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Normal range of motion of hip and ankle in Indian population

Sudhir KUMAR[1], Renu SHARMA[2], Divesh GULATI[1], Ish K. DHAMMI[2], Aditya N. AGGARWAL[1]

[1]Department of Orthopaedics, University College of Medical Sciences, Delhi, India;
[2]Department of Orthopaedics, Guru Tegh Bahadur Hospital, Delhi, India

Objective: Most studies that determine the range of motion of joints of the lower limbs study the Western population. The Asian population differs significantly, as daily activities demand different sitting positions. Our study aimed to establish the normal values of hip and ankle range of motion in various age groups in the Indian population and the effect of various functional positions of the hip on range of motion.

Methods: Three hundred and twenty-six Indian subjects, between the ages of 1 month to 75 years, were randomly selected for measurement of the range of motion of the hip and ankle joint. Exclusion criteria included history of injury or disease related to the lower extremities. Changes with age in the arc of joint motion were studied. The influence of various functional positions of the lower limb on the range of motion of the hip and the effect of weight-bearing on the ankle joint range of motion were also analyzed.

Results: Hip range of motion differed in various positions. Hip rotations were significantly greater when measured with the knee in flexion in both the sitting and prone positions than in the supine position. The arc of hip rotation was highest in the prone position. A significant increase in the arc of ankle dorsiflexion was found in a weight-bearing (squatting) position. Age related reduction in movement was found mainly in the rotations of the hip and dorsiflexion of the ankle.

Conclusion: The data compiled in this study on the range of motion in the hip and ankle joint of the Indian population will be useful in the evaluation of patients with disorders of these joints, especially in the Indian and Asian population.

Key words: Indian; range of motion of the ankle; range of motion of the hip.

Most studies that determine the range of motion of various joints of the lower limb and the effect of age on arc of motion, have come from the Western population.[1-3] The Asian population differs significantly in its cultural habits and daily chores demand sitting cross-legged and squatting on the ground.[4] The few studies based on the Asian population have shown that hip external rotation and ankle dorsiflexion are significantly greater, compared to the Western population.[5,6] There is only one study comparing range of motion of the hip, knee and ankle in various positions in the Asian population is available in the published literature.[5] Few studies investigating ankle range of motion are available[2,3,6,7] and only one study focused on weight-bearing ankle dorsiflexion.[7]

Joint motion is known to vary with age and is generally more restricted in the elderly. The aim of our study was to establish the normal value of the range of motion for the ankle and hip in various age groups in the Indian population. We also studied the effect of various functional positions of hip on the measured range of motion, and the effect of squat weight-bearing on ankle dorsiflexion.

Correspondence: Aditya N. Aggarwal, MD. E-6, GTB Campus, Dilshad Garden, Delhi-110095, India.
Tel: +91-99 99657874 e-mail: dranaggarwal@hotmail.com

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Patients and methods

Three hundred and twenty-six subjects were selected randomly from visitors to the orthopedics clinic at a tertiary care hospital in Delhi, India. Selected subjects were free from apparent musculoskeletal or neurological disorders or trauma in the lower extremities, either at the time of examination or historically. All subjects gave informed consent for the study. In the case of infants and children, consent was obtained from a parent. Data collection was done by a single observer and range of motion was measured by a standard goniometer.

Arcs of passive range of hip and ankle motions, without exerting undue force, were measured in the basic planes, using an ordinary goniometer with long limbs. The principles recommended in the manual of American Academy of Orthopaedic Surgeons (1965)[1] were followed wherever applicable. Presuming that the range of motion of the left and right joints is consistently similar with a difference of only 5 degrees,[2,3] only the right side was measured.

Hip flexion was measured with the patient in the supine position. The hip was flexed towards the abdomen and held in this position by the subject or by an assistant if necessary. Hip flexion was measured in, (a) flexed, and (b) extended positions of the knee. The opposite hip was kept extended and stabilized by the examiner's hand placed on the pelvis. Hip abduction was measured in the supine position, (a) with the hip and knee extended and (b) in 90° of hip flexion and complete flexion of knee. Rotations of the hip were measured, (a) in the supine position with the hip and knee extended, (b) in the sitting position with the hip and knee flexed to 90° and the legs hanging over the edge of the table and, (c) in the prone position with the hips extended and knee flexed to 90° with the pelvis stabilized by the examiner's hand to prevent rotations. We did not include the measurement of arc of hip extension and adduction, as restriction of these movements is compatible with the functional oriental way of life.

Non-weight-bearing ankle range of motion was measured in the supine position with the knee flexed to 45°. Weight-bearing ankle dorsiflexion range was measured in the standing position. In addition, we measured and compared the range of ankle dorsiflexion in a weight-bearing squatting position with the patient gently leaning forward without lifting the heel. The long arms of the goniometer were placed along the long axis of the leg and the other along the foot. Ankle plantar flexion was assessed by measuring the angle between the leg and long axis of the foot with the patient standing on tiptoes.

All measurements were performed by a single observer and recorded to the nearest 5°.

Data were expressed as the mean and standard deviation. Student's t-test was used to ascertain the significance of differences between the mean values of two continuous variables. Pearson's correlation coefficient was used to evaluate the strength of association between two continuous variables.

Results

The mean range of motion of hip and ankle are given in Tables 1-3.

There were no significant differences in hip flexion when measured with the knee extended nor when measured with the knee in flexion ($p>0.05$). Similarly, hip abduction measured in both the flexed and extended positions showed no significant differences ($p>0.05$). Hip rotations were significantly greater when measured with the knee in flexion in both the sitting and prone positions than in supine position ($p<0.05$). The arc of hip rotation was greater when measured in the prone position, i.e. with hip extended than with the hip in a flexed position (sitting), the knee flexed to 90° in both the positions (Table 2). External rotation of the hip in a sitting position was greater than internal rotation in 254 cases (77.9%, n=326), less in 28 cases and equal in 44 cases. External hip rotation in the supine position was greater than the internal rotation in 231 cases

Table 1. Range of hip flexion and abduction (n=326).

Variable name	<1 yr. (n=32)	1-3 yrs (n=25)	3-10 yrs (n=43)	10-15 yrs (n=65)	15-25 yrs (n=57)	25-100 yrs (n=104)
A. Hip flexion (Leg straight)	145.16 ± 4.11	146.00 ± 2.50	146.40 ± 3.33	143.77 ± 3.96	137.02 ± 6.93	134.81 ± 7.50
B. Hip flexion (Knee flexed)	145.16 ± 4.11	146.40 ± 3.07	146.21 ± 3.45	141.85 ± 17.37	138.54 ± 6.09	136.97 ± 6.88
C. Hip abduction (Leg straight)	46.66 ± 2.67	46.00 ± 2.04	45.58 ± 1.95	45.46 ± 1.71	43.77 ± 4.04	42.60 ± 5.12
D. Hip abduction (Knee flexed)	46.66 ± 2.67	46.00 ± 2.04	45.52 ± .05	45.51 ± 1.78	43.68 ± 4.07	42.64 ± 5.02

Table 2. Range of external and internal rotation of hip and arc of rotations (n=326).

Variable name	<1 yr. (n=32)	1-3 yrs (n=25)	3-10 yrs (n=43)	10-15 yrs (n=65)	15-25 yrs (n=57)	25-100 yrs (n=104)
A. ER (Sitting)	75.19 ± 8.57	50.80 ± 4.93	38.93 ± 2.05	38.62 ± 4.80	35.79 ± 5.81	30.52 ± 5.20
B. ER (Supine)	61.53 ± 7.85	52.11 ± 7.33	31.13 ± 5.37	31.08 ± 4.88	30.70 ± 3.30	25.91 ± 7.13
C. ER (Prone)	73.13 ± 4.00	68.95 ± 5.67	47.38 ± 7.42	48.08 ± 8.04	44.68 ± 10.71	38.06 ± 10.32
D. IR (Sitting)	61.22 ± 7.39	40.20 ± 7.70	32.31 ± 4.57	31.31 ± 6.01	31.23 ± 6.50	27.15 ± 6.94
E. IR (Supine)	39.00 ± 8.14	45.42 ± 8.57	29.00 ± 6.72	26.15 ± 4.90	23.68 ± 5.63	20.45 ± 5.82
F. IR (Prone)	46.33 ± 9.28	57.37 ± 6.32	42.00 ± 5.75	44.15 ± 7.88	38.30 ± 9.52	32.20 ± 11.17
G. Sum of ER and IR in sitting position (G=A+D)	136.41 ± 14.37	91.00 ± 11.73	71.24 ± 8.29	69.92 ± 9.21	67.02 ± 9.77	57.67 ± 9.25
H. Sum of ER and IR in supine position (H=B+E)	100.53 ± 12.23	97.53 ± 15.26	60.13 ± 10.03	57.23 ± 8.15	54.39 ± 9.59	46.37 ± 10.65
I. Sum of ER and IR in prone position (I=C+F)	119.47 ± 11.09	126.32 ± 10.65	89.38 ± 10.75	92.23 ± 13.55	82.98 ± 18.22	70.26 ± 18.79

ER: External rotation; IR: Internal rotation

(70.9%, n=326), less in 38 and equal in 57 cases. External rotation of the hip in a prone position was larger than the internal rotation in 221 cases (67.8%, n=326), less in 45 and equal in 60 cases. External rotation was greater than internal rotation in the majority of cases in all positions. However, there were no significant differences in this increase amongst various positions ($p>0.05$).

Ankle dorsiflexion was greater when measured in a weight-bearing squatting position than in a non-weight-bearing supine position. Ankle plantar flexion was less when performed actively (weight-bearing) as in tiptoeing than when measured passively in the supine position (Table 3). Ankle dorsiflexion was found to be less than plantar flexion in 262 cases (80.4%, n=326), more in 40 cases, and equal in 24 cases.

All measured motion arcs in the basic planes of the hip and ankle decreased with age. However, the extent of motion reduction was not similar in all joints.

Maximum hip flexion range decreases occurred at ages 15 to 25 with little reduction seen thereafter. Abduction decreased throughout childhood with maximum reduction occurring again between ages 15 to 25. Maximum hip rotation decreased between the ages of 3 and 10. Squatting ankle dorsiflexion and tiptoe ankle plantar flexion were lowest in ages 15 to 25.

There were no significant differences in the range of joint motion between males and females of the same age.

Discussion

Variations in the pattern of the normal range of motion exists throughout the world.[6] Joint mobility also varies from race to race.[6] For example, Negroes and Indians have a greater range of motion than Caucasians.[4]

Daily routines of the Asian Indians include squatting and sitting cross-legged for eating, personal hygiene and religious discourse. These lifestyle activities possibly contribute to an increased ankle dorsiflexion in weight-bearing squatting position.

It is hoped that the data compiled in this study will be useful in the evaluation of patients with hip and

Table 3. Ankle range of motion (n=326).

Variable name	<1 yr. (n=32)	1-3 yrs (n=25)	3-10 yrs (n=43)	10-15 yrs (n=65)	15-25 yrs (n=57)	25-100 yrs (n=104)
A. Ankle DF	48.00 ± 9.60	32.80 ± 4.10	27.00 ± 4.94	29.80 ± 4.77	24.30 ± 5.9	24.33 ± 7.32
B. Ankle PF	43.28 ± 6.04	46.40 ± 5.50	38.60 ± 5.94	36.17 ± 4.97	39.95 ± 8.52	36.97 ± 6.83
C. Squat DF	Only one case	48.00 ± 10.95	46.19 ± 5.72	44.11 ± 5.27	41.79 ± 7.60	40.49 ± 6.32
D. Tiptoe PF	No case	No case	40.00 ± 7.34	36.91 ± 5.58	34.38 ± 9.07	33.36 ± 7.28
E. Sum of DF & PF (E= A+B)	91.28 ± 10.49	79.20 ± 8.12	65.79 ± 9.28	65.97 ± 7.20	64.25 ± 9.29	61.30 ± 10.39

DF: Dorsiflexion; PF: Plantar flexion

ankle disorders. The obtained values have been compiled considering the functional and cultural needs of the Indian and Asian populations as a whole. The range of motion for the ankle and hip in both weight-bearing and non-weight-bearing functional positions were compared. Measurements were based on passive range of motion similar to those in most studies.[2] Exceptions included ankle dorsiflexion, which was measured in weight-bearing and gravity-assisted positions, and ankle plantar flexion measured actively against gravity in a tiptoe position.

In our study, hip flexion was measured with the patient in the supine position and the knee flexed while the opposite hip was kept extended. The values obtained in our study were similar to those obtained by Hoaglund et al.[5] and Ahlberg et al.[6] Ahlberg et al., whose patients were between 30 and 40 years of age, flexed the opposite hip to the abdomen to have a better control over pelvic motion.[6]

There are very few clinical studies which contain estimates of the average range of joint motion in a normal healthy population. These studies have generally been carried out in small samples of limited age range (Glanville et al.[8] – 10 men; Ahlberg et al.[6] – 50 patients between 30 and 40 years of age; Roaas and Andersson[2] – 105 subjects for hip and 96 subjects for ankle between 30 and 40 years of age, all male; Boone and Azen[3] – 109 subjects between 18 months and 54 years of age; Wesley et al.[7] – 50 ankles between 7 and 68 years of age). The present study was carried out with 326 subjects ranging from 1 month to 75 years of age. The hand book of the American Academy of Orthopaedic Surgeons[1] contains estimates of joint motion obtained from three referenced sources, although neither the populations nor the measurement methods are described in these surveys as is pointed out by Roaas et al.[2] and Boone and Azen.[3]

The purpose of this study was to determine the arcs of motion of the hip and ankle joints and to analyze the influence of age on these motions in the Indian Asian population. The present study also investigated the influence of ageing on the ranges of motion. A decrease in the range of motion was usually observed between 15 and 25 years with the exception of hip rotations in which maximal reduction was observed between 3 and 10 years of age. Although some studies reported a decrease in the range of motion with age,[9] data were usually based on separate studies of adult subjects using different methods of measurements.

The influence of mechanical stresses imposed on the body through vocational, recreational and other daily activities, as well as the physiological changes, should be considered when evaluating these conclusions on the influence of ageing. We found that hip movements, especially abduction and rotations, appear to decrease by approximately 15 degree per decade for the first two decades of life and then decrease by small values or remain stable during the middle years. These findings are in agreement with earlier studies.[3]

Limitations of the study were that only measurements of the right side were taken. Additionally, the patients included in the study resided mainly in the catchment area of the hospital and it is not known whether differences in the range of motion from people native of different regions within India exist.

In conclusion, hip range of motion differed in various positions and age-related reduction in movement was found mainly in the rotations of the hip and dorsiflexion of the ankle. As the data compiled in this study was based on a sample of Indians of various ages, we believe it will be useful in the evaluation of patients with disorders of the hip and angle joints, especially in the Indian and Asian population.

Conflicts of Interest: No conflicts declared.

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