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Correlation between Toe Grip Strength and Knee Function in Patients with Knee Osteoarthritis-Protocol for a Cross-Sectional Study

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Research Article

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Abstract

Objective: Although the association between foot posture and altered mechanics of the knee joint in osteoarthritis (OA) has been investigated by several authors, the actual toe kinematics and function in individuals with knee OA has received little attention. Hence, the objective of this study is to determine the association between toe grip strength and knee function in individuals with knee OA.

Patients and Methods: In this cross-sectional study, 145 participants will be recruited using purposive sampling. The toe grip strength will be measured using a pinch dynamometer and the Timed Up and Go test will be used assess knee function. The measurements will be recorded in a single session.

Results: The data will be tabulated and subjected to statistical analysis using the Karl Pearson correlation coefficient.

Conclusion: The findings of this study may assist in modifying treatment approaches to include strengthening of the toe grip musculature in the management of knee OA.

Keywords: Muscle Strength; Osteoarthritis; Pain; Physical Function; Toe Grip

Abbreviations: OA: Osteoarthritis; TGS: Toe Grip Strength; TUG: Timed Up and Go test; VAS: Visual Analogue Scale; WOMAC: Western Ontario and McMaster University.

Introduction

Osteoarthritis (OA) is a degenerative and progressive joint ailment affecting nearly 250 million people worldwide [1]. Besides being the most prevalent form of arthritis, knee OA is associated with the risk of mobility and disability. This can be particularly defined as needing help walking or climbing stairs in people aged 65 years and above. The societal burden, both in terms of personal suffering and use of health resources is expected to increase with the rising prevalence of obesity and ageing of the community [2].

High mechanical stress exerted on the joint surfaces is the one of the important risk factors for the development and progression of knee OA [3-6]. Abnormal loading on the knee joint can also result from an altered relationship between the kinematics of the foot and knee [7,8]. Gross, et al. 2011 stated that the association between pes planus and frequent knee pain is independent of the presence of either varus or valgus knee alignment. They claimed that changes of foot characteristics may lead to knee pathology, however, they did not support the reverse causation that knee OA leads to knee joint malalignment and subsequent pes planus morphology as a compensatory posture. Therefore, abnormal foot

posture or altered foot kinematics may be one of the reasons for degenerative changes in the knee joint cartilage due to abnormal loading on the knee. The foot is now more often considered when the lower limb is being examined.

Toe grip is a complex motion that involves several muscles, similar to hand grip. It is known that the function of the first metatarsal joint, which exerts toe grip strength (TGS), is vital for maintaining postural balance while walking [9]. The TGS decreases by approximately 30% in the 70s compared to 20s, and this may be accompanied by decreased functional performances [10]. For instance, weakness in toe flexor strength in older adults correlates with decreased walking speed and stride length, as well as longer timed up-and-go test time and decreased functional reach [11,12]. Moreover, TGS is also shown to be strongly correlated with the anterior limit of the functional base of support [13]. In addition, reduced TGS is considered to be a risk factor for falls in older adults [14,15]. These findings indicate that TGS can be a determinant factor for mobility in older adults which can further lead to derangements in the proximal joints.

The relationship between foot posture and altered mechanics of the knee joint in individuals with OA has been previously investigated, however the actual toe kinematics and function in individuals with knee OA is not prioritised [6,7,16-20]. Of specific interest is the effect of toe flexor function, which is important for walking [21,22]. Toe flexion during terminal stance is a key component of the windlass mechanism which supports the rigid supination of the foot for push-off required for smooth progression of the body during walking [23]. Yet, the inability of patients with knee OA to maintain contact of the toes with the ground over the stance phase of gait until push-off is a frequent observation in clinical practice and is indicative of a possible association between knee OA and an impaired function of toe flexors during walking. As the mechanics of the forefoot and the hallux are functionally linked to the mechanics of the rearfoot via the midfoot, dysfunction of the hallux may indirectly influence the altered kinematics of the knee joint in individuals with knee OA through its effects on the kinematics of the rearfoot during walking [16-20,24]. Researchers also described the association between impairment in the range of motion of the hallux and alterations in the mechanics of the foot and motion of the lower leg during walking, which may lead to compensatory malalignment of the knee [25,26].

Strength of knee extensor muscles is often applied to attain better functional performance in individuals with knee OA [27]. Also, the association between knee extensor strength and functional performance among people who underwent total knee replacement has been reported [28]. On the other hand, the association of TGS on knee pain and function in persons with knee OA is not well established. Uritani, et al. found that preoperative TGS was associated with postoperative TUG in patients who had undergone total knee replacement. A multi centre cross-sectional study also found a probable association between altered forefoot function and the incidence and progression of knee OA in Japanese women [12]. However, the correlation of these factors are not well determined in the Indian set up, where OA is the second leading cause of disability with a prevalence upto 39 percent [29].

Hence, the objective of the study was to find the correlation between TGS and knee function in patients with knee OA. We hypothesised that patients with knee OA who have poor toe grip strength would demonstrate low scores in outcomes of knee function. If a relationship is established, it may assist clinicians and researchers to modify their treatment approaches to include strengthening of the toe grip musculature that is otherwise ignored in the rehabilitation of individuals with osteoarthritis.

Methods

An observational descriptive cross-sectional study is proposed where eligible subjects will be selected using purposive sampling. Ethical approval is obtained from the Institutional Ethical Committee.

The study will include individuals between 45 to 65 years of age, diagnosed with knee OA according to the scale described by Kellgren and Lawrence (Grade 2- minimal osteoarthritis with definite osteophytes and possible joint space narrowing on radiograph), for a duration of more than three months, able to ambulate without assistive devices/ caretaker, with minimum educational level of 4th grade of elementary education and willing to participate. Individuals with known neuromuscular or musculoskeletal pathologies, undergone total knee replacement, lumbar spine or any lower extremity surgery, diagnosed with any health condition which could influence the function of foot such as diabetes mellitus or any neurological or orthopaedic impairment and those who do not give consent will be excluded from the study.

After screening for inclusion and exclusion criteria, an informed consent will be obtained from the participants and the study procedure will be explained to the subjects after which measurements of the primary outcome measures will be recorded on the same day. An initial examination including demographic data and secondary outcome measures will also be documented.

Primary Outcome Measures

Toe Grip strength: Assessment of the flexor hallucis longus strength or TGS will be done using the pinch gauge

dynamometer [30]. The patient will be seated in a chair with the foot completed rested on the floor. The pinch gauge will be placed under the great toe, with its proximal end directly underneath the distal crease of the metatarsophalengeal joint. The gauge will be stabilised with one hand by the tester. The patient will be then asked to push down as hard as possible for three seconds without raising the heel from the floor. Three trails were recorded with less than five seconds allowed between repetitions, and the average of the three scores will be used for further analysis.

Timed Up and Go Test [TUG]

It is a simple screening test that is a sensitive and specific measure of physical function, particularly dynamic balance and fall risk in the elderly [31,32]. The patients will be asked to wear their regular footwear and will not be allowed to use any walking aid/assistance to perform the test. The patient will first be seated on a chair with armrest. Starting in a seated position, the patient will stand up upon the therapist's command where the stopwatch will be started. The patient will then walk at a normal pace upto three meters which will be marked with a floor marker, turn around, walk back to the chair and sit down. The stopwatch will be stopped as soon as the patient is seated back on the chair. The total time taken from rising to sitting back in the chair will be recorded in seconds. After two practice trails, one final recording will be used for statistical analysis.

Secondary Outcome Measures

Will be used as part of the screening process along with age, BMI and duration of knee OA to assess pain and quality of life related to knee OA.

Visual Analogue Scale (VAS)

The VAS will be used as a unidimensional measure of pain intensity [33]. A single straight horizontal line of fixed length i.e. 100 mm (10cm) will be used. The ends will be defined as the extreme limits of the pain that the patient is currently experiencing orientated from the left (0=no pain) to the right (100=worst pain). The patient will be asked to mark on the point that represents his/her perception of the current pain intensity. Using a ruler, the score will determined by measuring the distance (in mm) on the 10cm line from 0mm to the point marked by the patient. A higher score indicates greater pain intensity.

Western Ontario and McMaster University (WOMAC) OA index: The WOMAC will be used to assess their activities of daily living, functional mobility, gait, general health and quality of life [34]. It is a self-administered questionnaire including a total of 24 items and three sub scales, scored on a five-point ordinal scale and will be taken on paper. A higher score indicates greater symptoms.

Sample Size Calculation: Sample size calculation was done with reference to the study conducted by Uritani, et al. [35] where there was observed a correlation coefficient of 0.23. With a confidence interval of 95% and 80% power, a sample of 145 will be considered.

Statistical Analysis

Statistical package SPSS ver.21.0 will be used to do the analysis. The collected information will be summarised in the form of mean and standard deviation. Correlation between TGS and TUG will be estimated using Karl Pearson correlation coefficient and scatter plot diagram. Spearman's correlation will be used if data does not follow normal distribution. All probability (p) values less than 0.01 was considered statistically significant.

Discussion

This cross-sectional study is designed to determine the relationship between TGS and knee function in patients with knee OA. A frequent observation in clinical practice in patients with knee OA is the inability to maintain contact of the toes with the ground over the stance phase of gait until push-off. This indicative of a possible association between knee OA and an impaired function of toe flexors [16,24]. Previous studies also observed decreased pressure under the toes during gait, described as "gait with a floating toe" which generates larger vertical acceleration of the knee compared to gait with normal foot kinematics [36].

Saito, et al. reported that partial foot pressure under the hallux was significantly lower in patients with knee OA than in healthy young and older adults during walking, with a shorter overall path of the center of pressure in the OA group than the healthy control group [37]. Arnold, et al. further reported a decreased range in sagittal plane motion at the hallux in patients with knee OA compared to a healthy control group [38]. Based on these reports, an association is inferred between toe function and knee OA.

An apparent difference in the feet and gaits of patients with hip OA and medial compartment OA of the knee that was noted during routine clinical assessment by Reilly, et al. Differences in foot type between patients with OA of hip and knee were confirmed [19]. Mickle, et al. found that reduced toe flexor strength and the presence of toe deformities increased the risk of falling. They suggested that in order to reduce this risk, interventions designed to increase strength of the toe flexor muscles combined with treatment of toe deformities would be beneficial [15].

Although the results of Uritani, et al. [14] could not explain a causal relationship between TGS and knee OA, they suggested that a reduced TGS may influence dynamic balance and force generation for propulsion, and thus increase the mechanical stress on the knee [10]. The relationship between falls in middle-aged individuals and physical strength factors such as TGS and knee extension strength was studied by Tsuyuguchi, et al. [39] and it was found that TGS is an independent risk factor for falls, and improvement of toe grip strength might prevent falls.

Conclusion

This cross-sectional study aims to determine the relationship between knee function and TGS in patients with knee OA which may assist clinicians and researchers to modify their treatment approaches to include strengthening of the toe grip musculature and also help facilitate the design of therapeutic exercises to reduce pain, improve mobility and preserve function.

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