The relationship between isokinetic strength and functional performance tests in patients with knee osteoarthritis

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Abstract. [Purpose] The main purpose of the study was to examine the relationship of a battery of frequently used functional assessment tests with quadriceps and hamstrings isokinetic strength in Knee-osteoarthritis (OA) patients. Secondly, the predictability of isokinetic strength on these performance variables was also assessed. [Subjects and Methods] Seventeen males and 23 females with Knee-OA, were assessed via a) the common functional tests: 6-minute walk test, Timed up-and-go test, 30-second chair test and 12-stair test and b) isokinetic concentric extension-flexion at 120°/s and 180°/s. [Results] Both Knee Extension and Flexion Peak Torque per Body weight showed moderate to strong, statistically significant correlation, with all 4-functional performance tests, for both velocities. Both 12-stair test and 30-second chair test were significant predictors in all analyses, while the 6-minute walk test was an additional significant predictor of the 120°/s knee flexion. [Conclusion] Thigh muscle strength in both tested velocities proved to be significantly correlated with functional performance. The 12-stair test and 30-second chair test results were significant predictors for isokinetic extension and flexion in both velocities. It appears that those two tests challenge the knee and the surrounding musculature in a manner that reflects muscle strength.

Key words: Knee osteoarthritis, Isokinetic strength prediction, Functional tests

INTRODUCTION

Knee-osteoarthritis (OA) is a degenerative articular cartilage disease, combined with variable and gradually advancing thigh muscle weakness leading to functional impairments. The population worldwide, is ageing and age-related osteoarthritis is the leading cause of disability, radiographically evident in one out of four individuals between 56–84 years old. Also, the annual total healthcare expenditures and earning losses related to osteoarthritis are very high. This evolving disease imposes functional deficits, thus, functional testing is very crucial for these patients in order to assess the developing disability. A combination of tests is necessary for a clinician in order to have a complete picture of the associated functional limitations. No single test is efficient enough to reveal the functional limitations, which are multifactorial by nature. It is agreed that a battery of tests should be used in order to challenge different metabolic pathways and also, cover multiple aspects of functional performance like power, endurance, balance and agility. Widespread tests include the 6 minutes’ walk test (6MWT), the timed up and go test (TUG), the 30 seconds chair test (30SCT) and the 12 stair test (12ST). Such tests,
supplemented by isokinetic testing comprise a holistic approach to patients’ assessment. From this 2-stage (single-joint and whole-body assessment) holistic assessment, the isokinetic part is the most costly and requires access to properly equipped clinical settings. The aim of the current study is to establish a connection between performance in the aforementioned functional tests and hamstrings and quadriceps isokinetic strength. Hence, in cases when isokinetic dynamometry is not feasible, the Physical Therapist could prescribe Quadriceps/Hamstrings exercise, if this is indicated by the functional performance. The main purpose of the current study was to examine the relationship of a battery of frequently used functional assessment tests with quadriceps and hamstrings isokinetic strength in Knee-osteoarthritis (OA) patients. The secondary purpose was to assess the predictability of isokinetic strength on these performance variables. Identifying the degree of predictability among variables would increase clinicians’ awareness of how much the thigh muscle strength affects functional performance. This would assist them by giving the proper attention on specific strengthening in case they have no access on isokinetic dynamometry.

SUBJECTS AND METHODS

A total of 40 consecutive patients (17 Male, 23 Female) with Knee-OA volunteered for the study. The main inclusion criterion was a radiographic diagnosis of knee osteoarthitis classified as 2nd and 3rd grade according to the Kellgren-Lawrence disease severity scale. Exclusion criteria comprised of any operation to the affected knee and severity outside the above radiographic limit. In case of any other joint involvement in OA surgical treatment (i.e. hip), either ipsilateral or contralateral, it should be ≤3 grade Kellgren-Lawrence scale or it should have been operated at least 1 year before participation in this study. Our inclusion-exclusion criteria were selected on the basis of targeting a group of patients, in a crucial stage that the disease is evident, but it does not compromise functionality to the degree of a severe impairment. Participation of patients with these characteristics in a functional program, could be beneficial and feasible, potentially minimizing complications and drop-outs and maximizing functional adaptations of a specific exercise program. All volunteers who participated in the study were initially briefed on the experimental procedure and signed a consent form. The experimental design of this study was approved by the Ethics Committee of the Technological Educational Institute of Western Greece (School of Health Sciences 4053/13-03-2017). Prior to testing, patients signed the consent form and completed a medical history report. Subsequently, the functional testing was performed in the following order: the 6MWT, the TUG, the 30SCT and the 12ST. There was a 10-minute rest between 6MWT and the next functional test (TUG), to ensure adequate recovery. The rest of the tests were separated by 3-minute intervals. The 6MWT measures the total distances walked in meters over 6 minutes (6). It was performed on a 4-meter wide corridor, where patients walked between 2 cones, 30 meters apart. The TUG measures the time needed to rise from an arm chair with standard seat height (46 cm), walk 3 meters, turn, and return to the initial sitting position (7). The 30SCT counts the total number of complete chair stands for 30 seconds (8). The 12 Stair test (12ST) measures the time to ascend and descend a flight of 12 stairs (18 cm step height). For the TUG, 30SCT and 12ST tests, the best of two trials was kept for analysis, while the 6MWT was performed only once. Finally, isokinetic-concentric strength testing took place for knee extensors and flexors (5 repetitions each), at the angular velocities of 120°/sec and 180°/sec on a Biodex System III (Biodex, Shirley, NY, USA). We chose not to use an even lower velocity (i.e. the commonly used 60°/s) since it has been shown that slower isokinetic angular velocities mechanically overload the knee (9, 10), irritating the joint and exacerbating symptoms. Faster speeds, unload the joint and according to Bernoulli’s theorem (11) the faster the speed of moving solid (cartilage in our case) into liquid (synovial fluid), the lesser the friction. The resulting pain from such a test, would potentially exacerbate symptoms and subsequently prevent participants from completing the test and maybe force them out of the study. The Peak Torque adjusted for body weight (Nm/kg), was the variable used for the analysis.

The association between variables was calculated using Pearson-r correlation coefficients and the predictability of the functional variables for strength was tested using stepwise regression analysis. The SPSS (Version 24.0, IBM Corporation, NY, USA) was used for analysis and the level of significance was set to p=0.05. Pearson-r categorization was made according to Cohen (12) (r=0.10 small, r=0.30 medium and r=0.50 large).

RESULTS

The anthropometric traits and the descriptive statistics for each measured parameter (Mean ± SD) for the 40 participants are presented in Table 1. Both Knee Extension PT/BW and Knee Flexion PT/BW at 120°/s, showed large, significant correlations with the 4-functional performance tests (6MWT, TUG, 30SCT, 12ST). Similar correlations, however, slightly lower were shown for 180°/s (Table 2).

Stepwise regression analysis was applied 4 times for the depended variables EXT 120°/s, EXT 180°/s, FLEX 120°/s and FLEX180°/s. The results in 6MWT, TUG, 30SCT and 12ST served as predictors for each model. The 12ST and SCT30 were significant predictors for all isokinetic variables, while for the FLEX 120°/s variable, the 6MWT was also included in the model (Table 3).
DISCUSSION

Large and statistically significant correlations were found between isokinetic strength of quadriceps and hamstrings (represented by the extensor and flexor PT/BW) and performance in all four functional tests (6MWT, TUG, 30SCT, 12ST), in a group of patients with Knee-OA. The slower angular velocity (120°/s) quadriceps strength showed higher correlation than the faster angular velocity (180°/s), in all of the 4-functional tests, included in this study. Regarding hamstrings isokinetic strength (represented by the flexor PT/BW) both angular velocities significantly correlated to all four functional tests (6MWT, TUG, 30SCT, 12ST).

Table 1. The anthropometric traits and the descriptive statistics for each measured parameter for the 40 Knee-OA patients who participated in the study

| Parameter     | Mean ± SD | Parameter     | Mean ± SD |
|---------------|-----------|---------------|-----------|
| Age (years)   | 61.7 ± 7.2 | FLEX 120°/s (Nm/kg) | 0.51 ± 0.17 |
| Weight (kg)   | 85.7 ± 13.5| FLEX 180°/s (Nm/kg) | 0.47 ± 0.16 |
| BMI (kg/m²)   | 31.8 ± 5.6 | 6MWT (m)      | 518.8 ± 73.6 |
| Fat (%)       | 37.7 ± 10.7| TUG (sec)     | 6.19 ± 0.73 |
| Muscle (%)    | 27.3 ± 5.0 | 30SCT (rep)   | 13.5 ± 1.3  |
| EXT 120°/s (Nm/kg) | 0.89 ± 0.28 | 12ST (sec)    | 12.19 ± 3.23 |
| EXT 180°/s (Nm/kg) | 0.78 ± 0.24 |

EXT 120°/s: Knee Extension Peak Torque at 120°/s angular velocity; EXT 180°/s: Knee Extension Peak Torque at 180°/s angular velocity; FLEX120°/s: Knee Flexion Peak Torque at 120°/s angular velocity; FLEX 180°/s: Knee Flexion Peak Torque at 180°/s angular velocity; 6MWT: Six Minute Walk Test; TUG: Timed up and Go Test; 30SCT: 30 Second chair test; 12ST: 12 Stair test.

Table 2. Correlation between knee extension, knee flexion peak torque and the four functional tests, for the two angular velocities for the 40 Knee-OA patients who participated in the study

| Parameter | 6MWT (518.8 ± 73.6 m) | TUG (6.19 ± 0.73 sec) | 30SCT (13.5 ± 1.3 rep) | 12ST (12.19 ± 3.23 sec) |
|-----------|-----------------------|-----------------------|------------------------|-------------------------|
| Pearson r | p value               | Pearson r             | p value                | Pearson r               | p value                |
| EXT 120°/s (0.89 ± 0.28 Nm/kg) | 0.644 0.000* | -0.625 0.000* | 0.534 0.000* | -0.662 0.000* |
| EXT 180°/s (0.78 ± 0.24 Nm/kg) | 0.618 0.000* | -0.597 0.000* | 0.509 0.000* | -0.624 0.000* |
| FLEX 120°/s (0.51 ± 0.17 Nm/kg) | 0.666 0.000* | -0.561 0.000* | 0.557 0.000* | -0.644 0.000* |
| FLEX 180°/s (0.47 ± 0.16 Nm/kg) | 0.643 0.000* | -0.530 0.000* | 0.556 0.000* | -0.671 0.000* |

EXT 120°/s: Knee Extension Peak Torque at 120°/s angular velocity; EXT 180°/s: Knee Extension Peak Torque at 180°/s angular velocity; FLEX120°/s: Knee Flexion Peak Torque at 120°/s angular velocity; FLEX 180°/s: Knee Flexion Peak Torque at 180°/s angular velocity; 6MWT: Six Minute Walk Test; TUG: Timed up and Go Test; 30SCT: 30 Second chair test; 12ST: 12 Stair test. *p<0.001.

Table 3. Stepwise regression analysis results for the depended variables (EXT 120°/s, EXT 180°/s, FLEX 120°/s and FLEX 180°/s) for the 40 Knee-OA patients who participated in the study

| Depended variable | Predictors | R² value | Model predictive equation | F value | p value |
|-------------------|------------|----------|----------------------------|---------|---------|
| EXT 120°/s        | 12ST       | 0.555    | EXT 120°/s=0.458–0.47 (12ST)+0.074 (30SCT) | 23.081  | 0.000*  |
|                   | 30SCT      |          |                            |         |         |
| EXT 180°/s        | 12ST       | 0.497    | EXT180°/s=0.406–0.039 (12ST)+0.063 (30SCT) | 18.295  | 0.000*  |
|                   | 30SCT      |          |                            |         |         |
|                   | 12ST       |          |                            |         |         |
| FLEX 120°/s       | 30SCT      | 0.607    | FLEX 120°/s=-0.232+0.001 (6MWT)+0.042 (30SCT)–0.018 (12ST) | 18.506  | 0.000*  |
|                   | 6MWT       |          |                            |         |         |
|                   | 12ST       |          |                            |         |         |
|                   | 30SCT      |          |                            |         |         |
| FLEX 180°/s       | 12ST       | 0.581    | FLEX 180°/s=−0.193–0.027 (12ST)+0.045 (30SCT) | 25.673  | 0.000*  |
|                   | 30SCT      |          |                            |         |         |

EXT 120°/s: Knee Extension Peak Torque at 120°/s angular velocity; EXT 180°/s: Knee Extension Peak Torque at 180°/s angular velocity; FLEX120°/s: Knee Flexion Peak Torque at 120°/s angular velocity; FLEX 180°/s: Knee Flexion Peak Torque at 180°/s angular velocity; 6MWT: Six Minute Walk Test; 30SCT: 30 Second chair test; 12ST: 12 Stair test. *p<0.001.
TUG, 30SCT, 12ST), in a similar fashion with quadriceps. This result was surprising, since the hamstrings showed as being weaker than the quadriceps, exposing the knee joint to less compression, thus more discomfort, in a manner that makes no difference between 120°/s and 180°/s. Although quadriceps strength is established as a factor interrelated with knee clinical and functional status,13,14 hamstrings have not been identified as important performance predictors for the Knee-OA. Maybe, more attention should be given to this muscle group. Strength testing was connected to functional performance in Knee-OA patients with severity of 2–3 according to Kellgren-Lawrence scale. Sanchez-Ramirez et al.15 found that increased isokinetic muscle torque (mainly in knee flexors) was associated with decreased activity limitations in Knee-OA patients at 2 years. The most notable finding was that both the 12ST and the 30SCT performance proved to be significant predictors of quadriceps and hamstrings isokinetic strength, regardless angular velocity. Those two tests, were potentially more mechanically demanding for the joint and appeared to expose its functionally weaknesses more than the low-load tests. This finding suggests that in case of limited access to isokinetic dynamometry, Knee-OA patients who perform poorly in the 12ST and/or the 30SCT could be advised towards strengthening of their quadriceps and hamstrings. Probably the TUG was not as hard as those repetitive weight-bearing tests, but rather agility oriented, thus naturally failing to predict maximal strength. Regarding the 6-minute walk test, this might be too mild in terms of mechanical loading to reflect maximal thigh muscle strength. It is an aerobic test, performed on level ground with minimal stress to the joint. Because the participants of the subject were not incapacitated by the disease, their performance in this test, probably was not affected by its physiological and biomechanical loading. However, it was included within the significant predictors of the FLEX120°/s. Overall the ability of those tests to explain each strength variance in knee-OA patients ranged from 49.7% to 60.7%, with the respective equations being available for strength estimations.

In conclusion, thigh muscle strength in both tested velocities proved to be significantly correlated with functional performance. The 12-stair test and 30-second chair test results were significant predictors for isokinetic extension and flexion in both velocities. It appears that those two tests challenge the knee and the surrounding musculature in a manner that reflects muscle strength.

Conflict of interest

Panagiotis Gkrilias received a scholarship for his Ph.D. studies from General Secretariat for Research and Technology (GSRT) and Hellenic Foundation for Research and Innovation (HFRI). For the remaining authors none were declared. All authors have declared that no competing interests exist.

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