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Variation of Range of Joint Motion in Bengalee (Indian) Healthy Adult Subjects

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ABSTRACT The present investigation was made to find out the effect of age and sex on Range of Motion (ROM) and gradation of ROM among healthy adults. A total number of 353 subjects (180 male and 173 female) having the age range of 19-60 years were selected at random from Bengali population of different districts of West Bengal for the study. The subjects were further classified into age and sex groups. A digital goniometer was used for the study. The results showed that there was no significant difference of ROM between right and left side of the body of both sexes' subjects. There was a significant difference of ROM among different age groups ($p<0.05$, $p<0.001$). In most of the body joint angles, a gradual decrease of ROM was observed with advancement of the age. According to the computed norms for each ROM, most of the subjects belonged to "C" grade (that is,'average') for both sexes. It can be concluded that gender wise difference in ROM may be attributed to the difference in activity level. Age related decrement of ROM may be related to the reduced flexibility of the body in older age and may be a helpful guide for designing different workstations.

INTRODUCTION

Two important biomechanical properties of the intact musculoskeletal system are joint mobility and muscle strength. Joint mobility or range of motion is important in several ways. For example, in designing a vehicle door opening, the expected population's ability to flex the knees, hips and neck is as critical as the size of the population (Andreoni et al. 2004).

Range-Of-Motion (ROM) is the natural distance and direction of movement of a joint. Limited range of motion is a relative term indicating that a specific joint or body part cannot move through its normal and full range of motion.

Evaluating the range and patterns of movement is a key concern for a clinician in the diagnostic and functional assessment of patients with musculoskeletal disease. These (ROM) measures are also used to obtain a record of the degree of permanent impairment of an individual (Lowery et al. 1992; American Medical Association 1993).

Currently, clinicians use all or any of visual estimation, a universal goniometer, an inclinometer or a tape measure to make these assessments. Patients are followed over a long period of time for many diseases, particularly chronic diseases such as ankylosing spondylitis (Dziedzic 1998). It is important, therefore, to ensure the reliability of measurement of ROM for clinical purpose (Shrout 1998).

The evidence from a systematic review for cervical spine ROM demonstrates that either these tools lack reliability or their reliability is unproven, studies purporting to assess their reliability often containing major flaws in design or analysis (Jordan 2000).

Measurements of the range of motion of joints commonly are recorded in a patient's medical record, as they are considered to be acceptable clinical data for the evaluation of physical movement impairment (Pynsent 1993). Operative intervention frequently is necessary for the treatment of fracture, dislocation, traumatic injury, or other impairment of or about a joint, and the functional outcome of the treated extremity must be evaluated critically.

Goniometric method is the standard technique for measurement of joint motions in different rotations including saggital, frontal, transversal and rotational (SFTR) (Gerhardt and Rondinelli (2001). Goniometey has been described as a tool to measure angle. It gives the physician a useful method to diagnose musculoskeletal function in terms of ROM, monitor the progress of an intervention, record the data

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for future follow-up, and meet statutory and legal requirements for impairment rating and disability determinations where applicable (Gogia et al.1987; Anouchi et al.1996). Range of motion (ROM) of the joint is one of the factors that determine function of the musculoskeletal system.

A number of reports have provided estimates of the normal ranges of motion of joints of the upper extremity (Ahlberg 1988; American Academy of Orthopaedic Surgeons 1965). Some of these reports did not describe the population distribution or left/right etc. that was surveyed or specify the method of measurement that was used. As it often has been assumed that there is no important difference between the ranges of motion on the right and left sides, the uninvolved limb has been used routinely for comparison with the affected limb in the presence of disease or other lesions (Gajdosik and Bohannon 1987; Spilman and Pinkston 1969). Much of the available data regarding side-related changes in the range of motion have been derived from studies in which the size of the sample was too small to demonstrate a difference between the sides (Palmer et al. 1985; Boone 1978).

Inflammatory as well as mechanical insults to joints can cause restriction of joint motion. Early detection of restriction of joint motions in disease states requires that the normal range of joint motions be known. The key to effective therapy, in these conditions, is largely dependant on the knowledge and understanding of normal and abnormal range of joint motions which vary with the patient's age and gender as well as the applied technique of measuring the joint motion (Allander et al. 1974; Russe and Gerhardt 1975).

The normative data of ROM for Bengalee (Indian) population was lacking in the literature. Its variation with different parameters was not comprehensively studied. The present study was performed to check the age and sex variation of ROM charecteristics of selected Bengalee population.

Various studies determined the normal range of joint motion of a large group of patients with diverse socio-economic and ethnic background (Ahlberg et al. 1988; Dvorak et al. 1992) and varying degree of routine daily activities (Batti'e et al. 1987; Russe and Gerhardt 1975). Indian requirement is not met with the available data sources, which are not taken from Indian population; this study objective is set to provide a data base specific to Bengal population to see the trend of joint movement ranges that follows age and sex differences.

METHODOLOGY

The study was conducted in twelve different locations of different districts, viz., West Midnapore, East Midnapore, Bankura and Howrah of west Bengal. . The present study was approved by the institutional human ethical committee. All subjects volunteer for the study and consent was taken from all the subjects before conducting the experiments.

The present study was conducted on 353 subjects. Among them 180 were male and 173 were female subjects having the age range 19-60 years. The total age group was further classified in to four age groups, that is, 19-30 years, 31-40 years, 41-50 and 51-60 years. The study was approved by the Institutional Human Ethical committee.

The ROM at different joint angles was measured by a digital goniometer. The following measures were taken –

Figures 1 and 2. Flexion was recorded as the maximal movement of the forearm from neutral towards the humerus. Extension was the return of the forearm from the fully flexed position to neutral.

Figure 3. Hip extension was recorded as the maximum upward movement of the femur from the neutral position.

Figure 4. Adduction was recorded as the return of the shoulder from full abduction

Figure 5. Ankle dorsiflexion was recorded as the maximum movement of the footupward from the neutral position.

Figure 6. Flexion was recorded as the maximal forward and upward movement of the arm from the neutral position.

Figure 7. Extension was recorded as the maximal backward and upward movement of the arm from zero.

Figure 8. Abduction was recorded as the maximal movement of the arm in the coronal plane from neutral.

Figures 9 and 11. Knee flexion was recorded as the movement of the lower leg from the neutral position to a position in which the lower leg and heel were maximally drawn towards the buttocks.

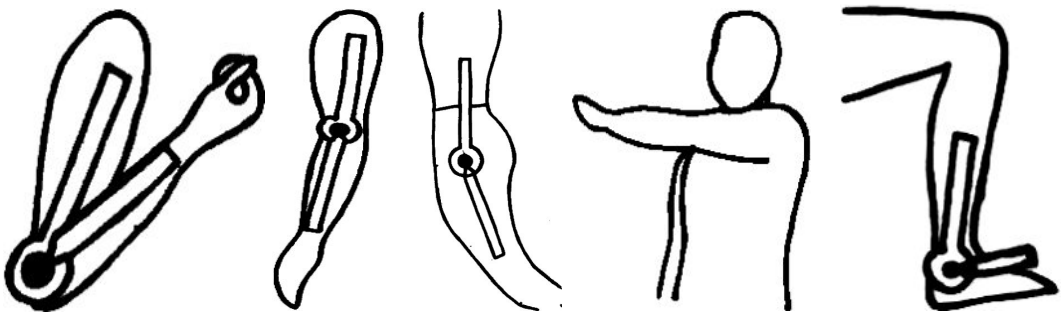


Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5.

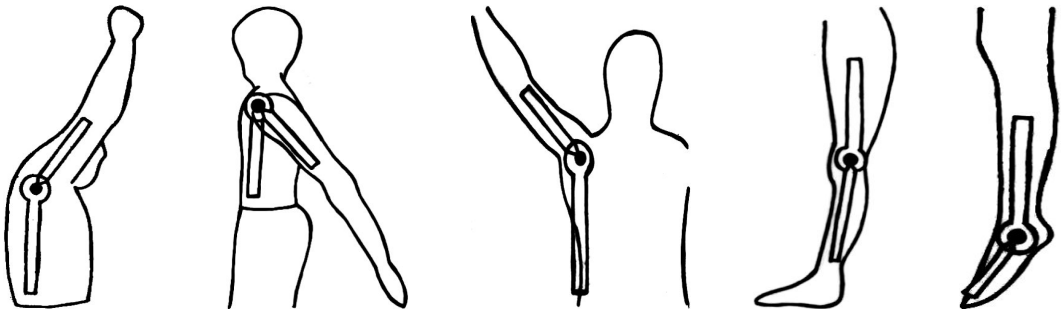
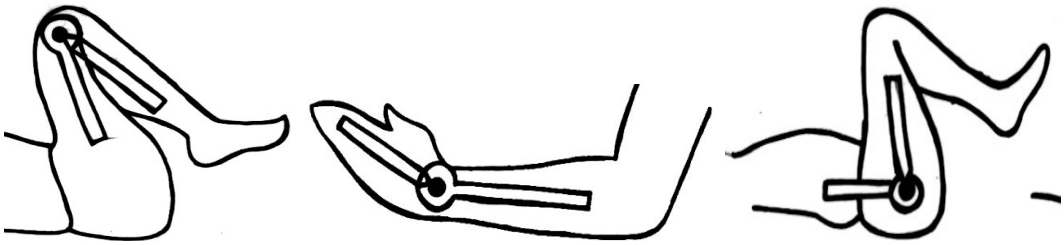


Fig. 6. Fig. 7. Fig. 8. Fig. 9. Fig. 10.



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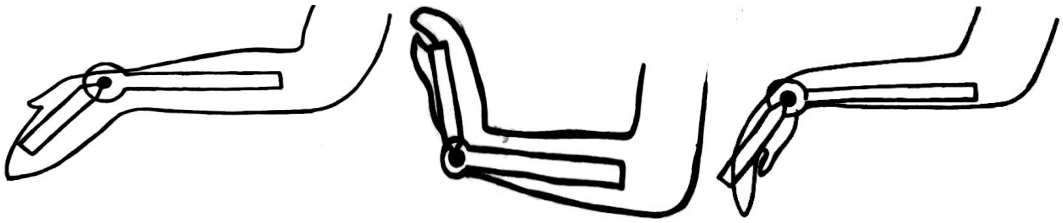

Fig. 14. Fig. 15. Fig. 16.

Fig. 1-16. Range of Joint Motion (ROM) measured at different joint angles

Figure 10. Ankle planter flexion was recorded as the maximum movement of the foot downward from the neutral position.

Figure 12. Radial deviation was recorded as the movement from neutral to a position in which the hand was maximally directed towards the inside.

Figure 13. Hip flexion was recorded as the maximal movement of the femur toward the chest from the neutral position.

Figure 14. Ulnar deviation was recorded as the movement from neutral to a position in which the hand was maximally directed towards the outside.

Table 1: Comparison of Range of Motion (ROM) at elbow joint between male (n=180) and female (n=173) subjects

Body side	*Elbow joint (Degree)*					
	Male			*Female*		
	Extension	*Flexion*	*ROM*	*Extension*	*Flexion*	*ROM*
Right Side	174.3±2.98	47.9±4.75	**126.3±4.56**	175.5±2.11 ***	43.5±7.09 ***	**131.9±7.79** ***
Left Side	174.0±2.43	47.3±4.8	**126.7±4.34**	175.5±2.04 ***	43.5±7.20 ***	**132 ±7.83** ***

w.r.t. male*** $p<0.001$

Figure 15. Wrist flexion was recorded as the movement of the wrist from the neutral position to a position of full flexion.

Figure 16. Wrist extension was recorded as the movement from the neutral position to full extension with the palm of the hand facing forward.

Data were summarized into mean and standard deviation values using Microsoft Excel. The effect of gender, age and side of the body on Range of Motion was determined by studying the level of significance between two group means after performing t-tests as well as by using one way ANOVA.

Different software packages were used during those analyses.

After measuring the ROM values of different joint angels, an attempt was made to find out a norm for grading the ROM for the studied population. Grading of scores was made by computing T-scores. (Jhonson and Nelson 1986) by the following steps:

i. At first T score of the individual scores were calculated by standard T score computation procedure.
ii. The computed T-scores was converted into absolute T-scores.
iii. After that percentage of the T-scores was calculated by the following formula and the percentage was converted into absolute percentage.

% of T-score = [(Any T-score/ Highest value of T-score)* 100]

The following guidelines were used to find the norms of the scores, which was designed as A, B, C…etc. The lowest 10% of the scores could be assigned as 'A', the next 20% as 'B', the next 40% as 'C', the next 20% as 'D' and the highest 10% as 'E'. The assigned codes A, B, C, D and E (respectively) represented the degree of Range of Motion (ROM), that is, A- Excellent, B- Good, C- Average, D-Poor and E- Very Poor (Fabricius 1967).

RESULTS

The results depicted that there was a distinct gender difference in range of motion all body joints studied. A significant difference in the magnitude of the ROM at different joints was observed ($p<0.05$ or above) between male and female subjects. The females showed significantly higher range of motion (ROM) at elbow, hip, knee and ankle joints in left and right side of the body than that of their male counterpart (Table 1, Table 4, Table 5, and Table 6). However, the males had significantly higher ROM at wrist and shoulder joint angle than that of the female subjects (Table 2 and Table 3) in either side of the body.

Table 2: Comparison of Range of Motion (ROM) at wrist joint between male (n=180) and female (n=173) subjects

Body side	*Wrist joint (Degree)*	*Gender*	
		Male	*Female*
Right Side			
	Extension	232.2±5.75	223.7±14.3 ***
	Flexion	121.3±6.05	125.4±10.9 ***
	ROM	**110.9±7.24**	**98.3 ±21.5** ***
	Radial deviation	148.8±6.18	151.7±8.85 ***
	Ulnar deviation	214.0±9.01	214.2±9.66
	ROM	**65.3 ±9.45**	**62.5 ±14.1** **
Left Side			
	Extension	232.2±5.21	224.3±15.4 ***
	Flexion	121.0±5.26	124.3±11.3 ***
	ROM	**115.2±7.14**	**99.9 ±23.4** ***
	Radial deviation	148.3±5.20	151.5±9.81 ***
	Ulnar deviation	214.9±5.22	214.3±9.33
	ROM	**66.6 ±6.39**	**62.8 ±14.8** **

w.r.t. male*** $p<0.001$ ** $p<0.05$

No significant difference in range of motions was observed between right and left side of most of the joints of the body. However, in case of shoulder joint, a significant difference in hyperextension and flexion was observed ($p<0.05$) between right and left side of the body.

The male and female subjects had a significant difference ($p<0.001$) in the magnitude be-

Table 3: Comparison of Range of Motion (ROM) at shoulder joint between male (n=180) and female (n=173) subjects

Body side	*Shoulder joint (Degree)*	*Gender*	
		Male	*Female*
Right Side			
	Hyper extension	174.4±2.39	175.8±2.95 ***
	Flexion	24.9 ±3.01	35.8 ±6.74 ***
	ROM	**149.5±3.09**	**140.0±8.04** ***
	Adduction	76.2 ±4.13	70.5 ±10.4 ***
	Abduction	113.1±5.82	108.4±7.07 ***
	ROM	**37.0 ±6.34**	**37.9 ±13.1 NS**
Left Side			
	Hyper extension	174.4±2.04	175.7±3.15 ***
	Flexion	23.9 ±2.72	35.3 ±6.87 ***
	ROM	**150.9±2.91**	**140.4±7.73** ***
	Adduction	75.9 ±3.48	70.4 ±11.5 ***
	Abduction	113.2±5.79	108.6±6.85 ***
	ROM	**37.4 ±6.45**	**38.2 ±14.0 NS**

w.r.t male *** p<0.001 NS=Not significant

Table 4: Comparison of Range of Motion (ROM) at hip joint between male (n=180) and female (n=173) subjects

Body side	*Hip joint (Degree)*	*Gender*	
		Male	*Female*
Right Side			
	Hyper extension	210.1±5.31	208.9±9.59
	Flexion	152.6±12.3	137.1±10.5 ***
	ROM	**57.5±14.1**	**71.8±14.7** ***
Left Side			
	Hyper extension	210.0±4.63	209.4±8.64
	Flexion	151.0±9.68	136.1±10.3 ***
	ROM	**59.0±10.8**	**73.4±13.7** ***

w.r.t. male *** p<0.001

tween extensions and flexions. Such difference was also noted in the subjects with the advancement of the age (p<0.001, p<0.05).

The selected subjects were divided into four age groups, for example, 19-30 years, 31-40 years, 41-50 years, and 51-60 years to find age

Table 5: Comparison of Range of Motion (ROM) at knee joint between male (n=180) and female (n=173) subjects

Body side	*Knee joint (Degree)*	*Gender*	
		Male	*Female*
Right Side			
	Extension	174.2±2.67	176.0±2.01 ***
	Flexion	63.4 ±7.21	54.3 ±7.00 ***
	ROM	**110.7±7.40**	**121.7±7.37** ***
Left Side			
	Extension	173.9±2.28	175.8±2.18 ***
	Flexion	62.8 ±7.01	54.8 ±7.15 ***
	ROM	**111.2±7.14**	**121.1±1.65** ***

w.r.t. male *** p<0.001

Table 6: comparison of Range of Motion (ROM) at ankle joint between male (n=180) and all female (n=173) subjects

Body side	*Ankle joint (Degree)*	*Gender*	
		Male	*Female*
Right Side			
	Planti flexion	136.9±5.87	136.9±7.95
	Dorsi Flexion	82.3 ±6.46	75.9 ±5.50 ***
	ROM	**54.7 ±7.65**	**61.0 ±9.93** ***
Left Side			
	Planti flexion	136.4±5.16	138.0±7.77 **
	Dorsi flexion	81.7 ±6.23	76.3 ±4.98 ***
	ROM	**54.7 ±7.35**	**61.7 ±9.48** ***

w.r.t. male *** p<0.001 **p<0.05

related changes. A significant difference in ROM was observed (p<0.01 and above) among four age groups. In case of elbow joint, lower ROM values were observed in higher age groups for the subjects of both sexes in comparison to lower age groups. Similar result was observed at wrist joint for the subjects of both sexes excluding ulnar and radial deviation. In this joint lower value of ROM was found in case of the age group of 19-30 years for male subjects (Table 7 and Table 8). In shoulder joint, lower values were

Table 7: Age wise comparison of Range of Motion (Degrees) at elbow joint among three age groups of male and female subjects

Gender	*Elbow joint (Degree)*	*Right side*				*Left side*			
		Age groups (years)				*Age groups (years)*			
		19-30	*31-40*	*41-50*	*51-60*	*19-30*	*31-40*	*41-50*	*51-60*
Male	Extension	174.2±3.26	172.9±3.58	174.4±2.54	175.3±1.85	173.9±2.60	173.3±2.63	173.2±2.21	175.3±1.52
	Flexion	46.7±3.81	45.0 ±4.46	46.5 ±4.26	52.1 ±2.98	45.9 ±3.19	44.3 ±3.90	44.8 ±4.49	52.3 ±2.25
	ROM	127.5±4.69	127.9±3.77	127.9±4.30	**123.3±3.70**	128.0±3.64	128.9±3.65	128.4±4.55	**123.0±2.72**
	F value	**15.33****	**30.24****						
Female	Extension	176.1±2.05	176.0±2.26	175.7±2.27	174.4±1.4	176.1±2.22	176.3±2.03	175.6±1.83	174.3±1.42
	Flexion	39.6±8.14	43.7 ±4.87	43.4 ±6.62	47.8 ±4.47	39.3 ±8.01	43.5 ±5.08	42.8 ±6.32	48.5 ±4.35
	ROM	136.5±8.59	132.4±5.79	132.3±6.99	**126.6±4.50**	136.7±8.35	132.8±5.98	132.8±6.30	**125.8±4.51**
	F value	**19.13****	**25.12****						

*** p<0.001

Table 8: Age wise comparison of Range of Motion (Degrees) at wrist joint among three age groups of male and female subjects

Gender	*Wrist joint (Degree)*	*Right side*				*Left side*			
		Age groups (years)				*Age groups (years)*			
		19-30	*31-40*	*41-50*	*51-60*	*19-30*	*31-40*	*41-50*	*51-60*
Male	Extension	232.7± 6.32	232.4± 6.64	234.0± 4.36	230.4±4.82	232.6± 7.39	232.4± 4.88	233.4± 3.45	230.9±3.80
	Flexion	121.4± 7.57	120.5± 6.62	121.7± 4.14	121.6±5.13	120.9± 6.17	120.4± 6.09	120.8± 4.27	121.8±4.19
	ROM	111.3±10.2	111.9± 7.77	112.3± 3.71	**108.8±4.64**	111.7±10.6	112.1± 7.04	112.5± 4.15	**109.1±4.06**
	F value	**2.33NS**	**2.27NS**						
	Ulnar Deviation	214.4±15.5	214.8± 5.69	214.9± 4.88	212.7±4.63	215.6± 6.25	216 ± 5.51	215.2± 5.04	213.4±3.52
	Radial Deviation	153.4± 5.76	148.8± 5.91	147.2± 4.74	145.8±5.24	151.4± 6.00	148.9± 3.97	147.6± 4.15	145.5±4.42
	ROM	**62.5± 8.20**	66.0± 5.51	67.7± 4.91	66.9±4.19	**64.3± 9.53**	67.1± 5.13	67.5± 4.93	67.9±3.75
	F value	**6.65*****	**3.30****						
Female	Extension	228.5±11.1	229.6±11.1	234 ±10.1	207.3±4.84	229.2±13.4	231.2±10.0	234.1±13.3	207.8±5.48
	Flexion	123.6± 8.60	119.6±11.6	119.6± 9.03	134.8±7.65	120.0± 8.40	120.4±12.3	120.3±10.3	134.1±7.80
	ROM	104.9±12.1	110.0±19.1	114.4±14.4	**72.5±9.20**	109.1±18.1	110.8±19.0	113.8±17.4	**73.7±9.64**
	F value	**95.29*****	**65.33*****						
	Ulnar Deviation	216 ± 6.78	217.2±13.0	218.210.6	207.5±5.50	215.2± 7.24	218.9±11.8	218.5± 9.53	207.8±5.61
	Radial Deviation	157.4± 6.97	144.0± 9.59	148.6± 7.58	151.7±7.01	156.1± 6.89	144.3± 8.91	147.5± 9.27	153.5±10.2
	ROM	58.6± 9.61	73.2±18.9	69.6 ±14.3	**55.7±8.75**	59.1± 9.96	74.6 ±17.0	71 ±14.5	**54.4±11.2**
	F value	**17.83*****	**22.42*****						

** p<0.05 *** p<0.001

observed in the age group of 19-30 years among the male subjects. But in case of females lower ROM values were observed in higher age groups. In hip joint, lower values of ROM was observed in the age group of 41-50 years for the male subjects but for female subjects lower values of ROM was observed at lower age groups. In knee joint, lower values of ROM was observed at lower age groups in case of male subjects but in case of females lower ROM values were observed at higher age groups. In ankle joint, lower ROM values were observed at higher age groups.

However, no definite pattern of change in ROM was observed with the variation of age. It showed different pattern of age specific changes in male and female subjects.

In case of shoulder joint angle (Table 9) the male subjects exhibited lower values of ROM in lower age groups than that of the subjects of higher age groups. However, in case of female higher ROM values was observed in upper age groups

Results depicted from Table 10 that in case of hip joint the ROM was lowest in upper age group (41-50 years) in male subjects. But in case of female the ROM showed the lowest value in lower age group (19-30 years). In case of knee joint an opposite trend of results was noted (Table 11). The male subjects had the lowest value in the age group of 19-30 years and in females it was in the upper age group (51-60 years). In case of ankle joint (Table 12) the ROM was the lowest in higher age groups (41-50 year and 51-60 years) in both the sexes.

It may be summarized that the magnitude of ROM at most of the joints was decreased in the subjects of higher age group, although in some of the body joints, for example, shoulder, and knee in males and hip in females, the lowest value of ROM was found in the subjects of younger age group.

The range of motion of all body joints was divided into five grades. As the magnitude of ROM between male and female was different the norms of the grades were different in two sexes. It was noted from the gradation of Range of Scores (Table 13 to Table 16) that the most of the subjects belonged to Grade C, that is, average category.

DISCUSSION

The ability to perform functional tasks is closely related to the available motion of joints (Nicol 1989). Despite the significant functional deficits, the literature on the functional range of motion is limited, especially in Indian population. The present study was designed to in-

Table 9:Age wise comparison of Range of Motion (Degrees) at shoulder joint among three age groups of male and female subjects

Gender	*Shoulder joint position (Degree)*	*Right side*				*Left side*			
		Age groups (years)				*Age groups (years)*			
		19-30	*31-40*	*41-50*	*51-60*	*19-30*	*31-40*	*41-50*	*51-60*
Male	Hyper extension	175.3±2.46	174.2±2.61	174.0±2.59	174.1±1.88	174.2±2.30	174.6±2.11	174.2±2.06	174.4±1.67
	Flexion	26.1±3.67	25.0±2.93	24.6 ±2.67	24.1±2.35	24.9±3.92	23.2±2.18	23.4±2.14	23.9±1.91
	ROM	**149.2±3.69**	149.1±3.31	149.5±3.00	150.0±2.35	**149.3±3.34**	151.4±2.95	150.8±2.57	150.5±2.38
	F value	**0.79NS**	**4.42****						
	Adduction	78 ±4.49	76.5±4.18	75.8 ±4.21	74.6±3.07	77.7±3.95	76.2±3.74	75.1±3.16	74.6±2.18
	Abduction	108.6±6.50	115.2±4.92	115.6±5.05	114.0±3.99	108.3±6.47	115.1±5.16	116.5±4.28	114.3±3.29
	ROM	**30.6±6.96**	38.7±4.86	39.8 ±4.36	39.4±3.55	**30.6±6.74**	38.8±5.22	41.4±4.30	39.7±3.07
	F value	**34.13*****	**41.02*****						
Female	Hyper extension	176.9±1.63	175.7±4.85	175.6±3.62	174.7±1.42	176.6±2.27	175.6±5.02	175.8±3.91	174.8±1.42
	Flexion	29.2±4.65	36.4±5.58	38.5 ±4.54	40.5±4.90	28.8±4.45	37.0±6.84	36.6±4.61	40.7±4.61
	ROM	147.7±4.80	139.3±8.55	137.2±5.62	**134.2±5.23**	147.8±4.01	138.6±8.53	139.2±5.56	**134.1±4.79**
	F value	**52.73*****	**57.33*****						
	Adduction	74.3±6.02	76.0±8.73	77.3 ±6.99	58.3±5.90	73.3±6.78	78.6±9.67	78.5±7.24	56.7±5.13
	Abduction	106.2±7.07	111.4±7.26	108.6±6.29	109.0±7.00	106.5±6.65	110.3±6.70	108.3±7.15	110.1±6.43
	ROM	31.9±9.99	35.4±11.9	**31.3 ±8.21**	50.8±10.4	33.2±10.2	31.8±12.9	**29.8±8.50**	53.4±9.00
	F value	**40.38*****	**57.27*****						

** p<0.05 *** p<0.001 NS=Not significant

Table 10: Age wise comparison of Range of Motion (Degrees) at hip joint among three age groups of male and female subjects

Gender	*Hip joint position (Degree)*	*Right side*				*Left side*			
		Age groups (years)				*Age groups (years)*			
		19-30	*31-40*	*41-50*	*51-60*	*19-30*	*31-40*	*41-50*	*51-60*
Male	Hyper Extension	212.7±5.98	210.2±5.64	210.6±4.19	207.8±3.44	211.0±5.41	210.9±4.19	210.4±3.57	208.5±3.80
	Flexion	142.0±7.72	158.2±17.9	159.9±5.31	153.0±4.08	139.9±8.00	154.9±9.73	158.6±4.46	153.0±3.09
	ROM	70.7±10.5	52.0±19.8	**50.7±5.21**	54.8±3.55	71.0±9.86	56.0± 11.2	**51.8±4.90**	55.5±3.11
	F value	**27.96*****	**49.35*****						
Female	Hyper Extension	209.67.68	210.413.9	211.310.4	205.46.99	209.77.42	211.310.9	211.99.77	206.16.58
	Flexion	142.211.0	136.511.9	136.511.4	132.44.90	140.911.2	137.610.6	135.010.8	130.64.39
	ROM	**67.513.9**	73.921.6	74.916.0	72.97.60	**68.713.3**	73.818.7	77.015.6	75.57.18
	F value	**2.56NS**	**3.59***						

*** p<0.001

Table 11: Age wise comparison of Range of Motion (Degrees) at knee joint among three age groups of male and female subjects

Gender	*Knee joint position (Degree)*	*Right side*				*Left side*			
		Age groups (years)				*Age groups (years)*			
		19-30	*31-40*	*41-50*	*51-60*	*19-30*	*31-40*	*41-50*	*51-60*
Male	Extension	174.8±2.82	173.2±2.82	174.3±2.48	174.5±2.36	173.9±3.23	173.2±2.04	174.0±1.74	174.6±1.50
	Flexion	69.9±7.69	59.2±6.35	58.7±4.82	64.0±3.35	69.5±7.64	59.0±5.66	56.9±3.53	63.4±2.95
	ROM	**104.8±8.30**	114.0±6.87	115.5±5.76	110.4±3.63	**104.4±7.87**	114.1±6.19	117.1±3.52	111.1±3.25
	F value	**23.73*****	**38.59*****						
Female	Extension	176.6±2.11	176.6±1.60	176.8±1.54	174.4±1.48	176.6±2.11	176.2±2.42	176.3±1.94	174.3±1.48
	Flexion	54.6±9.65	54.3±3.75	51.6±4.86	56.1±5.62	55.7±9.82	53.6±4.67	52.4±4.21	56.2±6.04
	ROM	121.9±9.86	122.3±3.98	125.2±5.13	**118.3±5.47**	120.9±10.2	122.7±4.68	124.0±5.03	**118.1±6.33**
	F value	**7.38*****	**5.20****						

*** p<0.001

Table 12: Age wise comparison of Range of Motion (Degrees) at ankle joint among three age groups of male and female subjects

Gender	*Ankle joint position (Degree)*	*Right side*				*Left side*			
		Age groups (years)				*Age groups (years)*			
		19-30	*31-40*	*41-50*	*51-60*	*19-30*	*31-40*	*41-50*	*51-60*
Male	Planti Flexion	138.4±7.83	136.9±5.36	135.4±4.38	136.7±4.92	137.9± 7.34	136.0±4.19	135.4±3.81	136.3±4.14
	Dorsi Flexion	76.6±6.14	81.9±5.22	83.5±4.21	86.6±4.94	75.5±5.08	81.6±5.03	82.9±4.11	86.4±4.28
	ROM	61.8±8.63	55.0±6.51	51.8±4.62	**50.1±3.51**	62.4±7.87	54.4±5.12	52.5±4.26	**49.8±3.91**
	F value	**33.96*****	**45.89*****						
Female	Planti Flexion	134.6±7.37	140.8±7.18	133.5±9.81	140.0±4.99	135.7±8.85	140.8±6.39	136.3±8.87	140.4±4.69
	Dorsi Flexion	74.9±5.39	77.3±4.56	79.8±3.71	73.3±5.45	75.4±5.08	76.4±4.14	80.4±3.04	74.1±4.74
	ROM	59.8±8.92	63.5±8.10	**53.7±10.8**	66.7±7.05	60.3±9.75	64.4±7.95	**55.9±9.65**	66.3±6.87
	F value	**17.30*****	**11.94*****						

*** $p<0.001$

Table 13: Gradation of Range of Motion of male subjects (n=180)

Body Joint Angles	*Mean±SD*	*Grade*				
		A	*B*	*C*	*D*	*E*
Elbow	126.0 ± 4.56	159-167	143-158	110-142	94-109	85- 93
Extension and flexion of wrist	111.0 ± 7.24	164-176	138-163	86-137	60- 85	46- 59
Radial and ulnar of wrist	65.28± 9.45	134-150	100-133	32- 99	0- 31	0
Hyper extension and flexion of shoulder	149.48± 3.09	172-177	161-171	139-160	128-138	121-127
Adduction and abduction of shoulder	37.00± 6.34	83- 94	60- 82	15- 59	0- 14	0
Hyper extension and flexion of hip	57.49±14.06	160-184	110-159	8-109	0- 7	0
Hyper extension and flexion of knee	110.74± 7.40	165-177	138-164	85-137	57- 84	43- 56
Planti flexion and dorsi flexion of ankle	54.66± 7.65	111-123	83-110	28- 82	0- 27	0

A=Excellent B=Good C=Average D=Poor E=Very poor

Table 14: Gradation of Range of Motion of female subjects (n=173)

Body joint angles	*Mean±SD*	*Grade*				
		A	*B*	*C*	*D*	*E*
Elbow	131.99± 7.79	187-200	160-186	106-159	79-105	66-78
Extension and flexion of wrist	98.28±21.55	251-286	176-250	27-175	0- 26	0
Radial and ulnar of wrist	62.51±14.09	163-185	113-162	16-112	0- 15	0
Hyper extension and flexion of shoulder	140.03± 8.04	197-210	169-196	114-168	85-113	71-84
Adduction and abduction of shoulder	37.88±13.09	131-152	85-130	0- 84	0	0
Hyper extension and flexion of hip	71.75±14.66	176-199	125-175	23-124	0- 22	0
Hyper extension and flexion of knee	121.65± 7.37	174-186	148-173	97-147	72- 96	59-71
Planti flexion and dorsi flexion of ankle	61.02± 9.93	132-147	97-131	28- 90	0- 27	0

A=Excellent B=Good C=Average D=Poor E=Very poor

Table 15: Percentage distribution of grade for Range of Motion of male subjects (n=180)

Body joint angles	*Grade*				
	A	*B*	*C*	*D*	*E*
Elbow	10.6%	19.4%	40.6%	19.4%	10%
Extension and flexion of wrist	10%	20%	40%	20%	10%
Radial and ulnar of wrist	10%	20%	40%	18.9%	0%
Hyper extension and flexion of shoulder	10.6%	20%	39.4%	20%	10%
Adduction and abduction of shoulder	10.6%	20%	39.4%	12.8%	0%
Hyper extension and flexion of hip	10%	20%	40%	3.33%	0%
Hyper extension and flexion of knee	10%	20%	40%	20.6%	9.4%
Planti flexion and dorsi flexion of ankle	10%	20.6%	39.4%	20%	0%
Average	11.6%	20%	40.0%	16.9%	4.9%

A=Excellent B=Good C=Average D=Poor E=Very poor

Table 16: Percentage distribution of grade for Range of Motion of female subjects (n=173)

Body joint angles	*Grade*				
	A	*B*	*C*	*D*	*E*
Elbow	10.4%	19.7%	40.5%	19.7%	9.83%
Extension and flexion of wrist	9.83%	20.2%	39.9%	7.51%	0%
Radial and ulnar of wrist	9.83%	19.7%	39.9%	6.94%	0%
Hyper extension and flexion of shoulder	9.83%	20.2%	39.9%	20.8%	9.25%
Adduction and abduction of shoulder	9.83%	20.2%	37.6%	0%	0%
Hyper extension and flexion of hip	9.83%	20.2%	39.9%	9.25%	0%
Hyper extension and flexion of knee	9.83%	20.2%	40.5%	19.7%	9.83%
Planti flexion and dorsi flexion of ankle	9.83%	20.2%	40.5%	16.2%	0%
Average	9.9%	20.1%	39.8%	12.5%	3.6%

A=Excellent B=Good C=Average D=Poor E=Very poor

vestigate the active range of joint motions in adult healthy Bengalee (Indian) population to provide a set of guide line for future reference. The results of the present study were consistent with some previously reported studies (Olsson 1953; Russe and Gerhardt 1975) but were in conflict with other reports (Batti'e et al. 1987; Allander 1974). The variation of results of present study with that of other studies might be due to the variation in population. The range of motion of joints so much depends upon the people living in different countries as well as their ages and sexes (Nemeith 1953; Olsson 1953). In addition to that it may vary with vocation and way of life (Olsson 1953; Shimada et al. 1986).

In the case of present study population, there was a significant difference of ROM between male and female subjects and the results showed that in most of the joints, female had significantly higher range of motion than that of their male counterpart and in some body joints the difference was opposite.

It was noted that at elbow, hip, knee, and ankle joints female had significantly higher range of motion than that of the male. A similar finding was also observed by Svenningsen et al. 1989. Considering peripheral joint motions, one study showed that the range of hip joint motions in women was higher than men (Svenningsen et al. 1989); however, in another study, no difference was observed (Allander 1974; Fairbank 1984). The results of the present study were in conformity with that of former study. In the present study at wrist and shoulder joints male had significantly higher range of motion than that of their female counterpart ($p<0.001$, $p<0.05$).

The values of ROM may be varying with the sex due to relatively different musculature at the shoulder, different hip breath and so on (deVries and Housh 1994). The results of some investigations agree that among elementary school age children, girls are superior to boys in flexibility (Kirchner and Glines 1957; Phillips 1955). It is likely that this difference exists at all ages and throughout adult life. In the present results the degree of flexibility was significantly greater in females than that of males. As we know that flexibility as a component of physical fitness is the ability to move the body and its parts through a wide range of motion (ROM) without undue strain to the articulations and muscle attachments (deVries and Housh 1994). So from the findings of the present study it can be stated that the sex variation of range of motion may be due to the significantly greater flexibilities among female subjects.

The present study showed that there was a gradual decrease of range of motion with increasing age at elbow, wrist, knee (in case of female) and ankle (in case of male) joints. A similar trend of results was also noted in the study of Russe and Gerhardt (1975). It was also observed from the present study that at shoulder, hip, Knee (in case of male), ankle (in case of female), the range of motion was higher at lower age groups. A progressive reduction of range of motion has been called limited Range of Motion. The limited range of motion was evident for most of the body joints with the advancement of age (Khalvat and Razavizadeh 2005) also reported similar observations.

The present study as well as those of other investigators (Russe and Gerhardt 1975) demonstrated a linear decrease in joint motions with increasing age. The inverse relationship between the increased age and decreased joint motion is mostly related to the vertebral columns (Dvorak et al. 1992; Einkauf et al. 1987; Lind et al. 1989;

Youdas et al. 1992). In peripheral joints, the reduced joint motility was most obvious in wrist, elbow, shoulder and knees joints (Khalvat and Razavizadeh 2005). The change of ROM with the age may relate to variation of flexibility. Dynamic flexibility apparently grows steadily poorer, from childhood on, with increasing age (Wright and Johns 1960). Some investigators noted age related decreases in flexibility of the head, shoulder, ankle and hip joints in males and females between the ages of forty-five and seventy-five years (Shephard and Berridge 1990). Evidence also shows that older adults have less flexibility than younger adults. The decrease in activity that characterizes aging is probably responsible for much of this loss. Loss of flexibility can contribute to postural problems such as lordosis, swayback, scoliosis, round shoulders and forward head position (Falls 1980; Londeree 1981).

The results of the present study were compared with the study of Leighton (1987) and it was observed that both male and female subjects of studied Bengalee population had lower average values of ROM than that of the other study. The percentage of variation between two studies was appreciably high in some of the cases. In male subjects the percentage differences of ROM scores between two studies were 24-9% for elbow joint, 35-10% for wrist joint, 38-34% for shoulder joint, 88-24% for hip joint, 37-6% for knee joint and 53-15% for ankle joint angles. In case of female subjects the percentage differences of ROM scores were, 26-2% for elbow joint, 80-15% for wrist joint, 49-31% for shoulder joint, 100-5% for hip joint, 83-15% for knee joint and 64-52% for ankle joint angles.

CONCLUSION

This research supports the hypothesis that Range of Motion as measured by movement of body joint angles was associated with the age and sex. It can be concluded from the results that there was a gradual decrease of Range of Motion with increasing age at elbow, wrist, knee (in case of female) and ankle (in case of male) joint angles. From the findings of the present study it can also be concluded that at elbow, hip, knee and ankle joint angles female had significantly higher range of motion than that of their male counter part.

Further research is needed for detailed study of Range of Motion in different age groups and in different occupations and other possible influencing factors.

RECOMMENDATIONS

The recorded database may be used in different organizations, offices, factories and so on to apply as ergonomic check points for workstation design and developing appropriate work posture, which may be relevant to the work method. The recorded database may also be used for personal selection, for example, sports specific selection of athletes, etc.

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