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RESEARCH

ASSOCIATION OF ULTRASONOGRAPHIC MEASUREMENTS OF UPPER ARM AND THIGH MUSCLE THICKNESS WITH FUNCTIONAL CAPACITY AND BALANCE IN ELDERLY INDIVIDUALS

Abstract

Introduction: Muscle loss is associated with increased frailty in the geriatric population. In this study, we aimed to explore the association of ultrasonographic measurements of extremity muscle thickness with functional capacity, balance and falls.

Materials and Method: Fifty patients aged >65 years were enrolled. Upper arm and thigh muscle thicknesses were measured using ultrasound, and hand grip strength was measured using a handheld dynamometer. The functional capacity of lower extremity was assessed on the basis of walking speed and a chair stand test. The timed up and go test and four square step test were used to evaluate dynamic balance. The fear of falling was assessed using Tinetti's Scale.

Results: The mean age of patients was 71.8±5.7 years. Measurements of the thigh muscle thickness of patients were negatively correlated with walking speed, timed up and go test, four square step test and the fear of falling ($p<0.01$) and positively with chair stand test ($p<0.05$) and hand grip strength ($p<0.001$). Hand grip strength was positively correlated with chair stand test and negatively with walking speed, timed up and go test, four square step test and Tinetti's scores ($p<0.01$). Measurements of upper arm muscle thickness were positively correlated with hand grip strength ($p<0.01$).

Conclusion: Ultrasonographic assessment of lower extremity muscle thickness seems to improve the predictability of decline in functional capacity and loss of balance, possibly contributing to prevention of falls in the elderly.

Keywords: Muscular atrophy; Sarcopenia; Ultrasonography

ARAŞTIRMA

YAŞLI BİREYLERDE ULTRASONOGRAFİ İLE ÖLÇÜLEN ÜST KOL VE UYLUK KAS KALINLIKLARININ FONKSİYONEL KAPASİTE VE DENGE İLE İLİŞKİSİ

Öz

Giriş: Yaşlı popülasyonda kas kayıplarının kırılganlığı artırdığı bilinmektedir. Bu çalışmada ultrasonografi ile ölçülen ekstremite kas kalınlıklarının fonksiyonel kapasite, denge ve düşmeler ile ilişkilerini incelemeyi amaçladık.

Gereç ve yöntem: Çalışmaya 65 yaş üstü 50 olgu dahil edildi. Ultrasonografi ile üst kol ve uyluk kas kalınlıkları, el dinamometresi ile el kavrama kuvveti ölçüldü. Alt ekstremite fonksiyonel kapasitesi 10 metre yürüme hızı ve otur kalk testi ile değerlendirildi. Dinamik dengenin değerlendirilmesinde zamanlı kalk yürü testi ve dört kare adım testi kullanıldı. Düşme korkusu Tinetti ölçeği ile değerlendirildi.

Bulgular: Elli olgunun yaş ortalaması 71.8±5.7 yıl olarak saptandı. Hastaların uyluk kas kalınlıkları; yürüme hızı, zamanlı kalk yürü testi, dört kare adım testi ve düşme korkusu ile negatif (p değerleri<0.01), otur kalk testi ($p<0.05$) ve el kavrama kuvveti ($p<0.001$) ile pozitif yönde ilişkili idi. El kavrama kuvveti de otur kalk testi ile pozitif, yürüme hızı, zamanlı kalk yürü testi, dört kare adım testi ve Tinetti skorları ile negatif yönde ilişkili bulundu ($p<0.01$). Üst kol kas kalınlıkları ise sadece el kavrama kuvveti ile pozitif yönde ilişkili idi ($p<0.01$).

Sonuç: Yaşlılarda ultrasonografi ile alt ekstremite kas kalınlıklarının değerlendirilmesi, fonksiyonel kapasite ve denge kayıplarının öngörülebilirliğini artırarak; düşmelerin önlenmesine katkı yapabilir gibi görünmektedir.

Anahtar sözcükler: Kas atrofisi; Sarkopeni; Ultrasonografi

INTRODUCTION

The loss of muscle mass associated with ageing has adverse effects on muscle functioning in the geriatric population (1). The evaluation of muscle mass, muscle strength and physical performance is required for the diagnosis of sarcopenia in the geriatric population. To this end, dual-energy X-ray absorptiometry (DXA), bioimpedance analysis (BIA), anthropometric measurements, the assessment of hand grip strength (HGS) and walking speed (WS) and some physical performance tests are performed in clinical practice (2). HGS is a simple measure of muscle strength, and the age-related reduction in HGS strongly correlates with the loss of strength in other muscle groups (3).

Ultrasonography has been increasingly used in recent years to evaluate muscle mass and quality. Ultrasound is a safe and effective method for the assessment of muscle mass and offers several advantages such as low cost, the ease of use and relative accessibility (4). As has been reported in the literature, sarcopenia is not a uniform condition but affects postural muscles more than non-postural muscles (5,6). Therefore, since general modalities such as DXA and BIA fail to clearly establish sarcopenia, it is recommended that loss of muscle mass be evaluated using ultrasound in a site-specific manner to obtain an early and definite diagnosis (7,8). Some studies have shown that the manifestations of sarcopenia appear first in the thigh, particularly involving the quadriceps, before whole-body sarcopenia can be diagnosed (9). Thigh sarcopenia may be detected using ultrasonography as an initial finding before sarcopenia develops in the entire body (10).

Sarcopenia increases the risk of falls and frequency of fractures because of the accompanying loss of muscle strength and performance (11). Associations between low muscle mass and reduced muscle strength, HGS, WS and functional capacity have been investigated in the geriatric populations (12). However, limited data exist on the potential associations of the measurements of ultrasonographic muscle thickness (MT) and balance and the risk of falls. The ultrasound-assessed extremity MT may improve the predictability of potential balance problems and the risk of falls in the geriatric population. In this study, we aimed to investigate correlations between the ultrasonographic measurements of upper and lower extremity MT and HGS, WS, lower extremity functional capacity tests, the fear of falling, number of falls and dynamic balance tests.

MATERIALS AND METHOD

Patients aged >65 years who presented with chronic musculoskeletal problems at our physical therapy and rehabilitation outpatient clinics were enrolled. Approval to conduct the study was obtained from the local ethics committee of our hospital. All patients provided written informed consent before participating in the study.

Elderly patients with advanced lumbar spine pathology with postural and neurological disorders, advanced-stage osteoarthritis, cognitive dysfunction, chronic neurological disorders affecting mobility, impaired vision, vestibular pathology or vertigo causing imbalance were excluded. Demographic characteristics, including age, sex, body mass index (BMI), were recorded for all patients.

Measurement of extremity muscle thickness

Upper arm and thigh muscle thicknesses were measured using a Mindray DC-T6 ultrasound device (China) using a 5–10 MHz linear probe. All measurements were performed by a certified physiatrist with expertise in musculoskeletal ultrasonography. Upper arm MT was obtained from the anterior surface of the dominant arm, 60% distal from the distance between the acromial process of the scapula to the lateral epicondyle of the humerus while the elbow was in the extended and supinated position (12). Thigh MT was measured at the anterior surface of the dominant thigh, two-thirds distal from the anterior superior iliac spine to the upper pole of the patella with the patient lying in supine position and the knee extended (13). The distance from the fascia of the biceps muscle to the humerus was measured for the upper arm and that from the fascia of the rectus femoris muscle to the femur was measured for the thigh, with the probe placed in the transverse plane on the respective muscles (14) (Figures 1 and 2). MT data (in mm) averaged for three static measurements, each obtained from the upper arm and thigh, were included in the analysis. Because the height and body weight of the individual affects the extremity MT, muscle thickness must be estimated in proportion to the height, weight or BMI (7). In this study, we estimated thigh and arm MT in proportion to BMI.

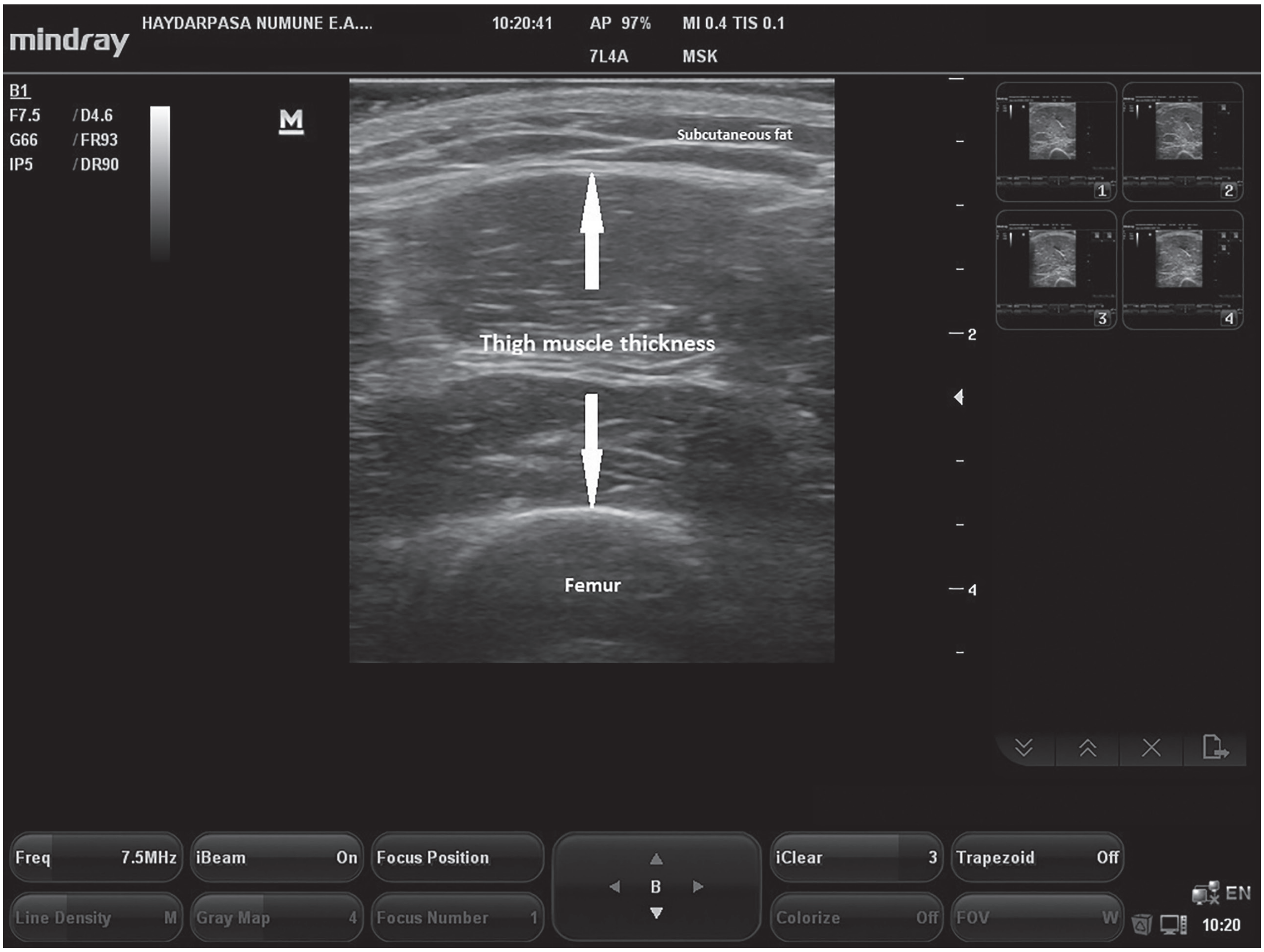

Figure 1. Ultrasound measurement of thigh muscle thickness.

Figure 2. Ultrasound measurement of upper arm muscle thickness.

Assessment of hand grip strength

Hand grip strength of patients was measured from the dominant extremity using the Baseline hydraulic hand dynamometer (Irvington, NY, USA) while patients sat with their elbows at 90° flexion and shoulders at 0° abduction in neutral position (15). Patients were asked to grip as hard as they could. Three measurements were taken, each at 30-s intervals, and the average value (in kg) was calculated.

Assessment of functional capacity of lower extremity

The 10-m walk test and chair stand test (CST) were performed to evaluate the functional capacity of the lower extremity. To estimate the 10-m WS, the time spent (in s) by the patient in walking on a predetermined 10-m walkway was measured and recorded. For the CST, the patient was seated at the centre of a 43-cm high chair with the back in upright position and hands placed on contralateral shoulders. The test score was determined on the basis of the number of chair stands taken during the 30-s period.

Assessment of dynamic balance

Dynamic balance was evaluated using the timed up and go test (TUGT) and four square step test (FSST). The TUGT is a measurement of the time (in s) that a person takes to rise from a chair, walk 3 m, turn around, walk back to the chair and sit down. The TUGT is recommended as an indicator of dynamic balance in the geriatric population (16).

In the FSST, a square is formed using four canes resting flat on the floor. The patient is asked to step as fast as possible into each square, sequentially numbered in a clockwise direction, with both feet contacting the floor in each square without touching the canes. The patient starts from the first square and moves into the second, third and fourth squares in a clockwise direction and then in the reverse direction to complete the sequence (17).

Assessment of number of falls and fear of falling

All patients were asked the number of falls that they had had in the previous year. The Falls Efficacy Scale (FES), developed by Tinetti, was used to evaluate the fear of falling (FOF). The FES is a 10-item questionnaire that is designed to assess patients' confidence in their ability to perform 10 daily tasks without falling, acting as an indicator of the impact of patients' FOF on their physical performance. The total possible score ranges from 0 and 100, higher scores indicating greater fear of falling (18).

Statistical analysis

Descriptive statistics (mean±sd and minimum, median and maximum) were used to summarise continuous variables. Correlation between normally distributed continuous variables was analysed using Pearson's coefficient of correlation and that between non-normally distributed variables was analysed using Spearman's coefficient of correlation. The statistical significance level was set at 0.05. Based on the sample estimation study using Pearson's coefficient of correlation, the sample size was calculated as 41 according to the correlation between thigh MT/BMI and the CST. Type I error rate was set at 5% and testing power at 80%. The analysis and sample size determination were conducted using MedCalc Statistical Software, version 12.7.7 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2013).

RESULTS

Of the 50 patients, 41 (82%) were female and nine (18%) were male. The mean±sd age of patients was 71.8±5.7 years, and the mean BMI was 28.1±4.1 kg/m^2. Demographic characteristics of patients are shown in Table 1. Twenty-four percent of patients were illiterate, 36% were primary school graduates, 24% were high school graduates and 16% were university graduates.

Average values for upper and lower extremity MT, HGS, lower extremity functional capacity indicators and balance and fall scales are presented in Table 1. Correlation analyses showed that the thigh MT/BMI ratios of patients were negatively correlated with the 10-m walk test (p=0.004), TUGT (p=0.000) and FSST (p=0.005) and positively correlated with the CST ($p<0.05$) and HGS (p=0.000). However, the upper arm MT/BMI ratio was not correlated with the 10-m walk test, the CST, TUGT, or FSST but was positively correlated with HGS (p=0.001). Tinetti's FES scores were negatively correlated with thigh MT/BMI ratios but not with upper arm MT/BMI ratios. While the thigh MT/BMI ratios were negatively correlated with the number of falls, the upper arm MT/BMI ratios showed no such correlation (Table 2).

Hand grip strength was positively correlated with the CST and negatively correlated with 10-m walk test, TUGT, FSST, Tinetti's FES scores and the number of falls. The CST scores showed strong negative correlations with the 10-m walk test, balance tests (TUGT and FSST), FES scores and the number of falls. However, the 10-m walk test showed strong positive correlations with dynamic balance test (TUGT and FSST) and Tinetti's FES scores. TUGT and FSST scores showed highly significant associations with FES scores, indicating a FOF. FSST, TUGT and FES scores were also positively correlated with the number of falls (Table 3).

Table 1 . Demographic characteristics of patients.

Characteristics of the study sample (n=50)	
Age, years	71.8±5.7 (65-86)
Sex (% females)	41 (%82)
BMI, kg/m^2	28.1±4.1
Thigh MT/BMI	0.89±0.17
Upper arm MT/BMI	0.96±0.18
Handgrip, kg	18 (9-30)[a]
Chair stand test	9 (6-16)[a]
10 meter walk test, s	10 (6.5-17)[a]
Timed up and go test, s	11 (7-18)[a]
Four square step test, s 14.6±3.2	
Tinetti	12 (9-33)[a]
Falls	0 (0-3)[a]

[a] Median (minimum-maximum), BMI: body mass index, kg: kilogram, m: meter, MT: muscle thickness, s: second

Table 2. Correlation analyses of muscle thickness with other parameters.

		ARM MT/BMI	THIGH MT/BMI
HANDGRIP	r	,461[1]	,512[2]
	P	,001**	,000***
CHAIR STAND TEST	r	151	,298[1]
	P	,297	,036*
10 METER WALK TEST	r	-,182	- ,404[1]
	P	,206	,004**
TIMED UP AND GO TEST	r	-,174	- ,475[1]
	P	,227	,000***
FOUR SQUARE STEP TEST	r	-,152	-,391[1]
	P	,293	,005**
TINETTI	r	-,236	-,416[1]
	P	,099	,003**
FALLS	r	-,099	-,297[1]
	P	,495	,037*

* p<0,05, ** p<0,01, *** p<0,001. [1] low correlated, [2] moderately correlated. BMI: body mass index, MT: muscle thickness

Table 3. Correlation analyses of balance, falls and functional capacity parameters.

		FALLS	HANDGRIP	CST	10-M WT	TUGT	FSST	TINETTI
HANDGRIP	r	1,000						
	P							
CST	r	,435[1]	1,000					
	P	,002**						
10-M WT	r	- ,413[1]	-,790[3]	1,000				
	P	,003**	,000***					
TUGT	r	-,475[1]	-,784[3]	,924*	1,000			
	P	,000***	,000***	,000***				
FSST	r	-,433[1]	-,790[3]	,769[3]	,786[3]	1,000		
	P	,002**	,000***	,000 ***	,000***			
TINETTI	r	-,447[1]-	-,684[2]	,661[2]	,670[2]	,699[3]	1,000	
	P	,447 ,001**	,000***	,000***	,000**	,000**		
FALLS	r	-,309[1]	-,431[1]	,286	,300[1]	,425[1]	,483[1]	1,000
	P	,029*	,002**	,044*	,034*	,002*	,000***	

* p<0,05, ** p<0,01, *** p<0,001. [1] low correlated, [2] moderately correlated, [3] highly correlated, [4] very highly correlated. CST: chair stand test, FSST: four square step test, TUGT: timed up and go test, 10-M WT: 10 meter walk test

DISCUSSION

Falls and related injuries are one of the major health problems among the geriatric population. Sarcopenic elderly adults carry a considerably greater risk of falling than healthy elderly adults (19). Our results showed that reduced thigh MT has adverse effects on the functional performance of the lower extremities and postural stability and increases the frequency of falls and FOF in our geriatric patients. In line with our findings, Abe et al has revealed an inverse relationship between mid-thigh MT ratios, as measured by ultrasound, with zigzag walking time in geriatric patients (10). Decreased thigh muscle mass is a recognised predictor of the decline in gait speed (20). Age-related ultrasonographic changes in thigh muscle quality have been shown to be associated with reduced muscle strength (21). Our findings suggest that measurements of thigh MT are positively correlated with HGS, which is an indicator of upper extremity performance. Similarly, Guerreiro et al have demonstrated a significant association between quadriceps MT and HGS, gait speed and the TUGT (22). In the context of the literature data, our results suggest that ultrasonographic measurements of thigh MT can predict declines in the functional capacity of the lower extremity and loss of dynamic balance in the geriatric population.

In our results, upper arm MT was positively correlated with HGS (an indicator of upper extremity performance) but not with lower extremity functional performance and dynamic balance tests. Similar findings supporting the association of upper extremity MT with HGS have been previously reported. The lack of association between upper extremity MT and gait speed at advanced ages as reported in literature also lends support to our findings. Abe et al have reported the correlation of forearm MT with HGS but not with gait speed. Thus, they suggested that forearm MT is a useful parameter for the assessment of HGS and total muscle mass (12). We did not identify any study in the literature that could allow us to make direct comparisons with our findings showing the lack of association between upper extremity MT with balance tests, FOF and the number of falls.

Hand grip strength is an important component of the diagnostic algorithm of sarcopenia and a well-known predictor of lower extremity functional capacity in the geriatric population (3,23,24). Consistent with previous findings, HGS was associated with lower extremity performance tests in our study. Additionally, we showed that HGS was negatively correlated with balance tests, FOF and the number of falls, which had not been previously demonstrated. Thus, we believe that measurements of HGS can be a used as a predictor of reduced postural stability and the risk of falls.

Low muscle mass and reduced muscle strength and physical performance are risk factors for an increased FOF in the sarcopenic geriatric population (25). An early detection of the functional disability and loss of postural control associated with sarcopenia is crucial to preventing falls, fractures and related morbidity and mortality in the geriatric population. An inability to test functional capacity and postural control because of age-related physiological deterioration or various health problems is common in the geriatric population. Devising a simple, convenient and time-saving tool that could be used irrespective of the physical status of the patient to predict the loss of balance, reduced functional capacity and the presence of sarcopenia in the geriatric population would greatly improve geriatric patient care and preventive rehabilitation efforts for the geriatric population. In that regard, the association between the measurements of thigh MT and HGS with both lower extremity performance and dynamic balance tests and the number of falls, as demonstrated in this study, represents a major finding.

Our study has a number of limitations. First, postural stability in our study population was not assessed using one of the more objective methods, such as posturography. Second, MT was measured for only one muscle group from each of the upper and lower extremities. Third, our study was designed as a cross-sectional study. Prospective studies involving long-term follow-up for falls and development of fractures in the geriatric population, with ultrasonographic MT data available, are needed.

In conclusion, reduced thigh muscle thickness is associated with lower functional capacity, balance problems and falls in the geriatric population. While reduced muscle mass in the lower extremities results in a loss of balance, upper extremity muscle thickness may not be a determinant of balance performance. The ultrasonographic measurements of thigh muscle thickness and determination of HGS could assist in the prevention of fractures related to falls by improving the early detection of the loss of balance and decreased functional capacity in the geriatric population.

Conflict of interest

None.

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