J. Phys. Ther. Sci. 30: 888–891, 2018

The Journal of Physical Therapy Science

Original Article

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

Panagiotis Gkrilias, PT, MSc, PhD Candidate[1, 2)*], Elias Tsepis, PT, MSc, PhD[2)], Zinon Kokkalis, MD, PhD[1)], Elias Panagiotopoulos, MD, PhD[1, 3)], Panagiotis Megas, MD, PhD[1)]

[1)] *Department of Orthopaedics, School of Medicine, University of Patras: Rio Patras 26504, Greece*
[2)] *Department of Physical Therapy, School of Health and Welfare, Technological Educational Institute (TEI) of Western Greece, Greece*
[3)] *Rehabilitation Clinic, Department of Medicine, University of Patras, Greece*

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. Secondarily, 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

(This article was submitted Feb. 4, 2018, and was accepted Mar. 28, 2018)

INTRODUCTION

Knee-osteoarthritis (OA) is a degenerative articular cartilage disease, combined with variable and gradually advancing thigh muscle weakness[1)] leading to functional impairments. The population worldwide, is ageing and age-related osteoarthritis is the leading cause of disability[2)], radiographically evident in one out of four individuals between 56–84 years old[3)]. Also, the annual total healthcare expenditures and earning losses related to osteoarthritis are very high[4)]. This evolving disease imposes functional deficits, thus, functional testing is very crucial for these patients in order to assess the developing disability[5)]. 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)[5)]. Such tests,

*Corresponding author. Panagiotis Gkrilias (E-mail: gkriliasphysio@gmail.com)

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 osteoarthritis 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).

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/m^2)	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 Torgue at 120°/s angular velocity; EXT 180°/s: Knee Extension Peak Torgue at 180°/s angular velocity; FLEX120°/s: Knee Flexion Peak Torgue at 120°/s angular velocity; FLEX 180°/s: Knee Flexion Peak Torgue 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	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 Torgue at 120°/s angular velocity; EXT 180°/s: Knee Extension Peak Torgue at 180°/s angular velocity; FLEX120°/s: Knee Flexion Peak Torgue at 120°/s angular velocity; FLEX 180°/s: Knee Flexion Peak Torgue 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 FLEX180°/s) for the 40 Knee-OA patients who participated in the study

Depended variable	Predictors	R^2 value	Model predictive equation	F value	p value
EXT 120°/s	12ST 30SCT	0.555	EXT 120°/s=0.458–0.47 (12ST)+0.074 (30SCT)	23.081	0.000*
EXT 180°/s	12ST 30SCT	0.497	EXT180°/s=0.406–0.039 (12ST)+0.063 (30SCT)	18.295	0.000*
FLEX 120°/s	12ST 30SCT 6MWT	0.607	FLEX 120°/s=−0.232+0.001 (6MWT)+0.042 (30SCT)–0.018 (12ST)	18.506	0.000*
FLEX 180°/s	12ST 30SCT	0.581	FLEX 180°/s=0.193–0.027 (12ST)+0.045 (30SCT)	25.673	0.000*

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

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), 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 torgue (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.

REFERENCES

1) Emrani A, Bagheri H, Hadian MR, et al.: Isokinetic strength and functional status in knee osteoarthritis. J Phys Ther Sci, 2006, 18: 107–114. [CrossRef]
2) Lespasio MJ, Piuzzi NS, Husni ME, et al.: Knee osteoarthritis: a primer. Perm J, 2017, 21: 16–183. [Medline]
3) Turkiewicz A, Gerhardsson de Verdier M, Engström G, et al.: Prevalence of knee pain and knee OA in southern Sweden and the proportion that seeks medical care. Rheumatology (Oxford), 2015, 54: 827–835. [Medline] [CrossRef]
4) Yelin E, Murphy L, Cisternas MG, et al.: Medical care expenditures and earnings losses among persons with arthritis and other rheumatic conditions in 2003, and comparisons with 1997. Arthritis Rheum, 2007, 56: 1397–1407. [Medline] [CrossRef]
5) Dobson F, Hinman RS, Roos EM, et al.: OARSI recommended performance-based tests to assess physical function in people diagnosed with hip or knee osteoarthritis. Osteoarthritis Cartilage, 2013, 21: 1042–1052. [Medline] [CrossRef]
6) Enright PL: The six-minute walk test. Respir Care, 2003, 48: 783–785. [Medline]
7) Podsiadlo D, Richardson S: The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc, 1991, 39: 142–148. [Medline] [CrossRef]
8) Jones CJ, Rikli RE, Beam WC: A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport, 1999, 70: 113–119. [Medline] [CrossRef]
9) Kaufman KR, An KN, Litchy WJ, et al.: Dynamic joint forces during knee isokinetic exercise. Am J Sports Med, 1991, 19: 305–316. [Medline] [CrossRef]
10) Perrin DH: Open chain isokinetic assessment and exercise of the knee. J Sport Rehabil, 1994, 3: 245–254. [CrossRef]
11) Encyclopedia Britannica: Bernoulli's theorem. https://www.britannica.com/science/Bernoullis-theorem (Accessed Feb. 1, 2018)
12) Cohen J: The significance of a product moment rs. In: Statistical power analysis for the behavioral sciences, 2nd ed. Hillsdale: Lawrence Erlbaum, 1988, pp 75–107.
13) McAlindon TE, Cooper C, Kirwan JR, et al.: Determinants of disability in osteoarthritis of the knee. Ann Rheum Dis, 1993, 52: 258–262. [Medline] [CrossRef]
14) Edelaar LM, van Dieën JH, van der Esch M, et al.: Nonlinear relationship between isokinetic muscle strength and activity limitations in patients with knee osteoarthritis: results of the Amsterdam-Osteoarthritis cohort. J Rehabil Med, 2017, 49: 598–605. [Medline] [CrossRef]
15) Sanchez-Ramirez DC, van der Leeden M, van der Esch M, et al.: Increased knee muscle strength is associated with decreased activity limitations in established knee osteoarthritis: two-year follow-up study in the Amsterdam osteoarthritis cohort. J Rehabil Med, 2015, 47: 647–654. [Medline] [CrossRef]