Quadriceps muscle strength in patients with knee osteoarthritis

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Abstract

Osteoarthritis is degenerative disease mainly affects weight bearing joints. Usually patients with knee osteoarthritis have pain, stiffness and functional limitation. This functional limitation might be caused by muscle weakness specially in quadriceps muscle. The hand held dynamometer is widely used in the clinical setting as a valid and reliable outcome measure, which used in this study to measure quadriceps muscle strength during supported and unsupported sitting. It can be concluded that subjects produce greater force in supported sitting than in unsupported sitting.

Key words: osteoarthritis, quadriceps strength, hand held dynamometer

INTRODUCTION

Osteoarthritis (OA) is defined as an inflammatory disease affecting the synovial joints, specially the weight bearing joints such as hip and knee joints. There are several reasons that may cause this disease such as; age, trauma, fracture, genetics, or metabolic disorders (1). The radiographic presentation of osteoarthritis is narrowing of the joint space with growing osteophytes (2). The main signs and symptoms are pain, stiffness, joint enlargement and functional impairment or limitation which eventually lead to disability (3). The quadriceps and hamstring muscles play an important role in knee joint stability, and the performance of daily life activities such as walking, sit to stand, and climbing stairs (4). Quadriceps muscle weakness is very common in patients with knee osteoarthritis as a result of pain or the fear of pain (5). However, such weakness might be observed in patients with radiographic osteoarthritis without complaining from knee pain, therefore, this muscle weakness could be resultant from muscle dysfunction rather than secondary to joint pain (6). Although there are several studies have searched for an association between the knee osteoarthritis and muscle weakness, this relationship is still not fully understood (7,3).

Andrews et al (8) carried out a study to obtain normative value for isometric muscle force of asymptomatic subjects aged between 50 to 79 years, by using hand-held dynamometer. The subjects were tested for knee extension measures while sitting upright with assistance supporting their shoulders. In this case the support might not be equalized for all subjects as it depends on the subject's strength. The authors presented reference value for 13 muscle actions and their presentation was based on; age by decade, gender, and dominance. Although they managed to obtain normative values for certain muscle action, these values can not be used as reference values for other studies that use different testing procedures. Also Bohnnon (9) used a descriptive study to provide reference values for ten muscle actions using hand-held dynamometer with an upper limit (650 N). A healthy population was used (20- 70 years), and normative values for all the muscle actions were obtained except for the knee extension as the force that some subjects could produce was more than the upper limit of the hand-held dynamometer, so it was recorded as 650 N, Bohannon et al (9) used similar testing position as Andrews et al (8) used. These findings can be accepted as the researchers used a large sample size (231 subjects), and all subjects tested in gravity-naturalized position to avoid the gravity effect on the results. Fransen et al (10) compared their data of the mean isometric muscle strength for knee osteoarthritis patients using loading cell while patients were sitting on a chair with back and thigh supported and knee flexed to 90^0, with published normative data for asymptomatic subjects. O'Reilly et al (5) conducted a nested case-control design to identify the relationship of Quadriceps strength and its activation with disability, and the psychological issue in patient with knee osteoarthritis. A modified Tornvall chair was used to measure quadriceps strength in which subjects were seated with their hip and knee flexed to 90^0 and a strap placed over the right medial malleolus attached by an inextensible chain to a strain gauge. The subjects in this study performed three trials, and the highest of them was selected as the maximum voluntary contraction (isometric). The authors found that patients with knee pain have significantly less quadriceps strength than those without knee pain. Slemenda et al (11) measured the eccentric and concentric mode of the quadriceps using isokinetic dynamometer to identify the relationship between the quadriceps weakness and knee osteoarthritis. The authors found that this weakness may results from the muscle disuse more than the pain or the disease itself.

It appears that many different testing positions are used which make comparison between studies difficult. Some used isokinetic dynamometer which provide back support as well as thigh support, or hand held dynamometer with back support or shoulder supported by assistance to measure quadriceps strength. The aim of this study was to investigate differences in measurement of quadriceps muscle strength in two different positions (with and without back support).

Methods:

1-Outcome measure:

The hand held dynamometer (HHD) is being used in this study to measure the quadriceps muscle strength in healthy people. This instrument showed good reliability and validity. Bohannon and Andrews (12) studied the inter-rater reliability of the hand held dynamometer, by measuring the strength of six muscle groups (upper and lower extremity) in a gravity eliminated position. The authors found that hand held dynamometer has a good to high inter-rater reliability, the correlation coefficient ranged from 0.84 to 0.94. Their findings can be accepted as they used a relatively large sample size (30 subjects) who had different diagnosis; the majority of them had neurological diseases, while the others had different musculoskeletal disorders which means there finding can be generalized to a wide population (13).

Riddle et al, (14) studied the reliability of hand held dynamometer (inter-session and intra-session) in a brain damaged population. The authors performed 10 isometric tests in both paretic and non-paretic limbs. They found that HHD had high intra-session reliability in both limbs, the obtained intraclass correlation coefficient (ICC) ranged from .90 to .98. Whereas, the inter-session reliability of the paretic limb was slightly higher than the non-paretic one in this population (ICC ranged .87-.99, .31- .93) respectively.

The construct validity was obtained by comparing the hand held dynamometer with the manual muscle strength test (as a gold standard) to measure knee extensor muscle strength (15, 16).

2-Subjects

A convenient sample of 5 healthy subjects participated in study. The participants had no history of lower extremity OA, fracture, muscle atrophy, hip dislocation or back pain. Verbal informed consent was obtained from the participants before the session started.

Due to the nature of the study all tests were conducted by the same therapist in a single session. Three trials were carried out on the participants' dominant leg based on questioning the subjects, and they were asked to perform their maximum effort to extend their knees, and each test lasts for 5 seconds with 1 minute rest in between (16,10). Verbal encouragement was used "after counting from 1 to 3 push as hard as possibly you can". The repetition was used in order to get the best representation of the muscle strength (11). In order to standardize the testing procedure the participants sat upright on a padded table (the first position) as the one used by Bohannon (16), and on a chair with back support (the second position) which was similar to the position was used by Bohannon (15). The tests were conducted in a natural gravity position (i.e. knee drawn passively into 90^0 flexion) (8,9), hands relaxed on the participant's thigh in the two positions and the loading cell was placed at 17 cm distal to the knee joint. To ensure that the subjects were comfortable a sponge was placed between the loading cell and their leg.

All data were collected and recorded manually on a separate sheet, then downloaded into a computer. An Excel software was used to perform descriptive data analysis (means and standard deviations) and presented as tables.

Results:

Descriptive data of mean value and standard deviation were calculated and were illustrated as below:

Table1: Demographic data.

Subjects number	Age(yrs) mean/SD	Gender M:F	Dominance lower limb R: L	Height(m) mean/SD	Weight(kg) mean/SD
5	31.6/ ± 7.6	1:4	5:0	1.56/ ± 0.05	74.8/ ± 14.8

Key: Yrs = years M = male, F = Female, SD = Standard deviation, L = left, R = right, m = meter, kg = kilogram

As shown in table 1 4 females and one male participated in the study, all subjects have relatively the same height as the standard deviation very small (0.05). Whereas, their age and weight vary greatly as the mean value and standard deviation 31.6/±7.6 years and 74.8/ ± 14.8 kg respectively.

Table 2: Quadriceps muscle strength without support

Subjects	**Trial 1/N**	**Trial 2/N**	**Trial 3/N**	**Mean value**	**SD**
1	52.8	50.6	57.2	53.53	± 3.4
2	90.2	81.4	112	94.53	± 15.8
3	68.2	88	85.8	80.67	± 10.9
4	94.6	96.8	88	84.13	± 4.6
5	77	74.8	77	76.27	± 1.3

Key: N = Newton, SD = standard deviation

Table 2 shows that great variation in muscle strength while sitting without back support in two subjects (# 2 and #3) as the mean value and standard deviation 94.53±15.8 and

80.67±10.9 respectively. While subject #5 shows the lowest variation with 1.3 standard deviation.

Table 3: Quadriceps muscle strength with back support

Subjects	**Trial 1/N**	**Trial 2/N**	**Trial 3/N**	**Mean value**	**SD**
1	59.4	68.2	90.2	72.6	± 15.9
2	99	101	107	102.33	± 4.2
3	85.8	96.8	83.6	88.73	± 7.1
4	94.6	103	74.8	90.8	± 14.5
5	107	112	103	107.33	± 4.5

Key: N = Newton, SD = standard deviation

Table 3 presents the quadriceps muscle strength while sitting with back, a great variation seen in subjects #1 and #4 with standard deviation 15.9 and 14.5 respectively. Subject #2 and #5 showed very close mean and standard deviation of 102.33±4.2 and 107.33±4.5 respectively.

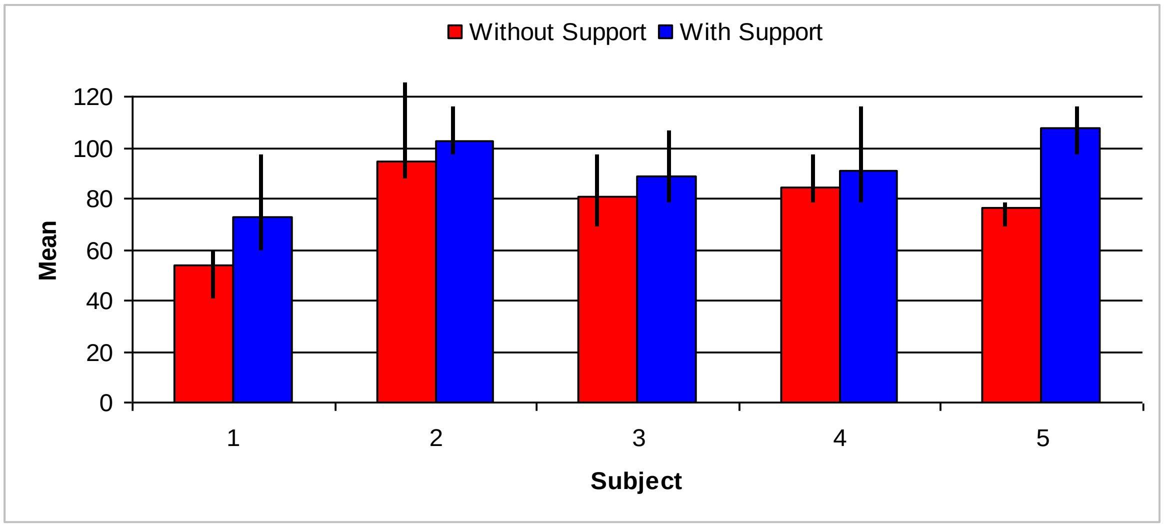
Table 4: comparison between mean and standard deviation of the strength without support and with support

Partcipant	Muscle strength without support	SD	Muscle strength with support	SD
1	53.53	± 3.4	72.6	± 15.9
2	94.53	± 15.8	102.33	± 4.2
3	80.67	± 10.9	88.73	± 7.1
4	84.13	± 4.6	90.8	± 14.5
5	76.27	± 1.3	107.33	± 4.5
Mean	77.83		92.36	
SD	± 15.2		± 13.5	

Key: SD = standard deviation, yrs = years

Figure1.

The mean and standard deviation between the two testing positions with the standard deviation for each participant.



As seen in table 4 and Figure (1) the subjects generates the highest muscle strength when tested using back support. The subjects #2 and #3 showed great standard deviation while tested without back support and smaller variation in the with back support testing condition. This was the completely opposite in subjects #1 and #4 as they showed the greatest variation during testing with back support and smaller one without support. Subject #5 showed small variation both conditions.

Discussion:

Although the background of this study based on patients with knee osteoarthritis, the population was asymptomatic healthy subjects aged from 20-40. All the subjects had relatively similar height which helped to standardize the loading cell position, but there was a difference in their weight and strength. During the testing it was clear that the younger subjects had stronger quadriceps than the older one (Table 4).

The results obtained from this study showed a difference between the strength values obtained from one subject as in subject 2 and 3 in the without support position (Table 2) and subject 1 and 4 in the with back support position (Table 3). Also, the between group difference was higher, showing higher means in the with support values than that without support, which could be explained by providing the back support allow the subjects to produce greater force. By comparing these mean values with the matching peers in the normative values obtained by Bohannon (8) in which the subject's back was supported by either the backrest or assistance support, the subjects in the current study had reduced quadriceps strength. By looking into the mean values in figure (1) it can be clearly seen that quadriceps strength was higher when subjects tested with their back supported than when they were seated on a padded table without any external support. Bohannon (16) obtained the convergent construct validity of the HHD by testing the subjects while sitting on a padded table but with hand supported, in order to give the maximum muscle contraction. Although several researchers gave full information about the testing position and the type of support that they used, some others did not give any details about the support that they used in their studies like Riddle et al (14). As they reported that subjects were seated on a mat table only, without giving any information about whether the subjects had used their hands to support or assistance supported them.

It was clearly observed that the subjects stronger than the tester itself which may influence the results (6). However, if the tester was strong enough to hold steady against high forces, this might inhibit the subjects to perform their maximum contraction, which also affect the findings (10). In this study the seat was placed away from the wall, which might not give constant support as the chair might slide over the floor.

In clinical setting, it is important to train patients in supported position to maximize their strength. Consequently, improve the functional daily activities and reduce the complications of OA. For future studies, it is highly recommended to compare the quadriceps muscle strength in matched healthy and knee OA groups in addition to investigating the functional limitation of active daily living and quality of life.

In conclusion, quadriceps muscle weakness is very common in patients with knee OA, this weakness could be due to muscle disuse rather than secondary to pain or joint stiffness.

Although it is very difficult to draw a proper conclusion from this study as the sample size was very small, and using healthy subjects instead of patients with knee OA. The subjects may produce greater quadriceps muscle power when they get proper support.

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