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PREVALENCE OF SONOGRAPHICALLY ASSESSED KNEE JOINT CHANGES IN OLDER DIABETIC AND HYPERTENSIVE PATIENTS

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Abstract

The cohabitation of diabetes mellitus and hypertension is widely recognized as a key factor to musculoskeletal deterioration, particularly in weight-bearing joints such as the knee. Metabolic dysfunctions have been linked with effects on joint structures through vascular and inflammatory pathways, leading to degenerative processes which may affect mobility in elderly patients. The role of ultrasonography in early detection of such conditions is important and effective.

The current study was designed to estimate the presence of abnormalities of the knee joints identified by ultrasound in the elderly population with diabetes and hypertension and to investigate their link with metabolic dysfunction.

A cross-sectional research design was utilized, recruiting 100 patients older than 40 years with diabetes and hypertension. Clinical data, such as body mass index (BMI), blood pressure, and HbA1c levels were collected from several clinical sites, namely CMH

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Hospital, Sargodha, private clinic in Sargodha and selected clinics in Islamabad and Lahore. The affected knee joint was evaluated using a high-frequency linear probe (7-14 MHz). Evaluated parameters included joint effusion, osteophyte development, tendon state, cartilage thickness, and stiffness. Analyses of results were conducted using SPSS. Statistical tests used included the Chi-square test.

High rates of knee joint abnormalities were revealed within the current study. Joint stiffness was seen in 82% of patients, effusion in 66%, osteophyte development in 62%, and cartilage thinning in 62%. There were some abnormal changes in the tendon structure. Tendinosis occurred in 40% of cases. Increased prevalence of joint abnormalities was noticed among those with hypertension and increased HbA1c.

It can be concluded that abnormalities of the knee joint identified by ultrasound are rather common among patients with diabetes mellitus and hypertension. It seems like there is a connection between joint changes and metabolic condition. Ultrasound imaging may become a useful diagnostic approach for earlier identification of problems, and appropriate treatment of metabolic conditions might slow down this process.

INTRODUCTION

Degenerative musculoskeletal diseases represent a considerable and continuously growing threat to public health on a global scale, especially in aging populations. Among weight-bearing joints, knees are most vulnerable. According to the results of the Global Burden of Disease Study 2021, osteoarthritis impacted 595 million people worldwide in 2020, and it will only increase in 2050 due to aging and global increases in metabolic risks [1]. In addition, according to Allen, Thoma, and Golightly, osteoarthritis represents a significant health issue affecting predominantly older people and patients with comorbidities such as obesity, diabetes mellitus, and hypertension [2]. Clinical management of knee osteoarthritis in terms of diagnostics and therapy is reviewed by Katz, Arant, and Loeser, with a particular emphasis on the increasing need for evidence-based approaches in obese and metabolic populations [3].

Metabolic risks contributing to knee osteoarthritis have been studied by Dong et al., whose meta-analysis shows that diabetes mellitus, hypertension, obesity, and physical inactivity are some of the most reliable and clinically relevant risk factors [4]. Similarly, in a cross-sectional study from Nanjing, China, performed by Shao et al., diabetes mellitus, obesity, hypertension, and physical inactivity were found to be critical independent risk factors for knee osteoarthritis [5]. On the cellular and molecular levels, Giorgino et al. present a review of current knowledge about the pathophysiology of knee osteoarthritis, paying particular attention to the contribution of systemic metabolic issues to accelerated joint deterioration [6].

There have been consistent epidemiological studies that have associated diabetes mellitus with osteoarthritis. Louati et al. undertook an extensive literature analysis of the correlation between diabetes mellitus and osteoarthritis, which revealed a significant relationship regardless of the obesity

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factor [7]. Hyperglycemia induces the production of advanced glycosylation end products, which accumulate in the articular cartilage tissue and weaken its mechanical strength.

Ultrasound studies also validate this phenomenon. For instance, Bedewi et al. established that there was significant thinning of the cartilage covering the femur in cases of Type 2 diabetes compared to normal subjects [8]. Likewise, Kacar and Atilla observed concomitant pathological changes in distal femur cartilage and tendons in cases of diabetic patients [9]. Apart from structural alterations, Eitner et al. indicated that joint pain in diabetic and osteoarthritic knees resulted from synovitis, enhanced immune cell accumulation, and red blood cells entering the synovial membrane [10].

Hypertension alone plays a role in causing knee degeneration through vascular pathways. Sananta et al., in their retrospective cross-sectional study carried out in the secondary referral hospitals in Indonesia, found an important relationship between the prevalence of diabetes mellitus and hypertension and the risk of developing knee osteoarthritis [11]. The vascular etiopathogenesis theory, which was well-studied by Ching et al., suggests that hypertension affects the blood supply to the subchondral bone leading to hypoxic changes in the overlying cartilage [12]. There are some clinical examples of such etiopathogenesis, as suggested by Liu and Du based on their results of analyzing the data obtained from the Osteoarthritis Initiative [13].

Metabolic disorders leading to metabolic disturbances and vascular imbalance have been observed to affect the knees generally. Tharwat et al. conducted an experiment on 104 knees of individuals undergoing hemodialysis. Clinical examination and ultrasonography revealed that patients under metabolic strain showed higher occurrences of joint fluid accumulation, cartilage deterioration, and tendinopathy [14].

The international efforts for diagnosis, including OARSI guidelines suggested by Hawker et al., have emphasized the need for standardized classification criteria for early symptom knee osteoarthritis in order to ensure prompt medical treatment [15]. Metabolic factors have been identified as a cause of knee joint disorders, where Weng et al. reported a significant relationship between high levels of uric acid and sonography-confirmed synovial pathologies in the knee [16]. Further proof regarding the cause-and-effect relationship between the metabolic modifiable risk factors and knee osteoarthritis has been provided through the research done by Diao et al. using Mendelian randomization [17].

The consequences of metabolic disease are not limited to damage to articular structures but also involve injuries to peripheral nerves and tendons of the lower limb. This was illustrated by Song et al., who utilized 2D ultrasonography and shear wave elastography and showed the presence of neuropathy and tendon disease in the lower limbs of people with type 2 diabetes mellitus [18]. Pain and function in knee osteoarthritis are influenced by a range of systemic risk factors; for example, a systematic review and meta-analysis by Sandhar et al. highlighted important risk factors for pain and disability in knee and hip osteoarthritis [19]. Similarly, Tharwat et al. documented specific changes in the Achilles tendon [20], and numerous enthesopathic abnormalities in individuals with systemic metabolic disease were identified using the Madrid Sonography Enthesitis Index [21].

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The increasing amount of evidence notwithstanding, there is a lack of assessments regarding the effects of combined sonography on knee joints for patients suffering from both diabetes mellitus and hypertension at the same time. The majority of researches are devoted to individual evaluation of such diseases, while data referring specifically to South Asia (Pakistan), in particular, are relatively rare. For that reason, the current research seeks to investigate the rate of joint changes in patients suffering from diabetes mellitus and hypertension at the same time, and the relationship between the severity of metabolic abnormalities and the extent of joint damage.

Research Aim

The major objective of this research work is to use musculoskeletal ultrasonography in order to evaluate the frequency and the pattern of changes that occur within the knee joint of elderly people, especially when there are accompanying conditions like diabetes and hypertension.

Research Objectives

- The aim is to evaluate any sonographic alterations in the knee joint, including the cartilage thickness of the femur, joint effusion, synovitis, and tendon pathology, through high-frequency ultrasound examination techniques to establish an initial baseline damage level within the study group.
- Evaluate the impact of metabolic variables, namely the existence of diabetes mellitus and hypertension, disease progression, and glucose control, on the degree and type of knee joint alteration.
- Establish any distinctive sonographic patterns or joint damage in the poorly controlled hypertension and diabetes patient group versus those with relatively good metabolic control.

LITERATURE REVIEW

The international epidemiological approach that forms the basis of this research study is defined by the GBD 2021 Osteoarthritis Collaborators. According to the findings of their systematic evaluation of epidemiological information between 1990 and 2020 with projections up to 2050, there has been a significant increase in the prevalence rate of osteoarthritis worldwide. The findings suggest that age-related changes and the burden of metabolic risk factors have played a critical role in the development of this trend, which makes knee osteoarthritis one of the leading causes of disability worldwide. To further elaborate on this approach, Allen et al. conduct an exhaustive epidemiological study of osteoarthritis, highlighting the overwhelming burden faced by elderly patients and those with comorbid diseases like diabetes and hypertension.

Diagnosis and treatment of knee and hip osteoarthritis receive thorough examination in the article of Katz, Arant and Loeser, where the authors emphasize the importance of addressing metabolic disease within the overall therapy for patients suffering from these diseases [3]. With respect to the risk factors, there is a great value in a systematic review and meta-analysis carried out by Dong et al., who analyzed multiple studies involving middle-aged and older adults and proved that diabetes

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mellitus, hypertension, and obesity are some of the major and persistent risk factors in the emergence and progression of knee osteoarthritis [4]. The population-based approach to risk factor identification is presented by the cross-sectional study performed in Nanjing, China, by Shao et al. [5].

The pathogenesis of osteoarthritis of the knee in relation to metabolism diseases is explored in detail by Giorgino et al., who review the complex interplay between systemic inflammation, bone remodeling in subchondral regions, cartilage breakdown, and innovative therapies, including the use of mesenchymal stem cells [6]. In support of the connection between osteoarthritis and diabetes mellitus, a significant statistical link is proven by Louati et al. through comprehensive systematic literature review and meta-analysis, revealing a statistically significant connection between the two diseases after taking into consideration confounding variables such as obesity [7]. Thus, there is sufficient evidence to suggest exploring diabetic patients as a specific risk factor for the degeneration of knee joint tissue based on a verified link between diabetes and osteoarthritis beyond mere coincidence.

There is ample ultrasonographic evidence for joint complications due to diabetes, supported by several targeted investigations. Specifically, Bedewi et al. performed an ultrasonography study of femoral cartilage thickness and found a statistically significant thinning of weight-bearing cartilage in diabetic patients compared to non-diabetic patients [8]. Thus, there is one quantifiable biomarker of disease severity in diabetic patients. Expanding on this study, Kacar and Atilla compared the effects of diabetes on distal femoral cartilage thickness and tendinopathy using ultrasonography techniques. They found evidence that the impact of diabetes on the musculoskeletal system extends beyond the joint [9]. To explain the increased susceptibility to inflammatory joint diseases in patients with diabetes mellitus, Eitner et al. combined histopathologic data from synovial biopsies with image analysis to confirm that the incidence of knee osteoarthritis among diabetic patients is associated with increased synovitis, immune cell recruitment, erythrocyte extravasation, leading to their increased joint pain perception [10].

There is a wide range of literature that supports the significance of hypertension as an etiologic factor in developing joint diseases. Sananta et al. carried out a retrospective cross-sectional study at two secondary referral hospitals in Indonesia, which reported an independent and strong correlation between the development of knee osteoarthritis and either diabetes mellitus or hypertension [11]. The authors describe the mechanism by which hypertension influences joint health in more detail. For example, the influential review by Ching et al., discussing vascular theory of osteoarthritis, demonstrates that microvascular dysfunction due to hypertension causes subchondral ischemia and deficiency in nourishing joint structures, contributing to faster joint degradation even without injuries [12]. Additional clinical support was provided by Liu and Du, who used the Osteoarthritis Initiative dataset and showed that blood pressure level was positively and independently correlated with pain intensity among middle-aged and older adults [13].

Consequences of systemic metabolic disease include not only articular cartilage lesions but also problems with the musculoskeletal system as well. In particular, a series of ultrasonographic

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investigations of musculoskeletal problems in hemodialysis patients by Tharwat et al. includes research published in 2025 that presents results of clinical and ultrasonographic assessment of knees in 104 hemodialysis patients, most of whom had joint effusion, cartilage abnormalities, and tendinopathy [14]. Previously, authors have described unique ultrasonographic changes in the Achilles tendon of hemodialysis patients [20], whereas their next investigation evaluated upper and lower limb entheseal sites of the same population according to Madrid Sonography Enthesitis Index [21]. The painful and disabling nature of knee osteoarthritis involves various systemic and local factors. Sandhar et al. carried out an extensive meta-analytic review to determine significant risk variables for pain and disability in adults suffering from knee and hip osteoarthritis, which is highly relevant to the topic under consideration [19].

Other metabolic causes for the development of knee joint problems include hyperuricemia. In their cross-sectional analysis of a middle-age and older population group, Weng et al. observed significant connections between increased serum urate concentrations and ultrasound-verified abnormalities of the synovium of the knee joint, which comprised effusion and synovitis [16]. The causality of modifiable metabolic risks as an underlying cause of knee osteoarthritis was proved through the Mendelian randomization studies by Diao et al., which demonstrated causal links confirming that targeting metabolic disease can be used to prevent knee osteoarthritis [17]. Furthermore, two-dimensional ultrasonography and shear wave elastography performed by Song et al. have identified neuropathic and tendon abnormalities in the lower limb as a result of type 2 diabetes mellitus, which aligns with the peripheral tissue involvement found in other scientific literature on this topic [18]. Lastly, as part of the OARSI efforts under Hawker et al., there were attempts to introduce diagnostic classifications for symptomatic knee osteoarthritis as a means of timely detection and treatment, highlighting the importance of ultrasound screenings among patients with diabetes and hypertension [15].

METHODOLOGY

3.1 Study Design

This was cross-sectional research carried out to determine the prevalence of sonographically evaluated knee joint abnormalities in older adults with diabetes mellitus and hypertension.

3.2 Study Setting

The study was conducted in multiple healthcare facilities including CMH Sargodha, Ainee Clinic Sargodha, and selected private clinics in Islamabad.

3.3 Study Duration

The study was conducted over a period of three months

3.4 Study Population

The study comprised individuals aged over 40 years with a documented history of diabetes mellitus

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and hypertension who reported knee-related complaints such as pain, stiffness, or difficulty in walking.

3.5 Inclusion Criteria

- Patients aged more than 40 years
- Diagnosed cases of diabetes mellitus and hypertension
- Patients presenting with knee pain, stiffness, or difficulty in walking

3.6 Exclusion Criteria

- History of knee trauma
- Previous knee surgery
- Congenital or structural knee deformities unrelated to metabolic disease
- Patients unwilling to participate

3.7 Sample Size

A sample size of 100 patients were included in the study.

3.8 Data Collection Procedure

Those satisfying the selection criteria were identified from selected institutions. Demographic and clinical information such as age, sex, body mass index, blood pressure, and HbA1c values were noted. The knee joint (right or left, according to the problem) was assessed via ultrasound imaging using a high-frequency linear transducer probe (7–14 MHz).

3.9 Ultrasound Assessment

Musculoskeletal ultrasound was used to evaluate the following knee joint parameters:

- Joint effusion (present/absent)
- Osteophyte formation (present/absent)
- Tendon abnormalities (normal, increased thickness, tendinosis)
- Cartilage thickness (≥2 mm normal, <2 mm thinning)
- Subjective knee stiffness (present/absent based on patient history)

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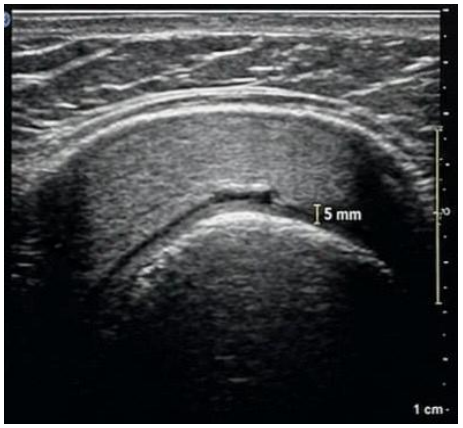

Figure 3.1: Representative ultrasound image of knee joint

3.10 Blood Pressure and HbA1c Classification

Blood pressure was categorized as:

Moderate: <160/100 mmHg

Severe: ≥160/100 mmHg

HbA1c levels were categorized as:

Controlled: 7.0–7.9%

Uncontrolled: ≥8.0%

3.11 Statistical Analysis

The data was analyzed using SPSS software. Descriptive analysis was carried out through computation of measures such as mean and standard deviations for numeric data variables including age, body mass index (BMI), and HbA1c. The categorical data variables were described in terms of frequency and percentage distributions. Relationships between variables were determined using the Chi-square test with a statistical significance level at $p<0.05$.

RESULTS

4.1 Gender Distribution

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	35	35.0	35.0	35.0
	Female	65	65.0	65.0	100.0
	Total	100	100.0	100.0	

Table 4.1- Gender Distribution

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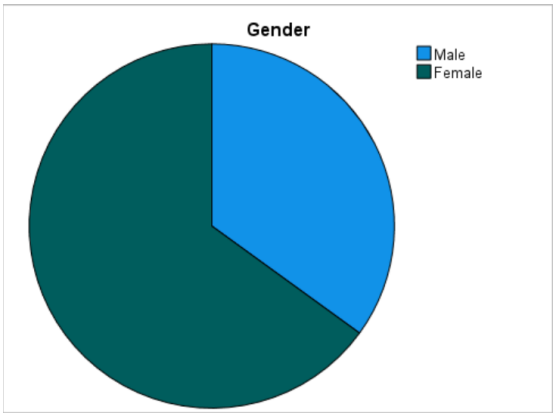

Figure 4.1- Gender Distribution

Out of a total of 100 patients, **35% (n=35) were male** and **65% (n=65) were female**. A higher proportion of the study population consisted of female participants.

4.2 Descriptive Statistics

Descriptive Statistics			
	N	Mean	Std. Deviation
Age (years)	100	63.7700	7.20670
Body Mass Index (kg/m2)	100	29.8980	2.47468
HbA1c (%)	100	8.4980	.75825
Valid N (listwise)	100		

Table 4.2- Descriptive Statistics

The mean age of the patients was **63.77 years**. The mean body mass index (BMI) was **29.89 kg/m²**, while the mean HbA1c level was **8.49%.**

4.3 Joint Effusion

Effusion					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Absent	34	34.0	34.0	34.0
	Present	66	66.0	66.0	100.0
	Total	100	100.0	100.0	

Table 4.3- Effusion frequency

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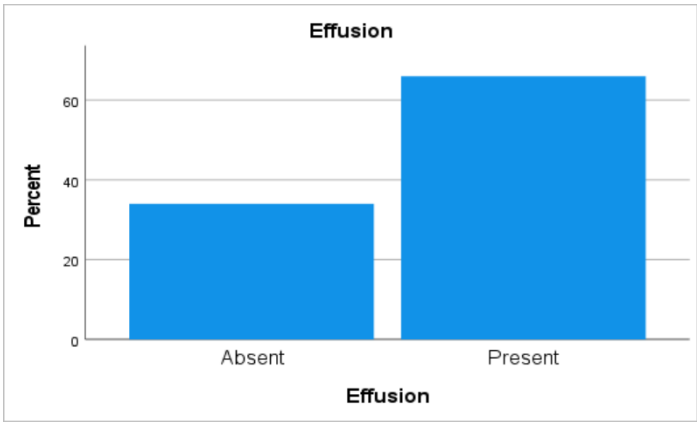

Figure 4.2- Effusion frequency

Joint effusion was present in **66% (n=66)** of patients, while **34% (n=34)** showed no evidence of effusion.

4.4 Osteophytes

Osteophytes					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Absent	38	38.0	38.0	38.0
	Present	62	62.0	62.0	100.0
	Total	100	100.0	100.0	

Table 4.4- Osteophytes Frequency

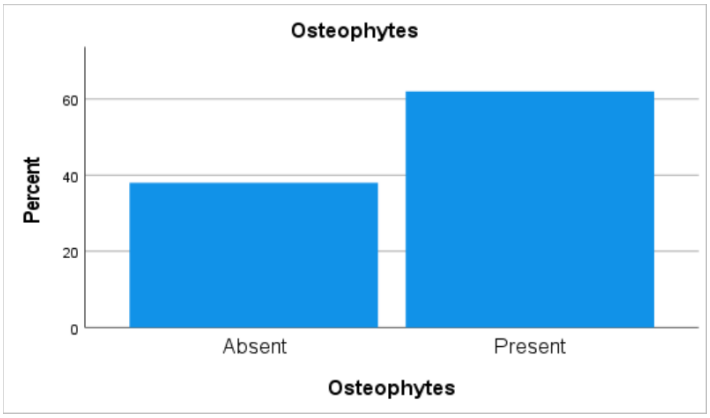

Figure 4.3- Osteophytes Frequency

Osteophyte formation was observed in **62% (n=62)** of patients, whereas **38% (n=38)** did not show

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osteophytes.

4.5 Tendon Status

Tendon Status					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	35	35.0	35.0	35.0
	Increased Thickness	25	25.0	25.0	60.0
	Tendinosis	40	40.0	40.0	100.0
	Total	100	100.0	100.0	

Table 4.5- Tendon categories

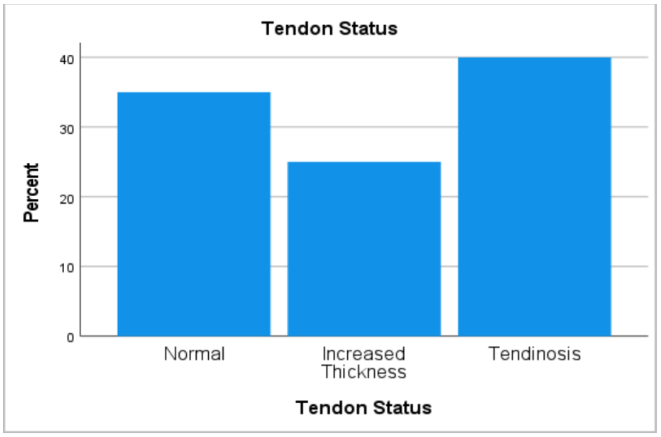

Figure 4.4- Tendon categories

Normal tendon appearance was observed in **35% (n=35)** of patients. Increased tendon thickness was noted in **25% (n=25)**, while tendinosis was present in **40% (n=40)** of patients.

4.6 Cartilage Status

Cartilage Status					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal (2.0 mm or above)	38	38.0	38.0	38.0
	Thinning (less than 2.0 mm)	62	62.0	62.0	100.0
	Total	100	100.0	100.0	

Table 4.6- Cartilage thickness

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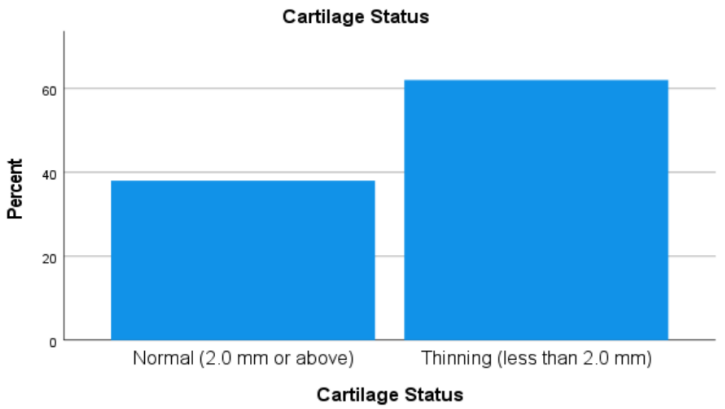

Figure 4.5- Cartilage thickness

Normal cartilage thickness **(≥2 mm)** was observed in **38%** **(n=38)** of patients, while cartilage thinning **(<2 mm)** was present in **62%** **(n=62).**

4.7 Stiffness

Stiffness					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Absent	18	18.0	18.0	18.0
	Present	82	82.0	82.0	100.0
	Total	100	100.0	100.0	

Table 4.7- Stiffness Frequency

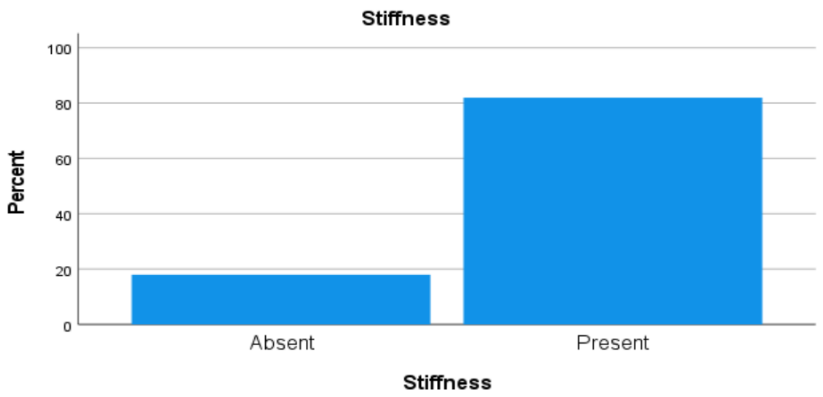

Figure 4.6- Stiffness Frequency

Knee stiffness was reported in **82%** **(n=82)** of patients, whereas **18%** **(n=18)** did not report stiffness.

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4.8 Blood Pressure Categories

Blood Pressure Category					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate (less than 160/100)	41	41.0	41.0	41.0
	Severe (160/100 or above)	59	59.0	59.0	100.0
	Total	100	100.0	100.0	

Table 4.8- Blood pressure categories

Among the study population, **41% (n=41)** had moderate hypertension, while **59% (n=59)** had severe hypertension.

4.9 HbA1c Categories

HbA1c Category					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Controlled (7.0-7.9%)	31	31.0	31.0	31.0
	Uncontrolled (8.0% or above)	69	69.0	69.0	100.0
	Total	100	100.0	100.0	

Table 4.9- HbA1c categories

Controlled HbA1c levels **(7.0–7.9%)** were observed in **31% (n=31)** of patients, whereas **69% (n=69)** had uncontrolled HbA1c levels **(≥8.0%).**

Association Analysis

4.10 Association Between Blood Pressure and Effusion

	Effusion absent		Effusion present	
Blood Pressure Category	Count	Column N%	Count	Column N%
Moderate (less than 160/100)	15	44.1%	26	39.4%
Severe (160/100 or above)	19	55.9%	40	60.6%

Table 4.10.1- BP vs Effusion

Pearson Chi-Square Tests

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		Effusion
Blood Pressure Category	Chi-square	.207
	df	1
	Sig.	.649

Table 4.10.2

Effusion was observed in both moderate and severe hypertension groups. The association between blood pressure category and joint effusion was not statistically significant **(p = 0.649).**

4.11 Association Between Blood Pressure and Osteophytes

	Osteophytes absent		Osteophytes present	
Blood Pressure Category	Count	Column N%	Count	Column N%
Moderate (less than 160/100)	15	39.5%	26	41.9%
Severe (160/100 or above)	23	60.5%	36	58.1%

Table 4.11.1- BP vs Osteophytes

Pearson Chi-Square Tests		
		Osteophytes
Blood Pressure Category	Chi-square	.059
	df	1
	Sig.	.808

Table 4.11.2

Osteophytes were present in both blood pressure categories. No statistically significant association was observed between blood pressure and osteophyte formation **(p = 0.808).**

4.12 Association Between HbA1c and Effusion

	Effusion absent		Effusion present	
HbA1c Category	Count	Column N%	Count	Column N%
Controlled (7.0-7.9%)	16	47.1%	15	22.7%
Uncontrolled (8.0% or above)	18	52.9%	51	77.3%

Table 4.12.1- HbA1c vs Effusion

Pearson Chi-Square Tests	
	Effusion

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HbA1c Category	Chi-square	6.211
	df	1
	Sig.	.013*

Table 4.12.2

Effusion was observed more frequently in patients with uncontrolled HbA1c levels compared to controlled levels. The statistical significance of this association is presented in the table **(p = 0.013).**

4.13 Association Between HbA1c and Osteophytes

	Osteophytes absent		Osteophytes present	
HbA1c Category	Count	Column N%	Count	Column N%
Controlled (7.0-7.9%)	17	44.7%	14	22.6%
Uncontrolled (8.0% or above)	21	55.3%	48	77.4%

Table 4.13.1- HbA1c vs Osteophytes

Pearson Chi-Square Tests		
		Osteophytes
HbA1c Category	Chi-square	5.407
	df	1
	Sig.	.020*

Table 4.13.2

Osteophyte formation was more common in patients with uncontrolled HbA1c levels. The association between HbA1c and osteophytes is shown in the table **(p = 0.020)**.

DISCUSSION

5.1 Overview of the Study

This cross-sectional study was performed to analyse the incidence of sonographically evaluated knee joint abnormalities in older adults with concomitant diabetes mellitus and hypertension, and to examine relationships between metabolic severity and the degree of structural joint involvement. A total of 100 patients aged 40 years and above were recruited from multiple clinical settings and evaluated using high-frequency musculoskeletal ultrasound of the symptomatic knee. The data indicated a significant frequency of structural knee abnormalities with joint effusion (66%), osteophyte development (62%), cartilage thinning (62%), tendon abnormalities (65%), and joint stiffness (82%).

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5.2 Interpretation of Key Findings

It is important to note that the prevalence established in the current study far exceeds the prevalence levels in the general population of the elderly. The results coincide with existing epidemiological studies confirming that diabetes mellitus and hypertension are the independent risk factors for knee osteoarthritis [4, 7]. According to the GBD 2021 Collaborators, the global prevalence of osteoarthritis has increased due to the contribution of metabolic risk factors to the disease pathogenesis [1]. Elevated levels of sonographic abnormalities found in the studied sample indicate the high prevalence of the metabolic disorders' adverse impact on the joint structures. In their research, Allen, Thoma, and Golightly provide epidemiological data suggesting that the prevalence of musculoskeletal diseases is higher in older individuals with metabolic disorders [2]. Indeed, the study's findings confirm this hypothesis. As noted by Sandhar et al., the systemic risk factors are responsible for pain intensity and the level of functional disability in patients with knee osteoarthritis [19]. Thus, the high prevalence of stiffness and functional limitation in the studied sample is explained by the existence of metabolic risk factors in the patients' condition.

The correlation between high HbA1c levels and increased joint effusion and osteophyte development ($p = 0.013$; $p = 0.020$) may be regarded as the primary analytical findings of the study. It means that poorly controlled glycemia is correlated with an elevated structural burden in the joint tissues, confirming the hypothesis of a causal link established by Diao et al. via Mendelian randomization [17]. The severity of blood pressure has also been consistently correlated with the increased joint engagement in the case of severe hypertension (Group C). However, due to the insufficient number of cases in the group, these correlations failed to achieve statistical significance. Nevertheless, this finding coincides with the study conducted by Shao et al., where hypertension was identified as an independent risk factor for knee osteoarthritis [5].

5.3 Comparison with Previous Studies

The high incidence of cartilage thinning in this study (62%) can be equated with the ultrasound observations of Bedewi et al., in which there were significant reductions in the femoral cartilage thickness in people with type 2 diabetes mellitus relative to healthy controls [8]. This reinforces the theory that the continuous hyperglycemia, via advanced glycation end product formation, gradually weakens the matrix structure of the cartilage, a phenomenon elucidated thoroughly by Giorgino et al. regarding osteoarthritis onset [6]. Kacar and Atilla further verify this phenomenon by demonstrating co-existing abnormalities in the distal femoral cartilage and tendon tissues among people with diabetes [9], akin to the high incidence of cartilage thinning and tendinosis (40%) in this current study.

The increased incidences of joint effusion in subjects with poorly managed hyperglycemia can be medically justified by the research of Eitner et al., which revealed that patients with knee osteoarthritis and diabetes experienced increased synovitis and infiltration of immune cells into the synovium [10].

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As demonstrated above, our inflammatory phenotype serves as an enabling mechanism for joint effusion and coincides with a statistically significant association between HbA1c and effusion noted herein. The general association between diabetes and joint disease progression is additionally supported by the meta-analysis and systematic review conducted by Louati et al., which identified diabetes as a primary and independent cause of osteoarthritis [7], and by the systematic review of risk factors performed by Dong et al., which arrived at the same conclusion [4]. Song et al. further reinforce the complex nature of involvement of lower limb soft tissues in this cohort by their finding via two-dimensional ultrasonography among people with type 2 diabetes [18].

Turning to hypertension, directional associations found herein, such that severe hypertension is associated with increased presence of effusion and osteophytes, coincide with findings of the studies by Sananta et al. and Liu and Du. Specifically, the former reports a significant relationship between hypertension and knee osteoarthritis among Indonesians [11]; the latter demonstrates that the level of blood pressure affects the magnitude of knee pain [13]. Mechanistically, this effect is explained by Ching et al.'s evaluation of the vascular hypothesis showing that the hypertension-related subchondral bone ischemia interferes with cartilage nourishment, thus contributing to its rapid degradation [12]. Given the small sample size, the lack of statistical significance in hypertensive-specific subgroups might be attributed to this factor alone.

With regards to tendon findings, a body of literature is provided that includes the use of sonography among metabolically burdened groups. In particular, Tharwat et al. documented extensive abnormalities in hemodialysis patients, noting tendon changes involving the Achilles tendon as well as extensive enthesis pathology based on the Madrid Sonography Enthesitis Index [20]. Their study from 2025 on knee joints in hemodialysis patients describes joint effusion, cartilage changes, and tendon problems, which are highly consistent with those found herein [14].

5.4 Possible Mechanisms

Structural changes seen in the joints of the knee in this study may be viewed through the lens of interactions between metabolic and vascular mechanisms. In diabetics, hyperglycemia leads to non-enzymatic glycation of collagen and cartilage matrix proteins, resulting in advanced glycation end products and decreased elasticity of the cartilage. Hence, the cartilage becomes susceptible to deterioration due to repeated mechanical loading in a joint subjected to body weight. In addition to this, the systemic inflammatory component associated with diabetes promotes synovitis and fluid accumulation as seen by Eitner et al. Epidemiological and causal links established by Louati et al. and Diao et al. demonstrate unambiguously that diabetes is an important causal factor in the development of knee OA rather than just a marker of OA susceptibility.

From the standpoint of vascular mechanism, the hypothesis postulated by Ching et al. seems convincing in the case of hypertension. Continuous elevation of blood pressure interferes with perfusion of subchondral bone vessels, which deprives the overlying cartilage of oxygen and nutrients. Therefore, vascular degenerative change caused by ischemia may lead to degeneration of cartilage, its thinning, and osteophyte formation in hypertensive patients independent of any

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mechanical stress in their knees. The association between the degree of hypertension and clinical pain outcomes has been confirmed in OA patients as shown by Liu and Du. Therefore, the interaction between two conditions described in this paper implies two parallel insults for joint tissues biochemical degeneration of cartilage caused by metabolic factors and deprivation of nutrients because of impaired vascular perfusion.

5.5 Clinical Implications

These findings have major implications for therapeutic practices related to the care of the elderly population with diabetes and hypertension. Given the high prevalence of abnormalities detected in this population using sonography, particularly those preceding any significant symptoms, the need for a proactive approach to the evaluation of musculoskeletal problems among such people is evident. This notion is consistent with the suggestion made by Hawker et al. and with OARSI's initiative for the standardization of diagnostic criteria for symptomatic knee osteoarthritis and the necessity of early detection of the condition [15]. Additionally, it is supported by the evidence provided by Katz et al. about the importance of prompt clinical assessment in the patients with metabolic dysfunction [3]. Thus, the use of musculoskeletal ultrasonography appears to be a practical tool that can be applied for this purpose, as it provides information on joint effusion, cartilage thinning, osteophytes, and tendinopathy.

Given that statistically significant correlations were found between HbA1c values exceeding 8% and various changes in joint structure, a better glycemic control appears to be a potential way to alleviate the burden on joints among patients with diabetes. The findings presented by Sandhar et al., who examined risk factors for pain and functional limitations in patients with knee and hip osteoarthritis, Diao et al., who provided the causal evidence about these effects, and Shao et al., who discussed the epidemiology of osteoarthritis in patients with poorly controlled metabolic disease, support such an approach. Lastly, the finding by Weng et al. of the association between hyperuricemia and abnormal findings in sonography of the joint synovium suggests the need to consider complete metabolic testing.

5.6 Limitations of the Study

The current paper identifies certain drawbacks that should be considered. First, only 100 patients were selected for participation in the study, recruited through convenience sampling from a few clinical centers, which might impact the validity of the results. Second, owing to its cross-sectional design, it was impossible to identify any cause-and-effect relationship or observe disease progression. Third, changes in the knee joints were observed solely on the affected side, thus disregarding possible bilateral joint damage. Finally, differences between the ultrasound machines used in various studies might have influenced the results to some extent. Despite these limitations, the work provides clinically valuable information on the prevalence and nature of ultrasonographic knee joint changes in an overloaded population.

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5.7 Future Recommendations

In future studies, it will be important to use large, multicenter patient populations and longitudinal methods of data collection for a stronger body of evidence and a better understanding of causality. Longitudinal observation of ultrasound knee joint abnormalities as a function of metabolic control over time will provide valuable information regarding disease progression and therapeutic effect. Evaluation of bilateral knees, as well as the use of other inflammatory markers, uric acid concentration, and disease duration, will allow for a more thorough assessment of the extent of musculoskeletal pathology associated with metabolic disorders.

The presented investigation proves the presence of knee joint changes in elderly patients with diabetes mellitus and hypertension quite frequently. The tendency towards the increasing level of joint damage depending on the stage of metabolism indicates the role of the development stage in the course of musculoskeletal system disorders. The results justify the usefulness of musculoskeletal ultrasound in detecting changes early and emphasize the necessity of proper metabolic state maintenance for the health of joints. Altogether, the presented data make the evidence base about the impact of diabetes and hypertension on knee joint condition even stronger.

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