (Table 3).

A weak negative correlation was observed between the pinch grip muscle strength and pain parameters in contrast to rough grip muscle strength in female musicians (Table 3).

Table 4 presents that a weak positive correlation was observed between muscle strength (extensor carpi ulnaris&radialis, flexor carpi ulnaris&radialis, flexor &extensor digitorum superficialis) and pain parameters in male musicians.

A significantly negative correlation was observed between rough grip, pinch grip muscle strength, and flexibility in male musicians (Table 4).

A significantly positive correlation was observed between rough grip, pinch grip muscle strength, and pain parameters in male musicians (Table 4).

There was mostly a weak positive correlation between radial & ulnar deviation ROM and pain parameters in female musicians (Table 5).

There was a weak negative correlation between the wrist and metacarpophalangeal joint (MCP) flexion&extension ROM and pain parameters in female musicians (Table 5).

There was a significantly negative correlation between flexibility and pain parameters in male musicians (Table 6).

There was a significantly negative correlation between ulnar ROM and pain parameters in male musicians (Table 6).

There was a weak negative correlation between radial, wrist, metacarpophalangeal (MCP) joints and pain parameters in male musicians (Table 6).

Table 3. The Correlation of Flexibility and Pain with Muscle Strength in Female Participating

Female (n:20) Muscle strength	Body Side	Flexibility	Resting Pain	Active Pain	Night Pain
Rough grip strength	Right	r:0.100 p:0.676	r: 0.462 p:0.040	r: 0.418 p:0.067	r: 0.336 p:0.147
	Left	r: 0.280 p:0.232	r: 0.633 p:0.003	r: 0.419 p:0.066	r: 0.496 p:0.026
Pinch grip strength	Right	r:-0.409 p:0.074	r:-0.165 p:0.488	r:-0.037 p:0.877	r:0.433 p:0.057
	Left	r:-0.232 p:0.325	r:-0.078 p:0.745	r:-0.121 p:0.610	r:-0.395 p:0.085
Extensor carpi ulnaris	Right	r:0.278 p:0.235	r:0.024 p:0.921	r:-0.152 p:0.523	r:-0.071 p:0.765
	Left	r:0.220 p:0.351	r:0.171 p:0.472	r:0.199 p:0.400	r:0.071 p:0.766
Extensor carpi radialis	Right	r:0.136 p:0.566	r:0.111 p:0.641	r:0.014 p:0.952	r:0.045 p:0.851
	Left	r:0.154 p:0.516	r:0.209 p:0.377	r:0.260 p:0.268	r:0.102 p:0.851
Extensor digitorum superficialis	Right	r:0.246 p:0.295	r:0.032 p:0.894	r:-0.052 p:0.827	r:-0.049 p:0.837
	Left	r:0.154 p:0.516	r:0.299 p:0.200	r:0.000; p:1.000	r:+0.102 p:0.667
Flexor carpi radialis	Right	r:0.152 p:0.522	r:0.192 p:0.416	r:0.074 p:0.755	r:-0.054 p:0.821
	Left	r:0.162 p:0.494	r:0.379 p:0.099	r:0.098 p:0.680	r:0.185 p:0.434
Flexor carpi ulnaris	Right	r:0.257 p:0.274	r:0.211 p:0.371	r:0.048 p:0.840	r:-0.026 p:0.914
	Left	r:0.235 p:0.319	r:0.410 p:0.073	r:0.101 p:0.671	r:0.145 p:0.542
Flexor digitorum superficialis	Right	r:0.129 p:0.589	r:0.015 p: 0.950	r:0.218 p:0.356	r:-0.152 p:0.522
	Left	r:0.017 p:0.944	r:0.137 p:0.564	r:0.093 p:0.698	r:-0.137 p:0.564
Thenar	Right	r:0.200 p:0.399	r:0.066 p:0.781	r:0.158 p:0.507	r:0.023 p:0.925
	Left	r:0.126 p:0.597	r:0.189 p:0.425	r:0.188 p:0.428	r:-0.005 p:0.985

Spearman Correlation test

Table 4. The Correlation of Flexibility and Pain with Muscle Strength in Male Participating

Female (n:20) Muscle strength	Body Side	Flexibility	Resting Pain	Active Pain	Night Pain
Rough grip strength	Right	r:-0.543 p:0.024	r:0.893 p:<0.001	r:0.921 p:<0.001	r:0.842 p:<0.001
	Left	r:-0.443 p:0.075	r:0.793 p:<0.001	r:0.851 p:<0.001	r:0.778 p:<0.001
Pinch grip strength	Right	r:-0.425 p:0.089	r:0.634 p:0.006	r:0.479 p:0.052	r:0.577 p:0.015
	Left	r:-0.467 p:0.059	r:0.701 p:0.002	r:0.536 p:0.026	r:0.667 p:0.003
Extensor carpi ulnaris	Right	r:-0.199 p:0.444	r:0.530 p:0.029	r:0.438 p:0.079	r:0.293 p:0.253
	Left	r:-0.291 p:0.256	r:0.242 p:0.350	r:0.248 p:0.337	r:0.181 p:0.487
Extensor carpi radialis	Right	r:-0.192 p:0.460	r:0.291 p:0.258	r:0.423 p:0.091	r:0.244 p:0.346
	Left	r:-0.360 p:0.156	r:0.357 p:0.159	r:0.453 p:0.068	r:0.421 p:0.092
Extensor digitorum superficialis	Right	r:-0.261 p:0.312	r:0.079 p:0.764	r:0.122 p:0.642	r:0.065 p:0.804
	Left	r:-0.409 p:0.103	r:0.479 p:0.052	r:0.542; p:0.025	r:0.493 p:0.044
Flexor carpi radialis	Right	r:-0.208 p:0.423	r:0.270 p:0.294	r:0.240 p:0.353	r:0.102 p:0.697
	Left	r:-0.236 p:0.361	r:0.427 p:0.088	r:0.371 p:0.142	r:0.364 p:0.150
Flexor carpi ulnaris	Right	r:-0.261 p:0.312	r:0.213 p:0.413	r:0.299 p:0.244	r:0.137 p:0.600
	Left	r:-0.204 p:0.433	r:0.223 p:0.390	r:0.287 p:0.264	r:0.277 p:0.281
Flexor digitorum superficialis	Right	r:-0.227 p:0.381	r:0.176 p:0.498	r:0.209 p:0.421	r:0.052 p:0.842
	Left	r:-0.235 p:0.364	r:0.312 p:0.223	r:0.280 p:0.277	r:0.267 p:0.301
Thenar	Right	r:-0.065 p:0.804	r:0.078 p:0.767	r:0.016 p:0.952	r:-0.171 p:0.512
	Left	r:-0.168 p:0.518	r:0.293 p:0.254	r:0.284 p:0.270	r:0.245 p:0.342

Spearman Correlation test

Table 5. The Correlation of pain and flexibility with Range of Motion (ROM) in Female Participating

Female (n:20)	Body Side	Resting Pain	Active Pain	Night Pain
Total Flexibility		r:0.012 p:0.959	r:-0.188 p:0.427	r:0.182 p:0.443
	Right	r: 0.083 p:0.727	r: 0.104 p:0.663	r:-0.091 p:0.704
Ulnar ROM				
	Left	r:-0.041 p:0.862	r: 0.143 p:0.862	r: 0.006 p:0.978
	Right	r:-0.029 p:0.905	r:0.105 p:0.658	r:0.089 p:0.708
Radial ROM				
	Left	r:-0.063 p:0.793	r:-0.049 p:0.836	r:-0.044 p:0.852
	Right	r:0.002 p:0.993	r:-0.032 p:0.892	r:0.175 p:0.461
Wrist flexion ROM				
	Left	r:0.145 p:0.542	r:-0.015 p:0.951	r:0.150 p:0.529
	Right	r:0.109 p:0.647	r:0.255 p:0.278	r:0.066 p:0.782
Wrist extension ROM				
	Left	r:-0.409 p:0.103	r:0.080 p:0.737	r:0.050 p:0.836
	Right	r:0.155 p:0.513	r:0.036 p:0.882	r:0.408 p:0.074
MCP flexion ROM				
	Left	r:0.113 p:0.634	r:-0.065 p:0.785	r:0.259 p:0.269
	Right	r:-0.166 p:0.484	r:0.016 p:0.948	r:-0.010 p:0.966
MCP extension ROM				
	Left	r:-0.115 p:0.630	r:0.056; p:0.816	r:-0.010 p:0.966

Spearman Correlation test

Table 6. TThe Correlation of pain and flexibility with Range of Motion (ROM) in Male Participating

Female (n:20)	Body Side	Resting Pain	Active Pain	Night Pain
Total Flexibility		r:-0.593 p:0.012	r:-0.656 p:0.004	r: -0.697 p: 0.002
	Right	r:-0.602 p:0.011	r:-0.642 p:0.005	r:-0.736 p:0.001
Ulnar ROM				
	Left	r:-0.403 p:0.109	r:-0.513 p:0.035	r:-0.591 p:0.013
	Right	r:-0.256 p:0.322	r:-0.276 p:0.283	r:-0.383 p:0.129
Radial ROM				
	Left	r:-0.277 p:0.282	r:-0.275 p:0.285	r:-0.425 p:0.089
	Right	r:-0.453 p:0.068	r:-0.386 p:0.126	r:-0.572 p:0.016
Wrist flexion ROM				
	Left	r:-0.333 p:0.191	r:-0.265 p:0.305	r:-0.440 p:0.077
	Right	r:-0.487 p:0.048	r:-0.464 p:0.061	r:-0.565 p:0.018
Wrist extension ROM				
	Left	r:-0.270 p:0.295	r:-0.259 p:0.315	r:-0.380 p:0.132
	Right	r:-0.524 p:0.031	r:-0.584 p:0.014	r:-0.608 p:0.010
MCP flexion ROM				
	Left	r:-0.415 p:0.097	r:-0.410 p:0.102	r:-0.435 p:0.081
	Right	r:-0.300 p:0.242	r:-0.416 p:0.097	r:-0.481 p:0.051
MCP extension ROM				
	Left	r:-0.209 p:0.422	r:-0.320 p:0.211	r:-0.395 p:0.116

Spearman Correlation test

Discussion

This study investigated the correlation of distal muscle strength, flexibility, and range of motion and pain according to gender in musicians playing string instruments. The results demonstrated that there was a negative correlation between flexibility, range of motion, and pain. Also, there was a negative correlation between muscle strength and flexibility. In contrast, there was a positive correlation between muscle strength and pain. To the best of our knowledge, this is the first study to correlate muscle strength, flexibility, and range of motion with pain in musicians playing string instruments.

According to the previous study, the risk of musculoskeletal symptoms (numbness, swelling, pain) was the highest rate in string players [19]. Therefore, this study evaluated the relationship muscle strength, flexibility, and joint ROM with pain in string players.

According to previous studies, playing musical instruments requires contrary to the natural posture of the body. This position brings about physical tension and pain. Agonist and antagonist tension is a muscle contraction accompanied by a contraction of a muscle that is its opposite. Stress and physical tension can lead to injuries. It is essential that the tension in the instrument technique is destroyed and musicians need to improve the flexibility of body parts [20]. Typically, in terms of the instrument technique, there is cooperation with the opposing muscles because of the tension of agonist, synergist, and antagonist. While playing a musical instrument in the instrument technique, the other muscle group relaxes at the same time, allowing it to extend and move. If the muscle that provides the relaxation remains always stretched, this situation causes that movement is inhibited, and disturbances establish [21]. This conclusion was similar to the conclusion of the current study in terms of relationship flexibility with pain parameters in musicians playing string instruments.

Robert Schumann found a way to keep the finger as 'extensible' as possible for strengthening his middle finger, but this way caused the shortening of the middle finger 'extensors. This situation resulted in severe loss of function in his hands [22]. Overstretching and laxity connected with a higher risk of musculoskeletal injury and pain [23]. This study included musicians no having joint laxity.

According to Lockwood, overuse syndrome, misuse syndrome, RSI-repetitive strain/stress injuries are observed in musicians. Bursitis, lateral and medial epicondylitis, carpal tunnel syndrome, trigger finger, and focal dystonia are seen mostly in musicians playing string instruments [24]. The most common discomforts in musicians are musculoskeletal injuries. The previous study has shown that the number of years playing, gender were significantly important on playing-related pain. This situation can be connected with high-speed movements in static, intensive workload; frequency repetition affected the negatively musculoskeletal system. Musicians use their musculoskeletal systems for long periods outside the natural range [25]. Because of lesser muscle mass, hormones (estrogen), women usually are more flexible than men because these causes affect positively connective tissue laxity. However, this study showed that there was no difference between male and female musicians in terms of flexibility, but female flexibility score was higher than male string players.

According to the biomechanics of the human body models, if there is a problem in the wrist, it affects the rough grip, pinch grip, and thenar muscle strength [26]. The grip position of the violin is far out of the normal joint positions. A professional violinist works for hours at this position and performance a long time with the same position. The musician has no chance to perform the affected area for weeks. The body biomechanics reflects the problem (pain, tension) in a particular region to other regions [27]. This study evaluated the correlation of grip muscle strength with pain in subjects playing string instruments.

Limitation

A limitation of this study was that only ROM, muscle strength of string players' hand and wrist were evaluated. Posture and compensatory mechanism were not observed in this study. Also, Flexibility can be measured with the specific test for a musician playing a string instrument.

Conclusion

In conclusion, according to scores between female and male string players, statistically, significant differences were noticed in the rough grip, pinch grip muscle strength, pain parameters in contrast with flexibility. This situation was no similar to literature because participants were selected from the Department of Conservatory. However, the female string player' flexibility total score was higher than male string player. A negative correlation was observed between rough grip, pinch grip muscle strength and flexibility in male musicians in contrast to female musicians. A significantly positive correlation was observed between rough grip, pinch grip muscle strength and pain parameters in male musicians. This study found flexibility is more important than muscle strength of hand and wrist on pain parameters.

Competing interests
The authors declare that they have no competing interests.

Financial Disclosure
The financial support for this study was provided by the investigators themselves.

Ethical approval
Approval for the study was granted by ethical commitee of Ankara Education and Research Hospital with 16.12.2009 date and 2781 number.

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