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Ankle-Foot Musculoskeletal Pathologies and Age-Related Arthro-Kinematic Changes: a Case-Control Study

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ABSTRACT

Background: *The aging process profoundly influences the health of foot and ankle joints, impairing stride and range of motion and resulting in several musculoskeletal disorders. Despite extensive research on ankle arthrokinematics in Western and East Asian populations, India has yet to witness any such studies. We conducted a two-phased research study to evaluate the arthrokinematics of the ankle joint-foot complex. The first phase investigated how different types of physical activity were affecting the biomechanics of the ankle joint-foot complex in both healthy people and those with painful conditions, and the results have already been published.*

Aim: *This article shares the results of phase 2 of the project, which looks at how age and gender affect the size and movement of the ankle-foot complex in healthy people and those with pain.*

Methods: *This observational cross-sectional study comprised 158 patients randomly selected from those presenting at the orthopaedic outpatient department. We obtained ethical clearance and finalized the Clinical Trial Registry of India (CTRI) registration for the study before commencement. The study assessed the impact of age and gender on the anthropometric and biomechanical parameters of the ankle joint-foot complex in patients experiencing foot and ankle joint pain (cases) and in pain-free individuals (controls).*

Results: *The middle age group (25-64 years) was identified as the most susceptible demographic for ankle joint-foot complex diseases, accounting for 146 out of all 158 cases (92.4%). The average dorsiflexion, plantarflexion, inversion and eversion in both unaffected and diseased feet diminished with advancing age. Female patients had a greater prevalence of ankle and foot diseases compared to male subjects.*

Conclusions: *As people get older, the range of motion of the ankle and foot decreases significantly because of several physical reasons such as weaker muscles, stiffer joints and less flexible connective tissues.*

Keywords: anthropometry, biomechanics, ankle joint-foot complex, aging effects, sexual dimorphism.

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INTRODUCTION

Aging reduces joint capsule flexibility, alters synovial fluid quality and quantity, stiffens ligaments, reduces elastic fibres and degrades joint receptors (1). Tendinopathy, which causes tendon degeneration, dysfunction and pain, is widespread in elderly people and accounts for many musculoskeletal problems (2). In 2024, Talia AJ and colleagues found that female athletes experienced more ankle joint and foot complex injuries, particularly ligament sprains and stress fractures. Ligamentous laxity was an intrinsic and extrinsic risk factor for these injuries, which may explain gender differences in injury patterns (3). Brockett *et al* found that aging reduced muscle mass, increased ligament and tendon rigidity, reduced bone density, deteriorated cartilage and altered the neural system, altering foot-ankle complex biomechanical performance. These changes ultimately impact balance and mobility, aggravating illnesses such as osteoarthritis (4). He stated that age and gender were both critical factors that could influence ankle range of motion (4). Kanayama *et al* highlighted that the main factor leading to reduced walking speed in older individuals was the deterioration of both plantarflexion strength and velocity with age (5). Numerous prior investigations have documented age-related alterations and sex disparities in plantarflexion strength (6-11), including a reduction of 34-42% from youth to advanced age (6, 7). Fugl-Meyer AR, Gustafsson L and Burstedt Y suggested that men had better plantarflexion strength than women (8). Kumar *et al* (12) studied ankle joint range of motion norms in India across age groups. Thus, there is no Indian study on the biomechanical function of the foot-ankle joint complex in normal and painful circumstances. This study differentiates itself from prior worldwide research carried out by Brockett *et al* (4), Zhao Y and Wang G (13) and Legault-Moore *et al* (14) by encompassing all patients with ankle joint and foot complex pain, irrespective of origin, and emphasizes its link with physical activity as well as age and gender disparities. To achieve this objective, we conducted a phase 2, one-year, observational, cross-sectional study to obtain baseline anthropometric and biomechanical measurements of the ankle joint-foot complex in both healthy individuals and those with painful conditions, correlating these findings with different age groups and genders of participants. ❑

MATERIALS AND METHODS

Study design and population

This observational cross-sectional study is the second phase of a two-year study with the Orthopaedics and Anatomy Departments. We conducted phase 1 from 1 August 2022 to 31 July 2023 and phase 2 from 1 October to 31 March 2024. Before the study began in July 2022, the Institutional Ethical Committee approved phases 1 and 2. A phase 2 CTRI registration has been completed.

Sample size calculation

The sample size was estimated using data reported by Keenan AM *et al* (2019), whose research on a British cohort found 18.4% of 55-year-olds experienced foot and ankle discomfort (15). The calculation formula was as follows: sample size (n) = $Z^2 \times PQ/L^2$, with 18.4% prevalence, 81.6% Q (1-P), 5% L, 95% confidence interval and 80.0 study power. The 230.68 sample size was rounded to 240, evenly split between 120 cases and 120 controls (16).

Criteria for eligibility

Participants in both case and control groups had to be 14–70 years old, to live in any region of the country and to have a normal body mass index. The case group comprised individuals with musculoskeletal pain in the foot and ankle joints, whereas the control group consisted of people without such type of pain. The completion of humeral ossification at 13-15 years for girls and 15-17 years for boys determined the 14-70 age range (17).

Sample selection method

Participants were recruited from patients with the relevant pathology during the study period who were visiting the orthopaedic outpatient department (OPD) and met the eligibility criteria. A simple random sampling method was used, considering the low incidence of the condition and the feasibility for the investigators.

Ethical approval

This was phase 2 of an intramural, non-funded research study in anatomy and orthopaedics. It received the Institutional Ethical Committee (IEC) approval after RRB approval. Two phases were conducted for Protocol ID: NF/15/2022 intramural research. The first phase studied the association between physical activity and ankle joint-foot complex pain disorders from August 1, 2022, to July 31, 2023. The authors reported those findings. Phase 1 of this project ran from 1 October 2023 to 31 March 2024. Phase 2 examined the association by age and gender. This article presents the findings of phase 2. Both phases of the study share a single ethical approval dated July 9, 2022, with the CTRI registration number CTRI/2023/10/058206.

Clinical Trial Registry of India registration

Subsequent to obtaining IEC permission, the project was registered with the Clinical Trial Registry of India (CTRI).

Patient information sheet/data collection form

A data collection form, accessible in English, Hindi and Gujarati, was utilized to gather demographic information, medical and surgical history, current diagnosis, type of treatment administered, unilateral or bilateral involvement and length of sickness. Informed consent was acquired by a distinct proforma accompanied by the information sheet.

Data collection procedure

The anthropometric measures of the foot and the biomechanical assessments at the ankle and subtalar joints were conducted as outlined by Charmode SH *et al* in phase one of the study (18, 19). The height was assessed *via* a stadiometer, with the individual positioned in the anatomical stance, feet together, back against the apparatus and head aligned with the Frankfort plane. Weight was measured using a digital scale and body mass index (BMI) was computed by dividing weight in kilograms by the square of height in meters (20). Foot length (FL), foot breadth (FB), truncated foot length (TFL), medial longitudinal arch height (MLAH), longitudinal arch angle (LAA), arch height index (AHI) and the Feiss line were assessed utilizing anatomical reference points (21, 22). We performed ankle and subtalar biomechanical testing, including dorsiflexion, plantar flexion, inversion and eversion, using a typical manual goniometer (23-26).

FIGURE 1. Foot length measurement using vernier callipers (courtesy: image captured and edited by Dr. Valency Pateliya and Dr. Rajdip Herma, junior residents of the Department of Anatomy, AIIMS, Rajkot, India)

FIGURE 2. Foot breadth measurement using vernier callipers (courtesy: image captured and edited by Dr. Valency Pateliya and Dr. Rajdip Herma, junior residents of the Department of Anatomy, AIIMS, Rajkot, India)

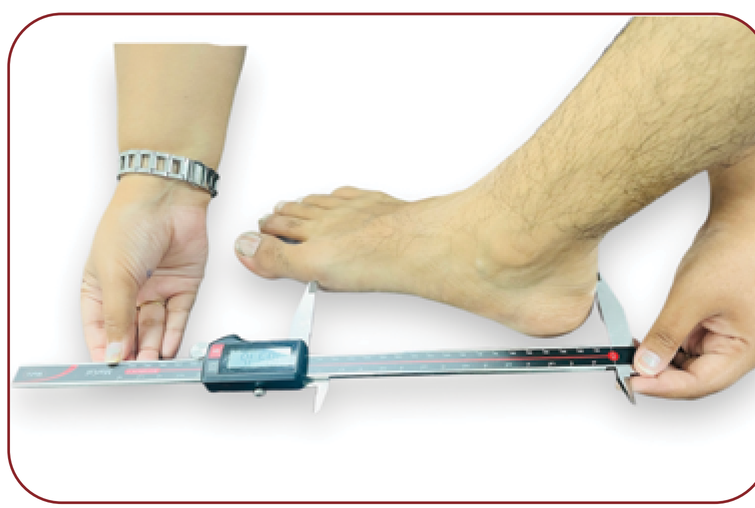

FIGURE 3. Measurement of truncated foot length via vernier callipers (courtesy: image captured and edited by Dr. Valency Pateliya and Dr. Rajdip Herma, junior residents of the Department of Anatomy, AIIMS, Rajkot, India)

FIGURE 4. Longitudinal arch angle measurement using goniometer (courtesy: image captured and edited by Dr. Valency Pateliya and Dr. Rajdip Herma, junior residents of the Department of Anatomy, AIIMS, Rajkot, India)

FIGURE 5. Medial longitudinal arch height measured using the triangular scale (courtesy: image captured and edited by Dr. Valency Pateliya and Dr. Rajdip Herma, junior residents of the Department of Anatomy, AIIMS, Rajkot, India)

The stadiometer had a standard error of 0.4 to 0.5 cm, while the goniometer had a standard error of 2.4 to 4.9 degrees, with less than 5 degrees of variation in repeated measurements. The standard error was from 0.4 to 0.5 cm, whereas the goniometer standard error was 2.4 to 4.9 degrees, with less than five degrees of fluctuation in repeated observations.

Data categorization

Statistics Canada established the Age Categories and Life Cycle Groupings to categorize the data collected from the study participants by age. We categorized participants into three distinct age cohorts: young adults (15-24 years), adults (25-64 years) and older adults (65 years and above) (27). This classification groups adolescents with young adults based on their minimal biomechanical differences and clinical significance, which aligns with previous research for comparison. This approach simplifies age-related analysis and ensures a larger sample size, enhancing the generalizability of the study. We did not use the standard life-cycle classification, as the International Society of Kinanthropometry (ISAK) offers universal anthropometry guidelines for all population groups.

Risk assessment

Selected participants were assessed for pain severity utilizing the numeric pain rating scale (NPRS), which classified pain levels as low, moderate, or severe. The study participants assessed their current, maximum and minimum pain experienced in the past 24 hours, with the average of these three evaluations indicating each patient's pain level during that period (28). Deviations exceeding normative range of motion (ROM) values in the unaffected, pain-free foot were compared with prior radiographs to evaluate intra-subject variability ROM at the ankle joint-foot complex and to assess angular bone alignment. In phase 1 of the study, which examined 100 participants from August 1, 2022, to July 30, 2023, the intra-rater and inter-rater reliability of ROM measurements was established at a sufficient level for both affected and non-affected sides.

The BMI is a vital variable that influences the biomechanical analysis of any joint, and we countered its confounding impact in the following manner. The analysis of the 240 patients based on their BMI enabled us to categorize them into five classes: 11 (4.4%) of them were individuals with underweight, 79 (32.9%) with normal weight, 108 (44.9%) with overweight, 21 (8.9%) with obesity and 21 (8.9%) with obesity grade-1. Variables were defined, namely ROM as the dependent variable, age as the independent variable and BMI as the covariate. A regression model was formulated as described below.

Range of motion = $\beta_0 + \beta_{1(A\gamma\varepsilon)} + \beta_{2(BMI)} + \varepsilon$, where β_0 is the intercept of the regression coefficient, β_1 the coefficient for age, β_2 the coefficient for BMI and ε the error term accounting for unexplained variation (29). A multiple regression analysis was performed in the Excel sheet and the coefficients with their associated p-values, R (degree of variation) and adjusted R values were estimated. The 158 participants chosen for the study had p-values that were not significant for the value-R, meaning that the BMI did not significantly affect the ROM at the ankle joint. ANCOVA test was not required as all 158 study participants showed an insignificant R value.

Data-collecting instruments

Anthropometric data collection employed accurate devices, such as digital vernier callipers, a stadiometer, a manual goniometer, a digital weighing scale, skin marking pens, a plastic ruler, triangle scale sets, measuring tapes, patient information sheets and stationery.

Data analysis procedure

Tables and graphs were created using data structured in an Excel Master chart. Participants' anonymity was carefully maintained. Means, standard deviations and statistical significance with a 0.05 p-value were calculated in quantitative data analysis. We used paired sample t-tests to compare foot length, width, truncated foot length, longitudinal arch angle and medial longitudinal arch height between genders and sides. ANOVA was used to compare juvenile, adult and elderly cohorts. Statistical analyses were performed using SPSS (version 25, IBM Corp.) and reported in tabular and graphical forms. ❑

RESULTS

We divided the project into phase 1 and phase 2. Patients with ankle joint-foot complex diseases were investigated for the relationship between ankle joint biomechanical function and workplace physical activity during a 12-month period. Phase 1 data was published (19). Phase 2 was conducted from 1 October 2023 to 31 March 2024. The same 158 patients were measured for foot anthropometry in phase 2. This was combined with repeated ankle biomechanical examinations for different age groups and genders. We used a spreadsheet to tabulate, graphically represent and statistically analyse the data from all 158 patients.

Table 1 shows that middle-aged people (25–64 years) were more prone to ankle joint-foot complex disorders. The most common illness was ankle-foot sprain, occurring in 65 of 158 patients (41.13%). The connection between these symptoms across age groups was substantial ($P<0.05$).

Female patients were observed to be more commonly associated with these conditions compared to male subjects. This association was found to be statistically not significant ($P>0.05$).

As shown in Table 2, no statistically significant differences were seen in mean foot length, foot breadth, medial longitudinal arch height, longitudinal arch angle, plantar flexion and inversion ($P>0.05$) across the age groups. The analysis revealed a statistically significant difference in mean dorsiflexion and eversion ($P<0.05$). The average measurements of dorsiflexion and eversion were seen to be lower in older individuals compared to those of middle and younger ages.

The study further reveals that there was a statistically highly significant difference in mean measurements of foot length, foot breadth and truncated foot length between genders ($P < 0.001$).

Table 3 shows that the mean ankle joint dorsiflexion declines in both the non-affected and afflicted foot as age proceeds from young to middle age and then to old age. Results were significant ($P<0.05$).

Furthermore, there was no statistically significant difference in mean dorsiflexion of the af-

Ankle joint-foot pathologies	15—24 years	25—64 years	≥ 65 years	Total (No.)
Sprain of ankle and foot	01 (25%)	62 (42.4%)	02 (25%)	65
Isolated ankle joint sprain	02 (50%)	34 (23.2%)	02 (25%)	38
Isolated foot sprain	0 (0.0%)	15 (10.2%)	01 (12.5%)	16
Plantar fasciitis	1 (25%)	07 (4.7%)	01 (12.5%)	09
Ankle joint pain	0 (0.0%)	05 (3.4%)	01 (12.5%)	06
Foot pain	0 (0.0%)	09 (6.1%)	01 (12.5%)	10
Flat foot	0 (0.0%)	07 (4.7%)	0 (0.0%)	07
Ankle and foot pain	0 (0.0%)	03 (2.0%)	0 (0.0%)	03
Others	0 (0.0%)	04 (2.7%)	0 (0.0%)	04
Total number of patients	**04**	**146**	**08**	**158**
Fisher Exact test	**P = 0.037, Significant**			

NS=not significant; S=significant; HS=highly significant

TABLE 1. Distribution of ankle joint-foot pathologies based on age groups

Variables	Age groups	Mean ± SD	ANOVA test	P-value
Foot length (FL) (mm)	15—24 (young age)	243.7 ± 19.97	F = 0.639	P = 0.529, NS
	25—64 (middle age)	231.4 ± 233.4		
	≥ 65 (older age)	233.4 ± 13.97		
Foot breadth (FB) (mm)	15—24 (young age)	91.4 ± 3.95	F = 0.215	P = 0.807, NS
	25—64 (middle age)	87.96 ± 15.47		
	≥ 65 (older age)	90.21 ± 6.16		
Truncated foot length (TFL) (mm)	15—24 (young age)	181.24 ± 14.14	F = 0.374	P = 0.689, NS
	25—64 (middle age)	173.82 ± 19.95		
	≥ 65 (older age)	172.78 ± 5.49		
Medial longitudinal arch height (MLAH) (cm)	15—24 (young age)	6.64 ± 0.65	F = 0.170	P = 0.844, NS
	25—64 (middle age)	6.40 ± 1.09		
	≥ 65 (older age)	6.28 ± 1.54		
Longitudinal arch angle (LAA) (degree)	15—24 (young age)	156.01 ± 5.47	F = 1.958	P = 0.145, NS
	25—64 (middle age)	156.35 ± 9.33		
	≥ 65 (older age)	155.98 ± 10.89		
Dorsiflexion	15—24 (young age)	23.60 ± 5.89	F = 2.973	P = 0.048, S
	25—64 (middle age)	20.00 ± 5.95		
	≥ 65 (older age)	16.11 ± 5.03		
Plantarflexion	15—24 (young age)	40.00 ± 14.14	F = 0.006	P = 0.995, NS
	25—64 (middle age)	40.43 ± 12.23		
	≥ 65 (older age)	40.11 ± 12.70		
Subtalar joint-inversion	15—24 (young age)	17.40 ± 4.82	F = 1.889	P = 0.095, NS
	25—64 (middle age)	17.56 ± 5.56		
	≥ 65 (older age)	13.89 ± 4.85		
Subtalar joint- eversion	15—24 (young age)	7.76 ± 2.50	F = 3.141	P = 0.045, S
	25—64 (middle age)	8.30 ± 2.95		
	≥ 65 (older age)	5.88 ± 1.83		

NS=not significant; S=significant; HS=highly significant

TABLE 2. Comparison of measurement of variables with age groups

Age wise groups	Affected foot	Non-affected foot	Difference in mean (MD)	t-test value	p-value
	mean ± SD	mean ± SD			
Younger age group (15-24 years)	22.67 ± 5.42	24.45 ± 6.11	1.78 ± 0.69	t = 2.43	P=0.031, S
Middle age group (25-64 years)	19.01 ± 6.21	21.03 ± 5.84	2.02 ± 0.37	t = 2.67	P=0.026, S
Old age group (≥ 65 years)	15.26 ± 4.82	16.99 ± 5.21	1.73 ± 0.39	t = 2.12	P=0.047, S
Total	19.03 ± 6.27	20.37 ± 5.89	19.71 ± 6.08	t = 2.11	P=0.045, S
ANOVA test, P-value	**F = 2.08 P = 0.263, NS**	**F = 2.171 P = 0.982, NS**	---	----	-----

NS=not significant; S=significant; HS=highly significant. For the t-test, if the P-value is <0.05, it is significant. The ANOVA test is considered significant if the P-value is less than 0.01.

TABLE 3. Age-wise analysis of dorsiflexion in affected and non-affected foot

Age wise groups	Affected foot mean ± SD	Non-affected foot mean ± SD	Difference in mean (MD)	t-test value	p-value
Younger age group (15-24 years)	39.72 ± 11.54	40.28 ± 10.75	0.56 ± 0.79	t = 0.673	P=0.821, NS
Middle age group (25-64 years)	39.19 ± 12.84	41.73 ± 12.22	2.54 ± 0.62	t = 2.214	P=0.027, S
Old age group (≥ 65 years)	39.92 ± 12.70	40.29 ± 14.98	0.37 ± 2.28	t = 0.921	P=0.873, NS
Total	39.57 ± 12.78	41.27 ± 12.33	1.7 ± 0.45	t = 1.351	P=0.182, NS
ANOVA test, P-value	**F = 0.481, P = 0.912, NS**	**F = 0.683, P = 0.851, NS**	---	-----	------

NS=not significant; S=significant; HS=highly significant. For the t-test, if the P-value is <0.05, it is significant. The ANOVA test is considered significant if the P-value is less than 0.01.

TABLE 4. Age-wise analysis of plantar flexion in affected and non-affected foot

fected foot between males and females (P>0.05) and also no statistically significant difference in mean dorsiflexion of the non-affected foot between males and females (P>0.05).

The average plantarflexion at the ankle joint was lowest in the medium age group (24-64 years) for both the non-affected and afflicted foot, according to Table 4. Results were statistically not significant (P<0.05).

The mean plantarflexion in the affected and non-affected foot was seen to be lower in females as compared to males, but it was statistically not significant (P > 0.05). Whereas there was a statistically significant difference in mean plantarflexion between the affected foot and the

Age wise groups	Affected foot mean ± SD	Non-affected foot mean ± SD	Difference in mean (MD)	t-test value	p-value
Younger age group (15-24 years)	16.13 ± 3.21	17.52 ± 4.04	1.39 ± 0.83	t = 2.373	P=0.029, S
Middle age group (25-64 years)	15.01 ± 3.92	16.32 ± 4.02	1.31 ± 0.1	t = 2.172	P=0.039, S
Old age group (≥ 65 years)	15.22 ± 3.56	15.22 ± 3.56	0 ± 0	t = 0.000	P=1.00, NS
Total	15.23 ± 3.94	16.10 ± 3.98	0.87 ± 0.04	t = 2.091	P= 0.043, S
ANOVA test, P-value	**F = 0.116 P = 0.935, NS**	**F = 0.255 P = 0.917, NS**	---	----	----

NS=not significant; S=significant; HS=highly significant. For the t-test, if the P-value is <0.05, it is significant. The ANOVA test is considered significant if the P-value is less than 0.01.

TABLE 5. Age-wise analysis of inversion in affected and non-affected foot

	mean ± SD	mean ± SD	mean (MD)	t-test value	
Younger age group (15-24 years)	8.00 ± 3.60	8.40 ± 2.52	0.40 ± 1.08	t = 0.573	P=0.752, NS
Middle age group (25-64 years)	7.31 ± 2.79	7.73 ± 2.92	0.42 ± 0.13	t = 0.383	P=0.893, NS
Old age group (≥ 65 years)	6.78 ± 2.14	7.00 ± 2.29	0.22 ± 0.15	t = 0.874	P=0.640, NS
Total	7.20 ± 2.76	7.69 ± 2.87	0.49 ± 0.11	t = 0.591	P=0.774, NS
ANOVA test, P-value	**F = 0.181 P = 0.616**	**F = 0.271, P = 0.893**	---	----	-----

NS=not significant; S=significant; HS=highly significant. For the t-test, if the P-value is <0.05, it is significant. The ANOVA test is considered significant if the P-value is less than 0.01.

TABLE 6. Age-wise analysis of eversion in affected and non-affected foot

non-affected foot in males, females, and all together ($P < 0.05$).

Table 5 indicates that the average inversion at the subtalar joint in both the unaffected and affected foot diminishes with advancing age, transitioning from the younger demographic to the middle-aged and elderly populations. The results were statistically significant ($P>0.05$).

The study indicated that females had a lower mean inversion in the affected and non-affected foot than males, but statistically it was found not significant ($P > 0.05$). Whereas there was a statistically significant difference in mean inversion between the affected foot and the non-affected foot with gender ($P<0.05$).

Table 6 indicates that the mean eversion at the sub-talar joint decreases in both the non-affected and affected foot as age progresses from the younger age group to middle age and into the older age group. The findings were not statistically significant ($P>0.05$).

The study showed that the mean eversion in the affected foot as well as in the non-affected one was lower in males compared to females, but statistically the findings were not significant ($P > 0.05$). Additionally, the study found no statistically significant difference in mean eversion between the affected and non-affected feet based on gender ($P > 0.05$). ❑

DISCUSSION

Eline van der Kruk and colleagues conclude that a combination of muscle stiffness, along with skeletal and joint changes, leads to a reduction in joint range of motion as aging progresses (30). The findings of the present study align with their observations. James B and Parker AW note that the ROM tends to decrease with age. Older adults exhibit a 12-30% reduction in dorsiflexion-plantarflexion at the ankle joint and inversion-eversion at the subtalar joint (31). Our study revealed analogous findings. The mean measurements of dorsiflexion and eversion were lower in older individuals compared to those in middle and young age groups. Similarly, Kumar *et al* observed an age-related decrease in ROM, specifically in dorsiflexion at the ankle joint, within the 15–25-year-old age group (12), which was consistent with our findings. Kerrigan indicated that the decrease in ankle ROM was attributable to diminished muscle strength and activation, resulting in lower pedal force relative to younger individuals. Elderly adults demonstrate enhanced hip extension during gait, characterized by an increased range of hip joint extension and a reduced ROM at the ankle joint (32). These findings are consistent with those of our study. Zhai *et al* reported that, with advancing age, there was a significant decrease in ROM in the lower limbs, particularly at the ankle joint, resulting in a sustained reduction in gait speed (33). Our research presents comparable results. Bok SK's study confirms that muscle weakness is a factor associated with falls in the elderly. The study indicated a decline in ankle joint strength, ROM and balance control, accompanied by an increased risk of falls with aging. Age causes a decline in plantarflexion at the ankle joint and eversion at the subtalar joint, both of which influence balance (34). Our study described analogous findings. Therefore, these two factors must be considered when evaluating patients with a higher incidence of falls. We propose intervention programs aimed at enhancing ankle joint strength and flexibility while assessing their role in improving balance and preventing falls in the elderly. Hernández-Guillen D *et al* discovered that for older adults living in the community, the ability to lift the foot upwards while standing can indicate how well they maintain balance while moving and the strength of the muscles that point the toes down is a strong predictor of how well they can stand still (35). The current study aligns with these observations, highlighting the significance of enhancing ankle joint strength and biomechanics to prevent falls among the elderly. DeVita P and his colleague report that as people get older, the way forces and movements work at the ankle joint changes, which suggests that the way we move to perform tasks also changes (36). Various studies indicate that with advancing age, there is a notable decline in motor abilities attributed to alterations in biomechanical and physiological aspects of the joints, alongside potential involvement of the underlying neuromuscular components in motor performance.

Limitations of the study

Anthropometric and biomechanical measurements of the foot and ankle joint were performed using vernier callipers and manual goniometers at a single point in time, which was consistent with cross-sectional design of the study. This limitation hindered subsequent evaluations of post-treatment recovery. A prospective study would have facilitated pre- and post-treatment comparisons, yielding more reliable biomechanical data. ❑

CONCLUSIONS

The prevalence of pathologies in the ankle-foot complex is highest among individuals aged 25 to 64 years. In this cohort, ankle joint and foot sprains, whether occurring in isolation or in conjunction with other injuries, are the most frequently observed musculoskeletal conditions. These injuries involve the overstretching or tearing of ligaments, typically caused by acute trauma or repetitive stress. The range of motion at the ankle joint-foot complex significantly decreases with age. The decline in ROM associated with aging is due to various physiological factors, such as diminished muscle strength, heightened joint stiffness and reduced elasticity of connective tissues. The cumulative effects of these changes diminish the functional capacity of the ankle joint, negatively impacting balance, mobility and overall quality of life in older adults. Understanding how these age-related changes work is important for developing specific strategies to prevent and treat problems with the ankle joint and foot, which will help improve muscle and bone health and independence for people of all ages.

Clinical recommendations

Based on the conclusions of both phases of our study, we recommend targeting prevention and rehabilitation techniques for middle-aged females (25-64 years) in low physical activity employment to reduce ankle-foot complex disorders. Mechanical diagnosis and therapy (MDT) have shown immediate and lasting improvements in ankle-foot pain and dysfunction, suggesting it may be beneficial in controlling these diseases. ❑

Conflicts of interest: none declared.

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