Abant Tıp Dergisi

Abant Medical Journal

Abant Med J 2024;13(3):123-133, doi:10.47493/abantmedj.1545327

The Relationship Between Radiological and Ultrasonographic Changes and Balance Disorders in Patients with Knee Osteoarthritis

Diz Osteoartriti (OA) Hastalarında Radyografik ve Ultrasonografik Değişikliklerin Denge Bozukluğu ile İlişkisi

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Geliş Tarihi (*Received*): 08.09.2024 **Kabul Tarihi (*Accepted*):** 19.12.2024 **Yayın Tarihi (*Published*):** 31.12.2024

Abstract

Objective: This study aimed to assess the relationship between radiological and ultrasonographic changes and balance disorders in patients with knee osteoarthritis.

Materials and Methods: Clinically and radiologically diagnosed 97 patients with knee osteoarthritis, 33 age and sex matched healthy volunteers were included in the study. Balance was analyzed utilizing the Berg Balance Scale (BBS) and Timed Up and Go Test (TUG). Kellgren Lawrence (KL) scale was used for radiographic staging of knee OA. Mean Femoral cartilage, quadriceps femoris muscle thickness (QFMT), thigh subcutaneous fat thickness (TSFT), QFMT/TSFT, quadriceps femoris (QF) tendon, proximal and distal patellar tendon thickness were evaluated using ultrasonography. The functional level and pain severity of the patients was determined by Western Ontario and McMaster University Osteoarthritis Index (WOMAC) score and Visual Analog Scale (VAS).

Results: Individuals with knee OA showed lower BBS, higher TUG scores (p<0.001 for both). Moderate correlations included negative associations of BBS with WOMAC (ϱ=−0.495 p<0.001) and a positive association of TUG with WOMAC (ϱ=0.428 p<0.001). QFMT/TSFT correlated moderately positive with BBS (ϱ=0.448 p<0.001), while TSFT showed a weak negative correlation with BBS (ϱ=−0.364 p<0.001). The KL score had weak negative correlations with BBS (ϱ=−0.201 p=0.048) and weak positive correlations with TUG (ϱ=0.239 p=0.019), and QFMT correlated weakly with BBS (ϱ=0.238 p=0.019). VAS had a weak negative association with BBS (ϱ=−0.255, p=0.012), while TSFT showed a weak positive correlation with TUG (ϱ=0.275, p=0.006). Regression analysis revealed WOMAC as a significant predictor of BBS (p <0.05).

Conclusion: Radiography and ultrasonography could be predictive of balance disorder and those patients with severe osteoarthritis should have an intensive rehabilitative approach to balance disturbance.

Keywords: Balance Disorder, Knee Osteoarthritis, Radiography, Ultrasonography.

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Öz

Amaç: Diz osteoartriti (OA) olan bireylerde radyografik ve ultrasonografik değişikliklerin denge bozukluğu ile ilişkisinin araştırılması amaçlandı.

Gereç ve Yöntemler: Klinik ve radyolojik diz OA tanılı 97 hasta ve 33 sağlıklı birey çalışmaya dahil edildi. Bireyler Berg Denge Ölçeği (BDÖ), Zamanlı Kalk Yürü Testi (ZKYT) ile incelendi. Osteoartrit Kellgren Lawrence (KL) skalası ile radyolojik olarak evrelendi. Ultrasonografi ile ortalama femoral kartilaj, quadriceps femoris (QF) kas, uyluk subkutan yağ, QF tendon, proksimal ve distal patellar tendon kalınlıkları, QF kas kalınlığının subkutan yağ kalınlığına oranı değerlendirildi. Diz OA tanılı hastaların ağrı ve fonksiyonel durumları Görsel Analog Skala (GAS) ve Western Ontario ve McMaster Üniversitesi Osteoartrit İndeksi (WOMAC) skoru ile değerlendirildi.

Bulgular: Diz osteoartritli bireylerde BDÖ skorların daha düşük, ZKYT skorları daha yüksek saptandı (her ikisi için p < 0,001). BDÖ ile WOMAC (ϱ = −0,495, p < 0,001) arasında orta düzeyde negatif, ZKYT ile WOMAC arasında pozitif bir ilişki vardı (ϱ = 0,428, p <0,001). QF kas kalınlığının subkutan yağ kalınlığına oranı, BDÖ ile orta düzeyde pozitif bir ilişki gösterirken (ϱ = 0,448, p < 0,001), uyluk subkutan yağ kalınlığının BDÖ ile zayıf negatif bir ilişkisi vardı (ϱ = −0,364, p < 0,001). KL skoru, BDÖ ile zayıf negatif (ϱ = −0,201, p = 0,048) ve ZKYT ile zayıf pozitif ilişki gösterdi (ϱ = 0,239, p = 0,019). QF kas kalınlığı, BDÖ ile zayıf pozitif ilişkiye sahipti (ϱ = 0,238, p = 0,019). GAS, BDÖ ile zayıf negatif bir ilişki gösterirken (ϱ = −0,255, p = 0,012), uyluk subkutan yağ kalınlığı, ZKYT ile zayıf pozitif bir ilişki sergiledi (ϱ = 0,275, p = 0,006). Regresyon analizi, WOMAC'ın BDÖ için anlamlı bir belirleyici olduğunu ortaya koydu (p < 0,05).

Sonuç: Radyografi ve ultrasonografi, denge bozukluklarını öngörmede etkili olabilir ve ileri derecede osteoartritli hastalar, denge bozukluklarını yönetmek için yoğun bir rehabilitasyon yaklaşımına tabi tutulmalıdır.

Anahtar Kelimeler: Denge Bozukluğu, Diz Osteooartriti, Radyografi, Ultrasonografi.

Atıf/Cite as: Alpoğuz Yılmaz Z, Genç H. The Relationship Between Radiological and Ultrasonographic Changes and Balance Disorders in Patients with Knee Osteoarthritis. Abant Med J. December 2024;13(3):123-133. doi:10.47493/abantmedj.1545327

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Introduction

Knee osteoarthritis (OA) is a prevalent and disabling condition, recognized as one of the leading causes of disability among older adults in developed nations (1). In Turkey, studies have shown a symptomatic knee OA prevalence of 20.9% in İzmir among individuals aged 40 and older and 14.8% in urban areas of Antalya among individuals aged 50 and older, with risk factors including age, female gender, certain daily activities, and residential type. (2,3). People with knee OA often experience increased balance issues, likely due to reductions in muscle strength and joint position sense (4). Consequently, treatment programs targeting balance improvements are essential to achieving effective rehabilitation (5).

Radiographic imaging plays a pivotal role in diagnosing OA due to its ability to reveal hallmark pathological alterations such as subchondral sclerosis, joint space narrowing, and osteophyte formation on X-ray. These radiographic alterations allow for the classification of OA depending on the location and seriousness of articular cartilage engagement (6,7). Studies have linked structural imaging findings with functional outcomes, such as balance and gait, with higher KL grades associated with greater fall risk as measured by the Berg Balance Scale (BBS) (6,7). Interestingly, this elevated fall risk was not reflected in Timed Up and Go (TUG) test results, suggesting a potential discrepancy between various balance assessment methods (6).

Beyond knee OA, studies on related conditions, such as multiple sclerosis (MS) and Parkinson's disease (PD), provide additional insight into the impact of cartilage degeneration on balance. For instance, ultrasonographic assessments of knee degeneration in MS patients show more pronounced femoral cartilage degeneration compared to healthy controls. However, within the MS group, no significant correlations were found between cartilage degeneration grade and functional scores from the Visual Analog Scale (VAS), BBS or Western Ontario and McMaster University Osteoarthritis Index (WOMAC) (8). Similarly, research into PD revealed that distal femoral cartilage thickness was notably lower in severe PD cases than in healthy individuals. This ultrasonographic evidence suggests early cartilage damage in PD, with a progressive decrease in cartilage thickness as the disease advances (9).

Studies have reported that individuals with knee OA show deficits in standing balance and proprioception, as observed through both clinical assessments and laboratory measurements (4,10–15). Insufficient or inaccurate proprioceptive feedback from the knee joint negatively impacts both static and dynamic balance control in these individuals. Additionally, factors such as muscle strength, OA severity on X-rays, knee alignment, pain levels, and proprioceptive accuracy further influence balance in those with knee OA. Improved standing balance has been associated with greater quadriceps strength, more advanced radiographic disease, reduced varus alignment, lower pain levels, and enhanced proprioception (16,17). Previous studies have also explored the relationship between pain and radiological findings using MRI (Magnetyic Resonance Imaging) and ultrasonography (USG) (18,19). A review analyzing the effects of balance training in knee OA patients found that balance exercises significantly enhance both balance and functionality. This underscores the importance of identifying balance impairments in knee OA to better target and optimize treatment (20).

Our study aimed to delve into the relationship between KL staging, ultrasonographic assessments, and balance metrics in knee OA patients. Unlike previous studies, we seek to determine if combining radiographic and ultrasonographic findings can more accurately predict balance impairments, providing a more holistic understanding of knee OA progression and its effects on postural stability. This could offer new insights for more targeted therapeutic approaches in clinical settings.

Materials and Methods

Tsonga et al. found the fear of falling among patients with OA to be 82.4%, while this rate ranged from 20.8% to 85% among elderly patients (21). Based on these rates, assuming a fear of falling rate of 60% in the control group and 82.4% in osteoarthritis patients, with a critical z value of 1.645, 80% power, and a significance level (α) of 0.05, a minimum of 94 volunteers in the patient group and 32 in the control group are required. This prospective and cross-sectional study was contained a total of 97 individuals between the ages of 50 and 70 diagnosed with knee OA based on the criteria found by the American College of Rheumatology (22) and 33 healthy individuals as control. Prior to participation, all individuals were notified about the study procedure

and written and verbal consent was acquired. This study approved by Ethics Committee of Ankara Numune Health Education and Research Hospital (approval numbered 2425/2018 dated 07.02.19) and the study followed the tenets of the Helsinki Declaration. All procedures adhered to the ethical standards of the responsible committee on human experimentation (institutional and national) and complied with the Helsinki Declaration of 1975, as revised in 2008.

The inclusion of patients aged 65 to 70 with knee OA in this study is important because balance problems often become more pronounced in this age range due to age-related physiological changes, including muscle weakening and altered proprioception. This age group is more susceptible to these balance impairments, which are further exacerbated by OA. By studying individuals within this age bracket, we aim to gain a clearer understanding of how OA-related changes impact balance and function, which can provide valuable insights for developing targeted interventions for fall prevention and mobility improvement in older adults with OA (23).

Trauma history to that knee in the last 6 months, knee prosthesis, osteotomy, arthroscopy and any surgical operation on the lower extremity in the past, those who have received intra-articular steroid injection within 4 weeks, those who have a neurological disease that may cause severe balance disorders (Parkinson's disease, stroke history, multiple sclerosis, epilepsy, cardiac syncope), those with a history of drug use that may cause balance disorders, those with severe visual impairment, those with depressive mood, those with severe respiratory, central, peripheral, vascular and subjects with uncontrolled metabolic problems, patients who need assistive devices for ambulation and those who did not sign the informed consent form were excluded from the study. The demographic data, including age, gender, weight, height, education, occupation and presence of additional diseases, was noted. Body mass index (kg/m2) (BMI) was computed.

Asssesment Criteria

Radiographic evaluation was performed using the KL scale on anteroposterior and lateral knee radiographs by the researchers. The early stages, typically KL grades 0, 1, and 2, are associated with minimal to moderate changes in the joint. These early grades typically correlate with mild symptoms or minimal functional limitations. As the disease progresses, KL grades 3 and 4 reflect more severe joint degeneration, with significant narrowing of the joint space, larger osteophytes, and possible deformities (24).

A GE P5 Model Ultrasonography device (GE Healthcare, Chicago, United States) with a 7-12 MHz linear probe for evaluations. The measurements were conducted by a researcher with over 2 years of experience in musculoskeletal ultrasonography, under the supervision of an individual with more than 8 years of expertise in the field. Quadriceps femoris muscle thickness (QFMT), QFMT/thigh subcutaneous fat thickness (TSFT), quadriceps femoris muscle tendon thickness (QFMTT), proximal and distal patellar tendon thickness, and femoral cartilage (FC) thickness were assessed. Care was taken to avoid unnecessary pressure during measurements to prevent probe interference with underlying tissue. Every measurement was carried out three times, the mean was recorded. QFMT and TSFT were assessed with the patient in the supine position, probe in the transverse plane, positioned 15 cm proximal to the midpoint of the patella (Figure 1). Distal FC thickness, medial, intercondylar and lateral FC thickness measurements were measured with the knee maximally flexed, in the transverse plane perpendicular to the femur and the average was recorded (Figure 2). QFTT measurement was conducted the knee bent at an angle of 20-30 degrees, in the sagittal plane from just before the QF tendon attachment to the patella. Proximal tendon thickness was measured at the lower end of the patella, and distal proximal tendon thickness was measured where the tuberosity attaches to the tibia.

The functional level of the patients due to knee OA was evaluated using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC). Pain was evaluated with 5, stiffness with 2, and functional level with 17 questions. For each measurement, questions were scored between 0-4 and the total score was determined (total score min 0, max 96). Turkish validity and reliability study of the index was carried out (25).

Participants' pain levels were evaluated with the Visual Analogue Scale (VAS) on a scale of 0-10 cm (0: no pain, 10: the worst pain imaginable). VAS was utilized to assess the knee pain experienced by patients over the past week. The patient was instructed to quantify the severity of his pain on a horizontal line marked between 0 and 10 (26).

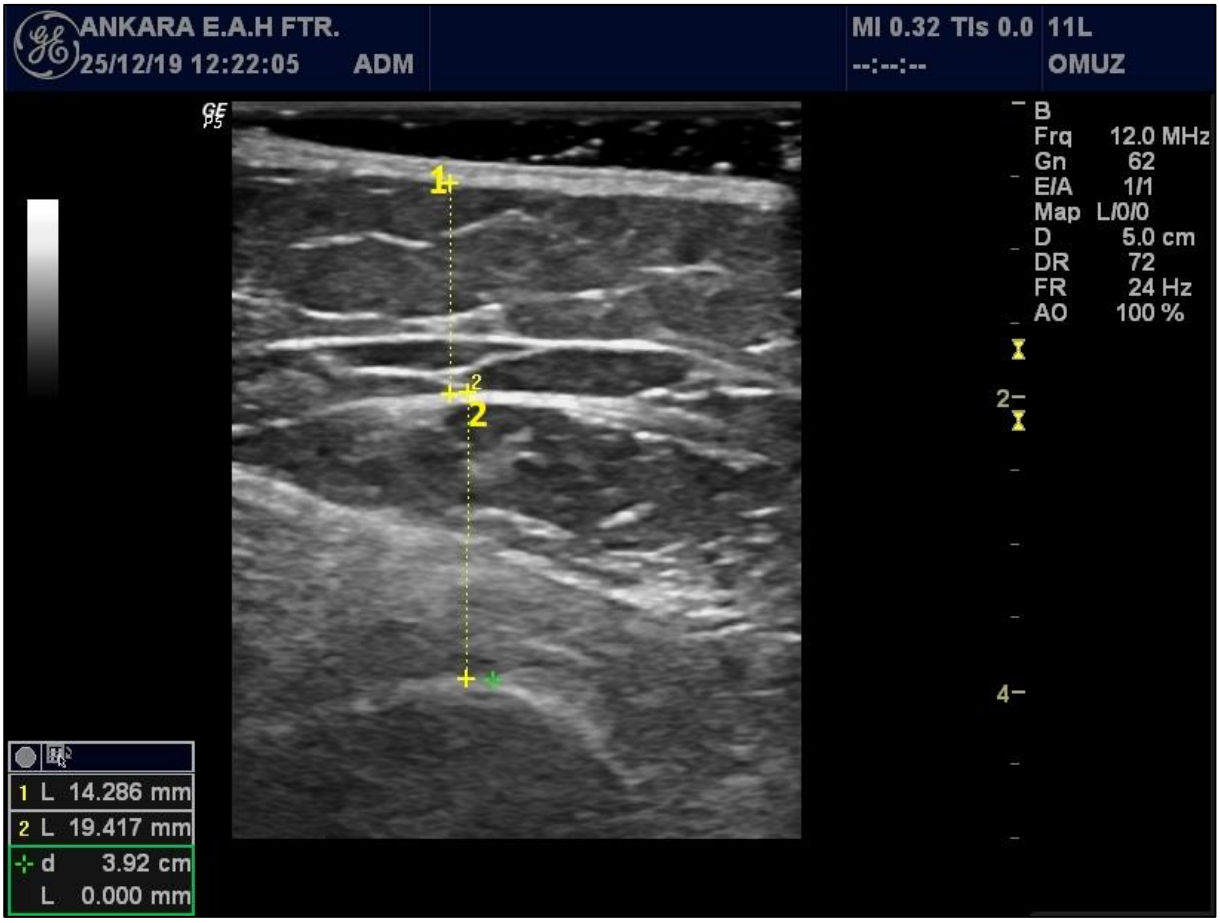

Figure 1. Ultrasonographic measurement of quadriceps femoris muscle thickness (2) /thigh subcutaneous fat thickness (1)

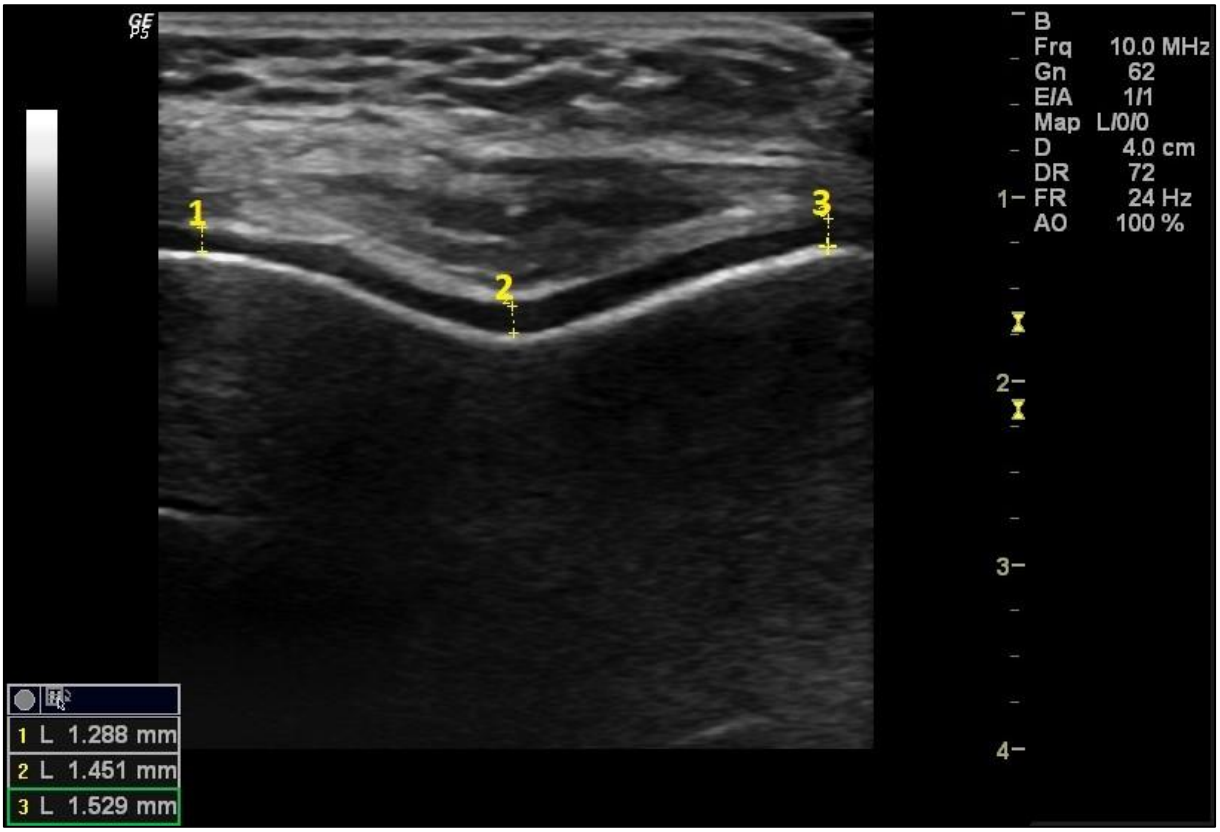

Figure 2. Ultrasonographic measurement of distal femoral cartilage thickness; medial (1), intercondylar (2) and lateral (3) femoral cartilage thickness

Participants' static and dynamic balances were evaluated with the BBS, and their dynamic balance and mobility with the TUG. BBS is utilized to evaluate both static and dynamic balance. The BBS has been used in many studies in older adults, Parkinson's patients, patients with osteoporosis, and those with a history of stroke, and is considered the gold standard in the evaluation of functional balance (27–29)Turkish validity and reliability study was conducted (30). BBS consists of 14 different questions. The patient is evaluated by the observer while doing these activities and scored between 0-4. In this scoring, while a score of 4 symbolizes performing the activity without any support, a score of 0 symbolizes full support or the inability to perform the activity at all. The highest total score is 56 and indicates perfect balance. If a patient scores between 0-20, they are wheelchair-dependent, while a score between 21-40 indicates the ability to walk with assistance. Independence in mobilization activities is considered for scores between 41 and 56. Scores below 45 are related to increased fall risk (31).

TUG, is primarily a functional test that assesses dynamic balance, walking speed and mobility can be swiftly assessed. The duration required for the patient to rise from the chair, walk 3 meters, return and sit is recorded. The average of 3 tests is taken. A shorter TUG indicates better functional performance and. Values of 13.5 seconds and above were linked to an increased chance of falling (32).

Statistical analyzes were performed with SPSS version 21.0 (IBM, Armonk, NY, USA). The normality assumption of variables was assessed utilizing the Kolmogorov-Smirnov test. For comparisons between groups, the Mann-Whitney U test was employed for non-parametric variables, while the Student's t-test was utilized for parametric variables. The Chi-Squared test was applied to assess categorical variables. In correlation analysis, either Pearson or Spearman correlation tests were chosen based on the distribution of the data. Regression analysis was performed for BBS and TUG scales that showed significant results in the correlation analysis. A significance level of $p<0.05$ was considered statistically significant for all tests.

Results

The study was completed with 97 individuals in the knee OA group and 33 people in the control group. There was no significant difference between the knee OA group and the control group with respect to age, gender, height, and presence of additional diseases ($p>0.05$, for all). Weight and BMI were discovered to be markedly greater in the knee OA group ($p<0.05$). In individuals with knee OA, BBS scores were discovered to be lower and TUG scores were higher ($p <0.001$ for both). Demographic data and balance impairment evaluations of knee OA and control groups is demonstrated in Table 1.

For KL scores, 75.8% of the control group had a score of 0, while none of the OA group had this score ($p<0.001$). Additionally, 24.2% of the control group had a KL score of 1, compared to 1% in the OA group. In contrast, higher KL scores were observed exclusively in the OA group, with 52.6% having a score of 2, 39.2% a score of 3, and 7.2% a score of 4, with none of the control group falling within these ranges.

In the OA group, correlation analysis revealed no significant differences in BBS scores and in TUG Scores in terms of gender, occupation, or education level. In this study, moderate correlations included negative associations of BBS with WOMAC ($\varrho=-0.495$ $p=0.000$) and age ($\varrho=-0.426$ $p=0,000$), as well as positive associations of TUG with WOMAC ($\varrho=0.428$ $p=0.000$). Additionally, the QFMT/TSFT correlated moderately positive with BBS ($\varrho=0.448$ $p=0.000$), while TSFT showed a weak negative correlation with BBS ($\varrho=-0.364$ $p=0.000$). Weak positive correlations were found between age and TUG ($\varrho=0.379$ $p=0.000$), VAS and TUG ($\varrho=0.242$ $p=0.017$), and BMI with both TUG ($\varrho=0.281$ $p=0.005$) and weak negative correlations BBS ($\varrho=-0.244$ $p=0.016$). Additionally, the KL score had weak negative correlations with BBS ($\varrho=-0.201$ $p=0.048$) and weak positive correlations with TUG ($\varrho=0.239$ $p=0.019$), and QFMT correlated weakly with BBS ($\varrho=0.238$ $p=0.019$). Height demonstrated a weak negative correlation with TUG ($\varrho=-0.251$ $p = 0.013$). Additionally, VAS had a weak negative association with BBS ($\varrho=-0.255$, $p=0.012$), while TSFT showed a weak positive correlation with TUG ($\varrho=0.275$, $p=0.006$). These findings suggest that factors like age, WOMAC, VAS, KL scores, TSFT, QFMT/TSFT and BMI play varying roles in balance and mobility among patients with knee OA (Table 2).

Table 1.
Demographic Data and Balance İmpairment Evaluations of Knee Osteoarthritis Patients and Control Groups

		Control (N=33)	Patient (N=97)	p value
Age (year)		59(54.5-61)	59(54-64)	0.229[a]
BMI (kg/m²)		25.05±2.46	30.74±4.71	**<0.001**[b]
		N(%)	**N(%)**	
Gender	Female	26(%78.8)	86(%88.7)	0.156[c]
	Male	7(%21.2)	11(%11.3)	
Occupation	House wife	5(%15.2)	80(%82.5)*	**<0.001**[c]
	Worker	5(%15.2)	9(%9.3)	
	Officer	15(%45.5)*	1(%1)	
	Other	8(%24.2)*	7(%7.2)	
Educational level	Literate	0(%0)	27(%27.8)*	**<0.001**[c]
	Primary school	10(%30.3)	60(%61.9)*	
	Middle school	0(%0)	2(%2.1)	
	High school	10(%30.3)	6(%6.2)	
	University	13(%39.4)*	2(%2.1)	
BBS		56(55-56)	52(50-54)	**<0.001**[a]
TUG (sn)		9(8-9)	10.5(9-12)	**<0.001**[a]

x̄±SD: Mean ± Standard Deviation,
Md (Q1-Q3): Median (Interquartile Range)
a: Mann-Whitney U test
b: Student's t-test
c: Chi-Square
BMI: Body Mass Index
BBS: Berg Balance Scale
TUG: Timed up and Go Test
*: Statistically significant higher ($p<0.05$)

When the OA group compared with the control group no significant differences were found between the two groups in terms of hypertension, diabetes mellitus, cardiovascular disease, kidney disease, lung disease, and other comorbidities ($p>0.05$ for all).

Table 2.

Correlations Of Balance Assessment Tests with Other Data in Knee Osteoarthritis Patients

Test		Berg balance	TUG
BBS	Rho		**-0.736**
	P		**<0.001**
TUG (sn)	Rho	**-0.736**	
	P	**<0.001**	
Age (years)	Rho	**-0.426**	**0.379**
	P	**<0.001**	**<0.001**
Weight (kg)	Rho	-0.097	0.141
	P	0.343	0.170
Height (m)	Rho	0.167	**-0.251**
	P	0.103	**0.013**
VAS (cm)	Rho	**-0.255**	**0.242**
	P	**0.012**	**0.017**
WOMAC	Rho	**-0.495**	**0.428**
	P	**<0.001**	**<0.001**
KL score	Rho	**-0.201**	**0.239**
	P	**0.048**	**0.019**
MFC thickness (mm)	Rho	0.163	-0.122
	P	0.112	0.233
IFC thickness (mm)	Rho	**0.209**	-0.156
	P	**0.040**	0.127
LFC thickness (mm)	Rho	0.185	-0.114
	P	0.069	0.265
Mean FC (mm)	Rho	**0.212**	-0.161
	P	**0.037**	0.115
QF muscle thickness (mm)	Rho	**0.238**	-0.198
	P	**0.019**	0.052
Thigh subcutaneous fat thickness (mm)	Rho	**-0.364**	**0.275**
	P	**<0.001**	**0.006**
QF tendon thickness(mm)	Rho	0.000	0.090
	P	0.998	0.382
Proximal patellar tendon thickness (mm)	Rho	-0.127	0.180
	P	0.214	0.078
Distal patellar tendon thickness (mm)	Rho	-0.112	0.188
	P	0.276	0.065
QFMT/TSFT	Rho	**0.448**	**-0.356**
	P	**<0.001**	**<0.001**
BMI (kg/m²)	Rho	**-0.244**	**0.281**
	P	**0.016**	**0.005**

BBS: Berg Balance Scale, TUG: Timed up and Go Test, KL: Kellgren Lawrence, MFC: Medial femoral cartilage, IFC: Interconylar femoral cartilage, LFC: Lateral femoral cartilage, Mean FC: Mean femoral cartilage, QF: Quadriceps femoris, QFMT: Quadriceps femoris muscle thickness TSFT: Thigh subcutaneus fat thickness BMI: Body Mass Index
rho: Spearman correlation coefficient.

Regression analysis was performed for BBS and TUG scales that showed significant results in the correlation analysis. A regression analysis was conducted to examine the relationship between WOMAC, VAS, and KL scores and BBS scores. It was found that 49% of the variance was explained ($p<0.001$). WOMAC scores showed a significant relationship with Berg balance scores ($p<0.05$ for all) (Table 3).

Table 3.
Regression Analysis for the BBS Test

	Unstandardized coefficients (B)	SE	Unstandardized coefficients (Beta)	p value	95% CI
(Constant)	55.424	5.757		<0.001	(43.965 to 66.883)
WOMAC	-0.05	0.021	-0.278	***0.016***	(-0.091 to -0.010)
VAS	-0.06	0.201	-0.034	0.767	(-0.459 to 0.340)
KL_skoru	-0.385	0.388	-0.087	0.324	(-1.157 to 0.388)

R2=0,493; 95% CI: Confidence interval for B, SE: standard error, BBS: Berg Balance Scale, WOMAC: Western Ontario and McMaster University Osteoarthritis Index, VAS: Visual Analog Scale, KL: Kellgren Lawrence.

A regression analysis was conducted to examine the relationship between WOMAC, VAS, and KL scores and TUG scores. It was found that 40% of the variance was explained (p<0.001). No significant relationship was found between WOMAC, VAS, and KL scores and TUG scores (p>0.05 for all) (Table 4).

Table 4.
Regression Analysis for the TUG Test

	Unstandardized coefficients (B)	SE	Unstandardized coefficients (Beta)	p value	95% CI
(Constant)	14.679	5.639		0.011	(3.451 to 25.908)
WOMAC	0.018	0.019	0.116	0.355	(-0.020 to 0.056)
VAS	0.000	0.193	0.000	0.998	(-0.385 to 0.385)
KL_skoru	0.264	0.384	0.069	0.495	(-0.502 to 1.029)

R^2=0.397; 95% CI: Confidence interval for B, SE: standard error, TUG: Timed up and Go Test, WOMAC: Western Ontario and McMaster University Osteoarthritis Index, VAS: Visual Analog Scale, KL: Kellgren Lawrence

Discussion

In this study, knee OA patients demonstrated significantly lower BBS scores and higher mobility impairment (TUG) times compared to the control group. The OA group also exhibited higher BMI and weight. Moderate negative correlations were observed between BBS and WOMAC scores, age, and moderate positive correlations between BBS and QFMT/TSFT, as well as between TUG and WOMAC. Weak negative correlations were identified between BBS and VAS, KL score, and BMI, while weak positive correlations were found between TUG and VAS, KL score, TSFT, and BMI. Regression analysis revealed a significant relationship between WOMAC scores and BBS. Conversely, no significant predictors were identified for TUG scores in the regression analysis. Additionally, demographic factors such as gender, occupation, and education level showed no significant differences in BBS or TUG scores. Overall, factors like WOMAC scores, body composition, and age play key roles in influencing balance and mobility in knee OA patients.

The demographic and clinical characteristics of the knee OA group in our study, including mean age, female-to-male ratio, and BMI, align well with findings reported in the general literature. The mean age of participants, as well as the predominance of female patients (88.7%), reflects the commonly observed higher prevalence of OA in older adults and a greater incidence among women, consistent with previous studies.

Furthermore, the significantly higher BMI in the OA group compared to controls is in line with established evidence that links increased BMI to a heightened risk of knee OA due to the added mechanical load on joints and its role as a modifiable risk factor in OA progression (33). These demographic and clinical patterns support the generalizability of our findings to the broader OA population.

Balance disorders have emerged as a significant public health concern, primarily attributed to the heightened risk of falling (34). Individuals with knee osteoarthritis (OA) are more likely to experience falls compared to those without OA (35). In the context of knee OA, the compromised proprioception is not only associated with articular cavity concerns but also stems from the reduction in mechanosensory receptors within periarticular tissues such as ligaments, tendons, and muscles, where sensory innervation is predominant. Due to the decrease in QF strength, postural stability deteriorates, leading to an increased risk of balance issues and incidents of falling in patients with knee OA (15,36).

While Analan et al. found no significant differences in postural stability between KL stage 2 and 3 knee OA patients (37), our study observed that balance decreases with more advanced KL stages, suggesting that KL staging may indeed influence balance as OA progresses. This supports our focus on assessing balance impairments in more severe OA cases, as evidenced through functional measures like the BBS and TUG tests. Our study's results corroborate existing research on the association between knee OA severity and declines in balance and mobility, as seen through functional measures such as the BBS and TUG test. Consistent with research by Ribeiro et al., individuals with higher KL grades exhibited poorer balance, consistent with our observations of reduced BBS scores as OA severity rose (6). However, as highlighted in previous studies, a discrepancy can exist between balance assessment methods, with fall risk not always captured by TUG times despite BBS sensitivity, a pattern also observed in our study (6).

Our study revealed a positive correlation between Balance Berg Scale (BBS) scores and mean femoral cartilage (FC) thickness, suggesting that better balance is associated with greater cartilage thickness. Beyond OA, research on related degenerative conditions like MS and PD offers insights into the broader implications of cartilage degeneration on balance (8). For example, Eroglu et al. found that MS patients exhibited significant femoral cartilage (FC) degeneration, though it did not strongly correlate with balance scores, similar to findings by Uysal et al. for distal FC thickness in PD patients (8). These findings indicate that while cartilage degeneration plays a critical role in balance and mobility in OA, the relationship varies across conditions, reflecting distinct mechanisms affecting physical function. Together, these studies highlight the need for diverse assessment tools to better understand the complex interplay between structural degeneration and functional outcomes in OA and other conditions.

We acknowledge that the primary limitation of our study is the lack of homogeneity in weight and BMI within our patient group, with the knee OA group having higher BMI and weight levels. As a higher BMI is often linked to an increased risk of balance impairments and falls, especially in older adults, due to the added joint stress, reduced mobility, and shifts in the center of gravity associated with excess weight. Secondly, the study group had a predominance of female participants. Ensuring similar gender distributions in future research could help to reveal knee OA related differences more clearly. Including patients aged 65-70 in the study is another limitation, as balance problems often develop within older adults. Our findings demonstrated that the following factors associated with balance function in patients with knee OA: age, VAS, WOMAC, KL score and BMI values, ultrasonographically measured intercondylar FC thickness, mean FC thickness, TSFT, QFMT and QFMT/TSFT. There is a need for studies with groups with different demographic and cultural characteristics to evaluate other factors affecting radiological and ultrasonographic changes in knee OA.

Conclusion

This study highlights balance disorders in knee OA and their significant associations with radiological and ultrasonographic findings. Key metrics like QFMT, QFMT/TSFT and KL scores were correlated with balance measures, and WOMAC emerged as a strong predictor of balance performance. These findings underscore the value of combining imaging and clinical assessments to better understand and address balance impairments in knee OA patients. Additionally, patients with severe OA should undergo an intensive rehabilitative approach to address balance disturbances effectively.

Ethics Committee Approval: The study was approved by the Ethics Committee of Ankara Numune Health Education and Research Hospital (date: 07.02.2019 and approval number2425/2018).

Informed Consent: Written consent was obtained from the participants.

Conflict of Interest: Authors declared no conflict of interest.

Financial Disclosure: Authors declared no financial support.

Author Contributions: Idea/Concept: Z.A.Y.,H.G.; Design: Z.A.Y.,H.G.; Supervision: H.G.; Funding: Z.A.Y.; Materials: Z.A.Y.; Data Collection/Processing: Z.A.Y.,H.G.; Analysis/Interpretation: Z.A.Y.; Literature Review: Z.A.Y.; Drafting/Writing: Z.A.Y.; Critical Review: H.G. The authors have accepted responsibility for the entire content of this manuscript and approved its submission. The authors have accepted responsibility for the entire content of this manuscript and approved its submission.

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