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Original Research Article

The study of variation of range of motion of knee joint with body mass index in normal, overweight and obese young adults

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ABSTRACT

Introduction: The incidence of overweight and obesity is increasing at a very rapid rate the world over. The increased body mass has a detrimental effect on the kinesiology of human body which hampers the individual's day to day activities by affecting the movements of various joints. The present study was undertaken with the aim of correlating the motion at knee joints of both sides with the body mass index of the individual.
Materials and Methods: A total of 235 subjects (108 males and 127 females) were enrolled for the cross-sectional study which was carried out in the Department of Anatomy of Sharda University, Greater Noida.
Result: Analysis by one way ANOVA showed a progressive decrease in the magnitude of knee joint range of motion with a gradual increase in body mass index in three groups of subjects from normal to obese.
Conclusion: The results obtained from study supports the importance of weight loss in improving the postural balance and activities of daily living in the overweight and obese individuals.

1. Introduction

Knee joint, being the largest joint in the body, is a modified hinge variety of synovial joint and acting with ankle joint is very important for forward propulsion of the body during gait cycle. The human body attains balance by maintaining the centre of gravity of body within a wide base. During locomotion the variation in centre of gravity is adjusted by muscular activity. An increase in the body weight interferes with the interaction of joints and muscles that are crucial to the functional capacity and postural balance. A decreased range of motion (ROM) of lower limb joints especially hip, knee, and ankle joint are mainly responsible for postural instability in overweight and obese individuals.[1–3] Obesity has a marked negative impact on gait which is seen as reduction in speed, cadence, stride, which gives rise to poor muscle co-ordination resulting in increased susceptibility to fatigue.[4] The biomechanical adaptations to increased body weight predispose such individuals to early onset of osteoarthritis and pain.

Weight reduction is crucial as obesity is a contraindication for bilateral total knee arthroplasty. Body mass index (BMI) of greater than 32 renders the procedure to be of no use to the patient.[5] The incidence of post-operative infection increases markedly from 0.37 percent in normal weight to 4.44 percent in the obese.[6] Anthropometric status can influence the lower limb joint range of motion. Hence, the purpose of the present study is to establish the body mass index related effects on the range of motion of the knee joints for both males and females in young adults from North India.

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2. Aims and Objectives

1. To estimate the body mass index from height and weight measurement.
2. To measure the range of motion of knee joints of both sides.
3. To correlate the effects of body mass index on the range of motion of knee joint.

3. Material and Methods

The present study, a cross-sectional study, consisted of 235 subjects consisting of 108 males and 127 females, in the age group of 18-25 years, selected randomly from various schools of Sharda University. The place of study was Anatomy department of Sharda University, Uttar Pradesh, India. The research work was commenced after being approved by the Institutional Ethics Committee of School of medical sciences and research, Sharda University (Ref. No. SU/SMS&R/76-A/ 2O21 / 12O). The participants recruited for the study signed an informed consent document and information sheet which discussed the methodology, aims and objectives of the study. Inclusion criteria were all healthy adults between 18 to 25 years of age of either sex, not falling in the category of exclusion criteria. All the subjects whose body mass index was less than 19kg/ m2, any neurologic and chronic conditions of lower limbs, leg length disparity, acute injury or surgery within 6 months of data collection were excluded from the study.

3.1. Methodology

Based on the BMI subjects were divided into three groups of normal (19-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (≥30 kg/m^2).[7] All the measurements were performed bilaterally on the subjects at the same time by a single observer. Weight of the subject was measured in light clothes and without shoes using standard apparatus, which read to the nearest 0.1 kg. The height of the subject was measured barefoot approximating to half a centimeter. Joint range of motion measurement was done by 180 degree system and was taken at both the knee joints by a standard universal goniometer.[8] he 180 degree system identifies the anatomical position as 0 degrees and movement away from anatomical position is described in degrees between 0 to 180 degrees. In the starting position (Figure 1), with the subject in prone position, fulcrum of goniometer was placed on the lateral epicondyle of femur. The stationary arm of goniometer was aligned along a line from lateral epicondyle to greater trochanter of femur and distal arm along a line from lateral epicondyle of femur to lateral malleolus of fibula. The joint was moved through full range of flexion without assistance and the recording was done in final end position with goniometer. (Figure 2)

3.2. Statistical analysis

The data of the three groups was subjected to standard descriptive statistics (mean ± standard deviation) for the BMI and knee joint range of motion. Gender difference and bilateral differences were tabulated and calculated for difference (p<0.05) by the paired student t test which was applied for the comparison of data among the North Indian normal, overweight and obese subjects. One way ANOVA analysis was done for multiple comparisons between the subject groups using a significance level of 0.05 (SPSS version 22). The indicator of statistical significance was adjudged to be a 5% level of probability.

4. Observation and Results

The number of subjects in the three groups consisted of 150 normal, 56 overweight and 29 were obese. Out of 235 subjects, 63.2% were normal, 24% overweight while 12% were found to be obese. The mean value and standard deviation of BMI (kg/m^2) in the normal,.28 and 33.79±2.14 respectively. Table 1 shows gender wise comparison of mean values of BMI in the three groups of normal, overweight and obese subjects. The mean value of BMI in males and females of normal group was 23.17±1.18 and 22.89±1.53 respectively. The mean and standard deviation in overweight males and females was 27.17±1.42 and 26.77±1.19, while in obese males and females, the values were 34.07±1.38 and 33.61±2.52 respectively.The mean values of BMI in three group of normal, overweight and obese subjects did not show any statistically significant gender difference when The mean and standard deviation of left and right knee joint flexion range of motion (ROM)was noted as 132.91±4.32° and 132.76±4.08° respectively (Table 2). The average left and right knee flexion range of motion in overweight°±11.71° and 120.94°±11.91±°(Table 2) of bilateral mean values of knee flexion with BMI did not exhibit significant difference (p>0.05) in overweight subjects.The knee joint flexion range of motion in obese on the left side was found to be 110.24°±12.43° w109.55°±12.00°.he values of knee flexion ROM on the left and right side were not statistically significant (p>0.05).The one way ANOVA.

5. Discussion

A study of 612 subjects (56.2 percent females and 43.79 percent males) in the age group of 18-21 years, in seven districts of India, revealed 61.74 percent to be of normal weight, which was similar to the present study.[9] About 12.35 percent were reported as overweight and 2.90 percent were classified as obese, which was not in agreement with the present study which reported a much higher percentage of overweight and obese. The possible reason for such a difference could be due to the fact that the sample size in the current study was comparatively smaller. In the

Table 1: Gender wise mean value of BMI in the three groups.

Variable (Number)		Sex (Number)	Mean	Standard Deviation (SD)	t-test	Two tailed P-value	
BMI	Normal (N=150)	Male (66)	23.17	1.18	1.282	0.202	NOT sig
		Female (84)	22.89	1.53			
	Over Weight (N=56)	Male (24)	27.17	1.42	1.153	0.254	NOT sig
		Female (32)	26.77	1.19			
	Obese (N=29)	Male (18)	34.07	1.38	0.549	0.588	NOT sig
		Female (11)	33.61	2.52			

BMI = Body mass index.
Not sig= Not significant.

Table 2: Comparison of knee flexion range of motion (degrees) in three groups

Groups	Normal (Mean ±SD)	Over Weight (Mean ±SD)	Obese (Mean ±SD)
Left Knee Flexion	132.91±4.32°	121.85±11.73°	110.24±12.43
Right Knee Flexion	132.76±4.08°	121.44±11.99°	109.55±12.00°

SD=Standard deviation

Fig. 1: Starting position of knee joint measurement in prone position

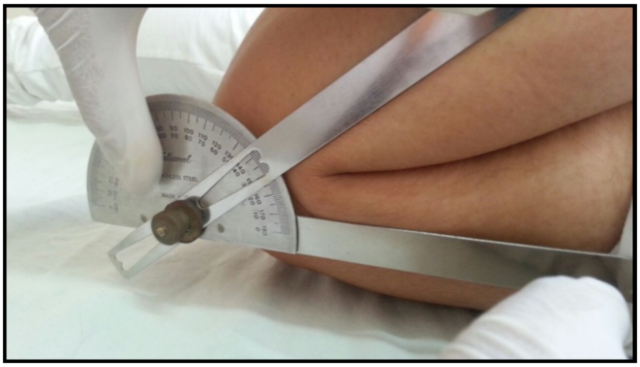

Fig. 2: End position of knee joint measurement in prone position

present study, the magnitude of ROM of knee flexion on the right and left side was found to be consistently similar with no bilateral statistically significant difference (p>0.05) observed in the normal, overweight or obese groups which has been supported earlier by Vinay et al from their evaluation of subjects in the age group of 6 to 80 years.[10]

Asbjorn and Schwarze found range of motion (ROM) on the both the sides as similar in all age groups.[11,12] So it was concluded that a subject's healthy limb ROM could be used for comparison with the affected side in the presence of a disease or a lesion.

The values of knee flexion ROM in the prone position in the normal subjects was found to be 132.76°±4.08 (Table 2) which were quite similar to that obtained by Norkin.[13] The ROM in the prone position was presumably lessened by the passive insufficiency of the rectus femoris and active insufficiency of the hamstrings, as the knee cannot complete the full ROM. The values of knee flexion ROM in the present study were lower than that obtained by Dutta who observed a higher ROM for the knee joint flexion (140° to160°), in the population of Calcutta, supposedly due to squatting. Frankel and Cochran have also reported a higher value of ROM of knee joint flexion in comparison to the present study, but the position of the body during measurement has not been specified by them.[14,15] Researchers have further reported that the ROM of knee joint decreases with advancing age, with a more marked decline in the second and third decade.[16] Decreased ROM accepted as a normal part of ageing was ascribed to the increased rigidity of connective tissue particularly in and around the muscles and tendons, in unison with the mechanical stresses imposed on the body through vocational, recreational and daily activities. Analysis of gait parameters of obese women of South America by Silva-Hamu also supported the negative impact of increased body mass on the knee joint but a higher knee joint flexion in the terminal swing observed by them could probably be ascribed to the increased mass which is directly proportional to the moment of inertia of the knee flexor muscles (Semitendinosus, Semimembranosus, Biceps femoris) which increase their action, thus increasing the range of flexion in knees in the terminal swing phase.[17] Overweight and obese group showed a statistically signjficant decrease in knee flexion ROM as compared to normal group (Table 2). The reduction in ROM of knee joint observed in the present study was similar to reduction in ROM amounting to 11.1 percent for the right knee joint flexion in obese male individuals by Parker et al.[18] The reduction of the range of motion was ascribed to the excess adipose tissue which could interfere with smooth inter segmental rotations of the joints. (Hills et al 2002).[19]

A decrease of as much as twelve percent in knee joint flexion ROM during the stance phase of gait cycle in obese individuals has been reported by DeVita and Hortobagyi.[20] The decreased ROM could be due to less pressure in the knee but it leads to less quadriceps activity and a larger excursion of the center of mass (COM) displacement which is responsible for the increase in the metabolic cost of the walking.[21] A decreased knee joint flexion ROM as obtained in the present study was corroborated by a study of the lower limb coordination pattern in obese subjects from Rome by Ranavolo et al which was thought to be due to the excess weight of the limbs which exerts an extra load for the muscles involved.[22] Reduction in the joint ROM may be due to the presence of extra fat in the thigh and calf which mechanically interferes with the intersegmental rotation to counteract the antigravity action of knee flexors. The present study showed no statistically significant gender difference (p>0.05) in the values of knee joint flexion range of motion within the three groups.

6. Limitations of Study

One of the limitation in the present methodology was in placing the fulcrum of goniometer over the axis of motion which has to be adjusted during movement of joint, during which a minor error can occur in measurement of range of motion. Also only the active range of motion was measured where the subject moves the joint without assistance. The present study involved less number of subjects from one region and of a single race. Also individuals with BMI less than19kg/m^2, leg length discrepancy and individuals with surgery or injury who were not included in present study may be included in further studies.

7. Conclusion

The results of the study can be beneficial in charting out preventive and rehabilitative programmes in order to improve the physical capabilities and performance of obese individuals. Weight loss combined with strength and balance training may prove to be the most effective intervention in the long run, which can be a new area of future research to determine the effects of different levels of weight loss and its effect on the various body attributes.

8. Source of Funding

None.

9. Conflicts of Interest

There is no conflict of interest.

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