

ORIGINAL RESEARCH ARTICLE

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Normal active range of motion of lower extremity joints of the healthy young adults in Cairo, Egypt

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Abstract

Background: Range of motion (ROM) can be considered as one of the most commonly measured variables in musculoskeletal health care. When interpreting ROM, a common method is to compare obtained ROM values to normative data. So the current study aimed to establish (1) normative active ROM (AROM) values for lower extremity joints in young Egyptian adults, (2) compare the AROM between dominant and non-dominant lower extremity joints, and (3) compare between the values of AROM of lower extremity joints in both genders.

Results: Paired *t*-test demonstrated that there was statistical but not a clinical difference between the dominant and non-dominant ROM values of the lower extremity joints. Unpaired *t*-test revealed that there was statistical but not a clinical difference between male and female ROM values of lower extremity joints.

Conclusions: This study summarized normative data of Egyptian young adults; there were statistical but not a clinical difference between dominant and non-dominant lower extremity joints in AROM and between males and females.

Keywords: Adult, Dominant and non-dominant side, Egypt, Normative AROM

Background

Range of motion (ROM) measurement is a basic assessment procedure in the medical field [1]. The definition of ROM varies among published sources; Kapandji and colleagues described ROM as “the extent of osteokinematic motion available for movement activities, functional or otherwise, with or without assistance” [2].

The ROM has been routinely used to determine baseline limitations of motion, assess injuries in the musculoskeletal system, guide the choice of the appropriate therapeutic interventions, and document the effectiveness of these interventions [2–5].

Abnormalities in joint ROM can affect the level of performance; in the upper limbs, poor ROM can hinder the performance of simple daily activities [1, 6]. While in the

lower limbs, ROM abnormalities may have an extensive impact on gait pattern [7], energy expenditure [8], and the distribution of forces within the spine and lower extremities [8].

The importance of ROM has encouraged health care professionals to search for more accurate data regarding the normal values of ROM to allow precise assessment and accurate comparison against these standard normal values [9].

The most popular sources for normative ROM references were usually extracted from different sources; the American Academy of Orthopedic Surgeons (AAOS), the American Medical Association (AMA) [10], and comparing to contralateral side, but there is still now contradiction and confusion in the available literature about using it as a source of normative ROM [11].

The data reported by these sources were extracted from old studies that encountered multiple methodological limitations. These limitations included undefined sample size, age, population characteristics, interracial,

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and between-gender variation in ROM. Moreover, the measurement tools or procedures, the type of motion measured either passive or active, were missed in these references [12].

Consequently, multiple attempts were conducted in order to establish normative reference values for ROM in younger subjects [13–15]. Other attempts were targeting adult [12] or older populations [16, 17].

It was reported from previous studies that ROM differs according to several factors like race and cultural habits [18]. Dominance is another factor that might affect normal ROM. This factor is not adequately studied. Literature shows controversy regarding the dominance effect on ROM [10]. Few authors reported no differences between both sides [5, 10, 11, 19], while a significant difference was noticed in other studies [12, 20].

Gender can be considered as a factor that may affect normal ROM. Gender differences in ROM were reported on several occasions [21]. The variation in genetic and hormonal factors may describe these differences. Moreover, the difference in fat deposition between gender [22, 23] can also play a role.

According to the authors' best knowledge, no studies were conducted before to establish normative values for AROM in lower extremity joints on North African populations including Egyptians. Consequently, this study aimed to (1) establish normative AROM values for lower extremity joints in young Egyptian adults, (2) compare the AROM between dominant and non-dominant lower extremity joints, and (3) compare between the values of AROM of lower extremity joints in both genders.

Methods

Study design and setting

This cross-sectional study was performed at a local research laboratory during the period between January and October 2018 to measure the normal AROM of the hip, knee, and ankle joints in healthy young adults. The study was ethically approved by local ethical committee board with number NO: P.T.REC/012/001698.

Subjects

There are a total of 1000 subjects (500 males and 500 females); their age ranged from 18 to 30 years, and body mass index (BMI) range from 18 to 24.9 kg/m². Subjects were participated in the study after assigned a written consent form and recruited through written advertisements, verbal announcements, and social media.

Subjects were excluded if they were participating in regular sports involving lower extremity, heavy-duty workers, obese or underweight, undergoing physical therapy procedures for lower extremity joints during the last 6 months, and had any previous fractures, injury, or surgery involving the lower extremity. Subjects with joint

pain, musculoskeletal disorders, neurological dysfunction, and pregnant women were also excluded from the study (Fig. 1).

Procedure

One 9-year experienced therapist performed all measurements. A universal transparent goniometer was used to obtain the AROM of all lower extremity joints. The universal goniometer has acceptable reliability, and it is commonly used in clinical practice to assess AROM [3, 10, 24].

Because measuring technique and patient positioning may affect ROM [25, 26], the standardized guidelines and instructions prescribed by Norkin and White were followed during measurements (Table 2) [27].

A pilot study was conducted on 20 participants at two successive days before the main experiment to examine the intra-rater reliability of the measurements. Intra-rater reliability of ROM measurement showed excellent reliability in both dominant and non-dominant sides. Intraclass correlation coefficient (ICC) ranged from 0.91 to 0.99 (Table 1). Measurements and procedures were replicated from the study conducted by Macedo and colleagues [11].

The recruited subjects signed a consent form after they were screened for eligibility to join the study. Demographic data were collected [28], and limb dominance was determined according to the limb self-preferred by the subjects to kick a football [29]. This limb-dominance determination technique is reliable and has a 97.7% agreement with task performance [30]. Subjects were instructed to wear light nonrestrictive clothes, and a universal plastic goniometer with 30 cm arms and 360° protractor (Baseline® HPMS Inc, USA) was used to perform all the measurements (Table 2). In order to avoid the carryover effect, measurements were carried out in random order; each movement was performed 3 times, and the average was taken.

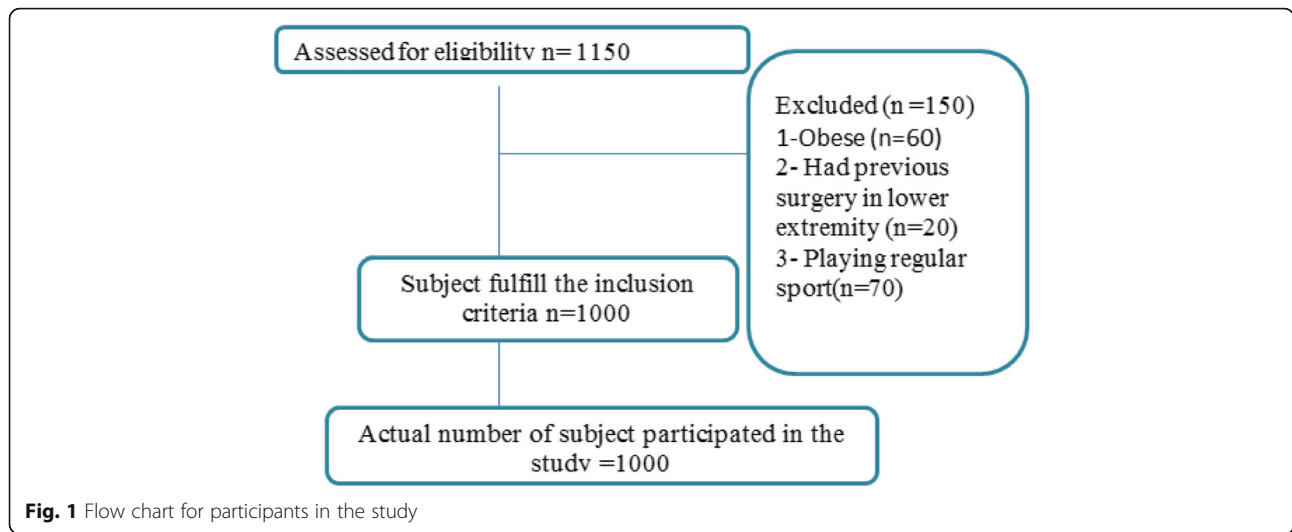
Statistical analysis

Descriptive statistics in the form of mean and standard deviation were used to present the measured parameters. Normal distribution of data was checked using the Shapiro-Wilk test. Paired *t*-tests were used to compare between the dominant and non-dominant lower extremity ROM values. Unpaired *t*-test was used to compare lower extremity ROM values between males and females. The level of significance was set at $p \leq 0.05$. All statistical tests were performed through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics

This study recruited 1000 Egyptian young adults with an equal number of males and females with a mean age of



20.98 years. Eight hundred eighty-eight subjects had the right side dominant while 112 subjects had the left side dominant. Subjects’ demographic data was summarized in Table 3.

Lower limbs AROM

Lower limb AROM data of dominant and non-dominant sides are presented in Table 4. Results revealed statistically significant differences between dominant and non-dominant sides in hip flexion and extension, hip adduction, hip external and internal rotation, knee flexion, and ankle eversion ($p \leq 0.05$). The mean difference in all measurements is very low.

The comparison between males and females showed significant differences in all movements except hip extension and adduction of both dominant and non-dominant sides in addition to the internal rotation of the non-dominant side ($p < 0.05$) (Table 5). The mean difference

in all occasions was trivial and did not reach the clinical significance difference described previously [31].

Discussion

Up to the authors’ best knowledge, this study is the first attempt to establish normative AROM data for the lower extremity joints in young Egyptian adults. This study is also among the few studies that were performed in the Middle East [18, 32].

Owing to the limitations encountered in data obtained by the AMA and AAOS and the hypothesized influences of gender and limb dominance on normative values of ROM, there is an increased need for nationally based standard references (normative) databases for joint ROM.

The major findings of the current study were as follows:

- Normative AROM data for lower extremity joints in young Egyptian adults were summarized.
- There were no clinically significant differences between dominant and non-dominant sides in AROM for all lower extremity joints.
- There were no clinically significant differences in ROM between males and females.

Various studies were conducted before to establish normative ROM values in many countries such as Iran [33], India [34], Sweden [5], Saudi Arabia [18], Nigeria [35], Iraq [36], and Turkey [10]. Only two studies addressed the Middle Eastern population. However, both are old, and they were conducted on a small population.

Although statistically significant differences in AROM which were demonstrated between dominant and non-dominant sides, they could be neglected clinically [31]. Therefore, the current study supports the use of the ROM of the health joint as a reference for the diseased one. This

Table 1 Intra-rater reliability for ROM measurement

	ICC (95% CI)	
	Dominant	Non-dominant
Hip flexion	0.99 (0.99:0.99)	0.99 (0.97:0.99)
Hip extension	0.98 (0.97:0.99)	0.96 (0.91:0.98)
Hip abduction	0.99 (0.99:0.99)	0.98 (0.97:0.99)
Hip adduction	0.97 (0.94:0.98)	0.96 (0.91:0.98)
Hip external rotation	0.94 (0.87:0.97)	0.95 (0.85:0.97)
Hip internal rotation	0.95 (0.91:0.98)	0.96 (0.91:0.98)
Knee flexion/extension	0.99 (0.99:0.99)	0.99 (0.97:0.99)
Ankle dorsiflexion	0.97 (0.93:0.98)	0.98 (0.97:0.99)
Ankle plantar flexion	0.94 (0.88:0.97)	0.94 (0.87:0.97)
Foot eversion	0.91 (0.8:0.95)	0.92 (0.83:0.96)
Foot inversion	0.93 (0.86:0.97)	0.93 (0.84:0.97)

ICC intraclass correlation coefficient, CI confidence interval

Table 2 Subject positioning and goniometer placement during active range of motion measurement

Joint movement	Subject position	Fixed arm of goniometer	Movable arm of goniometer	Fulcrum
Hip - Flexion - Extension	Supine prone	Lateral midline of the pelvis	Lateral midline of the femur toward the lateral femoral epicondyle	Over the greater trochanter
- Abduction - Adduction	Supine	Placed on a line between the anterior superior iliac spines	Parallel to the anterior midline of the femur toward the midline of the patella	The ASIS of the tested side
- Hip rotation	Sitting on table edge	Parallel to the ground	Parallel to the tibia	Anterior aspect of the patella
Knee* - Flexion/ - extension	Supine	Parallel to the lateral midline of the femur	Parallel to the lateral midline of the fibula	The lateral epicondyle of the femur
Ankle - Dorsiflexion - Planter flexion	Sitting on table edge	Placed parallel to the lateral midline of the fibula	Placed parallel to the lateral midline of the fifth metatarsal bone	Over the lateral aspect of the lateral malleolus
Subtalar - Eversion - Inversion	Prone	Over the posterior midline of the lower leg	Over the posterior midline of the calcaneus	Over the posterior aspect of the ankle midway between the malleoli

ASIS anterior superior iliac spine

*Knee joint extension is considered 0 (full extension) position, and flexion was measured from it

conclusion was also reported previously [10, 11, 37]. On the other hand, Gunal and colleagues in 1996 reported significant differences between both sides, and consequently, they doubted the reliability of using the contralateral side as a reference [38]; the cause of the difference between Gunal findings and ours may be argued to the differences in tested extremity, while the lower extremity was tested in the current study, Gunal and colleagues tested upper extremity; it is well known that the difference between dominant and non-dominant sides is obvious in upper extremity than lower extremity. Moreover, all participants included in Gunal study were right handed.

The lack of dominance related clinically significant differences could be attributed to the similarity of effort exerted by both lower limbs during ambulation, which is the main activity performed by the lower limbs in healthy nonathletic subjects.

The current study reported that gender has no clinical influence on AROM of lower extremity joints so that we agree with the findings which were reported in a previous work [10, 21].

Two previous studies reported no significant differences between both genders. However, their conclusion relied

on statistical significant differences but not clinically meaningful values [10, 21]. At the same time, statistically significant differences were reported between both genders in other experiments [39–41, 25].

The small clinically insignificant gender differences in ROM may be attributed to the narrow age range of the current study sample that limits the effect of age-related changes in body composition [42, 43]. The normal BMI that characterizes the recruited sample may also influence these results.

Clinical implication

This study provides reference data for AROM of lower extremity joints in Egyptian young adults. This data can be used during the rehabilitation process. This study supports the use of the contralateral healthy limb as a reference for the normal values of the affected limb and supports the similarity of the AROM values in males and females.

Limitation

The results of this study should be used with cautions because of the following limitations: the authors did not determine the appropriate sample size, but it was estimated depending on the samples used in the previous study a priori; the study includes to specific age group, and the findings might be not applicable to other age groups; the time of the assessment was not consistent through the study but to control this variable; and measurements were avoided in the early morning. Moreover, all patients were allowed to rest for 15 min before taking measurements.

Table 3 Subjects’ demographic

	Subjects demographic data			
	Age (years)	Weight (kg)	Height (cm ²)	BMI (kg/m ²)
Mean	20.98	71.45	173.9	23.62
SD	1.83	4.32	4.21	1.21

Table 4 Mean values of lower limb ROM of dominant and non-dominant sides

	Dominant	Non-dominant	MD (95% CI)	<i>p</i> value
Hip flexion	125.93 ± 6.44	125.62 ± 6.5	0.31 (0.11:0.52)	0.003**
Hip extension	19.51 ± 4.08	19.31 ± 3.95	0.2 (0.07:0.33)	0.003**
Hip abduction	42.23 ± 5.66	42.07 ± 5.57	0.16 (– 0.03:0.34)	0.093
Hip adduction	28.21 ± 4.78	28.02 ± 4.76	0.2 (0.03:0.36)	0.018**
Hip external rotation	37.61 ± 4.23	37.47 ± 4.34	0.14 (0.07:0.2)	0.001**
Hip internal rotation	27.91 ± 2.5	28.35 ± 2.7	– 0.44 (– 0.55:– 0.33)	0.001**
Knee flexion/extension	137.53 ± 4.6	137.24 ± 4.72	0.28 (0.1:0.47)	0.002**
Ankle dorsiflexion	20.72 ± 4.08	20.67 ± 3.95	0.06 (– 0.06:0.17)	0.353
Ankle plantar flexion	49.8 ± 6.51	49.85 ± 6.44	– 0.06 (– 0.2:0.07)	0.377
Foot eversion	15.52 ± 1.5	15.38 ± 1.54	0.14 (0.07:0.2)	0.001
Foot inversion	35.22 ± 2.14	35.26 ± 2.09	– 0.04 (– 0.10:0.02)	0.225

Data are expressed as mean ± SD

MD mean difference

***p* value ≤ 0.05 significant**Table 5** Comparison of mean values of lower limb ROM between males and females

		Males	Females	MD (95% CI)	<i>p</i> value
Hip flexion	Dominant	123.14 ± 4.55	128.73 ± 6.84	– 5.6 (– 6.31:– 4.87)	0.001**
	Non-dominant	122.82 ± 4.84	128.42 ± 6.72	– 5.6 (– 6.31:– 4.87)	0.001**
Hip extension	Dominant	19.39 ± 3.65	19.62 ± 4.47	– 0.23 (– 0.73:0.27)	0.377
	Non-dominant	19.13 ± 3.56	19.48 ± 4.30	– 0.35 (– 0.83:0.14)	0.164
Hip abduction	Dominant	39 ± 2.98	45.47 ± 5.86	– 6.47 (– 7.04:– 5.89)	0.001**
	Non-dominant	38.83 ± 3.15	45.31 ± 5.58	– 6.48 (– 7.04:– 5.92)	0.001**
Hip adduction	Dominant	28.19 ± 4.1	28.23 ± 5.38	– 0.04 (– 0.62:0.55)	0.905
	Non-dominant	28.07 ± 4.26	27.96 ± 5.21	0.11 (– 0.48:0.7)	0.715
Hip external rotation	Dominant	36 ± 4.61	39.22 ± 3.06	– 3.22 (– 3.7:– 2.73)	0.001**
	Non-dominant	35.72 ± 4.69	39.23 ± 3.08	– 3.51 (– 4:– 3.01)	0.001**
Hip internal rotation	Dominant	27.68 ± 2.64	28.15 ± 2.33	– 0.47 (– 0.78:– 0.16)	0.003**
	Non-dominant	28.5 ± 3.09	28.2 ± 2.21	0.31 (– 0.02:0.63)	0.072
Knee flexion/extension	Dominant	137.22 ± 4.13	137.84 ± 5.01	– 0.63 (– 1.19:– 0.05)	0.031**
	Non-dominant	136.89 ± 3.97	137.6 ± 5.35	– 0.71 (– 1.29:– 0.12)	0.018**
Ankle dorsi flexion	Dominant	21 ± 3.24	20.46 ± 4.76	0.54 (0.03:1.04)	0.038**
	Non-dominant	21.04 ± 3.18	20.29 ± 4.57	0.75 (0.26:1.24)	0.003**
Ankle planter flexion	Dominant	49 ± 5.88	50.58 ± 7	– 1.59 (– 2.38:– 0.78)	0.001**
	Non-dominant	49.14 ± 6.01	50.55 ± 6.78	– 1.41 (– 2.2:– 0.61)	0.001**
Eversion	Dominant	15.08 ± 1.6	15.95 ± 1.25	– 0.87 (– 1.05:– 0.69)	0.001**
	Non-dominant	15.07 ± 1.56	15.7 ± 1.45	– 0.63 (– 0.81:– 0.44)	0.001**
Inversion	Dominant	34.2 ± 2.14	36.25 ± 1.56	– 2.06 (– 2.29:– 1.82)	0.001**
	Non-dominant	34.3 ± 2.15	36.22 ± 1.5	– 1.93 (– 2.15:– 1.69)	0.001**

Data are expressed as mean ± SD

MD mean difference, CI confidence interval

***p* value ≤ 0.05 significant

Conclusion

This study identified normative ROM data for Egyptian young adults. The current study concluded that there were statistical but not a clinical difference between dominant and non-dominant sides and between males and females in AROM of the lower limb joints among Egyptian young adults.

Abbreviations

AROM: Active range of motion; AAOS: American Academy of Orthopedic Surgeons; AMA: American Medical Association; BMI: Body mass index; SPSS: Statistical package for social studies; ROM: Range of motion

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Authors' contributions

H.M.H formulated the idea, collected the data, critically reviewed, and approved the final draft. S.M.A and S.T.E were responsible for clinical evaluation and carried out the statistical analysis. E.M.K collected the literature and assisted in writing the original draft. All authors were responsible for the content and similarity index of the manuscript. The authors read and approved the final manuscript.

Availability of data and materials

Not applicable

Ethics approval and consent to participate

The study was ethically approved by the local ethical committee board with number NO: P.T.REC/012/001698. Subjects were participated in the study after assigned a written consent.

Consent for publication

Not applicable

Competing interests

Authors declare that there are no competing interests.

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