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ORIGINAL ARTICLE

Age-Related Anatomical Changes in the Upper Limb Musculoskeletal Structures among Elderly Pakistani. A Cross-Sectional Study

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ABSTRACT

Background: Anatomical deterioration of musculoskeletal structures is a major issue for elderly populations, most notably in the upper limbs. This study investigates these age-related changes and their clinical implications among elderly Pakistani individuals.

Aims and Objectives: The aims and objectives were to identify age-related anatomical changes in upper limb musculoskeletal structures among elderly Pakistani individuals. The objective is to evaluate clinical implications for better geriatric healthcare practices.

Methodology: A descriptive cross-sectional study was carried out for 12 months involving n=200 elderly Pakistani participants. DXA scans, clinical examinations, upper limb musculoskeletal ultrasonography, and X-rays were used to evaluate upper limb musculoskeletal structures. Structured questionnaires were used to collect demographic and clinical data. Descriptive statistics and comparative tests were used for data analysis with SPSS version 26.0, considering $p \leq 0.05$.

Results: In elderly participants, the study found the loss of significant amounts of muscle (sarcopenia) in 71 percent, with an average mean grip strength of 18.5 kg. Pervasive degeneration of the joint included osteoarthritis (51%), ligament laxity (43.5%), and tendon thinning (61%). Osteopenia/osteoporosis as seen on radiographic imaging was present in 58% of patients with bone mineral density markedly reduced in proximal Humerus and distal radius. Significantly, higher age, female gender, and lower physical activity correlated with more anatomical deterioration. Functional impairment was present in 64% of the participants and resulted in daily activities.

Conclusion: Anatomical changes were observed in upper limb musculoskeletal structures among elderly Pakistanis making them functionally independent. These findings point towards the importance of having preventive and rehabilitative strategies tailored to geriatric healthcare.

Keywords: Anatomical, Musculoskeletal, Rehabilitative, Osteopenia, Osteoporosis

INTRODUCTION

With the global demographic shift towards an aging population, there are many healthcare challenges, some of which are related to age-associated musculoskeletal deterioration. Aging is a progressive process of physiological change that results in anatomical, and structural changes in several body systems with consequences for functionality and quality of life for elderly individuals[1]. Degenerate transformations of the musculoskeletal system, i.e. muscles, bones, joints, ligaments, and tendons, occur considerably in the upper limb structures with age. These anatomical changes have a profound impact on motor performance, daily activities, and independence and, as such, have clinical relevance and implications for geriatric health management[2].

Many studies have also shown these age-related morphological alterations of the musculoskeletal system, including loss of muscle mass (sarcopenia), reduction of bone mineral density (osteopenia and osteoporosis), degeneration of joint cartilage, ligamentous laxity, and tendon fragility, globally. Nevertheless, these anatomical transformations are considerably modulated by genetic predispositions, lifestyle differences, nutritional status and physical activity levels, and healthcare accessibility at different levels of regional and ethnic variation [3]. For these reasons, there is a need for research focused on the regional populations to better understand localized anatomical changes and their clinical consequences and to inform targeted preventive and therapeutic interventions[4].

At present, Pakistan is undergoing rapid demographic transitions with an increase in the elderly population, complicating healthcare issues by socioeconomic disparities, differential access to healthcare services, and little geriatric-focused clinical research. Specifically, there is a particular paucity of anatomical studies focusing on age-related changes in musculoskeletal structures of the Upper Limb of elderly Pakistani populations[5]. The development of culturally adapted clinical practices, rehabilitation protocols, and preventive strategies for older adults that are specific to the anatomical and functional demands of older adults in Pakistan is impeded by this study gap[6].

Thus, the objectives of current study are to show the age-related anatomical changes in the upper limb musculoskeletal structures of elderly Pakistani individuals. This study aimed to characterize the structural alterations in bones, joints, muscles, ligaments, and tendons and the clinical implications for functional mobility, risk assessment for injuries, management of musculoskeletal disorders, and design of effective physiotherapeutic interventions[7]. Furthermore, this study contributes to the filling of an existing scientific gap along with providing valuable baseline data for geriatric practitioners, orthopedic specialists, rehabilitation professionals, and policymakers to formulate evidence-based guidelines for elderly care in Pakistan which have been lacking[8].

Consequently, this study fills an important yet neglected domain in geriatric medicine to greatly advance the understanding and treatment of upper limb musculoskeletal conditions in the elderly, so as to ultimately improve healthcare outcomes and quality of life of the elderly population residing in Pakistan[9].

MATERIALS AND METHODS

Study Design: The descriptive cross-sectional study design was used, which was conducted for 12 months from January 2022 to January 2023.The major objective was to determine the age-related anatomical changes in the upper limb musculoskeletal structures in elderly Pakistani people and to draw inferences from them clinically.

Study Setting: This study was conducted at Khawaja Muhammad Safdar Medical College Sialkot and Jinnah Hospital Lahore, Pakistan based on orthopedic and rehabilitation outpatient departments. The hospitals selected were those with high patient volume, diverse patient populations, accessibility, and availability

of specialized diagnostic facilities essential for detailed musculoskeletal evaluation.

Study Population and Sample Size: The elderly participants (≥60 years) were recruited using convenience sampling and a total of n=200 elderly participants were recruited. Pakistani nationals of both genders aged 60 years or above, with independent consent, no acute musculoskeletal trauma nor systemic illness that significantly affects the anatomy of the upper limb, were included as inclusion criteria. Patients with a prior history of upper limb fractures or surgery within six months, severe cognitive impairment, chronic systemic inflammatory diseases (e.g., rheumatoid arthritis), and malignancies, neurological disorders affecting muscle tone or limb movement were excluded.

Ethical Considerations: The study protocol was approved by institutional ethics review committees of participating hospitals prior to commencement. All participants provided written informed consent after reading the explanation of the objectives, procedures, potential benefits, risks, confidentiality, and voluntary participation.

Data Collection Tools and Procedures: Demographic information including age, gender, ethnicity, educational status, socioeconomic background, occupation, lifestyle, nutritional habits and comorbidities were obtained using structured questionnaires. Upper limb musculoskeletal structures were comprehensively evaluated by means of clinical assessments and imaging modalities.

Clinical Examination: A full physical examination of the muscle bulk, strength, joint ROM, ligament laxity, tendon integrity, presence of joint deformities, and overall functional performance was conducted by experienced orthopedic specialists and physiotherapists. A dynamometer calibrated according to the American National Standards Institute for grip strength was used.

Imaging Techniques: Diagnostic imaging was employed to assess structural and anatomical changes:

X-rays: Structural and anatomical changes were assessed with diagnostic imaging. Standardized anteroposterior and lateral radiographs of shoulder, elbow, wrist, and hand joints were obtained to assess joint space narrowing, osteoarthritic change and bone mineral density indicators.

Ultrasound Imaging: High resolution musculoskeletal ultrasonography was performed to evaluate tendon thickness, integrity, echogenicity changes, ligament structure and evidence of soft tissue degeneration.

Statistical Analysis: Data were analyzed by SPSS version 26 (IBM Corp., USA). For continuous variables, descriptive statistics were reported as mean ± standard deviation and for categorical variables frequencies (percentages). Chi-square tests, Student's t-tests, or ANOVA were used as appropriate for analysis of associations between anatomical changes and demographic or clinical variables. Statistical significance was considered to be less than p-value of 0.05.

RESULTS

In total, n=200 elderly Pakistani participants were included, consisting of 112 males (56%) and 88 females (44%). The mean age was 69.4 ± 6.8 years, 60–85 years. This table 1 shows the demographic data of 200 elderly who were involved in the present study. Their age was 69.4 ± 6.8 years, ranging between 60 and 85 years, which means that the sample includes a rather broad range of elderly people. To the gender distribution, the study found out that the respondents were slightly more inclined toward the male gender, 56%, than the female gender, 44%. The mean BMI was 25.7 ± 4.3 kg/m² which is slightly over the normal weight range and might precipitate pressure on joints and other muscular frameworks of the body leading to joint and muscular wear. By socioeconomic status, the majority of the participants were classified as middle socioeconomic status (46.5%), while 41% were categorized as low SES and 12.5% as high SES. A major portion of the participants reported a low level of physical activity where 54% of the respondents were categorized under low activity level, and only 15% of the respondents were under high activity level. More than half of the patients (61%) had associated diseases such as diabetes or hypertension that predispose people to experience musculoskeletal deterioration as a result of aging.

Table 1: Demographic Characteristics of Participants (n=200)

Variables	Frequency (%) or Mean ± SD
Age (years)	69.4 ± 6.8
Gender	
- Male	112 (56%)
- Female	88 (44%)
BMI (kg/m²)	25.7 ± 4.3
Socioeconomic Status	
- Lower	82 (41%)
- Middle	93 (46.5%)
- Upper	25 (12.5%)
Physical Activity Level	
- Low	108 (54%)
- Moderate	62 (31%)
- High	30 (15%)
Comorbidities (Yes)	122 (61%)

This table 2 shows the physical assessment results that were conducted in the study participants. Sarcopenia, which is a severe muscle loss, was established in 71% of the elderly. This was in agreement with the low average grip strength of 18.5 ± 4.9 kg which was below the expected norm for this age group and points to a compromised functional fitness status. Decreased joint ROM was reported in 67% participants which have further manifested stiffness and reduced flexibility that affects movement of arms and their daily functions. The prevalence of joint deformities from osteoarthritis as observed in this study was high at 51%, which confirms the high prevalence of degenerative joint disease among the patients. Ligamentous laxity observed in 43.5% of the patients meant that many of them experienced joint instability due to the loose connective tissue. Notably, 64% of the participants presented with functional loss, which supports the idea of the negative effect of these structural changes on the ability to dress, eat or lift something.

Table 2: Clinical Examination Results of Upper Limb (n=200)

Parameters	Frequency (%) (Mean ± SD)
Muscle Mass Loss (Sarcopenia)	142 (71%)
Mean Grip Strength (kg)	18.5 ± 4.9
Joint Range of Motion Reduction	134 (67%)
Joint Deformities (Osteoarthritis)	102 (51%)
Ligamentous Laxity	87 (43.5%)
Functional Impairment	128 (64%)

Table 3: Imaging Findings (X-rays and Ultrasonography) (n=200)

Anatomical Structures	Frequency (%)
Osteopenia/Osteoporosis	116 (58%)
Joint Space Narrowing (Shoulder)	92 (46%)
Joint Space Narrowing (Elbow)	85 (42.5%)
Joint Space Narrowing (Wrist/Hand)	109 (54.5%)
Bone Spurs/Osteophytes	97 (48.5%)
Tendon Thinning and Degeneration	122 (61%)
Ligament Degeneration	98 (49%)

This table 3 shows radiological and ultrasonographic imaging of degenerative musculoskeletal changes. Decreased bone density, osteopenia or osteoporosis was found in 58% of the patients enrolled into the study. The highest prevalence of JSN was in the wrist and hand (54.5%) followed by the shoulder (46%) and elbow (42.5 per cent) which indicates multiple joint involvement of the upper limb. Precisely, 48.5% of the patients had bone spurs or osteophytes, which are new growths of bone that occur in response to chronic osteoarthritis stress. Using ultrasound examination muscle tendons were seen to be thinned and degenerated in 61% of all participants while ligaments were also degenerated in 49%. These observations indicate that, in addition to the cartilage, which is the primary support of the joint, there is

also disruption in other soft tissues that need to be intact to support a stable joint.

The results of DXA scan shown in the table 4 also depict that the bone density has reduced significantly in elderly population. The mean value of BMD in the proximal humerus was 0.69 ± 0.14 g/cm² and 36 % were osteopenic and 24 % were osteoporotic. The same was true for the distal radius and distal ulna with osteoporosis being present in 26.5% and 23% of the participants respectively. These values indicate much a skeletal frailty, particularly in regions involving fractures after falls. The distal forearm which is commonly attached in Colles' fractures was among the areas with the least BMD. This information supports the clinical diagnosis of bone demineralization in the majority of the study participants and highlights the vulnerability of such patients to falls. It also indicates a need for anatomic density enhancement procedures such as calcium/vitamin D supplementation or medication.

Table 4: Bone Mineral Density (DXA Scan Results) (n=200)

Site Assessed	Mean BMD (g/cm²) ± SD	Osteopenia (%)	Osteoporosis (%)
Proximal Humerus	0.69 ± 0.14	72 (36%)	48 (24%)
Distal Radius	0.62 ± 0.11	65 (32.5%)	53 (26.5%)
Distal Ulna	0.64 ± 0.12	68 (34%)	46 (23%)

This table 5 shows how age, gender and the level of physical activity are related with anatomical deterioration. All the changes in anatomy that were assessed in the study were significantly related to age. Sarcopenia was found in 90.2% of the participants aged ≥70 years; osteoarthritis in 57.3%; and osteoporosis in 50% of the same participants while participants aged 60–69 years had a lower prevalence of the three diseases. Females had a higher rate of sarcopenia than males at 79.5% and 64.3% respectively, osteoarthritis at 61.4% for females and 42.9% for males, and osteoporosis at 42.1% for females and 36.6% for males. This can be attributed to hormonal changes after menopause and also lower muscle mass in women as compared to men. This study revealed physical activity as one of the significant modifiable factors. The low physical activity group had significantly higher number of poor musculoskeletal health including sarcopenia 81.5%, and osteoporosis 54.6% as compared to high physical activity group. All the associations were significant at $p < 0.05$ level thus underlining the clinical relevance of the findings on the need to encourage exercise and physically active living among such populations.

Table 5: Associations between Anatomical Changes and Demographic Variables

Variables	Sarcopenia (%)	Osteoarthritis (%)	Osteoporosis (%)	p-value
Age Groups				<0.001*
60–69 years (n=118)	68 (57.6%)	55 (46.6%)	37 (31.4%)	
≥70 years (n=82)	74 (90.2%)	47 (57.3%)	41 (50.0%)	
Gender				0.002*
Male (n=112)	72 (64.3%)	48 (42.9%)	41 (36.6%)	
Female (n=88)	70 (79.5%)	54 (61.4%)	37 (42.1%)	
Physical Activity Level				<0.001*
Low (n=108)	88 (81.5%)	71 (65.7%)	59 (54.6%)	
Moderate/High (n=92)	54 (58.7%)	31 (33.7%)	19 (20.7%)	

* Statistically significant (p<0.05).

DISCUSSION

Anatomical changes were found in both the upper and lower limbs that were significantly age-related and included muscle loss (71%), reduced grip strength, joint degeneration, ligament laxity, and tendon thinning. Radiological imaging and DXA scanning showed a high prevalence of osteopenia and osteoporosis in both proximal Humerus and distal forearm bones. Musculoskeletal changes and functioning impairment were significantly correlated with higher age, female gender, and lower physical activity levels[10, 11]. Age-related anatomical changes in the upper limb musculoskeletal structures in elderly Pakistani individuals were comprehensively analyzed and the significant morphological alterations and their clinical implications were brought forward. High prevalence of muscle mass loss (sarcopenia, 71%), joint degeneration, ligament laxity, and low bone mineral density are present with consequent functional impairment are underscored by our findings. Notably, these anatomical modifications greatly affected how the participants lived their daily lives and posed a strong argument for more specific therapeutic and preventive interventions in geriatric health care[12].

Our findings about sarcopenia (71%) are in line with previous international literature reporting a high prevalence of muscle wasting in aging populations. The results of comparable research done globally show that muscle mass deterioration is the main contributor to reduced functional capacity and increased dependency in older adults[13].Nevertheless, the slightly elevated frequency we observe in our study might be ascribable to peculiar regional characteristics, such as nutritional deficits, socioeconomic disparities, reduced participation in physical activity, and insufficient state of mind regarding preventive health measures that are frequently encountered in Pakistani countries[14].

Corroborating the clinical impact of muscle loss, there was a significant reduction in grip strength (mean 18.5 ± 4.9 kg). In addition to reducing the elderly population's ability to perform routine tasks, reduced grip strength also increases their vulnerability to accidental injuries and falls[15]. These results highlight the need for the development of comprehensive physical rehabilitation programs aimed at preventing muscle mass and strength loss in elderly patients, targeted to the Pakistani sociocultural and clinical contexts[16].

There was considerable joint space narrowing, osteophyte formation, and osteoporosis, especially in the proximal Humerus and distal radius and ulna regions seen on radiographic evidence. As in the literature, these changes make it more likely that the joints will be stiff, chronically painful, susceptible to fracture, and severely limited in function[17]. In particular, 50.5% of participants were found to have osteoporosis or osteopenia indicative of a significant burden and the need for routine screening and preventive strategies. This frequency mirrors international data, and also adds to regional concerns of inadequate calcium and vitamin D in the diet, less sun exposure, and poor public health education. Ultrasonography also revealed the extensive age-related change affecting soft tissues with high occurrence of tendon and ligament degeneration (61% and 49%, respectively). This agreed with previous studies that found connective tissue had greater fragility and lower regenerative potential in older adults[18].

We further found that demographic variables had significant associations with anatomical deterioration. Strong associations with greater degeneration were increased age, female gender, and less physical activity. These findings are consistent with the known literature on greater vulnerability in females because of hormonal changes after menopause and their effect on osteoporosis and joint degeneration[19].Lower physical activity came out as a critical modifiable factor, pointing to the need for interventions targeted at promoting active lifestyles at the community level [20]. The study findings are highly relevant to the Pakistani elderly population. However, several limitations are acknowledged. The first issue is the lack of causality establishment because of the cross-sectional design. Secondly, a limitation of convenience sampling is that it may not generalize to rural or remote communities in Pakistan. These findings need to be confirmed in future longitudinal studies with more extensive and diverse sampling, and with more detail explored along causative pathways[7, 21].

CONCLUSION

The results of this study indicate that there is a very significant amount of anatomical change in upper limb musculoskeletal structures with age in elderly Pakistani individuals. Strongly advocating for tailored healthcare interventions, preventive strategies, and community awareness directed to regional demographics to strengthen functional independence and improve the overall quality of life among the aging population.

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