Quadriceps Strength of Patients of Osteoarthritis Knee: Relationships to Pain and Disability

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Abstract

The study was conducted on two hundred patients ranging in age from 40 to 70 years with established osteoarthritis knee to examine the association of quadriceps strength with pain and disability of knee osteoarthritis. In addition the relationships between various components of health related fitness, pain, effusion and disability were also examined in the present study. Quadriceps strength seems to be an independent contributor to the severity of osteoarthritis knee; the findings illustrate the need of improving the muscle function in these patients. No association between knee pain and disability indicates that functional limitations in patients with osteoarthritis should be explored separately from the evaluation of symptoms.

Key Words: **Isotonic, Isometric, Lean Body Mass, % Fat**

Introduction:

Osteoarthritis has the distinction of being the oldest and most prevalent chronic joint disease known to humanity. Worldwide it touches the lives close to one billion people *(Gordon, 1993).* This is particularly apparent at the knee joint, one of the commonest sites to be affected. Despite major efforts in the past, little is known about the risk factors associated with pain and disability of osteoarthritis knee compared to other diseases with major public health impact. Recent attention has focused on Quadriceps mechanism. Quadriceps strengthening exercises are widely recommended for osteoarthritis knee based on longitudinal studies showing decreased muscle strength in patients of osteoarthritis knee in comparison to their healthy counterparts. *(Tan et al., 1995; and Wessel, 1996).* Studies of elderly, generally healthy subjects, have reported relationships between muscle strength and functional status *(Hyatt et al., 1990).* Such associations, however, have not yet been examined in patients of osteoarthritis knee.

The aim of the study was to examine the association of quadriceps strength with pain and disability of knee osteoarthritis. In addition the relationships between various components of health related fitness, pain, effusion and disability were also examined in the present study.

Materials and Methods:

Subjects: Two hundred patients with established osteoarthritis knee ranging in age from 40 to 70 years from physiotherapy O.P.D., Lyallpur Khalsa College, Guru Nanak Mission Hospital, Mangat Hospital and Oberoi Hospital of Jalandhar City (Punjab, India) were recruited for the study.

Clinical Health Status:

Pain, tenderness, effusion were recorded depending upon the severity and graded as per criteria laid by *Livesly et al. (1991).*

Body Composition:

The Skinfold caliper was used to measure the thickness of skinfolds at biceps, triceps, subscapular and suprailiac sites. For the purpose of calculation of percent body fat the four skin fold values were added to get the total skin fold value. The body density there after was calculated by using the *Durnin and Womersley (1974)* formula appropriate to the age and sex category of the subject. After the calculation of body density, percent body fat was calculated by using the formula devised by Siri (1961).

Muscle Strength Measurements:

Isotonic strength of quadriceps was recorded by 10 R.M. method and isometric muscle strength was recorded by using Back-Leg-Chest Dynamometer.

Range Of Motion:

Universal goniometer was used to measure R.O.M. of Knee joint. Both knee movements i.e. flexion and extension were measured in prone lying.

Cardiovascular Fitness:

Crompton test was used to record cardiovascular fitness.

Functional Status:

Patients were categorized into class I, II, III and IV according to the 1991 revised criteria given by American College of Rheumatology.

Statistical Analysis:

Pearson chi-square test was used to reveal the existence of association between disability as judged from the functional status of the patient and the variables of health related fitness status as well as clinical health status. The ensuing significant associations were further explored with paired samples correlation to establish the form of these relationships. Consequently multiple regression analyses were used to examine the predictability of one variable from several variables.

Results:

Pearson chi-square test was used to find out the association between disability in osteoarthritis knee and physical characteristics, various clinical parameters, the components of health related fitness and the radiographic changes. The results are being displayed in table 1.

It was observed that the calculated value of $\chi 2$ was less than the table value for the parameters of pain ($\chi 2$=6.081), effusion ($\chi 2$=7.754) and body mass index ($\chi 2$=7.151). This indicated that disability of the patients of osteoarthritis knee as judged from their functional status was not associated with pain, effusion and body mass index. On the other hand the significant value of χ^2 ($p<0.05$) for all other parameters has demonstrated a strong link of functional status with age, body weight, % body fat, lean body mass, isotonic strength of quadriceps, isometric strength of leg muscles, range of knee extension, cardiovascular fitness, the stage of osteoarthritis as judged from radiological changes and the level of physical activity determined by exercise habit of the patients of osteoarthritis of knee.

Table 1: Pearson chi-square applied between functional status and various subject characteristics in 200 patients with osteoarthritis knee

Variable	$\chi 2$	d.f.	N	Sig.
Functional Status & Age	18.76**	4	200	0.001
Functional Status & Pain	6.08	8	200	0.638
Functional Status & Effusion	7.75	6	200	0.257

Functional Status & Body Weight	22.14**	4	200	0.000
Functional Status & Body Mass Index	7.15	4	200	0.000
Functional Status & % Fat	35.67**	4	200	0.000
Functional Status & Lean Body Mass	20.32**	4	200	0.000
Functional Status & Isotonic Muscle Strength	119.9**	10	200	0.000
Functional Status & Isometric Muscle Strength	149.56**	8	200	0.000
Functional Status & Range of Knee Extension	35.19*	18	200	0.009
Functional Status & Cardiovascular Fitness	115.4**	4	200	0.000
Functional Status & Radiological Changes	23.04**	4	200	0.000
Functional Status & Exercise Habit	20.01**	4	200	0.000

*p<0.05

The results of Pearson chi-square test only indicated whether the different subject characteristics were or were not significantly related with functional status of the patients of osteoarthritis knee, without reference to any assumptions concerning the form of relationship. Consequently the test of statistics named paired samples correlation was applied to appraise a measure of the degree or form of the relationship of functional status with age, body weight, % body fat, lean body mass, isotonic strength of quadriceps, isometric strength of leg muscles, range of knee extension, cardiovascular fitness, the stage of osteoarthritis as judged from radiological changes and the level of physical activity determined by exercise habit of the patients of osteoarthritis of knee. However correlation analysis was not used to assess the linear association of functional status with pain, effusion and body mass index because the administration of Pearson chi-square test had already established that functional status of the patients of osteoarthritis knee was not associated with pain, effusion and body mass index.

Table 2: Correlation analysis between functional status and various subject characteristics in 200 patients with osteoarthritis knee

Variable	Correlation	N	Sig.
Functional Status & Age	0.23**	200	0.001
Functional Status & Body Weight	-0.24***	200	0.000
Functional Status & % Fat	0.39***	200	0.000
Functional Status & Lean Body Mass	-0.29***	200	0.000
Functional Status & Isotonic Muscle Strength	-0.65***	200	0.000
Functional Status & Isometric Muscle Strength	-0.62***	200	0.000
Knee Extension	0.11*	200	0.139
Functional Status & Cardiovascular Fitness	0.69***	200	0.000
Functional Status & Radiological Changes	0.32***	200	0.000
Functional Status & Exercise Habit	0.35***	200	0.000

*p<0.05

Table 2 shows the several significant linear correlations. In the total group of 200 patients of osteoarthritis knee, the functional status correlated positively with age ($r = 0.226$; $p<0.001$), % body fat ($r = 0.389$; $p<0.000$), knee extension ($r = 0.105$), cardiovascular fitness ($r = 0.692$; $p<0.000$), radiological changes ($r = 0.320$; $p<0.000$) and exercise habit ($r = 0.354$;

p<0.000). On the other hand functional status was found to be correlated negatively with body weight(r = -0.238; p<0.000), lean body mass(r = -0.289; p<0.000), isotonic strength of quadriceps (r = -0.658; p<0.000) and isometric muscle strength of leg muscles (r = -0.620; p<0.000).

The results of correlation analysis have established the close relationship of functional status with age, body weight, % body fat, lean body mass, isotonic and isometric strengths of leg muscles, knee extension, cardiovascular fitness, radiological changes and exercise habit of patients of osteoarthritis knee. Hence multiple regression analyses were used to examine the predictability of one variable from several variables associated with disability of osteoarthritis knee.

Table 3: Partial correlation coefficients derived from multiple regression analyses in 200 patients with osteoarthritis knee.

	Dependent Variables	
Independent Variables	**Functional Status**	**Radiological Changes**
Age	0.037	0.629*
Body Weight	0.128	0.128
Body Mass Index	-0.119	0.143
Isotonic Strength	-0.440*	-.364*
Isometric Strength	-0.332*	0.169
Knee Extension	0.352*	0.11
CV Fitness	0.475*	0.008
%Fat	0.172	-0.027
Lean Body Mass	-0.004	-0.154
Exercise Habit	-0.046	0.1705

Table 3 shows the results of multiple regression analyses with functional status and radiological changes as the dependent variables and age, weight, BMI, isotonic strength of quadriceps, isometric strength of leg muscles, cardiovascular fitness, %Fat, lean body mass and exercise habit as independent variables. Isotonic strength of quadriceps was the most important determinant of functional status and stage of osteoarthritis as judged from radiological changes.

Table 4: Partial correlation coefficients derived from multiple regression analyses in 200 patients with osteoarthritis knee.

	Dependent Variables	
Independent Variables	**Pain**	**Effusion**
Age	0.829	-0.029
Body Weight	0.029	-0.124
Body Mass Index	0.0396	0.1286
Isotonic Strength	-0.136	0.0658
Isometric Strength	-0.0283	0.082
Cardio-vascular Fitness	-0.114	0.0397
%Fat	-0.0594	0.0803
Lean Body Mass	0.0626	0.135
Exercise Habit	0.1493	-0.0571
Knee Extension	0.015	-0.0103

Table 4 shows the results of multiple regression analyses with pain and effusion as the dependent variables and age, body weight, body mass index, isotonic muscle strength, isometric muscle strength, cardiovascular fitness, %Fat, lean body mass and exercise habit as independent variables. None of the variables was correlated either with pain or with effusion. Thus, quadriceps strength was found not to be associated with pain.

Table 5: Partial correlation coefficients derived from multiple regression analyses in 200 patients with osteoarthritis knee.

Independent Variables	**Dependent Variables**	
	Pain	Effusion
Functional Status	-0.016	-0.104
Radiological Changes	-0.321	-0.039

Table 5 presents the results of multiple regression analyses with functional status and radiological changes as dependent variables while pain and effusion as the independent variables. The results confirmed that clinical health status was not associated either with functional status or radiological changes.

Discussion:

The present study could not establish any direct linkage between pain and disability. The findings does not hold good with usual assumption that pain is a primary factor in limiting function of the patients of osteoarthritis of knee. In addition, pain was also found not to be associated with any of the parameters of health related fitness. This suggests that a patient with knee osteoarthritis may experience considerable pain with either good muscle strength or even with good cardiovascular fitness. These findings can be explained on the basis that pain is the subjective phenomenon and the perception of pain can be subjectively modified by past experiences and expectations *(Bishop, 1980).* A poor relationship between pain and radiological changes has repeatedly been reported in patients of osteoarthritis *(Downie, 1993; Haslett et al. 2000; Braunwald et al., 2001; O'Sullivan and Schmitz, 2001).* Many individuals with advanced osteoarthritis have no symptoms. Pain arises in structures possessing nerve endings and may result from micro-fractures in subchondral bone, increased venous pressure in subchondral bone and osteophytes, capsular thickening and subluxation. With cartilage damage alone, there is no pain, since articular cartilage does not contain nerve endings. This might be the reason why the disease may be obvious radiologically long before symptoms appear. However the reverse is also true, and pain may be severe despite minimal clinical and radiological findings. In fact it has been reported that some patients may magnify the pain they experience (Melvin et al., 1989). According to *Downie (1993),* usually there are increasing complaints over a number of years but occasionally the history can be short, a matter of few months only, despite extensive radiological disease. Thus, the findings illustrate the need to explore functional limitations in patients with osteoarthritis separately from the evaluation of symptoms. In 2001, O'Sullivan and Schmitz also reported that a clinical examination, predicted on the assumption that pain is a primary factor in limiting function, could lead to the hasty conclusion that the patient's functional status is normal if pain is absent.

Decreased muscle strength has repeatedly been reported in arthritis patients *(Tiselius, 1969; Hsich et al., 1987; Ekdahl et al., 1989; Ekdahl and Broman, 1992; Philbin et al., 1995; Tan et al., 1995; Wessel at el., 1996; Joshi and Kotwal, 2000 and Braunwald, 2001).* The present study has also recorded the similar findings.

The studies of healthy subjects have reported relationships between muscle strength and functional status *(Hyatt et al., 1990),* chair rising ability *(Bassey et al., 1992)* and walking and stair climbing speed *(Bassey et al., 1988; Bendall et al. 1989 and Bassey et al., 1992).* Furthermore, an association between muscle strength and the risk of recurrent falls *(Whipple et al., 1987 and Lord et al., 1994)* and fractures *(Nguyen et al., 1993; Lord et al., 1994 and Cummings et al., 1995)* has been demonstrated. Obviously, muscle strength and endurance translates into good functional capacity and lessened disability. That is one of the reasons why muscle

strength is linearly and negatively correlated with disability in patients with osteoarthritis knee.

Another important factor contributing to disability is altered stereognostic control of opposing muscle groups surrounding knee joint, which is a major weight bearing joint. Normally strong periarticular muscles of knee joint are capable of withstanding the impact of loading. However this mechanism is reduced in case of reduced muscular strength and endurance in patients with osteoarthritis knee. In 1986, Radin reported that altered stereognostic control of loading force attenuation is an important regulator, as it can be modified in many patients by conservative physical therapy and gait control. These factors should be taken into consideration while managing the patients of osteoarthritis knee.

The primary concept involved at the knee is that of increased stress and the response of the musuloskeletal system to this stress *(Goldberg et al., 1992).* An understanding of this concept is imperative in understanding of the severity of osteoarthritis knee and its relationship with quadriceps strength. For example, unhealthy body composition produces increased articular surface stress, which is normally predominantly absorbed or attenuated by strong quadriceps. This is well in line with the finding of *Yang and co-workers (1989).* The present finding illustrates the need of improving muscle function in the management of osteoarthritis knee.

The present study has investigated the obesity, as a risk factor of disability of osteoarthritis knee, in terms of body weight, body mass index and body composition. A positive correlation between % body fat and functional status indicates that as the amount of % fat increases the functional status of patients with osteoarthritis knee moves from class I to class IV meaning % body fat is directly proportionate to the level of disability. On the other hand a negative relationship between lean body mass and functional status was observed meaning a decrease in lean body mass is closely associated with an increase in disability as judged from functional status. It is important to mention here that carrying too much fat in comparison to lean tissue is the main characteristic of unhealthy body composition or obesity. Thus we may conclude that an unhealthy body composition is closely related with an increase in the level of disability in cases of osteoarthritis of knee. The findings indicate that exercise rehabilitation programme of osteoarthritis knee should include a healthy body composition programme that helps a person lose weight and look thinner by targeting fat and preserving muscle.

It is important to emphasize that the present investigation could not demonstrate any direct linkage between body weight and the disability associated with the osteoarthritis knee. On the contrary, we observed a lower level of disability in patients with increased body weight. This observation needs to be interpreted in the light of body composition of the subjects. It is revealed in the results of the present study that healthy body composition probably is more important than the body weight alone in influencing the disability in patients of osteoarthritis knee. That is why body composition analysis, i.e., assessment of the percent of fat vs. lean body mass of an individual should be incorporated while evaluating the patients of osteoarthritis knee.

Conclusions:

1) Quadriceps strength seems to be an independent contributor to the severity of osteoarthritis knee; the findings illustrate the need of improving the muscle function in these patients.

2) No association between knee pain and disability indicates that functional limitations in patients with osteoarthritis should be explored separately from the evaluation of symptoms.

3) Healthy body composition probably is more important than the body weight alone in influencing the disease process of osteoarthritis knee.

4) In addition, treatment programme of osteoarthritis knee should have the potential to improve their cardiovascular fitness, flexibility and body composition.

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