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Does range of motion measurement and reference values differ?: a multi-centered study

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ABSTRACT. This study is aimed to estimate and measure reference values in the normal range of motion of extremity joints in females and to provide a database for the assessment of impairments related to the mobility of the joints. This observational cross-sectional study was conducted at seven major educational institutes areas of Rawalpindi and Islamabad in Pakistan from January to June 2020 with a sample size of 600 healthy females aged 15 to 45 years and divided into three groups through non-probability sampling technique. In study Instruments, an electronic Goniometer was used for the measurement of the range of motions for different joints and then those ranges were recorded. The questionnaire had two sections demographic characteristics and ROM for both upper and lower limbs. Data was analyzed using SPSS V21. A $p < 0.05$ was considered statistically significant.In the result,Out of 600 participants,there was a statistically significant difference of ($p < 0.001$) in both upper and lower extremities motion between all the three groups for the measurements and noticeably no significant difference ($p > 0.005$) between group 1, 2 comparisons for the knee joint extension.To conclude, In most joints, the range of motion increases with age. The transition from group 1 to group 2 was aided by increased hormone participation in growth, an active lifestyle, and generally good health. Because of degenerative changes and joint stiffness, group 3's range of motion deteriorated, leading to a sedentary lifestyle and lack of physical activity. Standardized biomechanical measurements can help health practitioners, such as physiotherapists, choose appropriate therapy interventions to assess musculoskeletal disorders. To resolve the inconsistencies in the reliability and validity of goniometry values, more research is required.

Keywords: BMI; range of motion; goniometry; mobility; joints.

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Introduction

The International Classification of Functioning, Disability, and Health (ICF) is a model that describes the function, level of disability, and the ability of a person to participate in an activity of daily living with any particular impairment or disability (Stucki, Cieza, & Melvin, 2007). The Mobility of a joint is considered a significant element for normal activity and any disability (Schultz, 1992). The Range of motion of joints is measured by physical therapists working in hospitals, with a purpose to evaluate the patient's normal movements, limitations in movement, and evaluate the prognosis of physiotherapy treatment. The joint examination aims to achieve mobility, strength, and complete range of motion of joints that were before any injury (Akizuki, Yamaguchi, Morita, & Ohashi, 2016).

A Universal goniometer is commonly used in clinical settings to measure joint range of motion. The joint range of motion is measured in degrees, by keeping stationary and movable arms of the goniometer on either side of the joint at a specific bony landmark, The American Academy of Orthopedic Surgeons (AAOS) has published reference values for different joints and is widely used by clinicians (Armstrong, MacDermid, Chinchalkar, Stevens, & King, 1998). However, the values are inconsistently by gender or age. Former research has been conducted on the measurement of joint range of motion in which the results were inconsistent and have limitations in subsequent aspects like age and gender of participants, sample size, particulars methods, and equipment in measuring range of motion of the joints, assessed for range of motion (Tucker, 1964; Allander, Björnsson, Olafsson, Sigfusson, &

Thorsteinsson, 1974; Boone & Azen, 1979; Walker, Sue, Miles-Elkousy, Ford, & Trevelyan, 1984; Roach & Miles, 1991; Alanen, Levola, Helenius, & Kvist, 2001).

Unluckily, there is not enough literature to address standardization in the normal joint range of motion particularly in south Asian countries like Pakistan. The female subjects, being in majority were included in the study demographics because in the multicentred settings they were in the working class. The purpose of this research was to spread light in the biomechanical measurement of range of motion as an evaluation procedure with application in physical therapy which tends to have a significant impact on therapeutic interventions. This study gives special emphasis on the reliability of goniometry with its procedures, and differences among joint movements in the body regions, passive versus active measurements.

Thus, the objective of our study was to estimate and measure reference value in a normal range of motion of extremity joints in females and to provide the database for the assessment of impairments related to the mobility of joints.

Methods

Study design and sampling

This observational cross-sectional study was conducted at seven major educational institutes areas of Rawalpindi and Islamabad in Pakistan including, Railway hospital, Rawalpindi Fatima Jinnah women university, NUML University, Islamabad Islamic international university, Riphah International University Islamabad, Askari-14 colony, and Army Public College of Management Sciences, Rawalpindi from (January to June 2020) that included a sample size of 600 healthy females. The elderly populations were divided into three major demographic groups from 15 to 45 years. We categorized to group 1, (15 to 25 years), group 2 (26 to 35 years), and group 3 (36 to 45 years) using the non-probability sampling technique. Similarly, participants with a known history of hypertension and diabetes mellitus were also included. We excluded the subjects who were pregnant, obese, and diagnosed with degenerative joint diseases such as rheumatoid and osteoarthritis and had a (BMI greater than 24 kg m^{-2}).

Ethical Consideration

Ethical Approval from the institutional review committee Ref (RCR/REC/337) at Riphah International University was obtained. Informed consent was taken from all participants. The study population received verbal and written questionnaires explaining the purpose including its significance and every step of data collection procedures of this study. The Respondent's identity was kept anonymous and their confidentiality was maintained.

Study Instrument

A Universal goniometer was used in performing the measuring of the range of motion for different joints and then those ranges were mentioned. The questionnaire had two sections demographic characteristics and ROM for both upper and lower limbs.

Procedure

A standardized Medigauge Electronic Goniometer was used throughout the data collection procedure. The ranges in the body measurements were screened and compared with the set of normal ROM manual. Participants with hypermobility and joint laxity were ruled out during the pre and post assessment protocols and then the ranges were recorded. Furthermore, The study participants were contacted at various educational institutions, residential areas, and hospitals. The Range of motion in the study subjects was measured passively (PROM). About Twenty-six joints were measured for every participant. Subjects were positioned in the supine for measurement in the shoulder flexion, abduction, adduction, lateral and medial rotation; elbow flexion and extension; hip flexion, abduction, and adduction; knee flexion and extension; ankle flexion and extension. A seated position was used for the measurement of elbow supination and pronation; wrist flexion, extension, ulnar and radial deviation; hip lateral and medial rotation; ankle inversion and eversion. They were positioned prone to measure shoulder extension and hip extension. Joints were passively moved to the full extent and endpoint goniometric readings were measured. The present study measured passive joint range of motions and included healthy individuals, which resulted in a greater range of motion concerning the study conducted earlier (Roach & Miles, 1991).

Statistical analysis

The data were analyzed using the SPSS version 21. In the descriptive analysis,theJoint range of motion was expressed as mean and standard deviation. In the inferential statistics, an Independent t-test was applied for the group variables to show the mean comparisons in three age groups (first: 15 to 25 years), (second: 26 to 35 years), and (third: 36 to 45 years) for the biomechanical joint ranges in the upper and lower extremities measurement. The Confidence Interval was set to 95%. A p-value (< 0.05) was considered statistically significant.

Results

The Range of motion measurements were obtained from 600 healthy females in which there was a significant difference ($p < 0.001$) between all the three groups for the measurement of shoulder flexion, extension, adduction, abduction in (Table 1); elbow flexion, forearm supination, and pronation in (Table 2); wrist ulnar deviation in (Table 3). There was also a significant difference between group 1, 3 and group 2, 3 for wrist flexion, extension, ulnar, and radial deviation however no significant difference ($p > 0.05$) was found between group1, 2 comparisons as illustrated in (Table 3).

For lower limb joint motions: There was a statistically significant difference ($p < 0.001$) between all groups for hip flexion, extension in (Table 4), knee flexion in (Table 5), ankle flexion-extension inversion, and eversion in (Table 6). However, it was also noted that there was a significant difference ($p < 0.001$) for hip adduction, abduction, medial and lateral rotation between (group 1, 3) (group 2, 3) and no significant difference ($p > 0.005$) between group 1, 2 comparisons (Table 4). For knee joint extension there was a significant difference ($p < 0.05$ for groups 1, 2 and 2, 3) and no difference ($p>0.05$ for groups 1, 3) in (Table 5).

Table 1. ROM for shoulder flexion, Extension, Adduction, Abduction, Medial rotation, and lateral rotation.

Joint motion	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD
Shoulder flexion	159.0350 ± 10.07179	163.4250 ± 10.62018	141.3750 ± 9.61492
Shoulder extension	37.8150 ± 9.54707	47.8150 ± 6.27196	40.4100 ± 4.86314
Shoulder adduction	22.7350 ± 7.04290	16.6500 ± 4.33955	19.6600 ± 4.09981
Shoulder abduction	171.5400 ± 14.21686	162.1200 ± 8.98550	147.3250 ± 13.42425
Shoulder Medial Rotation	84.0350 ± 8.64450	82.1350 ± 6.12243	76.6900 ± 7.13713
Shoulder Lateral Rotation	70.4700 ± 10.96037	75.3800 ± 6.79089	73.1150 ± 8.67166

Table 2. Elbow flexion, extension, supination, and pronation.

Joint motion	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD
Elbow flexion	143.7300 ± 4.90791	141.0200 ± 5.42742	129.2050 ± 5.89122
Elbow extension	0.0000 ± 0.00000[a]	0.0000 ± 0.00000[a]	0.0000 ± 0.00000[a]
Elbow supination	88.7750 ± 3.93724	87.6050 ± 2.76718	82.8000 ± 5.06044
Elbow pronation	89.4200 ± 2.53490	88.1950 ± 2.39072	82.4700 ± 5.22163

Table 3. Wrist flexion, extension, radial deviation, and ulnar deviation.

Joint motion	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD
Wrist flexion	84.0600±6.26359	84.4400±6.26359	79.3850 ± 4.83255
Wrist extension	76.8850±6.63187	76.5800±3.88963	72.2400 ± 4.22274
Wrist radial deviation	21.8650±7.45956	20.7950±3.91915	23.2600±6.08255
Wrist ulnar deviation	29.1500±5.70440	30.0750±3.16377	33.4200±6.46005

Table 4. Hip flexion, extension, adduction, abduction, medial rotation, and lateral rotation.

Joint motion	Group 1 Mean ±SD	Group 2 Mean ±SD	Group 3 Mean ±SD
Hip flexion	125.9600 ± 11.81296	122.5900 ± 9.06880	111.1600 ± 7.05288
Hip extension	19.3400 ± 4.76318	16.9950 ± 2.99161	14.9250 ± 3.95952
hip adduction	22.0500 ± 4.55425	15.7200 ± 4.87137	12.9450 ± 2.78040
Hip abduction	39.7450 ± 6.56930	40.6850 ± 3.42849	33.7100 ± 33.7100
Hip medial rotation	38.8600 ± 6.10135	37.9650 ± 3.27681	35.8150 ± 3.07049
Hip lateral rotation	43.1100 ± 29.91929	41.4000 ± 3.68073	36.0750 ± 4.08938

Table 5. Knee flexion and extension.

Joint motion	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD
Knee flexion	150.9400 ± 11.55395	145.7350 ± 8.22698	130.3950 ± 4.78156
Knee extension	2.7400 ± 98348	2.9300 ± 81758	2.7150 ± 99938

Table 6. Ankle flexion, extension, inversion, and eversion.

Joint motion	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD
Ankle flexion	20.6250 ± 3.43707	19.5800 ± 2.10374	26.5850v6.05608
Ankle extension	37.1850 ± 4.51249	38.1200 ± 3.66507	34.8750 ± 3.30667
Ankle inversion	36.4050 ± 5.99757	37.5650 ± 3.21207	33.2100 ± 4.44236
Ankle eversion	18.4350 ± 3.99066	19.2000 ± 2.35963	27.1750 ± 5.96846

Discussion

The study results provide comprehensive normative values which were inconsistent in the previous studies for the reason as they measured range of motion for one or two joints and their study included a sample of few participants (Roaas & Andersson, 1982; Günal, Köse, Erdogan, Göktürk, & Seber, 1996; James & Parker, 1989; Alanen et al., 2001). The Passive range of motion measures the optimal joint mobility however pain or any impairment may decrease the active range of motion in the joints. Furthermore, With the increasing age and puberty, changes are observed in body mass and joint laxity which leads to variations in the range of motion of joints (Bini et al., 2000; Quatman, Ford, Myer, Paterno, & Hewett, 2008). The Mobility of the joint is decreased with an increase in body mass index, however, in female individuals, there is an increase in joint range of motion and BMI at the start of puberty (Bini et al., 2000). An Onset of puberty influences the joint range of motion and BMI more than age (Ogden, Yanovski, Carroll, & Flegal, 2007).

Musculoskeletal changes are observed as a result of normal physiological aging resulting in variations in joint mobility related to age. Aging results in loss of skeletal muscle strength, decrease ligaments and cartilage elasticity, and distribution of fat is also changed with increasing age (Freemont & Hoyland, 2007). The Individuals diagnosed with osteoarthritis were excluded from our study, however, changes in morphology may be present among individuals which resulted in osteoporosis.

Another study was conducted on female subjects using the universal goniometer for assessment of a bilateral passive joint range of motion. Descriptive statistics were calculated for male and female subjects in four age groups. The study results showed that female subjects had greater joint mobility in all age groups in nearly all joints and the gender difference was most obvious in measures of ankle plantar flexion, elbow pronation, and supination. A former multicentered study in Pakistan has suggested a strong link between a sedentary lifestyle and decreasing health outcomes. About 56% of the factors, such as daily activities and health status, were observed, with an active lifestyle accounting for 55%. Because there is a link between daily activities and health status, those who are not physically active are more prone to have their health deteriorate (Memon & Qureshi, 2020).

Range of motion average values for all joints decreased with advancing age for both men and women and in most cases were significantly different than most commonly used normative values (Soucie et al., 2011). There were few limitations in the study, in addition to the time constraint and fewer resources, and small sample size. The findings could have been different if we included male participants in the demographics with females. Considering the multicentered design, we tried to minimize the errors caused by goniometric measurements. The existed reliability and validity of the instrument had some variations affecting our results.

Conclusion

The range of motion in most of the joints tends to increase at a younger age. The rise from group 1 to group 2, was due to increasing growth involvement of hormones, active lifestyle, and health being mostly at its peak. The range of motion was declined in group 3 because of progressing degenerative changes, and joint stiffness leading to a sedentary lifestyle and physical inactivity. Health professionals including, Physiotherapists can benefit from standardized biomechanical measurements for choosing suitable therapeutic interventions in the assessment of various musculoskeletal disorders. Further research is needed to address the discrepancies in the reliability and validity of goniometry.

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