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Differences in body fat mass, muscular endurance, coordination and proprioception in woman with and without knee pain: a cross-sectional study

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Objective: The aim of this study was to compare body fat mass, muscular endurance, multi-joint coordination and proprioception between sedentary adult woman with and without knee pain.

Methods: This cross-sectional study included 149 women. All participants were evaluated using the Visual Analog Scale to determine knee pain during specific functions and divided into 2 groups accordingly. The knee pain group (n= 52; mean age: 42.6±4.1 years; mean height: 1.56±5.11 m; mean weight: 75.2±14.1 kg) included patients with mild to moderate knee pain scores. The without knee pain group (n=97; mean age: 41.7±4.2 years; mean height: 1.58±5.06 m; mean weight: 73.4±10.6 kg) included cases who reported no pain. Body composition was assessed using the TANITA Body Composition Analyzer. Concentric maximal torque of the knee flexor and extensor muscles was recorded using an Isomed 2000 isokinetic dynamometer at 180 deg/s. Coordination and proprioception were assessed using the Functional Squat System.

Results: There was no significant difference in terms of physical characteristics, body composition parameters and coordination results between groups ($p>0.05$). Peak torque of flexion (0.65±0.21 N/kg) and extension (0.88±0.23 N/kg) of the affected side in the knee pain group were significantly lower than the without knee pain group dominant side flexion (0.74±0.19 N/kg) and extension (0.98±0.19 N/kg) ($p<0.05$). A significant difference in knee extension was observed between the affected (0.88±0.23 N/kg) and non-affected sides (0.93±0.21 N/kg) of the knee pain group ($p<0.05$). There were no significant differences for both legs between groups in terms of coordinative concentric side-to-side deficits and eccentric deficits ($p>0.05$). The deviation on visible movement for proprioception was significantly higher in the knee pain group (3.23±1.01 cm) than in the without knee pain group (2.78±1.03 cm) ($p=0.012$).

Conclusion: Knee pain impairs flexor and extensor peak torques of knee endurance and multi-joint proprioceptive accuracy in sedentary woman. No differences were observed in terms of body composition and joint coordination of the groups with or without knee pain.

Key words: Isokinetic testing; joint position sense; sedentary lifestyle.

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Knee pain affects more than 80% of the population of older adults and women are affected more often than men.[1-4] Knee pain is the most common musculoskeletal complain and its prevalence increases with age.[5-7] Autopsy studies have shown that the degenerative changes in the knee begin in the second decade and roentgen signs in the third.[5] The majority of knee pain is likely to be relatively mild in nature in the general population. Many people do not regard such symptoms as illness but as a sign of 'normal aging' or 'result of loading'.[8] However, knee pain starting at early ages may be an important sign of knee osteoarthritis (OA). Sedentary behavior, increased body weight or obesity, lack of muscle strength, coordination, proprioception, flexibility and some structural abnormalities have been found to be strongly associated with knee pain.[6,9]

The majority of knee pain studies have focused on impaired muscle strength. Several studies suggested that quadriceps weakness might play an important role in the development of knee symptoms.[10-15] Lankhorst et al. declared that lower concentric peak torque values for knee extensors were risk factors for knee pain.[16] However, a similar relationship could not be established with the knee flexors.[16] Controversially, some studies could not show any relationship.[17,18] Segal et al. declared that neither concentric quadriceps strength nor hamstring/quadriceps ratios predicted the development of frequent knee symptoms.[19] Moreover, endurance-based impairment has not been mentioned in the literature.

In addition to strength and endurance of the muscles, joint position sense (JPS) has been linked with knee pain.[18,20] Baker et al. highlighted proprioceptive reeducation in the management of knee problems.[21] However, in a study of athletes with and without patellofemoral syndrome (PFS), no difference was shown in JPS.[22] Proprioception and coordination as parameters for JPS has been highly popular lately. Knoop et al. concluded that the mechanisms underlying the impact of impaired proprioceptive accuracy on knee pain and activity limitations need to be further clarified.[23]

Therefore, the purpose of this study was to assess the differences in body fat mass, muscular endurance, coordination and proprioception between groups of sedentary adult woman with and without knee pain in a cross-sectional study. The investigated hypotheses were: 1) Sedentary women with knee pain have higher body mass index and body fat than women who do not have knee pain and 2) muscular endurance, proprioception and coordination impairments are related with knee pain in sedentary woman.

Patients and methods

Two hundred-forty female volunteers aged between 35 and 50 years applying to a sport center for exercise consultation were assessed. All participants were asked to get a health certificate from a general practitioner. Subjects were questioned using a health history questionnaire for eligibility criteria. Those with systemic pathology including any inflammatory joint disease, prior history of injury or surgery relating to musculoskeletal system, active intervention in the last 3 months including corticosteroid/hydro dilatation injection or physiotherapy, anti-inflammatory medication history, prior history of knee instability, severe knee pain and symptomatic range of motion limitation or menopause were excluded from the study.

The study included 149 women. All subjects were evaluated using the Visual Analog Scale (VAS) to determine knee pain while ascending/descending stairs, squatting, running, kneeling, hopping, and jumping. The VAS is scored on a 10-cm horizontal line with 0 indicating 'no pain' and 10 'unbearable pain'. The participant was asked to mark the strength of her knee pain on the horizontal line. The reliability of this measure has been determined by Clark et al.[24] VAS pain scores of 30 mm or less were defined as mild pain, 31 mm to 69 mm moderate pain and 70 mm or more severe pain.[25] Subjects who scored mild to moderate knee pain (average knee pain: 40.12±10.42 mm) during at least 3 activities were included in the knee pain group. Subjects scoring 70 mm or over were not included. The knee pain group was composed of 52 subjects (mean age: 42.6±4.1 years; mean height: 1.56±5.11 m: mean weight: 75.2±14.1 kg) and the without knee pain group 97 subjects (age: 41.7±4.2 years; mean height: 1.58±5.06 m; mean weight: 73.4±10.6 kg).

All subjects provided approved consent. The University Ethical Committee approved the study (Ethical Committee Approval Number: 426).

Body composition, muscular endurance, coordination and proprioception were evaluated. The same examiner who was blinded to group allocation conducted all evaluations. All subjects were informed about the particular requirements of the tests, and were warmed up on a stationary bicycle for 10 minutes. Testing was performed between 14:30 and 15:30.

Body weight, body mass index (BMI), basal metabolic rate, percentage of body fat and fat mass were measured using TANITA (Tanita TBF-300 GS Pro Body Composition Analyzer; Tanita Corporation of America, Inc., Arlington Heights, IL, USA). After personal data were recorded in the system, participants stood still on the platform in bare-feet and impedance measurements were taken after subjects' weight stabilized within ten seconds.

Muscular endurance measures of the quadriceps and hamstring muscles were recorded using an Isomed 2000 isokinetic dynamometer (D&R Ferstl GmbH, Hemau, Germany) with the knee positioned from 90 degree flexion to 0 degree extension. The concentric maximal torque production (Nm/Kg) was evaluated in both the knee flexor and extensor muscles at 180 deg/s. During testing, the subjects were restrained by straps applied across their shoulder girdle and chest in a sitting position. The subjects received five submaximal consecutive contraction trials to familiarize the procedure. Each test consisted of 10 repetitions and lasted for one minute. The best three maximal contractions were automatically selected by the software.

Functional Squat System (FSS) (Monitored Rehabilitation Systems, Haarlem, The Netherlands) was used to evaluate coordination and proprioception throughout the concentric and eccentric phases. The concentric phase was defined as the concentric quadriceps contraction starting in a half-squat position and ending in full knee extension. The eccentric phase was defined as the eccentric quadriceps contraction starting in full knee extension and ending in 90 degrees of knee flexion. The system has been used both for assessment and rehabilitation in previous studies with good reliability scores.[26-30] For testing, subjects were instructed to lie on the bed of the FSS in the supine position, with legs lifted up, hips and knee flexed to 90 degrees and feet in full contact on the platform of the machine in a half-squat position. They were asked to extend their knees to 0 degree with full contact of their feet to determine the minimum and maximum range of motion of the lower extremity. Subjects were allowed a 30-second practice session before the test. The coordination test was performed unilaterally with a load minimizing force control (5 kg) for 60 seconds. Subjects were provided with ongoing visual feedback of their position by means of a cursor displayed on the monitor in front of them. They were instructed to match the criterion trajectory as accurately as possible. Sixty seconds of target tracking was completed unilaterally, and repeated with contralateral leg. The software automatically calculated side-to-side differences in deficit.

In the proprioception test, the same positions were applied. Subjects were instructed to keep the red cross-hair sign on the blue line on the computer screen, even after the visual aid had disappeared. The test was performed bilaterally for 60 seconds. The software calculated the non-visible and visible deviations and deficit in cm.

The Student t-test was used to analyze differences between subjects with and without knee pain. The level of significance was set at $p<0.05$.

Results

Subjects' physical characteristics are presented in Table 1. There were no significant differences in age, height, weight, BMI, basal metabolic rate, body fat percentage

Table 1. Physical characteristics of the subjects.

	With knee pain group (n=52)	Without knee pain group (n=97)	p
	Mean±SD (Min-Max)	Mean±SD (Min-Max)	
Age (year)	42.6±4.1 (35-50)	41.7±4.2 (35-50)	0.256
Height (m)	1.56±5.11 (1.45-1.73)	1.58±5.06 (1.48-1.7)	0.153
Weight (kg)	75.2±14.1 (50.8-129)	73.4±10.6 (54.5-111.5)	0.365
BMI (kg/m^2)	30.5±5.3 (19.6-51)	29.4±4.6 (20.0-41.7)	0.185
BMR (Kcal)	1429±134 (1150-1727)	1420±98 (1228-1730)	0.663
Fat (%)	39.29±7.86 (20.1-66.4)	38.13±7.67 (22.5-59.8)	0.382
Fat mass (kg)	30.46±11.77 (10.3-85.7)	28.64±9.59 (12.3-61.3)	0.310

*p<0.05. BMI: Body Mass Index; BMR: Basal Metabolic Rate; SD: Standard deviation.

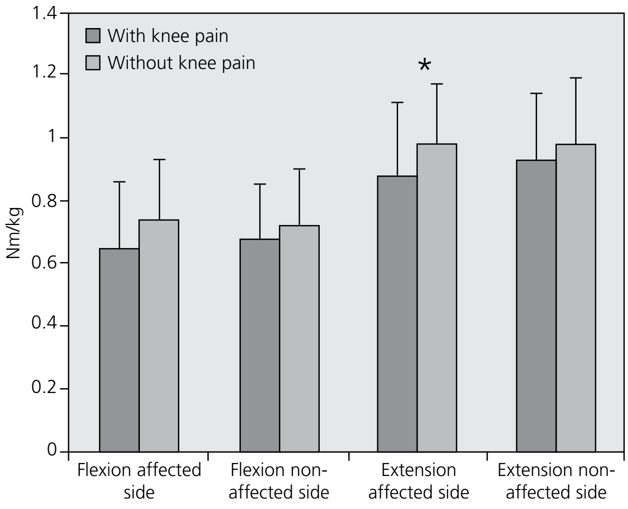

Fig. 1. Isokinetic muscle torques (peak torque, Nm/kg) of knee extensors and knee flexors at 180°/sec in the affected and non-affected sides for the with knee pain and without knee pain groups. *p<0.05.

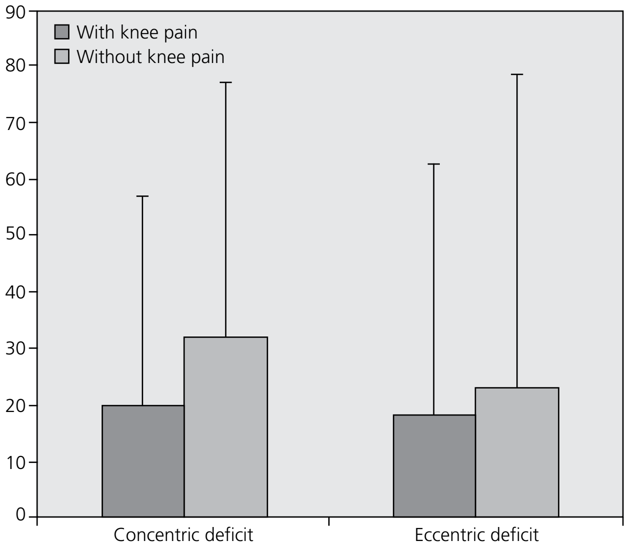

Fig. 2. Coordinative concentric and eccentric deficit results of the groups with and without knee pain.

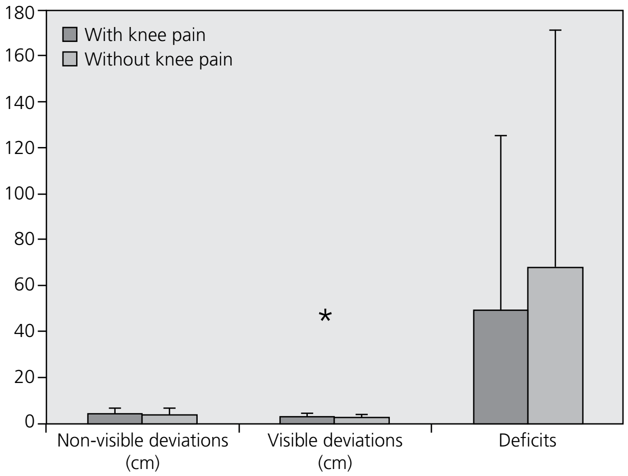

Fig. 3. Proprioception test results for the non-visible and visible deviations of both groups.

or fat mass between subjects with and without knee pain ($p>0.05$).

In the knee pain group, concentric peak torque results of flexion on the affected side was 0.65±0.21 N/kg and 0.68±0.17 N/kg on the non-affected side ($p=0.112$). Peak torque results of extension of the affected side (0.88±0.23 N/kg) were significantly lower than those of the non-affected side (0.93±0.21 N/kg) ($p<0.05$). However, in the without knee pain group, no significant differences were observed in flexion between the dominant (affected) (0.74±0.19 N/kg) and non-dominant side (non-affected) (0.72±0.18 N/kg) sides ($p=0.298$) or in extension between the dominant (0.98±0.19 N/kg) and non-dominant (0.98±0.21 N/kg) sides ($p=0.514$). Concentric peak torque of flexion and extension of the affected side in the without knee pain group were higher than in the knee pain group ($p=0.014$ and $p=0.007$, respectively) (Fig. 1).

There were no significant differences in coordinative concentric side-to-side deficits (knee pain=19.9±37; without knee pain=32.1±45) and eccentric deficit results (knee pain=18.39±44.23, without knee pain=23.33±55.18) for both legs between groups ($p>0.05$) (Fig. 2).

Deviation on visible movement for proprioception was significantly higher in the knee pain group (3.23±1.01 cm) than in the group without knee pain (2.78±1.03 cm) ($p=0.012$). However, no significant differences were observed in non-visible deviation (knee pain=4.55±2.04; without knee pain=4.24±2.07) or side-to side deficit results (knee pain=49.7±75.48; without knee pain=68.37±103) ($p>0.05$) (Fig. 3).

Discussion

Macfarlane et al. found that BMI is associated with knee pain.[31] People with a BMI of over 30 kg/m^2 between the ages of 23 and 33 years experienced an approximately two fold risk of developing knee pain at 45 years of age.[31] Furthermore, the role of obesity as a risk factor for OA has been well documented. Blagojevic et al. examined 36 papers and found that all studies demonstrated obesity and excess weight to be risk factors for OA.[32] The effect size for obesity as a risk factor for OA was reported as I2=97% and the random effects pooled odds ratio for obesity compared to normal weight was 2.63 (95% CI of 2.28 to 3.05).[33] In this study, mean BMI of both groups was approximately 30 kg/m^2 and mean age was approximately 40 years. No significant difference between knee pain and body composition were found. However, both groups were overweight, with the knee pain group slightly heavier and with more fat mass. Moreover, the knee pain group was older. We believe that age and BMI of our groups can be considered a cut-off value and is a critical time to further develop or prevent OA.

The quadriceps muscle is the principal dynamic stabilizer of the knee joint. Muscle spindles provide a substantial contribution to proprioceptive ability. Thus, impaired proprioceptive ability and quadriceps muscle weakness may leave the knee joint vulnerable. Many studies have evaluated multiple variables of peak torques of knee extensors and flexors in isokinetic tests.[12,28,34] Diraçoglu et al. evaluated at velocities of 60, 180 and 240°/s and showed that the knee flexor-extensor muscle strength values were lower at all velocities in patients with OA compared to healthy subjects.[35] Another study reported that lower relative concentric peak torque for the knee extensors relative to BMI, measured at 60°/s and 240°/s, was significantly associated with future PFS while it was not associated with concentric peak torques for knee flexors.[16] Witvrouw et al. reported that the quadriceps muscle has a lower concentric peak torque in individuals with future PFS.[30] Duvigneaud et al.[36] evaluated additional variables related to peak torques. Concentric flexor-extensor peak torque ratios measured at 60°/s and 240°/s were significantly higher in those with future knee pain. No difference between groups was found for both flexor-extensor peak torque values which was measured at 30°/s in an eccentric mode. In the current study, endurance specific velocity was measured at 180°/s concentric/concentric mode. The reliability of these measures has been previously determined.[37] Impairments on the peak torque for knee flexors and extensors were observed in the women with knee pain. Although a decrease in knee extensor strength has been highlighted in the literature, knee flexor impairment is underestimated.

Although we are not aware of any longitudinal studies evaluating whether a combination of quadriceps endurance, coordination and proprioceptive acuity reduce the risk of developing knee pain with which to compare these results, cross-sectional studies evaluating each of these relationships separately have been published.[38] It was found that individuals with symptomatic OA have weaker quadriceps, reduced knee joint proprioception and increased postural sway.[38] Mohammadi et al. reported that women with symptomatic OA had reduced dynamic balance, muscular endurance and JPS.[39] In our study, coordination and proprioception tests were chosen as assessment. Coordination results remained same for both groups while visible proprioceptive deviations were higher in the knee pain group. This finding supports the idea that proprioceptive output is impaired in the knee pain group in our sample. Impairment of proprioception and coordination in knee pain may contribute to, and/or result from OA. Sharma et al.[40] reported that impaired proprioception was not exclusively a local result of disease in OA. They pointed out the need for longitudinal studies on the relative importance of impaired proprioception in the development and progression of OA. Our study corroborated this idea.

Mild knee pain in earlier adulthood may be a 'predictor' or a 'sign' of OA. Many people do not regard such symptoms as illness and those with knee pain visiting the doctor represent only a fraction of those experiencing pain.[41] This study was composed of a group of sedentary adult woman with moderate knee pain or without knee pain, as determined using a self-questionnaire. The lack of professional diagnosis could be considered a limitation. However, we aimed to make the first step toward prevention through the identification of some possible risk factors, as the incidence of knee pain is high in the general population and the majority of knee pain is likely to be relatively mild. Another possible limitation was the number of subjects. We were only able to consider the outcomes of 149 subjects out of 240 candidates. Additionally, group numbers were not equally distributed due to the exclusion criteria created to standardize the groups. Furthermore, study subjects were women between the ages of 35 and 50 years and results cannot be generalized to other groups. Moreover, side-to-side compared deficit results were taken for proprioception and coordination measurements. The deficit analyses presented the results as positive and negative ranks. This increased the intervals of the standard deviations. However, using the deviations made the results simple to understand.

In conclusion, knee pain appears to impair flexor and extensor peak torques of knee endurance and proprioceptive accuracy in sedentary woman. However, no differences in body composition, fat mass or joint coordination was observed between subjects with or without knee pain. The age and the physical characteristics of the study sample may be a critical predictor for the further development or prevention of OA. Therefore, the declared impairments should be considered in conservative interventions.

Conflicts of Interest: No conflicts declared.

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