

## Is there a relationship between hand grip strength and knee osteoarthritis in terms of radiological and functional findings in female patients?

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### ABSTRACT

**Objectives:** The aim of this study was to assess the presence of the relationship between hand grip strength (HGS) and radiological and functional signs of knee osteoarthritis (KOA).

**Patients and methods:** Between March 2019 and January 2020, a total of 64 female patients (mean age: 63.4±8.8 years; range, 50 to 80 years) with bilateral chronic knee pain who were diagnosed with KOA using radiological and clinical findings according to the 2019 American College of Rheumatology guidelines were included in the study. Patient demographics, body mass index (BMI) values, and hand dominance were recorded. The Western Ontario and McMaster Universities Arthritis Index (WOMAC) and Lower Extremity Functional Scale (LEFS) were used for the assessment of KOA functionality. The Kellgren-Lawrence (KL) grading system was used for the radiological assessment of KOA. Electronic dynamometer was used for HGS measurement and values were normalized according to BMI results.

**Results:** In the assessment of relationship between HGS and functionality of KOA, a negative, moderate correlation was found between the WOMAC and HGS-Dominant (D) ( $r=0.312$ ,  $p<0.05$ ) and HGS-Non-Dominant (ND) ( $r=0.391$ ,  $p<0.01$ ). In addition, a positive, moderate correlation was found between the LEFS and HGS-D ( $r=0.344$ ,  $p<0.01$ ) and HGS-ND ( $r=0.371$ ,  $p<0.01$ ). There was a weak, negative correlation between the HGS-ND, KL-D ( $r=0.256$ ,  $p<0.05$ ) and KL-ND ( $r=0.283$ ,  $p<0.05$ ), while no significant correlation was found between the HGS-D and KL.

**Conclusion:** Our study results show that HGS-ND is associated with KOA radiologically and functionally. The HGS should be added in the WOMAC and LEFS scales in the functional assessment of KOA and new scales including HGS assessment should be developed.

**Keywords:** Hand grip strength, muscle, osteoarthritis.

Knee osteoarthritis (KOA) is a chronic degenerative disease of the knee joint that progresses with age and severely affects knee joint functionality, as well as daily life activities. The symptomatic KOA prevalence is 14.8% in adults over 50 years of age, and it is 22.5% in females and 8% in males in Turkey.<sup>1</sup> Although there are a number of risk factors associated with KOA, weakness in lower extremity muscles,

particularly in quadriceps muscle, was shown to play a major role in the development of symptomatic KOA.<sup>2,3</sup> However, there are contradicting results regarding the relationship of Quadrupedal Movement (QM) strength and radiological KOA in the literature.<sup>4,5</sup>

The hand grip strength (HGS) is a preferred method which is positively correlated with QM

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strength and used in the assessment of muscle strength required for sarcopenia diagnosis.<sup>6,7</sup> Patients with weak QM and/or sarcopenic obesity are reported to be under a higher risk of KOA development.<sup>8,9</sup> Therefore, HGS assessment can be beneficial in evaluating the functional and radiological results of KOA. There is only one study examining the HGS relation of radiological KOA; however, the radiological evaluation method used in this study is not applicable in routine practice.<sup>10</sup> No study is available evaluating the relationship of HGS with functionality of KOA in the literature.

In the present study, we hypothesized that HGS measurement could be related to KOA as radiologically and functionally and, thus, it could be implemented in functional and radiological assessment of KOA due to its simplicity, cost-effectiveness, and ease of application. In this study, we, therefore, aimed to assess the presence of the relationship between HGS and radiological and functional signs of KOA using objective measurement tools.

## PATIENTS AND METHODS

The prospective study was conducted at Giresun University Faculty of Medicine, Department of Physical Medicine and Rehabilitation between March 2019 and January 2020. A total of 83 female patients were included in the study who presented to clinic for bilateral chronic knee pain (>3 months) and diagnosed with KOA using radiological and clinical findings according to the 2019 American College of Rheumatology (ACR) guidelines.<sup>11</sup> Patients over 50 years old were included in the study to obtain an age and sex standard. No upper limit was set for age. Exclusion criteria were as follows: weakness or paresthesia in upper-lower extremity (n=3); pain or sensory symptoms on lower-upper extremity (except for knee) (n=2); muscle atrophy in upper-lower extremity muscles (except for bilateral QM atrophy due to KOA) (n=1); a pathology on deep tendon reflexes or sensory examination (n=2); trauma history within the past three months which might affect HGS and knee extension strength (KES) (n=1); uncontrolled diabetes mellitus

with polyneuropathy (n=1); cervical-lumbar disk hernia (n=1); cervical-lumbar spinal stenosis (n=2); nerve compression syndromes of upper-lower extremities (n=3); upper-lower extremity surgery history (n=3); active infection and malignancies; patients under medication which might affect muscle strength or pain level (muscle relaxants, analgesics, gabapentinoids, etc.); and having injection to knee or hand region within the past three months or receiving physical therapy. A total of 19 patients who met criteria were excluded from the study and, finally, 64 female patients (mean age: 63.4±8.8 years; range, 50 to 80 years) completed the study. A written informed consent was obtained from each patient. The study protocol was approved by the Giresun University Faculty of Medicine Ethics Committee (No. KAEEK-110). The study was conducted in accordance with the principles of the Declaration of Helsinki.

All assessments were done in face-to-face interviews. Patients' demographic characteristics, systemic diseases, body mass index (BMI), current medication use, tobacco and alcohol use, educational status, and dominant hand side were recorded. The Western Ontario and McMaster Universities Arthritis Index (WOMAC) and Lower Extremity Functional Scale (LEFS) were used for functional assessment, whereas the Kellgren-Lawrence (KL) grading system was used for radiological assessment of KOA. The HGS and KES were measured using electronic dynamometers.

### Instruments

The WOMAC is a valid and reliable method used in the assessment of knee and hip osteoarthritis (OA) patients. The Outcome Measures in Rheumatology Clinical Trials (OMERACT) also recommends using this scale for OA studies. The scale consists of three parts which assess pain, stiffness, and physical function including 24 questions. Higher WOMAC scores indicate a greater level of pain and stiffness with decreased physical functioning.<sup>12</sup> In Turkey, Tüzün et al.<sup>13</sup> performed the validity and reliability studies of the Turkish translation of WOMAC.

The Lower Extremity Functional Scale is a self-reported scale which can be filled out by

the patients to assess the functional status of lower extremities in the presence of an issue with musculoskeletal system.<sup>14</sup> The validity and reliability studies of the LEFS in the Turkish population were conducted by Citaker et al.<sup>15</sup> Higher LEFS scores indicate positive physical functioning.

Radiological KOA was assessed using KL grading system<sup>16</sup> with knee X-rays within the past month as follows:

Stage 0: Normal

Stage 1: Suspicious osteophytes, normal joint space

Stage 2: Significant osteophyte, suspicious narrowing of joint space

Stage 3: Moderate grade osteophytes, moderate narrowing of joint space and slight sclerosis

Stage 4: Big osteophytes, advanced joint space narrowing, significant subchondral bone sclerosis and cysts. The KL was staged by an experienced researcher on both dominant (-D) and non-dominant (-ND) knees, who was blind to the study population.

The HGS was measured using an electronic hand dynamometer (Camry, SCACAM-EH10117; Zhongshan Camry Electronic Co, Ltd., Zhongshan, Guangdong, China) bilaterally. The patients were positioned in a neutral shoulder position, with the elbow in 90 degrees flexion and in semi-pronation. The measurements were taken three times, with 30 sec resting period after each measurement,<sup>17</sup> and maximum values were recorded in Newtons.

The KES was measured using a Lafayette Model 01165 (Lafayette Company Inc., Lafayette IN, USA) hand-held dynamometer. For the QM measurement point, the midline point of 5 cm above the lateral malleolus, which was shown as valid and reliable in previous studies, was defined and bilateral measurement was performed.<sup>18</sup> Similar to HGS measurements, the measurements were taken three times with 30-sec intervals between each measurement. A force was applied from measurement point at least for 3 sec, and measured maximum values were recorded in Newtons. Both HGS and KES measurements were taken by a single researcher to obtain a standardization of the measurements.

Since BMI could affect the measured muscle strength values, they were normalized according to BMI values. In this context, the muscle strength was calculated in Newtons, as the measurements were taken using a dynamometer and the measured value was divided  $BMI^{2/3}$  to obtain the normalized muscle strength. All muscle strength measurements found within the study and the tables were expressed in normalized muscle strength values (Normalized muscle strength = Muscle strength measured in Newton/ $BMI^{2/3}$ ).<sup>19</sup>

### Statistical analysis

Statistical analysis was performed using the IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed in mean  $\pm$  standard deviation (SD), median (min-max) or number and percentage. The Shapiro-Wilk test and normal quantile plots were utilized to assess the normal distribution of the variables. The Pearson correlation was used to identify the relationship between dominant and non-dominant HGS and KES among each other, as well as functional assessment. The relation of KL-D and KL-ND with the muscle strength and functional assessment scores was examined using the Spearman rho correlation. A coefficient value of  $r \leq 0.30$  was deemed as a weak,  $r > 0.30$  to  $\leq 0.70$  was deemed as a moderate, and  $r > 0.70$  was deemed as a strong relationship.<sup>20</sup> For the relationship between HGS-D, HGS-ND and other variables, a linear regression analysis was performed. A  $p$  value of  $< 0.05$  was considered statistically significant.

## RESULTS

Patients' clinical and demographic characteristics are given in Table 1.

Patients' D and ND values of the HGS and KES and their correlations with functional assessment scores are shown in Table 2. According to the correlation analysis between KES and HGS, there was a moderate, positive correlation between the HGS-D and KES-D ( $r = 0.539$ ,  $p < 0.01$ ) and KES-ND ( $r = 0.572$ ,  $p < 0.01$ ). Also, there was a moderate, positive correlation with the HGS-ND and KES-D ( $r = 0.700$ ,  $p < 0.01$ ) and KES-ND ( $r = 0.680$ ,

**Table 1.** Demographic and clinical properties of patients (n=64)

	n	%	Mean±SD
Age (year)			63.4±8.8
Body mass index (kg/m <sup>2</sup> )			32.2±4.9
Education			
Primary education	19	29.7	
Secondary education	35	54.7	
High school-college	10	15.6	
Smoker			
Yes	8	12.5	
No	56	87.5	
Dominant/side			
Right	59	92.2	
Left	5	7.8	
Normalized muscle strength*			
HGS-D			20.6±6.3
HGS-ND			19.8±6.0
KES-D			17.7±6.0
KES-ND			15.0±5.8
KL-D			
1	10	15.6	
2	26	40.6	
3	19	29.7	
4	9	14.1	
KL-ND			
1	11	17.2	
2	35	54.7	
3	13	20.3	
4	5	7.8	
WOMAC			49.6±18.7
LEFS			37.7±14.1

SD: Standard deviation; HGS: Hand grip strength; D: Dominant side; ND: Non-dominant side; KES: Knee extension strength; KL: Kellgren-Lawrence; WOMAC: Western Ontario and McMaster Universities Arthritis Index; LEFS: Lower Extremity Functional Scale; \* Calculated by dividing muscle strength in Newtons by BMI<sup>2/3</sup> (N) / (kg/m<sup>2</sup>)<sup>2/3</sup>.

p<0.01) with a higher coefficient. Table 2 also shows the assessment of the relationship between muscle strength and functional assessment scales. Accordingly, the HGS-D, HGS-ND, KES-D, and KES-ND showed a moderate, negative correlation with the WOMAC scores and a moderate, positive significant correlation with the LEFS scores.

The correlation between the KL and muscle strength with functional assessment scales is shown in Table 3. There was a mild, negative, but significant correlation between the KL-D and HGS-ND (r=-0.256, p<0.01) and KES-D (r=-0.270, p<0.01). However, no significant correlations were found between the KL and HGS-D, KES-ND, WOMAC, and LEFS scores. There was a mild, negative correlation between the KL-ND and HGS-ND (r=-0.283, p<0.01), although no significant correlation was found with the other parameters.

In addition to the correlation analysis, a linear regression analysis was performed to examine a possible relationship between HGS-D, HGS-ND and KES-D, KES-ND, WOMAC, and LEFS (Table 4). The scatter plot of HGS-D, HGS-ND on KES-D, KES-ND, WOMAC and LEFS with regression line and %95 confidence interval (CI) are also shown in Figures 1 and 2. There was a statistically significant relationship between the HGS-D

**Table 2.** Pearson correlation analysis of normalized muscle strength values and functional assessment scales

Muscle strength***	HGS-D	HGS-ND	KES-D	KES-ND	WOMAC	LEFS
HGS-D		0.861**	0.539**	0.572**	-0.312*	0.344**
HGS-ND			0.700**	0.680**	-0.391**	0.371**
KES-D				0.805**	-0.405**	0.336**
KES-ND					-0.453**	0.380**

HGS: Hand grip strength; D: Dominant side; ND: Non-dominant side; KES: Knee extension strength; WOMAC: Western Ontario and McMaster Universities Arthritis Index; LEFS: Lower Extremity Functional Scale; \* Significance p<0.05; \*\* Significance p<0.01; \*\*\* Calculated by dividing muscle strength in Newtons by BMI<sup>2/3</sup> (N) / (kg/m<sup>2</sup>)<sup>2/3</sup>.

**Table 3.** Spearman correlation analysis of K-L grading system with normalized muscle strength values\*\* and functional assessment scales

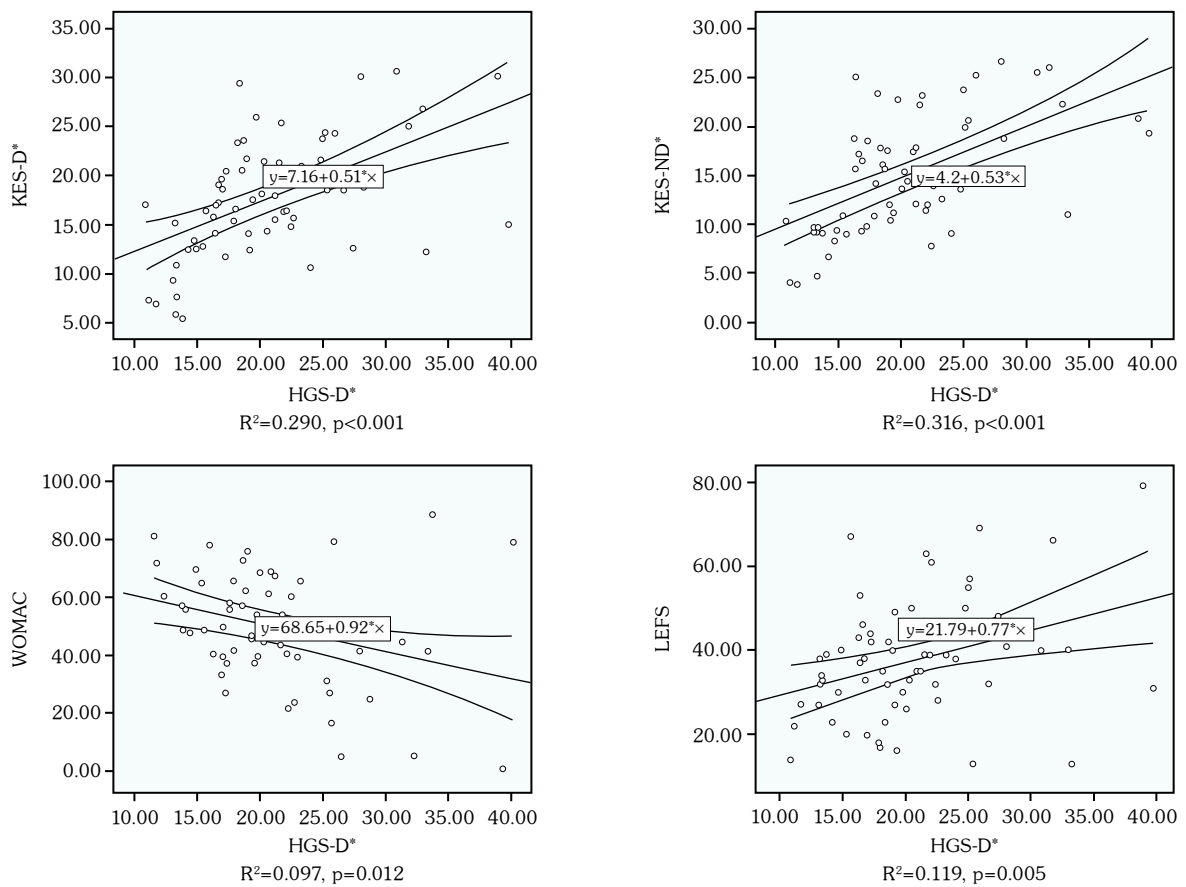
KL scale	HGS-D	HGS-ND	KES-D	KES-ND	WOMAC	LEFS
KL-D	-0.210	-0.256*	-0.270*	-0.121	0.218	-0.213
KL-ND	-0.167	-0.283*	-0.174	-0.124	0.238	-0.201

HGS: Hand grip strength; D: Dominant side; ND: Non-dominant side; KES: Knee extension strength; WOMAC: Western Ontario and McMaster Universities Arthritis Index; LEFS: Lower Extremity Functional Scale; \* Significance p<0.05; \*\* Calculated by dividing muscle strength in Newtons by BMI<sup>2/3</sup> (N) / (kg/m<sup>2</sup>)<sup>2/3</sup>.

**Table 4.** Linear regression analysis between dominant and non-dominant hand grip strength

Variables	HGS-D				HGS-ND			
	B (%95 CI)	SE	R <sup>2</sup>	p	B (%95 CI)	SE	R <sup>2</sup>	p
KES-D	0.570 (0.343-0.796)	0.113	0.290	<0.001	0.706 (0.523-0.889)	0.092	0.489	<0.001
KES-ND	0.622 (0.395-0.849)	0.113	0.316	<0.001	0.706 (0.513-0.900)	0.097	0.463	<0.001
WOMAC	-0.105 (-0.187- -0.024)	0.041	0.097	0.012	-0.126 (-0.201- -0.051)	0.038	0.153	0.001
LEFS	0.154 (0.047-0.261)	0.053	0.119	0.005	0.159 (0.058-0.259)	0.050	0.138	0.003

HGS: Hand grip strength; D: Dominant side; ND: Non-dominant side; B: Coefficient of linear regression; CI: Confidence interval; SE: Standard error; R<sup>2</sup>: Coefficient of determination; KES: Knee extension strength; WOMAC: Western Ontario and McMaster Universities Arthritis Index; LEFS: Lower Extremity Functional Scale.

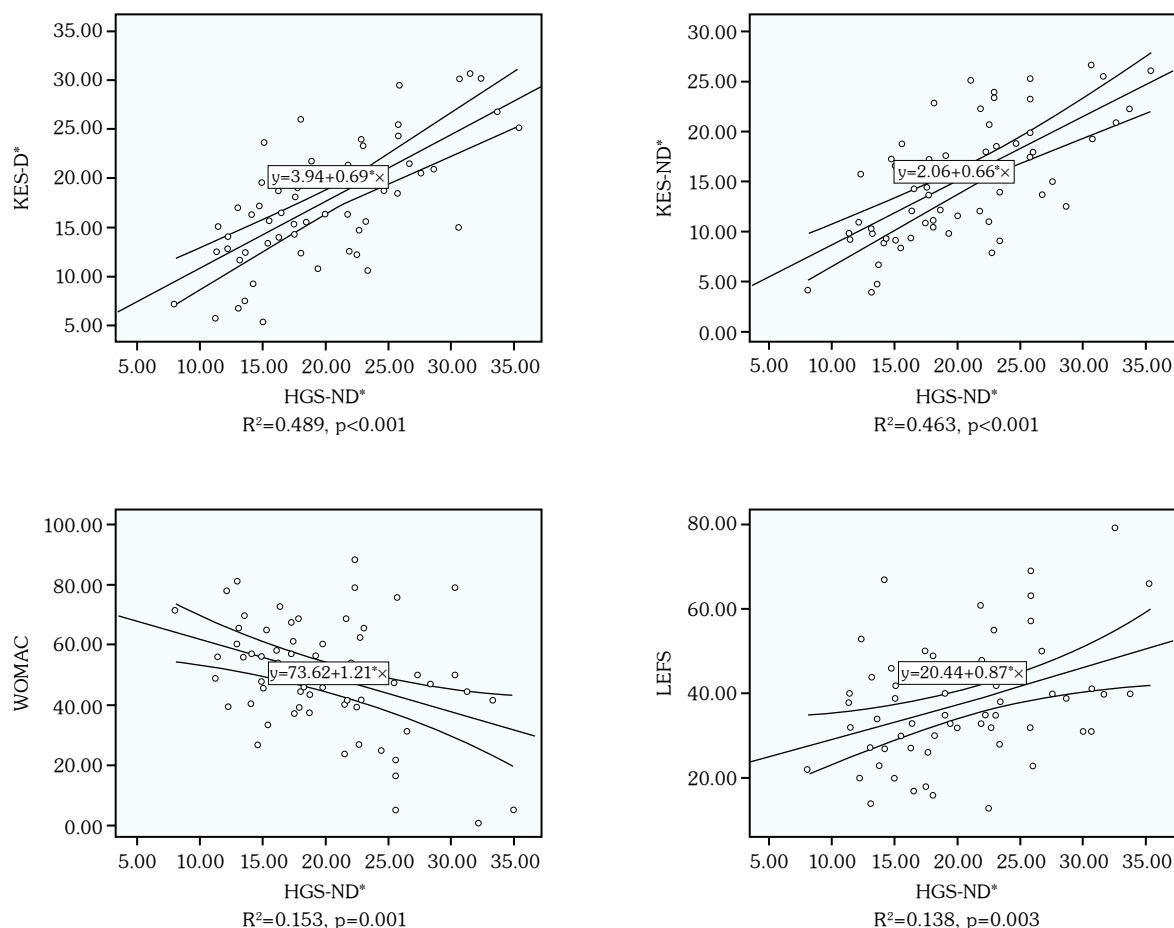


**Figure 1.** Relationship between HGS-D and variables tested (KES-D, KES-ND, WOMAC and LEFS) with scatter plot.

HGS: Hand grip strength; D: Dominant side; ND: Non-dominant side; KES: Knee extension strength; WOMAC: Western Ontario and McMaster Universities Arthritis Index; LEFS: Lower Extremity Functional Scale; R<sup>2</sup>: Coefficient of determination; \* Calculated by dividing muscle strength in Newtons by BMI<sup>2/3</sup> (N) / (kg/m<sup>2</sup>)<sup>2/3</sup>.

and KES-D (R<sup>2</sup>=0.290, p<0.001), KES-ND (R<sup>2</sup>=0.316, p<0.001), WOMAC (R<sup>2</sup>=0.097, p=0.012), LEFS (R<sup>2</sup>=0.119, p=0.005). Also there was a statistically significant relationship

between the HGS-ND and KES-D (R<sup>2</sup>=0.489, p<0.001), KES-ND (R<sup>2</sup>=0.463, p<0.001), WOMAC (R<sup>2</sup>=0.153, p=0.001), LEFS (R<sup>2</sup>=0.138, p=0.003).



**Figure 2.** Relationship between HGS-ND and variables tested (KES-D, KES-ND, WOMAC and LEFS) with scatter plot.

HGS: Hand grip strength; D: Dominant side; ND: Non-dominant side; KES: Knee extension strength; WOMAC: Western Ontario and McMaster Universities Arthritis Index; LEFS: Lower Extremity Functional Scale;  $R^2$ : Coefficient of determination; \* Calculated by dividing muscle strength in Newtons by  $BMI^{2/3}$  (N) /  $(kg/m^2)^{2/3}$ .

## DISCUSSION

Although the main question which comes to mind in this study is that how a method assessing the hand can have a relationship with KOA, it should be kept in mind that HGS has a positive correlation with QM strength and HGS is the most recommended assessment tool for muscle strength in the algorithmic approach for sarcopenia diagnosis.<sup>6</sup> Moreover, weak QM and sarcopenic obesity are known risk factors for KOA development, as previously reported in the literature.<sup>9</sup> In the light of these data, we hypothesized that HGS could be related to KOA radiologically and functionally, leading us to conduct this study. As a result of this study, the HGS-ND showed a significant correlation

with both radiological and functional parameters, supporting our hypothesis. Therefore, application of HGS, in particular HGS-ND, which is a cost-effective, easily accessible, and easy-to-use method, seems to be overlooked in the clinical and radiological severity assessment of KOA, despite being an important parameter. We, therefore, suggest that scales used to measure functional status in KOA should also include HGS values.

Another point that makes this study unique is that it is the first to analyze the HGS relation with KOA in terms of functional parameters. Additionally, this study is the first to assess the HGS relation with radiological KOA, as evidenced by KL grading. Finally, another important feature of this study which sets it apart from other studies

is that the measured muscle strength values were normalized using normalization formulas found in the literature to eliminate BMI effect.<sup>19</sup>

In the literature, there are a number of studies examining the relation of HGS with hand OA. Those studies reported a negative, but significant correlation between HGS and radiological and symptomatic hand OA.<sup>21,22</sup> However, there are controversial studies showing the opposite and reporting that increased HGS also increased the hand OA development risk.<sup>23</sup> Although there are many studies examining the relationship between HGS and hand OA, there is only one study investigating the relationship between HGS and KOA.<sup>10</sup> In this study, the relationship between HGS and radiological hand OA and KOA was examined and weak HGS was related to more severe radiological hand OA and KOA results.<sup>10</sup> Again, KL was not used for radiological KOA assessment and the authors used a radiological scale they developed for the study, instead. Although we used different radiological assessment methods in our study, Wen et al.<sup>10</sup> showed similar results: i.e., a negative, but significant correlation between the HGS and radiological KOA. However, our study found a significant relationship only between the HGS-ND with KL-D and KL-ND and none with HGS-D. Different from Wen et al.'s study,<sup>10</sup> patients with conditions which might affect HGS, and also those having findings during examinations that were thought to affect HGS were excluded, to effectively eliminate the risk of contradicting results with the measurement of HGS values. Another different point of this study is that the muscle strength values were normalized using BMI and the effect of BMI over muscle strength was eliminated which allowed us to examine the pure muscle strength. Therefore, it was able to obtain more reliable results by assessing the muscle strength in a more clarified setting, free from secondary causes.

The HGS and knee extension torque were shown to have a strong relationship between each other, as reported in the literature, and HGS has a strong correlation with the lower extremity strength.<sup>7</sup> Also, in our study, a moderate, positive, and significant correlation was found between the HGS-D and HGS-ND with KES-D and KES-ND. The HGS-ND and KES-D and KES-ND had also a moderate, positive, and significant correlation with higher correlation coefficients. The weakness of

QM was found to be associated with an increased radiological severity in KOA in previous studies;<sup>24</sup> however, whether it has a significant effect is still unclear. On the other hand, the QM strength is still considered as an important parameter in KOA management.<sup>4</sup> Consistent with these contradicting results, our study also showed a weak, negative, but significant correlation between the KES-D and KL-D, yet KES-ND and KL showed no relation at all. Of note, we consider that QM strength is a crucial parameter in radiological and functional management of KOA. Based on these data, we suggest that normalized HGS-ND measurements should be used more often in both KES and radiological KOA assessments. This is due to the fact that dominant hand is usually stronger, as it is used more in the daily tasks, thereby, leading to incorrect results in the measurements and, thus, HGS-ND is more suitable for the assessment in radiological KOA and KES.

There are studies showing increased functionality and decreased pain in KOA patients with stronger QM,<sup>8</sup> which is consistent with the results of this study. However, there are no previous studies examining the relationship between HGS and KOA functionality. In our study, we observed a significant correlation between the functionality of KOA with both HGS-D and HGS-ND. To sum up, HGS measurement, which is an easy and applicable method, can be considered a valuable tool in the functional assessment of KOA. On the other hand, the WOMAC and LEFS scales, that are used in the functional assessment of KOA, which were also used in this study, are not helpful for HGS assessments. Thus, we believe that questions which can evaluate the HGS should be included in these scales or new scales including HGS assessment should be developed.

Although sarcopenia presence is not shown as a clear risk factor for KOA development, sarcopenic obesity is a defined risk factor for KOA in the literature.<sup>9</sup> Yet, it is evident that sarcopenia can cause weakness in QM, which is also proven that decreased QM strength is a risk factor for KOA development.<sup>4</sup> The HGS measurement is the most important method recommended in the algorithmic approach for sarcopenia diagnosis.<sup>6,7</sup> Therefore, the importance of HGS measurement in sarcopenia assessment becomes evident. Although HGS, on its own, is not enough to make a definitive sarcopenia

diagnosis, it is still important as a measurement method to distinguish sarcopenia. Since KOA and sarcopenia are usually seen in similar age groups, for the clinical assessment for sarcopenia and KOA, particularly in individuals over 50 years of age, HGS measurement should be used more frequently.

Although not being the main objective of this study, no significant relationship was found between radiological KOA and functionality of KOA, as previously reported in the literature.<sup>25</sup> This finding indicates that evaluation of radiological results alone is not enough for a clear assessment of functional status of the patients.

In this study, only female patients were included to provide a better standardization, which can be considered the main limitation.

In conclusion, our study results show that HGS-ND is associated with KOA radiologically and functionally. The HGS should be added in the WOMAC and LEFS scales in the functional assessment of KOA and new scales including HGS assessment should be developed.

#### Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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