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Original Research Article

EFFECT OF AGE, CARTILAGE HEALTH AND PAIN ON THE ISOMETRIC STRENGTH OF KNEE MUSCULATURE: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background of the Study: Knee muscle strength is a major contributor to the quality of life particularly in the elderly population. Various factors that can contribute to the strength needs to be examined, so that intervention can be taken at appropriate time to maintain the quality of life.

Objectives of Study: The present study was conducted to investigate the relationship of age, pain and cartilage health on the isometric strength of knee flexors and extensors.

Study Design: Cross-sectional study design

Methodology: 320 subjects with age group 31-70 years were made part of study and were divided into 8 groups. Readings were noted down of age, VAS, height, weight, BMI, isometric strength of knee musculature and sonographic readings were noted down of cartilage clarity and interface of both knees. One time readings were taken.

Results: Correlation analysis was performed to find association of cartilage clarity and interface, VAS and age with muscle strength. The r-value calculated came out to be significant for all the associations at $P < 0.05$.

Conclusion: It can be concluded that the muscle strength is moderately associated with age and cartilage health and high association was noted with pain.

KEY WORDS: Cartilage Clarity, Cartilage Interface, Isometric.

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INTRODUCTION

Joints are composed of specialized connective tissues which, from a functional point of view, act synergistically, to effectively and efficiently deal with the mechanical loads, encountered over a lifetime [1,2]. One of the most important connective tissue, contributing to this normal articular function is articular cartilage. Due to unique structural composition and biomechanical properties, articular cartilage performs this function without sustaining substantial wear.

Optimum mechanical loading is a significant factor in regulating metabolism and enzymatic activity, required for the production of proteoglycans, which act as a sort of shock absorbers, as they get compressed and dissipate force on the rest of the joint surface, thereby minimizing the pressure on articular cartilage [3], hence is important in maintaining healthy articular cartilage.

Aging influences articular cartilage homeostasis and is, thereby, involved in the pathogenesis of degenerative joint diseases such as osteoarthritis. Aging process has been characterized by changes in almost all the tissues of the body, be it connective, muscular or skeletal, which leads to gradual reduction in capacity to do work. The changes in the body tissues are marked with decreased joint mobility, decreased muscle strength, increased stiffness, generalized weakness, increased risk of falls, increased incidence of fractures, decreased immunity and reduction in water content of the body [4]. The relationship between aging and joint changes is well known but the mechanisms of how the aging is predisposing the joint to changes is not completely understood [5].

Age related changes that occur in articular cartilage has been one of the contributing factor of osteoarthritis which is indeed the most common condition which effect the aging population. There have been studies which have found thinning of articular cartilage of knee with aging particular at the femoral site [6] and the patella [7] suggesting a gradual loss of cartilage matrix. Exact underlying mechanism of gradual loss of cartilage matrix is not fully understood. Probably this could be due to loss of cells and decreased growth factor activity. Another reason could be the reduction in water content of the cartilage since the cartilage is 70-80% water [5].

Cartilage health can be assessed by a wide variety of equipments. Previously in older times, radiography was considered as gold standard for assessment of osteoarthritis. In recent times, more advanced have been evolved to visualize soft tissue, cartilage and bony health which include High-frequency Sonography, Magnetic Resonance Imaging (MRI), and Optical Coherence Tomography etc [8].

MRI remains a powerful tool that is able to visualize a broad spectrum of cartilage health, but its cost, limited availability and exclusionary criteria for use in certain patients are practical disadvantages [9]. High Resolution sonography is an accurate, inexpensive, readily accepted, non- ionizing and non-invasive method for imaging the musculoskeletal system [10]. Sonography may provide information of cartilage thickness [11] as well as integrity [12]. It has also evolved as a tool to study progression of osteoarthritis [13]. Recently ultrasound has been developed to measure surface fibrillation and tissue thickness [11]. Previous researches have suggested that sonographic examination is highly sensitive for determining structural properties, roughness and thickness of cartilage [12,14,15].

Cartilage integrity is evaluated in terms of Cartilage clarity and Cartilage grade. Cartilage clarity is defined as how well the cartilage borders can be distinguished from the overlying intra-articular soft tissues. Cartilage clarity is ranked into 4 grades. Grade 1 implies to excellent; grade 2 implies to good; grade 3 implies to fair and grade 4 implies to poor [16]. Cartilage interface is estimated by the criteria as laid down by the International Cartilage Repair Society (ICRS). This criterion divides the cartilage integrity or interface into 5 grades. Grade 0 implies to normal cartilage; grade 1 implies to near-normal cartilage with superficial lesions; grade 2 implies to cartilage with lesions extending to less than 50% of the depth of the cartilage; grade 3 implies to cartilage with defects that extend to more than 50% of the depth of the cartilage and grade 4 implies to severely abnormal cartilage with cartilage defects reaching to subchondral bone [17].

Muscle wasting can be a consequence of normal aging process. Muscle loss starts at around the age of 30 years and continues throughout the life. There is gradual reduction in the number and size of muscle fibers which is turn causes gradual loss of muscle mass and strength. This mild loss of strength put increased stress on joints particularly the weight bearing joints such as knee, hip etc. predisposing the person to joint degenerative changes and finally pain and reduced mobility. The aging process is also marked with reduction in the number of fast contracting muscle fibers than slow contracting muscle fibers which unable the muscle fibers to contract quickly in old age [18].

There are number of methods to assess muscular strength of different muscle groups of lower limb. The most commonly used methods are cable tensiometer, isokinetic dynamometer, push-pull dynamometer, Jamar's dynamometer

etc. Cable tensiometer has been used in the number of previous studies to measure isometric strength of both upper limb as well as lower limb musculatures [19-22].

Previous studies have found the effect of aging on the muscle strength. The authors were not able to find out the effect of changes in the cartilage on muscle strength of knee flexors and extensors. Therefore, the present study was aimed to find the variation of knee musculature strength with the progression in age, pain and cartilage health.

PATIENTS, MATERIAL AND METHODS

The study design was cross-sectional in nature. The study was conducted in Gian Sagar Hospital, Rajpura, in the state of Punjab in India. The subjects were recruited from the patients coming to Physiotherapy OPD and surrounding areas. Sonography was conducted in the radiology department of Gian Sagar Hospital by the radiologist.

Inclusion criteria of the subjects include: Subjects in the age range of 30-70 with or without knee pain. Non-traumatic knee pain. Both male and females

Exclusion criteria of the subjects include: Subjects with any history of fracture of lower limb in the last 1 year, Any history of surgery in lower limb, Subjects with soft tissue injury during the last 1 year, Tumour, Any diagnosed neuromuscular disease.

The study was approved by the ethical committee of Gian Sagar group of Institutes. 320 subjects satisfying the inclusion and exclusion criteria were made part of the study. To ensure uniform distribution of age of subjects, 8 groups, with 40 subjects each, was made taking age as criterion such that there was a difference of 5 years between different groups such as 31-35, 36-40, 41-45 and so on till 66-70. After taking written consent from the subjects, detailed assessment of the subjects was done for knee pain. Readings were noted down of age, height, weight, BMI and VAS. Isometric muscle strength of knee flexors and extensors was estimated using cable tensiometer with the subject in prone lying position [20] and high sitting position [19] respectively. Then the sonograph of the subjects was done by the radiologist. The cartilage integrity of interface was viewed and the appropriate grade was given to the cartilage clarity and cartilage grade by the radiologist as per the criteria laid down by ICRS. One time readings of the patients were taken.

STATISTICAL ANALYSIS AND RESULTS

Table 1: Gender distribution.

S.No	Males	Females
1	162	158
2	50.63%	49.38%

Table 2: Demographic details.

S.No	Parameter	Mean ± SD
1	Age	50.48 ± 11.61
2	BMI	27.91 ± 4.37
3	VAS score	3.23 ± 2.83

Table 1 & 2 gives the male female ratio and demographic details of the subjects. 320 subjects (162 males: 158 females) with mean age of 50.4750 with standard deviation of 11.6134 were made part of study. The mean BMI score of the subjects is 27.9146 ± 4.3710. The subjects recruited were normal to mild obese category. The pain perception reading as measured by VAS is 3.2250 ± 2.8305 which gives an impression that the pain level of the subjects as measured by VAS lies in mild to moderate range.

Table 3: Isometric Muscle Strength of Right and Left Knee.

S.No	Parameter	Right Knee	Left Knee	S.E.	5% LOS
1	Extensors	18.4563 ± 8.1362	17.5156 ± 8.2166	1.455	NS
2	Flexors	18.6438 ± 8.6594	18.1031 ± 8.7363	0.786	NS
Value of S.E. of Mean at 5% Level of significance is 1.96					

Table 3 presents the mean value of knee musculature strength. The strength was calculated with cable tensiometer. The mean value of extensors of right knee came out to be 18.4563 ± 8.1362 and of left knee came out to be 17.5156 ± 8.2166. The mean value of flexors of right knee is 18.6438 ± 8.6594 and of left knee is 18.1031 ± 8.7363. Standard error of mean was calculated and the values came out to be non-significant at 5% level of significance showing that there was non-significant difference between right and left knee strength.

Table 4: Correlation of Age with Isometric Strength of Right and Left Knee.

S.No	Isometric Strength Parameter	r-value	P-value
1	Extensor strength of Right Knee	-0.34	0
2	Flexor strength of Right Knee	-0.39	0
3	Extensor strength of Left Knee	-0.3	0
4	Flexor strength of Left Knee	-0.38	0

Table 4 denotes the correlation of age with strength of extensors and flexors of knee. There came out to be mild to moderate negative correlation between the age and isometric strength of right and left knee indicating that there was reduction in muscle strength with progression in age.

Table 5: Correlation of Cartilage Clarity with Isometric Strength of Right and Left Knee.

S.No	Isometric Strength Parameter	Right Knee		Left Knee	
		r-value	P-value	r-value	P-value
1	Extensor strength of Right Knee	-0.24	0	-0.3	0
2	Flexor strength of Right Knee	-0.26	0	-0.34	0
3	Extensor strength of Left Knee	-0.2	0	-0.29	0
4	Flexor strength of Left Knee	-.0.24	0	-0.34	0

Table 6: Correlation of Cartilage Interface with Isometric Strength of Right and Left Knee.

S.No	Isometric Strength Parameter	Right Knee		Left Knee	
		r-value	P-value	r-value	P-value
1	Extensor strength of Right Knee	-0.26	0	-0.34	0
2	Flexor strength of Right Knee	-0.27	0	-0.36	0
3	Extensor strength of Left Knee	-0.25	0	-0.33	0
4	Flexor strength of Left Knee	-0.25	0	-0.35	0

Table 5 and 6 denotes the correlation of cartilage clarity and cartilage interface respectively of each knee with the isometric strength of extensors and flexors. There came out to be mild negative association between the cartilage parameters of clarity and interface with isometric strength of both flexors as well as extensors of both knees.

Table 7: Correlation of VAS with Strength of Right and Left Knee.

S.No	Cartilage Parameter	r-value	P-value
1	Extensor strength of Right Knee	-0.6776	0
2	Flexor strength of Right Knee	-0.7006	0
3	Extensor strength of Left Knee	-0.6088	0
4	Flexor strength of Left Knee	-0.6815	0

Table 7 represents the correlation of VAS with the isometric strength of both knees. There came out to be highly significant negative relationship between VAS and all the strength parameters of both knee which indicates that increase in pain score is causing significant reduction in the knee musculature strength.

DISCUSSION

The present study was conducted to evaluate the effect of age, VAS and cartilage health on the strength of knee flexors and extensors. 320 subjects in the age range of 31-70 years, with and without knee pain were made part of study. The cartilage health was elucidated using cartilage clarity and interface was examined using sonography and appropriate grading was done by the radiologist. The isometric strength of knee flexors and extensors was measured with the help of cable tensiometer.

Table 1 represents the gender distribution of the subjects. 162 males (50.625%) and 158 females (49.375%) were made part of the study. It is clear that the there is no significant difference between the male and female ratio and the subjects were fairly distributed. Table 2 represented the demographic details of the subjects. The mean age of the subjects is 50.4750 ± 11.6134. This shows that the subjects were fairly distributed in the age range taken for the study. The mean BMI of the subjects is 27.9146 ± 4.3710. The subjects taken are normal to mild obese category. The mean VAS score of the subjects is 3.2250 ± 2.8305. The subjects recruited for the study has mean VAS score in mild to moderate category. The uniform distribution of the subjects in the study helps the result to be generalized to the whole population. The uniform distribution of the subjects selected has been supported by the study done by Slemenda et al., 1997; Douma et al., 2014. There was non-significant difference in the number of the male and female subjects [23, 24].

The isometric strength of flexors and extensors showed non-significant differences between right and left knee at 5% level of significance (Table 3), giving an inference that there is no difference between the isometric strength of both the muscle groups. Our findings are in compliance with the study done by Douma et al., in 2014 which have also concluded non-significant difference of knee musculature strength of both the lower limbs [24].

There came out to be moderate negative association between age and isometric strength of

knee musculature This might be attributed to the fact that with advancement of age, the number and size of muscle fibers decrease leading to muscle wasting. The finding that there is reduction in the muscle strength with BMI and advancement of age is supported by the finding of Douma et al., 2014 who also concluded that there is reduction in muscle strength with age but the variation is less significant [24]. The moderate association gives an inference that age definitely leads to reduction in the muscle strength but it seems, not the only factor which causes reduction in muscle strength.

The correlation between the cartilage parameters of clarity and interface and knee musculature strength showed negative mild association (Table 5 & 6). Cartilage parameters degenerate with advancing age. Due to this degenerative process, there is reduction in cartilage resiliency and hydration, resulting in increased degradation of cartilage, increased roughness of its surface and increased susceptibility to osteoarthritis [3, 25-31]. Hence, due to proven negative impact of osteoarthritis on muscle strength [23, 33-37], cartilage health showed reduction in muscle strength with advancing grades of clarity and interface.

The relationship between VAS and strength of knee flexors and extensors came out to be highly significant in the negative direction (Table 7). This signifies that the VAS and strength are inversely proportional i.e. when pain increases, strength or force exerted by muscles decreases and vice versa. This might be attributed to the fact that pain causes the surrounding muscles into spasm, so those muscles will not be able to exert full force or strength. Previous researches have also supported this finding of gradual reduction in strength with pain [38,39].

Limitations: The main limitation of the study is the small sample size. This study can be replicated by taking a larger sample size.

CONCLUSION

Therefore, the conclusion of the study is that there is a gradual reduction in knee musculature strength with progression in age. The deterioration of cartilage health also leads to reduction in the isometric muscle strength of both knee flexors as well as extensors. Further, it is also concluded that the knee musculature strength is significantly dependent on VAS i.e. there is gradual decrease in muscle strength with pain level.

ABBREVIATIONS

VAS- Visual Analog Scale
BMI- Body Mass Index
ICRS- International Cartilage Repair Society
MRI- Magnetic Resonance Imaging

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Conflicts of interest: **None**

REFERENCES

[1]. Ateshian GA and Wang HA. Theoretical solution for the frictionless rolling contact of cylindrical biphasic articular cartilage layers. Journal of Biomechanics, 1995;28(11):1341-1355.
[2]. Cohen ZA, Mow VC, Henry JH, Levine WN and Ateshian GA. Templates of the cartilage layers of the patellofemoral joint and their use in the assessment of osteoarthritic cartilage damage. Osteoarthritis and Cartilage 2003; 11: 569-579.
[3]. Eckstein F, Hudelmaiyer M and Putz R. The effects of exercise on human articular cartilage. Journal of Anatomy 2006; 208: 491-512.
[4]. Freemont AJ and Hoyland JA. Morphology, mechanisms and pathology of musculoskeletal aging. Journal of Pathology 2007; 211: 252-259.
[5]. Loeser RF. Age related changes in musculoskeletal system and the development of osteoarthritis. Clinical Geriatr Med, 2010; 26 (3): 371-386
[6]. Hudelmaier M, Glaser C and Hohe J. Age-related changes in the morphology and deformational behavior of knee joint cartilage. Arthritis Rheum. 2001; 44 (11): 2556–2561.
[7]. Ding C, Cicuttini F and Scott F. Association between age and knee structural change: a cross sectional MRI based study. Ann Rheum Dis. 2005; 64(4): 549–555.
[8]. Braun JH and Gold GE. Diagnosis of osteoarthritis: Imaging. Bone; doi: 10.1016/ J.Bone. 2011.11.019.
[9]. Tarhan S, Unlu Z and Goktan C. Magnetic resonance imaging and ultarsonographic evaluation of the patients with knee osteoarthritis: a comparative study. Clin Rheumatol. 2003; 22: 181-188.
[10]. Naredo E, Acebes C, Moller I, Canillas F, Augustin, E, Filippucci E, Lagnocco A, Moragues C, Tuneu R, Uson J, Garrido J, Delgado B and Saenz NI. Ultrasound validity in the measurement of knee cartilage thickness. Ann Rheum Dis. 2009; 68: 1322-1327.

[11]. Jurvelin JS, Rasanen T, Kolmonen P and Lyyra T. Comparison of optical, needle probe and ultrasonic techniques for the measurement of articular cartilage thickness. J Biomech 1995; 28: 231-235.
[12]. Adler RS, Dedrick DK, Laing TJ, Chiang EH, Meyer CR, Bland PH and Rubin JM. Quantitative assessment of cartilage surface roughness in osteoarthritis using high frequency ultrasound. Utrasound Med Bio 1992; 18: 51-58.
[13]. Joiner GA, Bogoch ER, Pritzker KP, Buschmann MD, Chevrier A and Foster FS. High frequency acoustic parameters of human and bovine articular cartilage following experimentally induced matrix degradation. Ultrason Imaging, 2001; 23: 106-116.
[14]. Kim HK, Babyn PS, Haraseiwicz KA, Gahunia HK, Pritzker KP and Foster FS. Imaging of immature articular cartilage using ultrasound backscatter microscopy at 50 MHZ. J Orthop Res 1995; 13: 963-970.
[15]. Myers SL, Dines K, Brandt DA, Brandt KD and Alvrecht ME. Experimental assessment by high frequency ultrasound of articular cartilage thickness and osteoarthritic changes. J Rheumatol 1995; 22: 109-116.
[16]. Kazam JK, Nazarian LN, Miller TT, Sofka CM, Parker L and Adler RS. Sonographic evaluation of femoral trochlear cartilage in patients with knee pain. JUM 2011; 30(6): 797-802.
[17]. Kaleva E, Viren T, Saarakkala S, Sahlman J, Sirola J, Puhakka J, Paatela T, Kroger H, Kiviranta I, Jurvelin JS and Toyras J. Arthroscopic ultrasound assessment of articular cartilage in the human knee joint: a potential diagnostic method. Cartilage 2011; 2 (3): 246-253.
[18]. Forte AV. Effect of aging on musculoskeletal system. viewed 2nd April, 2016. www.msdmanuals.com/home/bone,-joint,-and-muscle-disorders/biology-of-the-musculoskeletal-system/effecs-of-aging-on-the-musculoskeletal-system.
[19]. Noose LJ. Assessment of selected reports on the strength relationship of the knee musculature. Journal of Sports and Physical Therapy 1982; 4 (2): 78- 85.
[20]. Lord SR, Menz HB and Tiedemann A. A physiological profile approach to falls risk assessment and prevention. Physical Therapy 2003; 83 (3): 237-252.
[21]. Rhodes LE, Freeman BK, Auh S, Kokkinis AD, La Pean A, Chen C, Lehky TJ, Shrader JA, Levy EW, Di Prospero MHNA and Fischbeck KH. Clinical features of spinal and bulbar muscular atrophy. Brain 2009; 132 (12): 3242-3251.
[22]. Olaogun MOB, Lamidi RE and Obembe AO. Balance confidence and standing balance performance among stroke survivors with hemiparesis. Journal of Medicine and Medical Science 2011; 2 (3): 750-757.
[23]. Slemenda C, Brendt KD, Heilman DK, Mazzuca S, Braunstein EM, Katz BP and Wolinsky FD. Quadriceps weakness and osteoarthritis of the knee. Annals of Internal Medicine 1997; 127: 97-104.
[24]. Douma RKW, Soer R, Krinjen WP, Reneman M and Van-der- Schans CP. Reference values for isometric muscle force among workers for the Netherlands: A comparison of reference values BMC Sports Science and rehabilitation 2014; DOI: 10.1186/2052-1847-6-10, viewed 2nd April, 2016, www.ncbi.nlm.nih.gov/pmc/articles/PMC3996060/.
[25]. DeGroot J, Verzijl N, Bank RA, Lafeber FPJG, Bijlsma JWJ and TeKoppele JM. Age related decrease in proteoglycans synthesis of human articular chondrocytes. Arthritis & Rheumatism 1999; 42 (5): 1003-1009.
[26]. Loeser RF, Shanker G, Carlson CS, Gardin JF, Shelton BJ and Sonntag WE. Reduction in the chondrocytes response to insulin-like growth factor 1 in aging and osteoarthritis. Arthritis & Rheumatism 2000; 43 (9): 2110-2120.
[27]. Martel-Pelletier J. Pathophysiology of osteoarthritis. Osteoarthritis and Cartilage 2004; 12: S31-S33.
[28]. Scott JL, Gabrielides C, Davidson RK, Swingler TE, Clark IM, Wallis GA, Boot-Handford RP, Kirkwood TBL, Taylor RW and Young DA. Superoxide dismutase down regulation in osteoarthritis progression and end-stage disease. Annals of Rheumatic Diseases 2010; 69 (8): 1502-1510.
[29]. Hugle T, Guerts J, Nuesch C, Muller-Gerbl M and Valderrabano V. Aging and osteoarthritis: an inevitable encounter?' Journal of Aging Research 2012; 2012: 1-7.
[30]. Hosseini SM, Veldink MB, Ito K and Van Donkelaar CC. Is collagen fiber damage the cause of early softening in articular cartilage? Osteoarthritis and Cartilage 2013; 21: 136-143.
[31]. Li YP, Wei XC, Zhou JM and Wei L. The age related changes in cartilage and osteoarthritis. BioMed Research International 2013; 1-12.
[32]. Musumeci G. The effect of mechanical loading on articular cartilage. Journal of Functional Morphology and Kinesiology 2016; 1: 154- 161.
[33]. Madsen OR, Bliddal H and Egsmose C. Isometric and isokinetic quadriceps strength in gonarthrosis: inter-relations between quadriceps strength, walking ability, radiology, subchondral bone density and pain. Clinical Rheumatology 1995; 14: 308–314.
[34]. Wessel J. Isometric strength measurements of knee extensors in women with osteoarthritis of the knee. Journal of Rheumatology 1996; 23: 328–31.
[35]. Haq I Murphy E and Dacre J. Osteoarthritis. Postgraduate Medical Journal 2003; 79: 377-383.
[36]. Alnahdi AH, Zeni JA and Synder- Mackler L. Muscle impairments in patients with knee osteoarthritis. Sports Physical Therapy 2012; 4 (4): 284-292.
[37]. Anwer S and Alghadir A. Effect of isometric quadriceps exercise on muscle strength, pain and function in patients with knee osteoarthritis: a randomized controlled study. Journal of Physical Therapy Science 2014; 26 (5): 745-748.
[38]. Danneels L, Cagnie B, D'hooge R, Deene YD, Crombez G, Vanderstraeten G, Parlevliet T and Oosterwijck JV. The effect of experimental low back pain on lumbar musce activity in people with a history of clinical low back pain: a muscle functional MRI study. Journal of Neurophysiology 2016; 115 (2): 851-857.
[39]. Nielsen G and Nielsen A. Impact of clinical and experimental pain on muscle strength and activity' Curr Rheumatol Rep 2008; 10 (6): 475-481.

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