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Poor Core Stability is Associated to Progression of Osteoarthritis of the Knee in Adult Patients: A Case-Control Study

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SUMMARY

Introduction. Osteoarthritis (OA) of the knee is a known public health problem. It is a chronic degenerative joint disorder that is more prevalent in India. Weak core may be a result of increased knee loading. Therefore, it may be a factor that leads to the occurrence of OA knee and a reason for the increase in the progression of diseases. As osteoarthritis of the knee is more prevalent in older people (about 70%). The classic representation of OA knee is within the age of 40 to mid-50s.

Objectives. The purpose of the article is 1) to explain the prevalence of core strength in OA knee subjects; 2) to highlight the relationship between core strength and physical function; and 3) to summarize the evidence examining the effectiveness of exercises in improving core strength in subjects with OA knee.

Methods. This case-control study was done among 190 subjects, including males and females of age above 40 years among which 95 subjects with mild to moderate OA (grade 1 and 2) and 95 matched healthy controls were included using a method of convenient sampling. Subjects were exposed to a core stability assessment consisting of a Pressure Biofeedback unit and the KOOS Physical function scale was used to measure the strength of the core and physical performance respectively in individuals with OA knee.

Results. A total of 95 adults participated in this study. The overall mean age of the participants was 55.26 ± 4.3 years, the mean BMI was 27.4212 ± 3.68, and the mean score of the self-reported KOOS physical function score was 68.34 ± 18.34. The final multivariate logistic model predicted that the cases were about 7 times more likely to demonstrate poor core strength with the estimates: AOR 6.95, 95%CI 2.4-11.0. The odds of cases being overweight or obese class II were more likely (AOR 2.83, 95%CI 1.56-5.39 or AOR 3.53, 95 CI 2.1-12.85).

Conclusions. A higher proportion of patients living with osteoarthritis of the knee were observed to have poor core stability compared to their counterparts. This finding implies the importance of considering the evaluation of core strength among OA knee patients, and we also propose the inclusion of core exercise regimes in the OA knee physical rehabilitation programs.

Study registration. The trial was prospectively register at Clinical Trial Registry of India, CTRI/2023/04/051550.

KEY WORDS

BMI; core muscle strength; KOOS-PS Physical function; lumbo-pelvic stability; osteoarthritis of knee; Pressure bio-feedback unit.

INTRODUCTION

Osteoarthritis (OA) is a chronic degenerative joint disease more common in India. It is one of the causes of pain and disability globally. The incidence of OA knee is projected to be 240 per 100,000 people or around 2.5 times that of hip OA (1). The disease's global prevalence in 2010 was 3.8%, with a greater incidence in women than in males and a peak in the Asia-Pacific area (2). It is a well-known fact that the core plays a significant role in walking and physical activity as it helps in both static as well as dynamic control which acts as a foundation for mobility (3) which is one of the problems encountered by Knee OA subjects with the lack of core stability which remains an unobserved area in many researches. The whole-body movement and the equilibrium are supported by the core muscles. In most of the recent journals, the core has been recognized as the lumbopelvic hip complex (4). The ability of the kinetic chain to function depends on the lumbopelvic hip complex, also referred to as the core. It's been standard practice to train the core, also known as the lumbopelvic hip complex in science, to improve performance and the biomechanics of the lower extremities (4). The ability of the trunk to remain in place following a disturbance is known as core stability. All kinetic chain segments may sustain damage as a result of the neuromuscular complex's latency in core control, which can also lead to unstable behavior (5). A lack of endurance in the core muscles increases the load on the knee and, consequently, the contact force between the knee and the joint during dynamic movement. When there is a weak core muscle, there are chances of getting some asymmetries in gait and limb loading, and muscle activation. Walking becomes more difficult for people with osteoarthritis (OA) in their knee joints due to the increased intensity of knee discomfort caused by weak core muscles or trunk control to maintain body weight (6). Consequently, a weak core may have a role in both the onset and advancement of knee OA. A collection of muscles around the lower back and pelvis is called the core (6, 7). Core stability is the active capacity to keep the trunk in place, allow for movement throughout motions, and control and transfer force while engaging in functional tasks. According to studies, people who have weak core muscles may be more likely to get OA knee (8).

Pelvic retroversion is associated with hip external rotation and varus knee deformity in standing posture, as per the kinematic chain in biomechanics (9). Knee Osteoarthritis is linked to varus knee position, which raises the medial tibio-femoral burden (10, 11). Thus, lumbopelvic malalignment can lead to pelvic retroversion, which further leads to the progression of knee osteoarthritis. People execute many of their daily activities in early to mid ranges of joint mobility, therefore the movement of the pelvis that happens early in an active, voluntary action is thought to be significant. There is a suggestion that the frequency of lumbopelvic motion may increase during the day if it occurs during the early ranges of limb movement. Its motion's higher frequency might be a factor in the area's higher tissue stress (12). Previous studies have discovered that knee OA results in a decrease in muscular strength. The majority of studies have concentrated on the specific lower body muscles, like the hamstrings, quadriceps, and hip muscles, but very few have examined the core body muscles as a group, which includes the trunk muscles (13) established that proximal stability and core stability are valid and reliable measures of core muscular strength, which is why these terms were employed in this study.

To date, no study has established a correlation between core (LumboPelvic) stability and knee osteoarthritis. Core muscles are required for increasing force generation and also to reduce joint loads, so the core muscles are involved in providing stability particularly proximally (14). So, this question was framed for the study: *Is there a difference in core strength between the groups?* Therefore, we establish the Null hypothesis (HO) because there is no discernible variation in core strength between OA knee patients (grades 1 and 2) and healthy controls and the alternative hypothesis (H1) where Individuals with OA knee (grades 1 and 2) have lower core strength compared to healthy controls. The study aims to find out the correlation between lumbopelvic stability and osteoarthritis of the knee joint**.** The evidence regarding core strength, including physical activity in OA knee subjects, stands unclear. Thus, the goal of this article is to assess the core strength of individuals with knee OA, examine the correlation between core strength and physical function, ascertain the association between core muscle strength and knee osteoarthritis, and highlight the significance of core strength in those with osteoarthritis.

METHODS

This study was part of the research project aiming to establish a core-strength rehabilitation program for OA knee patients. The full proposal was presented by the investigators and approved by the SRM Medical College Hospitals and Research Centre's Institutional Ethical Committee (Ethical clearance Number – 8501/IEC/2023 – date of approval: January 25, 2023).

Study population and design

In this case-control study, 95 case subjects with primary

knee osteoarthritis of grades 1 and 2, who were analyzed according to American College of Rheumatology criteria for knee OA (15, 16) were taken for the study from the outpatient Department of Orthopaedics in SRM Hospitals, Chennai. The investigator used inclusion and exclusion criteria to recruit each individual, and blinding was not used to find participants for case and controls, a practical sampling strategy was employed. Subjects were evaluated by an orthopedician.

Age and gender-matched healthy controls (n = 95) were chosen from the same locality with the help of their family members, caretakers, friends, neighborhood, and those attend the outpatient department of physiotherapy for consultation purposes. The healthy controls were selected based on clinical examination. Participants of a similar age category without any history of knee pain were selected. Subjects underwent core stability assessment using a Pressure bio-feedback unit. Informed consent of all the participants was obtained.

Study settings

The study design was aimed at an exploratory case-control design matched for gender and age groups *versus* a healthy control group. Enhancing the disclosure of observational research in epidemiology (STROBE) guidelines was taken into consideration, being a case-control study. All participants explained the study and received oral and written information with their signature in the informed consent before the commencement of the study. We selected subjects with Knee OA referred by an Orthopedician to Physiotherapy Departments from August 2023 to November 2023. Similar age-gender matched (17) relatives and attendees of the cases were included as healthy volunteers.

Participants

The eligible study participants were approached and requested to participate in this study. Written informed consent was obtained from those who can read and write the regional language (Tamil) and if the eligible participants were unable to read/write the consent form was read to them by an impartial witness and a thumb impression was obtained. The following operational definition was used for cases; adult male or female aged 40 and above, medically diagnosed to suffer OA knee either unilaterally or bilaterally diagnosed by a physician or orthopedic specialist based on radiographic evidence. The inclusion criteria for cases were aged 40 and above years of age, knee OA unilateral/bilateral and a Kellgrene Lawrence (K-L) grade 1 and 2 and more than 3 months duration after diagnosis. The definition for healthy control was aged 40 and above years, no physical ailments or deformities, absence of recent surgeries and injuries. The criteria by which the subjects were excluded are secondary post-traumatic osteoarthritis, post-total knee replacement (TKR), any inflammatory diseases, recent pregnancy, recent surgeries, and renal problems.

Variables

A conceptualized framework was developed from an extensive literature review and expert opinions to identify the independent variables that are likely to be associated with the physical function and core strength (**figure 1**) among those living with OA Knee.

Dependent variables

Core strength: core stability is defined as the ability of the trunk muscles to control trunk movements of the pelvis and lower limbs to provide stability for a required force that transfers throughout the kinetic chain (18).

Knee injury and Osteoarthritis Outcome Score (KOOS) Physical Function Questionnaire: it is a physical function that is self-reported questionnaire that was developed by the Research Society of Osteoarthritis (OARSI). They identified KOOS Function items, and The Western Ontario and McMaster Universities Arthritis Index (WOMAC) Physical Function items which are identical (19-21).

Independent variables

All adults aged 40 years and above diagnosed with OA of the knee joint were recruited and assigned to the case group and likewise the healthy males and females were chosen for the control group. This age may influence the causes of disease or progression of the disease, so this is taken

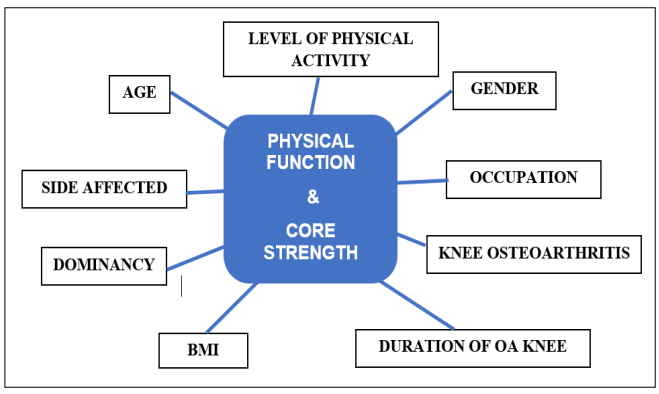


Figure 1. Conceptual framework of the study in the case group.

into consideration, along with which the individual's BMI is also taken into consideration as of which the person's body weight plays a major role in influencing or changing outcome values. Further, sex, BMI, height, weight, occupation, and affected side are studied for a better result.

Instrument and calibration

Pressure Bio-feedback Unit (PBU): the PBU (Chattanooga Group Inc, LLC Vista, CE 205844, Stabilizer pressure bio-feedback, CA, USA) consists of a non-elastic airbag that when placed between the lumbar spine and couch, detects pressure fluctuations according to movements in that region. The reliability of PBU was found to be reliable (24). This PBU consists of an airbag, a cuff inflator, a catheter, and a pressure gauge. The airbag is made of latex material with a size of 16.7 × 24.0 cm. The same equipment was used throughout the study to avoid bias. Calibration was done by bringing down the pressure valve and squeezing the airbag to make sure there was no pressure inside the airbag before using the machine. The equipment was tested for its accuracy by placing the 4 kg weight on the inflated airbag for 24 hours and making sure there was no pressure change happening after 24 hours (22, 23, 31).

Procedure

Biofeedback unit and the KOOS Physical function score were used to measure the strength of the core in individuals with OA knee. Before the commencement of core muscle stability tests, all subjects went through an unofficial guided interview using a questionnaire. All the participants were guided by the assessor to fill in the KOOS-PS form to assess their physical function. The data containing forms given on personal traits like age, occupation, BMI, and information about other diseases were asked to fill by the participants. The core strength assessment using Pressure Bio Feedback was performed thrice to take the average value. Both assessors and the subjects were blinded.

Measurement

Core strength analysis was done by assessing Transverse Abdominis strength using Pressure Biofeedback. The subject is asked to lie down in a supine crook lying position with palm facing downward, face facing ceiling, feet approximately shoulder width apart, and knees bent up to their comfortable pain-free position. The PBU was placed open horizontally, in the center of the lumbar spine, then it was blown with a cuff up to 40 mmHg and left to stabilize, and the fluctuation range of 2 mmHG on either side of the reference point of 40 mmHG (38-42 mmHg) was considered optimal. All the participants were instructed to breathe normally by contracting the abdominal muscles without moving the pelvis. The instructions were given to breathe in and out and then, keep the spinal position steady. During this test, the investigator closely monitored whether any trick movements were done. This was repeated thrice to take the average of the readings. The rest time between the measurements was 1 min. The verbal commands to request for voluntary contraction of transverse abdominis were standardized and repeated for all the participants in the same way. The position of three three-compartment PBU devices was kept in the middle of the lumbar spine, between the last rib and posterior superior iliac spine with an open horizontal position (22).

KOOS Physical Function Questionnaire

It is a 7-item questionnaire including most of the common physical activities of daily living like getting up from bed, wearing and removing slippers, *etc.* These items were Rach analyzed on a score of 0 to 4 and were added against a total of 28, with the lowest score indicating the level of good functional status. These scores were converted to a score of 100 where the lowest score indicated functional inability as reported by Perruccio *et al.* (21).

Sample size determination

A single population proportion formula was used to calculate the required power calculated sample for this case-control study. The following assumptions were used to estimate the required sample: margin of error 5%, confidence interval 95%, and the prevalence was assumed as 50% with the lack of regional study. Further, a 5% attrition rate was added to the derived sample size to account for the possible non-responses. The derived estimated sample was 110 cases and 110 controls. The final sample size accommodating non-response was 230.

The single population proportion formula:

$$N = \left(\frac{Z\alpha}{2}\right)^2 Xp\frac{P(1-P)}{d2}$$

A systematic sampling approach was used to recruit the cases. About 10-15 patients with osteoarthritis visit the SRM Hospital, Orthopaedic Department every day. Based on the data from the SRM Hospital registry, the total estimated number of osteoarthritis of knee visiting SRM Hospital during the study period would be 600 out of which 110 were taken as the estimated sample size. Every participant in the initial sample, which was randomly selected between 1 and Kth, was followed by every Kth participant, where

the Kth sampling interval was determined by the registration list created for the day. The healthy controls were recruited using simple random sampling from the community-dwelling adults in the study zone. Until we achieved the required sample size the process was repeated. The next person in line was approached if someone declined to take part.

Quantitative variables

The pressure biofeedback unit and the KOOS Physical function score were used to measure the strength of the core in individuals with OA knee.

Data analysis

Data was cleaned, coded, and entered into the EPI-data version 3.1 and exported to the IBM SPSS version 26, Armonk, Chicago, USA. The characteristics of the participants were described as proportion and percentage, and the association was tested using the Chi-square test for the categorical variables. The continuous variables were described by mean and standard deviation, and an independent t-test was used to report associations. The optimal pressure biofeedback values for core strength were between 38 and 42 mmHg and values above and below this range were defined as impaired core strength, hence we categorized the core strength variable into a dichotomous variable (stable *versus* unstable). Independent factors related to the case and control were explored using a bivariate logistic regression model at p-value of < 0.25 and the factors associated were simultaneously entered into the multivariate regression model with a confidence interval at 95% and level of significance of 0.05.

RESULTS

The non-response rate was 17.39% and a total of 190 participants consented to participate in this study, which is more than 80% of the power calculated sample of 220 participants. The missing data were minimal due to the direct interview and performance-based data collection methods. The mean imputation method was used to address the remaining missing data.

The result table presents descriptive statistics of those who completed the baseline medical screening and were involved in the study. Among 110 participants who approached the hospital, only 95 subjects with OA knee responded and gave consent and participated in the study, which is 86.4 % of the response rate and 90% of the calculated sample size. The most common reasons found for nonresponse were not interest and no time. No missing data were found. The equivalent matched controls n = 95 were taken from the cases of close relatives, friends, and neighbors who have fulfilled the inclusion criteria. Overall, the participants had an average age of 55.26 years with an SD of ± 4.28. The mean age of the case group was calculated as 55.12 years with a standard deviation of ± 4.9. Among the participants most of them were female (n = 53.2%), the same was observed in both the groups, control (52.6%) and case (53.7%). According to Chi-square findings, there is no gender parity between groups: $\chi^2 = 0.021$, df 1, p = 0.884, phi = -0.011.

The results depict that the majority of the subjects (91.9%) are above the age of 50 years and only a few (8.9%) 50 and below age category. Among those more than half of the subjects (51.6%) were professionals by occupation, 22.1% were housewives and 16.8% were business people. The test revealed that there aren't any notable variations between the groups with chi-square value of 7.005[a], df 5, p = 0.220, phi = 0.192. Overall data of BMI category (**figure 2**) revealed almost half of the people (44.2%) are overweight, 31.1% are of normal weight and 20.5% belong to obese class 1 and it showed a significant difference between the groups based on

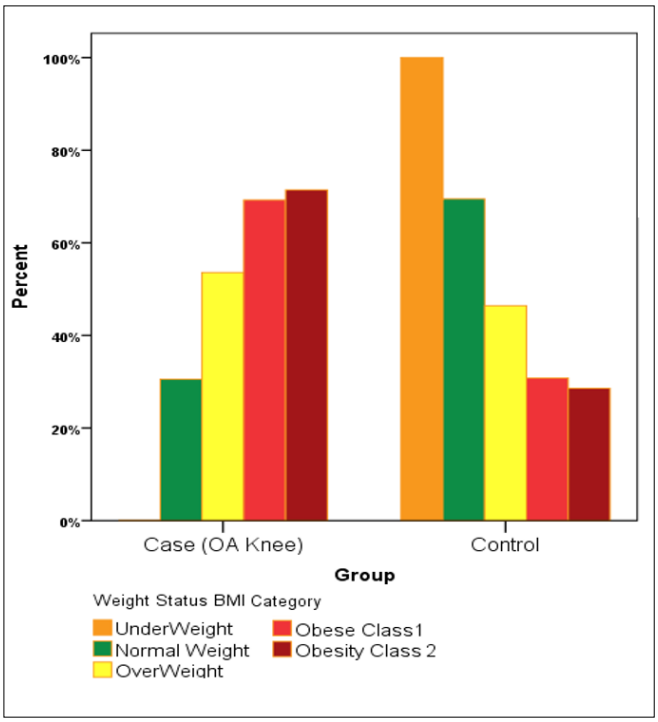


Figure 2. Frequency distribution of BMI category between the case (n = 95) and control (n = 95) among the study participants.

Table I. Socio-demographic characteristics and descriptive statistics within the groups and between the case (OA Knee) and control (healthy subjects) groups.

Variables	All Samples (n = 190)	Case (n = 95)	Control (n = 95)	P-value
Age (Yrs)	55.26 ± 4.3	55.12 ± 4.85	55.43 ± 3.68	0.134
Age Category				
50 & below	17(8.9%)	8 (8.4%)	9 (9.5%)	1.000
Above 50 years	173 (91.1%)	87 (91.6%)	86 (90.5%)	
Gender (n %)				
Male	89 (46.8%)	45 (47.4%)	44 (46.3%)	1.000
Female	101 (53.2%)	50 (52.6%)	51 (53.7%)	
Occupation (n %)				0.220
Beautician	2(1.1)	0 (0.0)	2 (2.1)	
Housewife	42 (22.1)	18 (18.9)	24 (25.3)	
Own Business	32 (16.8)	13 (13.7)	19 (20.0)	
Private	3 (1.6)	1 (1.1)	2 (2.1)	
Professionals	98 (51.6)	57 (60.0)	41 (43.2)	
Retired	13 (6.8)	6 (6.3)	7 (7.4)	
Height (cms)	161.43 ± 6.35	161.06 ± 6.292	161.81 ± 6.429	0.305
Weight (kgs)	71.46 ± 10.2	74.00 ± 10.263	68.86 ± 9.504	0.683
BMI (mean SD)	27.4212 ± 3.68	28.5381 ± 3.84	26.2843 ± 3.146	0.000**
BMI Category (WHO)				0.002*
Under Weight (< 18.5)	1 (0.5%)	0 (0.0%)	1 (1.1%)	
Normal Weight (18.5 to 24.9)	59 (31.1%)	18 (18.9%)	41 (43.2%)	
Overweight (25.0 to 29.9)	84 (44.2%)	45 (47.4%)	39 (41.1%)	
Obese Class I (30.0 to 34.9)	39 (20.5%)	27 (28.4%)	12 (12.6%)	
Obesity Class II (≥ 35)	7 (3.7%)	5 (5.3%)	2 (2.1%)	
Physical function (KOOS -PS)	68.34 ± 18.343	52.53 ± 6.302	84.49 ± 11.014	0.000**
Core strength (PBU)	40.43 ± 3.256	41.98 ± 3.084	38.84 ± 2.606	0.006*
Pressure Bio Feed Back-category cut off 38- 42 * Group				0.000**
Stable	71 (37.4%)	26 (27.4%)	69 (72.6%)	
Unstable	119 (62.6%)	69 (72.6%)	26 (27.4%)	

Knee Osteoarthritis Outcome Score-Physical Function (KOOS-PS scale), Core strength using PBU (Pressure Biofeedback Unit) among case and control. Student t-test was used for continuous variables and expressed as mean and standard deviation (± SD). **Significance at the level of P-value less than 0.0001; *significance at the level of P-value less than 0.001.

BMI category that was mentioned in **table I** in mean and SD with chi-square value as 17.450[a], df 4, p = 0.002*, phi = 0.303.

The readings of PBU and KOOS-PS score were noted in both cases and controls. The overall KOOS Physical function measured depicted in mean and SD as 68.34 and ± 18.34 respectively. The case group has a lower physical functional score (52.53 ± 6.302) than the control group with a high physical functional score (84.49 ± 11.01). The chi-square test run between the groups does indicate notable variation in physical function among groups (χ^2) with P-value less than 0.0001, Pearson's chi-square value 38.926[a], phi -0.453

The measurement of core muscle strength is done using pressure biofeedback equipment with the units of pressure measured in mm of Hg. The optimal range of core strength is 38-42 mmHg with the cuff inflated to 40mmHg and a range of 0-2 mmHg is considered normal (30). The overall mean core strength measured by the PBU device was 40.4 ± 3.26, the independent t-test findings observed a statistically significant difference between the core strength of the case and control group, 41.98 ± 3.08 *versus* 38.8 ± 2.6, P-value < 0.01. The pressure biofeedback assessment of stable and unstable categories is analyzed according to the group (**figure 3**). Among both groups, 71 (37.4%) had a stable core strength and 119 (62.6%) had an unstable core strength. The P-value is represented as < 0.001 which is less than 0.0001, which has a significant correlation between the groups.

The characteristics of OA knee among case groups are studied (**table II**) and analyzed to the fact that there is a mean value of 9.13 ± 5.350 as the variance for the categorical variable of the duration of disease and its Inter Quartile Range (IQR) is 8 (6, 12). 47 (49.5%) of subjects has OA knee on their right side, 25 (26.3%) has it on left side and 22 (23.2%) has it on both the knees.

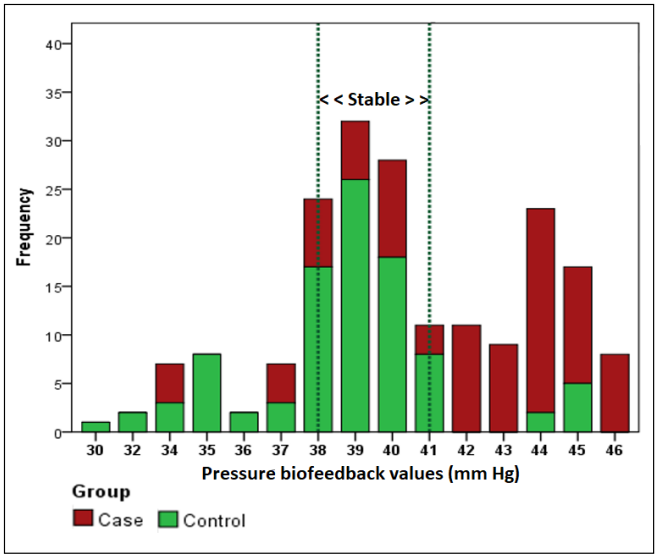


Figure 3. Distribution of pressure biofeedback core strength between cases and control.

The vertical reference lines indicate the range of pressure biofeedback values classified as stable core muscle.

Table II. Characteristics of osteoarthritis among cases (n = 95).

Variables	Case
Duration of disease	
Mean ± SD	9.13 ± 5.350
Range	21 (3-24)
Median (IQR)	8 (6-12)
Side involved (n %)	
Right side	47 (49.5)
Left side	25 (26.3)
Both sides	22 (23.2)

The values represented as proportion and percentage (%) for categorical variables, are indicated by a Chi-square. Student t-test was used for continuous variables and expressed as mean and standard deviation (± SD).

Regression analysis

Predictor variables that were significantly associated between the case and control at P-value < 0.25 were entered in the multivariate logistic using the simultaneous entry method. Age category (≤ 50 years *versus* > 50 years), BMI category and pressure bio-feedback-based core strength category were found to be associated with the binary regression. In the final model, BMI category and pressure biofeedback cut-off classified core strength were found to be associated with the case definition at 0.05 level of significance. The odds of being overweight and obese class II are most likely among the cases compared to the normal counterpart (AOR (95%CI): 2.829 (1.56-5.39), P-value 0.02) and (AOR (95%CI): 3.526 (2.103-12.852), P-value 0.0313) respectively. The odds of participants with unstable core strength were higher among the cases than the control group with cases about 7 times more at the risk of demonstrating unstable core strength (AOR (95%CI).

6.951 (2.351-11.02), P-value < 0.0001) than the healthy controls (**table III**). Using the logistic regression model, we predicted the factor associated with the likelihood of demonstrating a stable core muscle strength using a device-based outcome measurement and comparing the variables between the cases and healthy control matched for age and gender.

DISCUSSION

The main intent of this study was to find the abdominal core strength of individuals who had been medically diagnosed with osteoarthritis of the knee joint and then compare those estimations to the core strength of healthy adults who are deemed to be normal. Additionally, we also investigated the characteristics that are associated with physical function and core strength that were present in both the cases and the controls. A significant number of cases, 72.6%, were found to have inadequate control and strength of their core muscles, as determined by the pressure biofeedback device. This was in comparison to the healthy counterpart, which was 27.4%. The findings of this study were the most important discoveries. It is important to pay attention to the fact that approximately one-fourth of the healthy people who participated in this study did not exhibit optimal core control and strength. Some studies suggest that diseases related to the lower extremities, such as osteoarthritis of the knee, maybe the cause of poor core strength, and *vice versa* (8, 6, 18).

As explained by Ag Daud *et al.*, a lack of core muscle endurance is indicative of weakness in the muscles that are responsible for supporting the body's weight. A lack of core muscles can result in increased strain on the knee joint as well as a greater knee joint contact force when dynamic motions are performed. Our study found a statistically significant link between a higher BMI class and osteoarthritis of the knee, which is in agreement with the findings of the majority of the other studies. In addition, it was calculated that the

Table III. Regression analysis between the Case group and Control group (reference).

Variables	OA knee		COR (95%CI)	P-value	AOR (95%CI)	P-value
	Case (n = 95)	Control (n = 95)				
Age category						
≤ 50 years	8 (8.4%)	9 (9.5%)	Ref		Ref	
> 50 years	87 (91.6%)	86 (90.5%)	1.879 (1.324- 2.384)	0.119	1.02 (0.053- 1.010)	0.844
BMI category (WHO)	28.5381 ± 3.84	26.2843 ± 3.146				
Normal Weight (18.5 to 24.9)	18 (18.9%)	42 (44.3%)	Ref		Ref	
Overweight (25.0 to 29.9)	45 (47.4%)	39 (41.1%)	5.694 (1.009- 32.150)	.049	2.829 (1.56- 5.39)	0.0274*
Obese Class1 (30.0 to 34.9)	27 (28.4%)	12 (12.6%)	2.167 (0.40- 11.8)	0.37	3.190 (1.88- 9.58)	0.0852
Obesity Class 2 (≥ 35)	5 (5.3%)	2 (2.1%)	1.11 (0.19- 6.56)	0.90	3.526 (2.103- 12.852)	0.0313*
Pressure Bio-feedback category						
Stable	26 (27.4%)	69 (72.6%)	Ref		Ref	
Unstable	69 (72.6%)	26 (27.4%)	4.160 (2.258- 7.665)	0.000**	6.951 (2.351- 11.02)	0.000**

CI: confidence interval; BMI: Body Mass Index; COR: Crudes odds ratio; AOR: Adjusted Odds Ratio; **level of significance at 0.001; *level of significance at 0.05; pressure bio-feedback was categorized as stable if the reading falls between the cut off value 38- 42mmHG, values > 38 and < 42 were categorized as unstable core.

likelihood of unstable performance-based core strength was seven times higher among the aforementioned cases (8). Surprisingly similar to this study, a study conducted by Marks *et al*., in which there were no cases that could be classified as underweight and the percentage of cases with normal weight was low, more than 80 percent of the cases were overweight, our study also did not include any cases that were classified as underweight, and as a result, they were included in the category of normal weight (26). The gender difference in our study, which is considered as the matched case and control, is comparable to the study that was carried out by Breslow and Day (1980). According to Breslow and Day's research (27), case-control studies that are matched, attempt to increase the amount of information that is collected from each of the participants that are participating in the study. Additionally, the age category that is mentioned in the results is a mean age of 55 years (27). This is one of the important features of the study that is comparable to this remark by Suzuki *et al*., in which the enrolled controls were age-matched, which is suitable for comparing OA and non-OA. In addition to this, the results indicate that the age category is 55 years (28).

On the other hand, there are reports that musculoskeletal illnesses are growing more prevalent in individuals who are in their early 30s, which contributes to an increase in the overall burden of diseases around the world (29). At this time, it is not known whether core strength has an effect on OA or whether OA knee promotes weakness in the core muscles. As stated by Suzuki *et al*., in their research conducted on various grades of osteoarthritis of the knee, the strength of the trunk muscles varies as the grades of OA knee continue to progress (28). It was also revealed in our research that there was a comparable disparity between the case group and the control group. The control group, which was considered to be healthy, demonstrated a higher level of core strength than the study group. Additionally, there is a potential that healthy people who do not exhibit any obvious symptoms could serve as subtle markers of core weakening. When it comes to overall core strength, the strength of the transverse abdominis muscle is a good indicator. Researchers assessed the amount of pressure reduction on the pressure biofeedback unit (PBU) when individuals were in a supine or prone lying position (25) in order to estimate the amount of core strength that the subjects possessed. An additional outcome measure that we implemented in this investigation was the PBU, which was used to evaluate the participants' core strength while they were lying in a supine posture. We built the reference range by using the research that was carried out by Rathore and colleagues (24), and we thoroughly evaluated the elements that could potentially confuse, such as age, body mass index, and gender. When the cuff was inflated to 40 mmHg, it was discovered that the best range for core strength values was between 38 and 42 mmHg. The findings of the research that Park and Lee (30) conducted in 2013 indicate that a range of 0-2 mmHg is deemed to be typical. When compared to healthy controls, patients with OA exhibited a greater range of pelvic floor muscle pressure (PBU) values, according to the findings of this study. During the process of muscular contraction, these PBU levels are a reflection of the pressure changes that take place. More specifically, larger PBU readings result in a greater amount of pressure being applied to the muscles that make up the pelvic floor. When compared to the healthy controls, the PBU levels of the healthy controls were lower, which suggests that they may not be adequately engaging their core muscles. It is interesting to note that several healthy control patients also demonstrated weaker abdominal muscles (30, 31).

Limitation

To aid in future research, a few limitations shall be discussed. Firstly, because the assessors in this study were not blinded, there may have been unintended bias when completing the outcome measures. However, because the investigators were blinded to the PBU readings from the corseting effect carried out during the test, there could have been a minimal bias concerning the measurement of core muscular strength. Secondly, selection bias may have occurred during the participant recruitment phase when patients were chosen from hospitals (not from the community) based on their need for medical attention, and misclassification bias may have occurred because the patients were symptomatic cases. However, the study's strength is in its use of performance-based objective measures to assess core strength, which enabled us to investigate the association between core strength and OA knee by comparing variables between patients and controls. Further, the investigators have employed standardization of testing position, testing surface, verbal commands, and device calibration procedures to minimize procedural biases.

CONCLUSIONS

There are glimpses of the study which states that core stability gets weaker for those with OA knee and also some studies suggest that OA knee can be an influencing factor for

weaker core muscles. Studies have to explore this part of the study which stands unclear. Core strength might be considered as a predicting factor for OA knee in future studies. Furthermore, as this study revolves around the stability of core strength and its impact on the causation of the disease, core strength can be taken as a primary component to be studied in the future related to OA knee and also for physical function.

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DATA AVAILABILITY
Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS
KS, RK: conceptualization, methodology. KS, RK, BJ: validation. BJ: formal analysis. KS, SM: investigation. KS: writing -original draft. KS, BJ, RK AA: writing - review & editing. RK: supervision.

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CONFLICT OF INTERESTS
The authors declare that they have no conflict of interests.

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