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Original Research

Association Between Knee Osteoarthritis and Functional Changes in Ankle Joint and Achilles Tendon

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ABSTRACT

Increasing evidence has shown that biomechanical forces often drive the progression of knee osteoarthritis (OA). Attention should be given to the changes in adjacent joints and their relation to knee OA. The purpose of the present study was to examine the changes in Achilles tendon thickness of individuals with knee OA and to evaluate the correlation between Achilles tendon thickness and knee OA severity in a case-control prospective observational study. A total of 93 participants with no previous ankle injuries were recruited. Of the 93 participants, 63 had knee OA of the medial compartment and 30 served as controls. The subjects underwent a clinical examination that included measurements of weight, height, Achilles tendon thickness, and 1-leg heel rise. The subjects also underwent a computerized gait test and completed the Hebrew version of the Western Ontario and McMaster Osteoarthritis Index and 36-item short-form (SF-36) health survey. Significant difference was found in Achilles tendon thickness between the subjects with knee OA and the healthy controls (17.1 ± 3.4 versus 15.1 ± 3.1; $p = .009$). Significant differences were also found between the 2 groups in the 1-leg heel rise test, Western Ontario and McMaster Osteoarthritis Index scores, SF-36 scores, and all gait measures. Significant correlations were found between the Achilles tendon thickness and the following measures: weight ($r = 0.46$), body mass index ($r = 0.55$), Kellgren and Lawrence OA severity grade ($r = 0.25$), 1-leg heel rises ($r = -0.50$), and SF-36 score ($r = -0.25$). Subjects with knee OA presented with a thicker Achilles tendon compared with the healthy controls. Furthermore, a significant correlation between Achilles tendon thickness and knee OA severity was found. A comprehensive assessment of the Achilles tendon and ankle joint should be a part of the knee OA evaluation process.

Many factors have been reported to be associated with knee osteoarthritis (OA) prevalence and progression, including muscle weakness, proprioception deficits, age, excessive weight, and knee alignment that decreases joint stability (1,2).

Increasing evidence has shown that biomechanical forces often drive the progression of knee OA and that the pathologic response of tissues to such forces leads to further joint deterioration, symptoms, and reduced functioning (3). Studies have found increased muscle activity in subjects with knee OA (4,5). This increase in muscular activity is considered to be the bracing of the muscles around the knee (4,5) in an attempt to increase the stability of the joint and could lead to altered forces around the ankle joint.

It is known that subjects with knee OA demonstrate different gait patterns compared with their matched controls (6–9). This could potentially be damaging to the Achilles tendon because an improper gait is one of the risk factors for developing Achilles tendinopathy (4,10,11). Studies have also shown that the ankle joint movement strategy was more prominent in those with symptomatic knee OA, which might explain the compensatory action to achieve gait patterns similar to those of healthy controls (12).

Few studies have examined the relationship between knee OA and ankle joint parameters (13–16). To the best of our knowledge, no data

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are available regarding the association between knee OA and Achilles tendon pathologic features. The purpose of the present study was to evaluate the association between knee OA and the clinical and functional measures of the ankle joint. The primary objective was to examine the association between knee OA severity and Achilles tendon thickness. We hypothesized that significant differences would be found in Achilles tendon thickness between subjects with knee OA and healthy controls. Furthermore, we hypothesized that a moderate to high correlation would be found between knee OA severity and Achilles tendon thickness.

Patients and Methods

Design

The present study was a cross-sectional prospective study that was approved by the Helsinki Committee of our medical center. Each subject received an explanation about the aim of the study and the methods of data collection. Only after providing written informed consent were the subjects included in the present study.

Participants

Ninety-three participants were evaluated in a single session examination. Of the 93 subjects, 63 had a diagnosis of symptomatic unilateral or bilateral knee OA of ≥3 months duration and had been referred by their doctor or self-referred for medical care at a private medical center. All the subjects had met the inclusion and exclusion criteria for the present study. The inclusion criteria were as follows: age ≥50 years and chronic (≥3 months) unilateral or bilateral knee OA diagnosed using the American College of Rheumatology criteria (17). All subjects underwent weightbearing posteroanterior radiography of the knee using the protocol of Buckland-Wright et al (18), with a finding of Kellgren and Lawrence (19) grade ≥2 (radiographic criterion for the presence of OA). One trained orthopedic surgeon, who was unaware of the clinical status of the patients, independently evaluated the radiographs of the knee. The exclusion criteria were ≥1 of the following: traumatic knee pain, previous trauma or surgery to the Achilles tendon, a history of Achilles tendinitis, tenderness over the Achilles tendon on physical examination, peritendinous injections within the previous 6 months, ulceration or skin pathologies in the area of the knee or Achilles tendon, rheumatoid arthritis or other systemic inflammatory arthritis, avascular necrosis, periarticular fracture, Paget's disease of bone, villonodular synovitis, chronic knee joint infection, osteochondrosis, neuropathic arthropathy, acromegaly, hemochromatosis, Wilson's disease, osteochondromatosis, gout or recurrent pseudogout, osteoporosis, total knee replacement in either knee, flexion contracture >15° in either knee, OA of the ankle or hip greater than moderate (on a scale of none, mild, moderate, and severe) by history and physical examination using the American College of Rheumatology criteria (17), morbid obesity (body mass index [BMI] >45 kg/m^2), hip or spinal disease as the major source of disability, active treatment for cancer, shortness of breath or chest pain at rest, and/or a score of <24 on the Mini-Mental State Examination (20). In addition, none of the subjects had any history of surgical treatment or concurrent clinically active arthritis in any other joints of the lower extremities. Subjects who were unable to walk without a cane or walker were also excluded from the study.

For every second patient, an asymptomatic control subject was included (30 subjects). None of the asymptomatic control subjects had a clinical diagnosis of OA or rheumatoid arthritis, a history of knee trauma or pain, previous trauma or surgery to the Achilles tendon, peritendinous injections within the previous 6 months, or ulceration or skin pathologies in the area of knee or Achilles tendon. The control participants were recruited from the same private medical center. They were caregivers of patients seeking treatment at the clinic.

Outcome Measures

Subject Characteristics

The demographic data (age, gender, occupation, family status, leisure and physical activity), health history, dominant side, and data on the present disease were collected. The patients' height and weight were recorded, and the BMI was calculated. The radiographs of those with knee OA were saved for further evaluation.

Achilles Tendon Evaluation

The assessment of the Achilles tendon's side-to-side thickness using a digital caliper has been described (21). However, the validity and reliability of this method is unknown, and the use of this measurement has been mentioned in only 1 study. Therefore, we conducted a preliminary study to evaluate the validity and reliability of caliper measurement of the Achilles tendon thickness and found that this measurement method is valid and reliable (fat caliper validity, $r = 0.847$, $p = .002$ vs. ultrasound evaluation; fat caliper reliability, intraclass correlation = 0.838, $p < .001$). The Achilles tendon side-to-side thickness was measured by an experienced physiotherapist. It was measured at the level of the upper point of the medial malleolus with the ankle joint at 90°, about 5 cm proximally to its attachment to the calcaneus.

Gastrocnemius Muscle Strength Evaluation

To measure the gastrocnemius muscle strength, we used the manual muscle test (MMT) method. The subject stood on the limb to be tested with knee extended for the gastrocnemius and soleus muscle. The subject was allowed an external support that was no more than 1 or 2 fingers on a wall for balance assistance only. The subjects were asked to raise their heel from the floor consecutively through the full range of plantar flexion. The physical therapist demonstrated the correct heel rise to the patient. The instructions were as follows: "stand on 1 leg, go up on your tiptoes and down. Repeat as much as you can." The grading score was from 3 to 5. Grade 5 was given for the completion of ≥25 heel raises from the floor through the full range of motion of plantar flexion. Grade 4 required completion of 11 to 24 heel raises, with difficulty subsequently in completing the movement. Grade 3 equated to completion of 1 to 10 heel raises. Finally, for grade 2, the patient was unable to complete 1 heel rise, although the heel could just be raised from the floor (22).

Gait Evaluation

All subjects underwent a computerized gait test (Gait Mat System; E.Q., Inc., Chalfont, PA) (23). During the gait test, all subjects walked barefoot at a self-selected speed. The subjects walked 3 m before and after the walkway mat to allow for sufficient acceleration and deceleration time outside the measurement area. Each gait test included 4 walks, and the mean value of the 4 walks was calculated for each parameter. The following gait measurements were recorded and calculated: velocity (cm/s), step length (cm), and single limb support (SLS) phase (percentage of gait cycle).

Pain, Joint Stiffness, Functioning, and Quality of Life Assessment

All participants in the present study were evaluated using the Hebrew version of the Western Ontario and McMaster Osteoarthritis Index (WOMAC) for pain, joint stiffness, and functioning and the 36-item short-form (SF-36) health survey for quality of life (24,25). The WOMAC questionnaire is a disease-specific, purpose-built, high-performance instrument for evaluating pain, joint stiffness, and functioning in patients with OA. It is designed to assess pain (5 questions), stiffness (2 questions), and function (17 questions). Each question contains a visual analog scale ranging from 0 to 10 cm, with 0 cm indicating no pain or limitation in function and 10 cm, the most severe pain or limitation in function (26). The SF-36 health survey is a standardized self-administered survey. The survey score is from 0 and 100, with 0 indicating the worst quality of life and 100, the best quality. The survey is divided into 8 subcategories: physical functioning, role limitation due to physical health, role limitation due to emotional health, energy, emotional well-being, social functioning, pain, and general health. The SF-36 has been found to be a valid generic outcome measure in clinical trials of subjects with OA and rheumatoid arthritis (27).

Statistical Analysis

The data were analyzed using SPSS software, version 21.0 (IBM Corp., Armonk, NY) and the significance level was set at $p \leq .05$. The data are presented as frequencies and percentages for categorical variables and as the mean ± standard deviation for continuous variables. The distributions of the continuous variables in the study were examined using the Kolmogorov-Smirnov nonparametric test. For all analyses, the results of the more symptomatic limb (knee) were evaluated. To demonstrate differences between those with knee OA and the controls for characteristics, gait spatiotemporal parameters, and self-evaluation questionnaires, the independent samples *t* tests and chi-square tests were performed for continuous and categorical variables, respectively. Comparisons between genders were conducted using an independent *t* test for continuous variables. The correlations between measurements for each group separately were calculated using Pearson's correlation.

Results

Study Flow

The present study included 63 subjects (41 [65.1%] females and 22 [34.9%] males) with unilateral or bilateral knee OA (medial tibiofemoral compartment) and 30 asymptomatic controls (9 [30%] females and 21 [70%] males). The mean age was 64.2 ± 8.1 years and 67.9 ± 8.9 years for the patients with knee OA and healthy controls, respectively, and this difference was not statistically significant ($p = .063$). No dropouts occurred because all the data were collected at 1 session. Recruitment was between June 2011 to October 2012. No adverse events occurred during any of the procedures during the research.