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Normal hip, knee and ankle range of motion in the Turkish population

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Objective: The aim of this study was to ascertain the effect of gender and cultural habits on hip, knee and ankle range of motion (ROM) and to determine the differences between the ROM of right and left side symmetric joints of the lower extremities.

Methods: The study included 987 (513 males and 474 females) healthy volunteers. Individuals with a history of illness, prior surgery or trauma involving any joint of either lower extremity were excluded from the study. The terminology and techniques of measurements used were those suggested by the American Academy of Orthopedic Surgeons.

Results: Left side passive hip flexion and active internal rotation was higher than the right side. Passive flexion of the hip joint was higher in male subjects and internal and external rotation was higher in female subjects. In the knee joint, passive extension was higher in males. Plantarflexion and inversion of the ankle joint were higher in male subjects and dorsiflexion and eversion were higher in female subjects. The differences were considered insignificant in clinical terms as all were less than 3 degrees.

Conclusion: There is no clinically significantly difference between right and left side hip, knee and ankle joints ROM. Gender and cultural habits do not appear to have clinically significantly effects on lower extremity joint ROM.

Key words: Ankle range of motion; hip range of motion; knee range of motion; Turkish population.

The use of range of motion (ROM) measurements in musculoskeletal disorders is a common procedure for diagnosis and treatment progress measurement. The most commonly used resource for average ranges of joint motion is the handbook of the American Academy of Orthopedic Surgeons.[1] Range of joint motion can be measured actively or passively. To our knowledge, only one study has been published in which active and

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passive ROM were measured together.[2]

Few reports have been published on the influence of age, gender, race and cultural habits on lower extremity ROM.[3-7] Most studies have been conducted with a Western population.[2,8-10] There are very few studies regarding the normal ROM of lower extremity joints in the Asian population.[3,11,12] Cultural habits, such as squat toilet use, sitting cross-legged, squatting and kneeling on the ground and religious exercises involving kneeling can affect normal ROM of the hip, knee and ankle joints.

A simple method to estimate normal ROM is to presume an identical ROM of the patient's uninjured side to the injured side before injury. To date, the validity of this assumption has not been adequately tested in the lower extremity.

The purpose of the present study was to ascertain the effect of gender and cultural habits on the normal ROM of lower extremity joints and to determine the differences in the active and passive ranges of motions of the right and left side hip, knee and ankle joints in healthy young Turkish subjects.

Patients and methods

Measurements were performed in 5 different cities in Turkey; Hatay, Isparta, Eskisehir, Kayseri and Denizli. Five physical therapists with 10 to 15 years of specialty practice evaluated each of the subjects independently. The study included a total of 987 (513 males and 474 females) healthy volunteers. Individuals with a history of illness, prior surgery or trauma involving any joint of either lower extremity were excluded from the study. Mean age and age range of the subjects are given in Table 1.

Ranges of motions were measured using a universal goniometer with arms that were 30 centimeters long. The protractor portion was divided into 1-degree increments. A small scale on one of the arms made it possible to obtain measurements to the nearest degree.

Bilateral hip, knee and ankle active and passive ranges of motions were measured.

Terminology and techniques of the measurements were used according to those of the American Academy of Orthopedic Surgeons.[1] Positions and pivot points are given in Table 2.

A pilot study was first carried out to ascertain if the measurements were associated with acceptably low intra-observer and inter-observer errors. Thirty subjects not included in the study group were evaluated independently by the 5 observers. The first observer made and recorded sequential measurements of the active and passive ranges of motion. The second observer then

Table 1. Demographic data of the subjects.

	Male	Female	Total
n (%)	513 (%51.97)	474 (%48.03)	987 (%100)
Range of age	19-30	19 - 32	19-32
Mean age±SD	22.8±5.74	22.74±5.38	22.97±5.73

Table 2. Positions of the body and pivot points.

Range of motion	Position	Pivot point
Hip		
Flexion	Supine	Greater trochanter
Extension	Prone	Greater trochanter
Abduction - adduction	Supine	The anterior center of hip joint
Internal - external rotation	Sitting	Tuberosity of the tibia
Knee		
Flexion	Prone	Lateral femoral condyle
Extension	Supine	Lateral femoral condyle
Foot		
Tibiotalar joint		
Dorsiflexion	Supine	Lateral malleolus
Plantarflexion	Supine	Lateral malleolus
Subtalar joint		
Inversion - eversion	Sitting	Base of calcaneus

measured the active and passive ranges of motion of the same subject in the same sequence. To reduce the effects of muscle fatigue, the subject was allowed to rest for 2 minutes between measurements. The procedure was repeated so that ranges of motions of each subject were measured twice by each observer.

The first and second measurement of each motion of each observer was compared to determine intra-observer reliability. Inter-observer reliability was determined by the difference between the lowest and the highest measurements in the first measurement of each motion for each subject.

Subsequently, the active and passive ranges of motion of the hip, knee and ankle of both extremities in the 987 subjects were measured using the same protocol as the pilot study. Measurements were performed first on the left extremity and then on the right.

SPSS for Windows v.13.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Normality was analyzed using the Kolmogorov-Smirnov test. Relationships between nominal variables were calculated using the chi-square test. The Student t-test was used to compare the motions on the right side with those on the left and to compare the range of motions of male and female subjects. P values of less than 0.05 were considered significant.

Results

Pilot study intra-observer reliability was a mean of 1.3 degrees and mean inter-observer reliability 1.5 degrees for each measurement.

The left side measurements of passive hip flexion and active internal rotation was significantly different than the right side ($p<0.05$). Results for the comparison of the right and left side are given in Table 3.

Passive hip flexion, passive hip extension, active hip abduction, passive hip abduction, active and passive knee extension, active ankle plantarflexion, passive ankle plantarflexion, active ankle inversion and passive ankle inversion values were statistically significantly higher in male subjects. Conversely, active hip internal rotation, passive hip internal rotation, active hip external rotation, passive

Table 3. Comparison of right and left side range of motions.

	Range of motion (mean±SD)		T score	p
	Left	Right		
Hip flexion A	118.38±8.24	119.03±8.62	-1.735	0.083
Hip flexion P	127.56±8.95	128.84±9.35	-3.114	0.002
Hip extension A	15.17±10.07	15.36±10.25	-0.418	0.676
Hip extension P	19.65±10.93	19.87±11.02	-0.439	0.661
Hip abduction A	40.25±7.57	40.75±8.15	-1.415	0.157
Hip abduction P	45.16±7.70	45.74±8.16	-1.635	0.102
Hip adduction A	19.52±11.68	19.92±11.95	-0.756	0.450
Hip adduction P	23.69±11.48	24.21±11.96	-1.000	0.317
Hip internal rotation A	37.23±6.58	37.85±6.37	-2.113	0.035
Hip internal rotation P	43.06±7.85	43.44±7.68	-1.105	0.269
Hip external rotation A	36.19±6.51	36.12±6.75	0.224	0.823
Hip external rotation P	41.90±7.23	41.86±7.29	0.124	0.901
Knee flexion A	132.77±11.72	132.62±7.12	0.360	0.719
Knee flexion P	141.42±7.57	142.39±35.82	-0.831	0.406
Knee extension A	5.33±3.61	5.35±3.52	-0.140	0.889
Knee extension P	7.53±3.90	7.52±3.83	0.053	0.957
Ankle dorsiflexion A	18.92±6.87	19.19±6.92	-0.862	0.389
Ankle dorsiflexion P	22.38±7.13	22.48±7.23	-0.326	0.744
Ankle plantarflexion A	44.93±8.86	45.15±8.83	-0.552	0.581
Ankle plantarflexion P	49.96±9.27	49.99±9.08	-0.087	0.931
Foot inversion A	29.17±9.22	30.22±15.49	-1.831	0.067
Foot inversion P	33.41±10.04	34.08±10.72	-1.427	0.154
Foot eversion A	16.67±5.88	16.67±5.69	0.008	0.994
Foot eversion P	19.92±6.21	19.80±5.87	0.436	0.663

A: Active; P: Passive.

Table 4. Comparison of male and female range of motions.

	Sex		T score	p
	Male	Female		
Hip flexion A	118.41±8.54	119.03±8.32	-1.627	0.104
Hip flexion P	128.69±8.87	127.67±9.46	2.465	0.014
Hip extension A	15.56±10.32	14.94±9.98	1.366	0.172
Hip extension P	20.25±11.25	19.21±10.63	2.080	0.038
Hip abduction A	40.88±8.27	40.09±7.39	2.238	0.025
Hip abduction P	45.99±8.32	44.87±7.47	3.125	0.002
Hip adduction A	19.91±10.90	19.51±12.73	0.732	0.464
Hip adduction P	23.97±10.81	23.93±12.64	0.066	0.947
Hip internal rotation A	36.88±6.43	38.25±6.47	-4.726	0.000
Hip internal rotation P	42.92±7.59	43.61±7.93	-1.993	0.046
Hip external rotation A	35.50±6.60	36.86±6.59	-4.583	0.000
Hip external rotation P	41.46±7.13	42.35±7.37	-2.733	0.006
Knee flexion A	132.41±7.04	133.00±11.91	-1.344	0.179
Knee flexion P	143.01±35.18	140.72±7.39	1.965	0.050
Knee extension A	5.78±3.67	4.86±3.38	5.682	0.000
Knee extension P	8.02±3.93	6.97±3.72	5.918	0.000
Ankle dorsiflexion A	18.66±7.18	19.48±6.55	-2.648	0.008
Ankle dorsiflexion P	22.13±7.39	22.76±6.93	-1.949	0.051
Ankle plantarflexion A	45.60±9.43	44.43±8.12	2.930	0.003
Ankle plantarflexion P	50.73±9.59	49.13±8.62	3.842	0.000
Foot inversion A	30.42±13.81	28.91±11.45	2.623	0.009
Foot inversion P	34.56±11.56	32.85±8.83	3.624	0.000
Foot eversion A	15.76±5.72	17.64±5.69	-7.288	0.000
Foot eversion P	19.05±5.97	20.76±6.00	-6.270	0.000

A: Active; P: Passive.

hip external rotation, active ankle dorsiflexion and active and passive ankle eversion values were higher in female subjects. Complete results of male and female active and passive ROM measurements are given in Table 4.

Discussion

Few clinical studies have been published investigating the average range of joint motion in a normal healthy population.[1,8,9,11] These studies have generally been carried out in small samples of a limited number of subjects. Kouyoumdjian et al. carried out a clinical evaluation of hip joint rotation in 120 adults.[10] Roaas and Andersson reported ROM for 105 subjects for the hip, 90 subjects for the knee and 96 subjects for the ankle.[9] Kumar et al. carried out a study of hip and ankle ranges of motions including 326 subjects.[11] The present study was carried out with 987 subjects. This is the highest number of subject in the literature for normal active and passive ROM of lower extremity joints. Günal et al. examined 1000 subjects for normal ROM of the upper extremity joints.[13]

The oldest and most commonly used source for average ranges of joint motion is the handbook of the American Academy of Orthopaedic Surgeon.[1] Both this handbook and some reports in the literature give no information about the evaluated population (age, gender, race, etc.) or the measurement technic (active or passive).[1,14,15] The majority of studies measured only active or passive ROM. Roaas and Andersson and Kumar et al. measured passive ROM.[9,11] Boone and Azen measured active ROM.[8] Macedo and Magee measured both active and passive ROM.[2]

A universal manual goniometer was used for joint ROM measurement in the present study. Although its reliability is affected by many factors, the goniometry is still the most commonly used method.[13,16,17]

Few reports have been published comparing the ranges of motions between right and left side lower extremity joints. Boone and Azen, Roaas and Andersson, Stephanyshyn and Engsberg, and Macedo and Magee found no significant differences between right and left side range of motion.[2,8,9,18] There is no report in the literature find-

ing any clinically significantly difference between sides in lower extremity joints. Only Günal et al. reported a significant difference between ROMs of right and left side joints of the upper extremity.[13] It is important to not only analyze the statistically significant differences, but also the clinically significant differences. According to the American Medical Association, changes of less than 10 degree may be neglected clinically.[19] The results of the present study were consistent with the literature; there were no clinically significantly differences between ROMs of left and right side.

Different reports have been published about the relationship between gender and normal ROM. Svenningsen et al. and Beighton et al. reported greater hip motions in females.[7,20] However, Allander et al. and Fairbank et al. did not find any differences between male and female total hip rotation.[21,22] In the present study, passive and active hip flexion, active and passive hip abduction and active and passive knee extension were significantly higher in male subjects. Active and passive hip internal and external rotations were higher in female volunteers. However, the differences were not high enough for clinical importance and it can be said that gender had no clinically significant effect on the range of joint motion in this study.

The few studies based on Asian populations have shown that hip external rotation, knee flexion and ankle dorsiflexion are significantly greater than those of the Western population.[3,11,12] Kumar et al. reported passive hip external rotation of 30 degrees and passive ankle dorsiflexion of 24 degrees in the Indian population.[11] In a study with a population of 50 Arab males, Ahlberg et al. reported passive ROMs of 72 degrees of hip external rotation, 159 degrees of knee flexion and 32 degrees of ankle dorsiflexion.[3] On the other hand, Roaas and Andersson reported passive ROMs of 33 degrees of hip external rotation, 143 degrees of knee flexion and 15 degrees of ankle dorsiflexion in males aged between 30 and 40 years aged from the city of Göteborg.[9] A comparison of the current study with the literature is difficult because we measured both active and passive ROM. However, the results of this study have shown that despite having a common culture (squatting toilet, eating on the floor, rituals of Islamic worship) with other Asian countries, there is no clinically significant increase in hip, knee and ankle joints range of motion compared to the majority of reports of the Western population.

In conclusion, there are no clinically significant differences between right and left side ROM in lower extremity joints. Gender does not have a significant importance in normal ROM. Cultural habits, such as kneeling during religious exercises, squat toilet use, sitting cross-legged and squatting and kneeling on the ground do not increase the ROM of hip flexion, hip external rotation, knee flexion and ankle dorsiflexion.

Conflicts of Interest: No conflicts declared.

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