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Research Article

INVESTIGATION OF FLEXOR AND EXTENSOR HALLUCIS LONGUS MUSCLE STRENGTH IN RELATION TO HALLUX VALGUS DEFORMITY SEVERITY

Cansu BULUT[1], *Bahar ANAFOROĞLU*[2]

[1]*Ankara Yıldırım Beyazıt University Institute of Health Sciences Department of Physiotherapy and Rehabilitation, Ankara, Türkiye*

[2]*Professor Doctor, Ankara Yıldırım Beyazıt University Institute of Health Sciences Department of Physiotherapy and Rehabilitation, Ankara, Türkiye*

Keywords

Extensor hallucis longus, Flexor hallucis longus, Hallux valgus deformity, Muscle strength.

ABSTRACT

Purpose: This study aimed to investigate changes in the muscle strength of the flexor hallucis longus (FHL) and extensor hallucis longus (EHL) muscles, and their relationship with deformity severity in individuals with halluks valgus (HV), a condition affecting the big toe.
Methods: Thirty-three individuals aged 18 to 65 years (44.46 ± 11.132) with unilateral HV deformity were included. Demographic data was recorded. The severity of HV deformity was evaluated using Manchester Scale. Muscle strength of FHL and EHL muscles was assessed by a hand-held dynamometer, while pain, functionality and activity limitations were assessed using the Foot Function Index (FFI).
Results: A statistically significant relationship was found between deformity severity and the muscle strength of FHL and EHL ($p < 0.001$). Furthermore, the muscle strength of the FHL and EHL in the affected foot was significantly associated with the pain, disability score, activity limitation and the total scores of FFI ($p < 0.001$). Muscle strength in the HV-affected foot was significantly lower compared to the unaffected (healthy) foot for both FHL and EHL ($p< 0.001$).
Conclusion: An increase in deformity severity was associated with a significant reduction in FHL and EHL muscle strength. This reduction correlated with increased pain, functional limitation, decreased and participation in daily living activities. The observed decline in function and increase in pain may be attributed to reduced muscle strength, which leads to increased mechanical load on the joints.

INTRODUCTION

Hallux valgus (HV) is a common forefoot deformity characterized by a lateral deviation and internal rotation of the big toe (hallux) toward the second toe at the first metatarsophalangeal (MTP) joint. This deformity is accompanied by medial displacement of the first metatarsal bone (1-3).

Although its prevalence varies across age groups and populations, HV affects approximately 23% of individuals aged 18 to 65 years, and 35.7% of those aged 65 years and older (4). Hallux valgus is typically associated with progressive pain in the big toe and may result in visible strüktürel deformitesi. If left untreated, it can reduce mobility, decrease physical

Corresponding Cansu BULUT ✉, *cnsblt126@gmail.com*
Ankara Yıldırım Beyazıt University Institute of Health Sciences Department of Physiotherapy and Rehabilitation, Ankara, Türkiye

activity levels, and impair the performance of daily activities (5,6). Additionally, HV has been linked to diminished health-related quality of life (7,8).

Both intrinsic and extrinsic factors are believed to contribute to the development of HV (9). Genetic predisposition, foot morphology, and musculoskeletal imbalances are among the primary intrinsic factors (10,11). Biomechanical abnormalities such as pes planus, excessive pronation, and ligamentous laxity also play a significant role in the onset and progression of HV (12-14). Additionally, prolonged use of narrow and high-heeled shoes can increase pressure on the hallux and accelerate deformity progression (15). The higher prevalence HV among women is often attributed to both biomechanical differences and footwear choices (16). Age-related loss of connective tissue elasticity with may may further contribute the progression of the deformity (17).

Muscle imbalance is considered one of the intrinsic factors contributing to the development of HV (18). Inadequate coordination among the muscle groups in the foot and ankle impairs the big toe's ability to maintain its normal anatomical position. Particularly, weakness or dysfuntion of the abductor hallucis (AbH) muscle, which abducts the big toe, can lead to abnormal load distribution across the joints and exacerbate the deformity (19,20). Additionally, flexor hallucis longus (FHL) and extensor hallucis longus (EHL) muscles have been identified as key contributors to HV progression (21). The directional pull of these muscles may gradually alter joint alignment and exacerbate the deformity (22). Functional impairments in these muscles can further display the toe from its natural axis of motion and intesify existing muscle imbalance (23,24).

This study focuses on the FHL and EHL muscles due to their significant role in the development and progression of HV deformity. The biomechanical effects of these muscles on the hallux positioning warrants further exploration, particularly in relation to the severity of deformity. While existing literature suggests a contributory role of FHL and EHL muscles in increasing the deformity severity (25,26), empirical data directly linking muscle strength to deformity degree remain limited. Current evidence does not provide a definitive understanding of this relationship, highlighting the need for more comprehensive investigation. Therefore, the aim of this study is to assess the changes in FHL and EHL muscle strength in individuals with HV deformity, and to examine the relationship between deformity severity and muscle strength. The aim was to determine the differences between groups with and without HV deformity and to identify how these differences manifest according to the severity of HV.

METHODS

Purpose and Type of Research

This study aimed to investigate changes in the muscle strength of the FHL and EHL muscles, and their relationship with deformity severity in individuals with HV, a condition affecting the big toe. This study was designed as a descriptive-correlational investigation involving individuals with HV deformity.

Population and Sample of the Study

Participants were selected using a random sampling method, comprising 19 males and 14 females. To ensure the reliability of the study results, a preliminary power analysis was conducted using G*Power 3.1 software, which indicated that, for an effect size of $r \geq 0.5$, 33 participants were required. Subsequently, 33 participants were included in the study to achieve the desired statistical power.

Participants:

The study included individuals aged 18–65 years with unilateral HV deformity. Inclusion criteria were:

- Presence of unilateral HV deformity graded as B or C according to the Manchester Scale
- Having unilateral HV deformity,
- Age between 18 and 65 years
- No cognitive and cooperation impairments that could interfere with participation
- No orthopedic conditions or rheumatoid arthritis affecting the lower extremities
- No history of lower extremity surgery
- Voluntary consent to participate in the study.

Exclusion criteria included:

- Diagnosed diabetic neuropathy
- History of lower extremity trauma within the past 6 months
- Previous lower extremity surgery
- Current use of orthoses or assistive devices for the lower extremities
- Ongoing or prior treatment for HV.

Ethical Aspects of the Research

Ethical approval for the study was obtained from the Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee (23.11.2023 – Decision No: 09-042). The study was conducted between June 1, 2024, and May 8, 2025.

Data Collection and Analysis

All participants were informed about the purpose of the study, evaluation procedures, expectations, and the forms used. They were assured of the confidentially of their data, and they signed an "Informed Consent Form" indicating their voluntary participation in the study.

The evaluation methods applied to all participants included in the study are listed below:

- Sociodemographic Information
- Manchester Scale
- Muscle Strength Assessment
- Foot Function Index (FFI)

Sociodemographic Information:

Demographic data including age (years), height (cm), body weight (kg), sex, education level, and occupation were recorded. In addition history of any surgeries was documented. The side affected by HV (right or left) was noted. Body mass index (BMI) values (kg/m²) were calculated by dividing body weight (kg) by the square of height (m²).

Manchester Scale:

The Manchester Scale, developed by Garrow et al. (27) was used to assessed the severity of HV through visual observation The scale comprises four standardized photographic categories. The four levels on the scale are defined as no deformity with a normal appearance (A), mild (B), moderate (C), and severe (D) HV (27).

Grade A indicates a normal structural alignment of the first phalanx. In Grade B, there is slight medial deviation of the first metatarsal bone and a slight lateral displacement of the first phalanx. At the moderate level (Grade C), the medial translation of the first metatarsal bone increases,leading to a more prominent bony protrusion (bunion) at its distal end, and the first phalanx. In the severe level (Grade D), the deformity at the distal end of the first metatarsal bone becomes highly pronounced, and the first phalanx is completely displaced under the second phalanx (27).

In this study, only individuals classified as Grade B or C according to the Manchester Scale were included. This scale enables visual assessment of foot structure while the individual is in a standing position. Since it does not require radiographic imaging, it allows for a safe; non-invasive assessment without exposure to harmful radiation. The validity and reliability of the scale were established by Menz and Munteanu (28). The Turkish validity and reliability study was conducted by Talu et al. (29).

Muscle Strength Assessment:

The muscle strength of the FHL and EHL muscles was evaluated using a handheld dynamometer. The Commander Muscle Testing device (JTECH Medical, USA), a scientifically validated tool, was used for the measurements. The device objectively measures force in both Newtons (N) and kilograms (kg), and the maximum force value on its screen. Its interchangeable heads allow for measurements across different anatomical regions (30).

EHL Muscle Strength Assessment:

Participants were positioned supine with the hip and knee in extension, and the talocrural joint (TCJ) and the hallux in maximum plantar flexion. The physiotherapist stood on the side being assessed, stabilized the foot proximally at the interphalangeal (IP) joint, and placed the dynamometer dorsally on the foot, aligned with the IP joint. Participants were instructed to apply force against the device for 3–5 seconds. Each participant underwent three trials, with the highest value recorded. A 30-second rest period was given between repetitions to reduce muscle fatigue (31). Bilateral measurements were performed.

FHL Muscle Strength Assessment:

For FHL evaluation, participants remained supine position, with the hip and knee semi-flexed to prevent compensatory movements. The ankle was stabilized and held in maximum plantar flexion to minimize co-contraction of plantar flexor muscles. Participants were again instructed to exert force against the dynamometer for 3–5 seconds. Three trials were conducted, and the highest value was recorded. A 30-second rest interval was provided between measurements to reduce fatigue (31). The measurements were taken bilaterally.

Foot Function Index (FFI):

The Foot Function Index (FFI) is widely used self-reported tool designed to assess the effects of foot pathologies on pain, functional disability, and activity limitation (8).

The index consists of three main subscales: pain, disability, and activity limitation, comprising a total of 23 items. The pain subscale includes nine items that evaluate pain intensity during various activities. The disability subscale, also with nine items, aims to measure the level of functional difficulties encountered in daily tasks. The activity limitation subscale consists of five items assessing the degree of limitation in the individual's activities due to foot problems (32).

Participants rates each item separately for the right and left foot on a scale from 0 (no pain/difficulty) to 10 (unbearable pain or difficulty preventing the activity). Ratings are based on symptoms experienced in the past week (33).

The score for each subscale is calculated by dividing the sum of the relevant items by the number of items and then multiplying by 100. The overall total score is obtained by summing all item scores, dividing by the total number of items, and multiplying by 100. Higher scores indicate more severe issues functional limitations (32).

The FFI was originally validated by Budiman et al. (34). It has since been widely used in research on orthotic treatments and foot/ankle disorders across different age groups (35,36). The Turkish validity and reliability study was conducted by Külünkoğlu et al. (37).

In our study, scoring was performed separately for each foot. Items were scored as zero for the foot without deformity. For the foot with deformity, the scores given were summed to calculate subscale and total scores.

Statistical Analysis

Data analysis was conducted by using the Statistical Package for Social Sciences (SPSS) Version 30.0 (SPSS Inc., Chicago, IL, USA) software. Following data collection and entery into the SPSS, frequency analysis were performed for demographic variables. Descriptive statistics including minimum and maximum values, arithmetic mean, and standard deviation were used to summarize continous variables, while the categorical data were expressed as frequencies and percentages.

Shapiro-Wilk test was applied to assess the normality of data distribution. Since the sample size was less than 50, the Shapiro-Wilk test results were primarily considered in data interpretation (38).

For between-groups comparisons of continuous variables, the Mann-Whitney U test was applied to non-normally distributed data. The Independent Samples t-test was used for normally distributed data. For within-group comparisons, the Wilcoxon Signed-Rank test was employed for non-normally distributed data, and the Paired Samples t-test was used for normally distributed data. The FHL strength of healthy and HV-affected feet, as well as the FHL and EHL muscle strength of mild and moderate HV feet, exhibited a normal distribution. The EHL muscle strength data (healthy and HV-affected feet) and the FFI pain, disability, activity limitation, and total score data (mild and moderate HV feet) did not exhibit a normal distribution. For normally distributed data, the median and IQR were reported, whereas for non-normally distributed data, the mean and standard deviation were presented.

Correlations between variables assessed using the Pearson Correlation coefficient for normally distributed data, and the Spearman Correlation coefficient for non-normally distributed data. Correlation strength was interpreted as follows: $r = 0.10–0.30$ indicated a weak relationship, $r = 0.30–0.50$ a moderate relationship, $r = 0.50–0.70$ a strong relationship, and $r = 0.70–0.90$ a very strong relationship. Statistical significance was accepted at $p \leq 0.05$.

RESULTS

The demographic characteristics of the participants in the study are presented in Table 1.

Table 1. Demographic Characteristics of the Participants

Variable (n=33)	Minimum (Min)	Maximum (Max)	Mean (X) ± Standard Deviation (SD)
Age (years)	23	64	44.36 ± 11.132
Height (cm)	148	183	167.12 ± 9.410
Body Weight (kg)	49	105	76.21 ± 15.604
Body Mass Index (kg/m²)	18.20	39.10	27.3152 ± 5.46958

cm: centimeters, kg: kilograms, m: meters, max: maximum, min: minimum, m²: square meter, n: number of participants, SD: standard deviation, X: mean

The 33 individuals with HV deformity included in the study had a mean age of 44.36 ± 11.13 years (range: 23-64 years). The participants' height ranged from 148 cm to 183 cm, with a mean of 167.1 ± 9.41 cm. Body weight ranged from 49 kg to 105 kg, with a mean of 76.21 ± 15.60 kg. The body mass index (BMI) ranged from a minimum of 18.20 kg/m² to a maximum of 39.10 kg/m², with a mean of 27.32 ± 5.47 kg/m² (Table 1). A total of 19 males (58%) and 14 females (42%) were included in the study, with all individuals having unilateral deformity. The education levels and occupational distributions of the participants are presented in Table 2.

Table 2. Education Levels and Occupational Distribution of Participants

		Number (n)	Percentage (%)
Education Level	**Primary School Graduate**	7	21,2
	Secondary School Graduate	2	6,1
	High School Graduate	14	42,4
	University Graduate	10	30,3
Occupation	**Non-commissioned Officer**	1	3,0
	Government Employee	6	18,2
	Pharmacy Technician	1	3,0
	Retired	2	6,1
	Tradesmen	11	33,3
	Freelancer	3	9,1
	Security Guard	1	3,0
	Student	1	3,0
	Unemployed	7	21,2

n: number, %: percentage

Seven participants (21%) were primary school graduates, two (6%) were secondary school graduates, fourteen (43%) were high school graduates, and ten (30%) were university graduates (Table 2).

In terms of occupation, seven participants (21%) were unemployed, six (18%) were government employees, eleven (33%) were tradesmen, three (9%) were freelancers, two (6%) were retired, one (3%) was a non-commissioned officer, one (3%) was a pharmacy technician, one (3%) was a security guard, and one (3%) was a student (Table 2). The distribution of the presence of HV and the severity of the deformity in the right and left feet of the participants is presented in Table 3.

Table 3. Distribution of Individuals According to the Presence and Severity of Hallux Valgus in the Right and Left Foot

		Number (n)	Percentage (%)
Distribution by Side of HV Involvement	**Right Foot**	20	60,6
	Left Foot	13	39,4
Distribution by Severity of HV	**Foot with Mild HV**	17	51,5
	Foot with Moderate HV	16	48,5

n: number, %: percentage

None of the participants had undergone surgery. When comparing the presence of HV between the right and left foot, 20 participants (61%) had HV in the right foot, while 13 participants (39%) had HV in the left foot (Table 3). Regarding deformity severity, 17 individuals (51.5%) had mild HV, whereas 16 individuals (48.5%) had moderate HV (Table 3).The difference between the FHL muscle strength of the healthy and HV-affected feet in the participants is presented in Table 4.

Table 4. Comparison of Flexor Hallucis Longus Muscle Strength Between Healthy and HV-Affected Feet

		Mean (X)	**Standard Deviation (SD)**	**P-value**
FHL	**Healthy Foot Muscle Strength (n=33)**	29,4424	1,24575	**<0,001***
	HV-Affected Foot Muscle Strength (n=33)	25,0606	1,55522	

*Paired Samples t Test, FHL: Flexor hallucis longus, HV: halluks valgus, n: number, SD: standard deviation, X: mean

When the FHL muscle strength of all participants was compared between the healthy and HV-affected feet, a statistically significant difference was found between the healthy and HV-affected feet ($p < 0.001$) (Table 4). The difference between the EHL muscle strength of the healthy and HV-affected feet in the participants is presented in Table 5.

Table 5. Comparison of Extensor Hallucis Longus Muscle Strength Between Healthy and HV-Affected Feet

		Median (Med)	**Interquartile Range (IQR)**	**P-value**
EHL	**Healthy Foot Muscle Strength (n=33)**	21,200	20,5-22,0	**<0,001***
	HV-Affected Foot Muscle Strength (n=33)	16,200	15,0-17,5	

*Wilcoxon Signed-Rank Test, EHL: Extensor Hallucis Longus, HV: Hallux Valgus, Med: Median, n: number, IQR: Interquartile Range

When comparing the EHL muscle strength between the healthy and HV-affected feet, a statistically significant difference was observed ($p < 0.001$) (Table 5). The difference between the severity of deformity and the strength of the FHL and EHL muscles in the participants is presented in Table 6.

Table 6. Comparison of Flexor Hallucis Longus and Extensor Hallucis Longus Muscle Strength According to Deformity Severity

		Mean (X)	Standart Deviation (SD)	P-value
FHL Muscle Strength of HV Foot	**Mild HV Foot (n=17)**	26,282	1,5287	**<0,001***
	Moderate HV Foot (n=16)	23,763	1,8745	
EHL Muscle Strength of HV Foot	**Mild HV Foot (n=17)**	17,176	1,2312	**<0,001***
	Moderate HV Foot (n=16)	14,375	1,5476	

*Independent Samples T-test, EHL: ekstensor hallucis longus, FHL: flexor hallucis longus, HV: hallux valgus, n: number of participants, SD: standart deviation; X: mean

When comparing individuals with mild and moderate severity of deformity in terms of FHL muscle strength, a statistically significant difference was found between the groups ($p < 0.001$) (Table 6). Similarly, when comparing individuals based on the severity of deformity in terms of EHL muscle strength, a statistically significant difference was also observed between the groups ($p < 0.001$). The FHL and EHL muscle strengths were found to be statistically higher in individuals with mildly affected HV feet (Table 6). The comparison of FFI scores according to deformity severity is presented in Table 7.

Table 7. Comparison of FFI Scores According to Hallux Valgus Severity

	Mild HV (n=17)			**Moderate HV (n=16)**			
	Median (Med)	**Minimum (Min)**	**Maksimum (Max)**	**Median (Med)**	**Minimum (Min)**	**Maksimum (Max)**	**P-value**
FFI Pain Score	15,50	6,60	22,20	29,40	18,80	40,00	**<0,001***
FFI Disability Score	20,00	10,00	23,30	33,10	12,20	47,70	**<0,001***
FFI Activity Limitation Score	6,00	0,00	12,00	17,00	10,00	30,00	**<0,001***
FFI Total Score	44,40	16,60	50,80	79,15	54,40	93,40	**<0,001***

*Mann Whitney U Test, FFI: Foot Function Index, HV: Hallux valgus, med: median, min: minimum, max: maksimum, n: number of participants, When the participants were compared according to deformity severity, a statistically significant difference was found in the FFI pain, disability and, activity limitation scores, as well as in the total FFI score (p < 0.001) (Table 7). The relationship between FHL and EHL muscle strength of the HV-affected foot and FFI scores is presented in Table 8.

Table 8. The Relationship Between Flexor Hallucis Longus and Extensor Hallucis Longus Muscle Strength and FFI Scores in the HV-Affected Foot

		Spearman's Correlation Coefficient	**P-value**
FHL Strength in HV Foot	**FFI Pain Score**	-0,751	**<0,001***
	FFI Disability Score	-0,635	**<0,001***
	FFI Activity Limitation Score	-0,697	**<0,001***
	FFI Total Score	-0,784	**<0,001***
EHL Strength in HV Foot	**FFI Pain Score**	-0,786	**<0,001***
	FFI Disability Score	-0,608	**<0,001***
	FFI Activity Limitation Score	-0,722	**<0,001***
	FFI Total Score	-0,797	**<0,001***

*Spearman's Correlation Test, FFI: Foot Function Index, EHL: extensor hallucis longus, FHL: flexor hallucis longus, HV: hallux valgus

When participants were compared in terms of FHL muscle strength and FFI scores, a strong negative significant correlation was found between HV-affected foot muscle strength and FFI pain score (r = -0.751, p < 0.001), FFI disability score (r = -0.635, p < 0.001), FFI activity limitation score (r = -0.697, p < 0.001), and total FFI score (r = -0.784, p < 0.001) (Table 8).

Similarly, a strong negative significant correlation was found between HV-affected foot EHL muscle strength and FFI pain score (r = -0.786, p < 0.001), FFI disability score (r = -0.608, p < 0.001), FFI activity limitation score (r = -0.722, p < 0.001), and total FFI score (r = -0.797, p < 0.001) (Table 8).

DISCUSSION

In our study, which aimed to examine changes in FHL and EHL muscle strength according to the severity of deformity in individuals with HV, a significant decrase in both FHL and EHL muscle strength was associated with the increase in severity of the HV. When comparing the muscle strength of the HV- affected foot with the contralateral healthy foot, both FHL and EHL muscle strengths were significantly lower in the affected foot. Additionally a significant correlation was found between deformity severity and FFI scores.

Regarding the prevalence of HV, a previous study has reported rates of 23% among adults aged 18-65 and 35.7% among individuals over 65 years old (4). It is defined as a chronic deformity affecting 12% to 70% of the general population (39). Consistent with the literature, the ages of the participants in our study ranged from 23 to 64 years.

Hallux valgus affects 30-58% of women (39,40) and epidemiological studies have consistently reported a higher prevalence in females (41). In a study by Nix et al. (42), the incidence of HV was reported to be 2.3 times higher in women than in men. Similarly, Nguyen et al. (41) found a prevalence of 58% in women and 25% in men, while Dufour et al. (43) reported HV in 44% of elderly female participants. A study examining the prevalence and risk factors of HV in the Japanese population identified female gender as a significant risk factor (44).

Contrary to these findings, our study included more men than women (19 males (58%) and 14 females (42%)), which may explain unexpected gender distrfibution. A study investigating the causes of HV deformity in men concluded that the deformity is mostly hereditary, begins at an early age, and is frequently inherited from the mother (45). Although genetic transmission may be a plausible explanation forf the higher proportion male participants with HV in our study, the absence of family history data represents a limitation.

Prolonged standing has been reported to negatively affect the progression of HV deformity and potantially increasing its severity (2,46,47). In our study, most participants were employed in occupations requiring extended periods of standing, which may have contributed to the development or exacerbation of their deformity.

In a Japanese population study, Okuda et al. (48) reported that 29.7% of individuals had HV symptoms in at least one foot. Another study found that the left foot was more frequently affected (49). Contrary to this study, our results showed a higher prevalence in the right foot (60.6%) compared to the left foot (39.4%). This discrepancy may be related to the predominance of right foot dominance; however, as foot dominance was not assessed in our study, this remains a limitation.

From a pathomechanical perspective, several theories emphasize abnormal alignment of the metatarsocuneiform joint and the imbalances in the periarticular soft tissues as key factors HV development (50,51,52). The abductor hallucis (AbH) and adductor hallucis (AdH) muscles, which help maintain first metatarsal alignment, are particularly implicated. In HV, AbH weakness and the unopposed action of the AdH contribute to lateral deviation of the hallux (19). Many previous studies have focused primarily on these two muscles.

However, the FHL and EHL muscles-central to the present study- also play an important role in HV pathogenesis. These muscles have been implicated in both the development and recurrence of HV. Their tendon pull vectors deviate laterally, drawing the proximal end of the distal phalanx toward the valgus direction (22). The change in the force direction of the FHL muscle generates an additional rotational torque on the hallux, promoting pronation of the first metatarsal and progression of the deformity. FHL contraction can also increase sesamoid subluxation. While these muscles typically provide stabilization during axial loading, in HV they contribute deforming forces that perpetuate the pathology (23).

Despite their potential significance, the functional characteristics of the FHL and EHL muscles in HV remain underexplored. In a three-dimensional magnetic resonance imaging study by Sanders et al. (53), it was demonstrated that lateral displacement of the FHL muscle plays a role in the pathogenesis of HV. However, there is insufficient information in the literature regarding changes in the muscle strength of these muscles as a result of HV deformity. Existing studies generally focus on anatomical displacements and structural impairments, while research examining changes in muscle strength levels remains limited. This highlights the necessity evaluate the functional characteristics of these muscle groups in the deformity process. Our study aims to shed light on these unexplored areas in the literature.

In our study, when comparing the FHL and EHL muscle strength between the healthy foot and the HV-affected foot, a statistically significant difference was found. The muscle strength in the HV foot was significantly lower compared to the healthy foot. Literature on muscle ultrasound studies indicates that HV deformity results in a reduction in muscle cross-sectional area and changes in pull angles due to positional shifts (53,54). Furthermore, we obserde that the FHL and EHL muscle strength was lower in feet with moderate deformity compared to those with mild deformity. We think this is due to changes in the muscle length-tension relationship and load transmission, ultimately resulting in decreased muscle activation.

The Manchester Scale is a clinical method that evaluates HV deformity through images representing four different severity levels (27). It offers advantages such as requiring minimal clinical expertise, providing a standardized framework for prospective monitoring of deformity progression, and being non-invasive (27,55). Additionally, its validity and reliability have been established (28,29). Studies examining the relationship between the Manchester Scale and radiological measurements have reported a significant correlation between the Hallux Valgus Angle (HVA) and Intermetatarsal Angle (IMA) (28,56). Another study on individuals with hallux valgus assessed the relationship between the Manchester Scale and plantar pressure distribution, concluding that this scale is an effective tool for reflecting deformity severity and pressure levels in painful areas. Moreover, that study reported that the Manchester Scale correlates with both HVA and IMA (57). For these reasons, the Manchester Scale was used to evaluate deformity severity in our study. Participants were classified as 17 with mild deformity and 16 with moderate deformity. Many studies investigating hallux valgus severity have used the Manchester Scale for severity assessment (57,58). The test reliability of the Manchester Scale and its high agreement with clinical evaluation have been demonstrated (58).

Hallux valgus is associated not only with physical impairments in the musculoskeletal system but also with pain, functional limitations, and the impact on an individual's quality of life (6,59-65).

In a study comparing healthy individuals and those with HV, it was determined that HV is associated with foot pain and levels of functional impairment (42). In a study conducted on women with hallux valgus deformity, a statistically significant relationship was found between pain levels and foot function. The results showed that as the severity of the deformity increased, pain complaints also increased, which negatively affected foot-specific functional status (5). Another study involving individuals with hallux valgus demonstrated that as the severity of the deformity increased, there was an increase in pain intensity (65).

In our study, when comparing the relationship between deformity severity and Foot Function Index (FFI) scores, a significant difference was observed, consistent with the existing literature. As the severity of the deformity increased, differences were noted in the FFI pain score, FFI disability score, FFI activity limitation score, and the total FFI score. These results align with findings from other studies in the literature. The progression of the deformity leads to an increase in pain, resulting in physical functional losses and consequently activity limitations in daily life.

When examining the relationship between FHL muscle strength and FFI scores in HV-affected feet, a significant correlation was found. As muscle strength decreased, an increase in FFI scores was observed. Similar results were found for the EHL muscle as well. Loss of strength in the lower extremity can lead to decreased joint stability, which may result in pain symptoms (66). Along with the increase in pain severity due to muscle weakness, physical functional losses are also observed (67). Considering the results of our study, the increase in FFI scores associated with muscle weakness reflects an increase in pain and functional limitations, which aligns with the existing literature.

Limitations of the Study

Although genetic transmission is an important factor in male individuals, not investigating family history constitutes a limitation of our study. Additionally, pes planus is considered one of the most significant risk factors for hallux valgus; however, no evaluation regarding pes planus was conducted in our study, which can be viewed as a limitation. Additionally, the absence of an assessment for hypermobility, another recognized risk factor, may also be regarded as a study limitation. Besides the muscle strength assessment performed on the FHL and EHL muscles, not examining muscle activation or conducting radiological evaluations can also be considered limitations. The lack of gender standardization in the sample group and the absence of related study findings can be considered a limitation of the study.

CONCLUSION

A significant decrease in the muscle strength of the FHL and EHL muscles was observed with increasing hallux valgus deformity severity, with feet exhibiting moderate deformity showing significantly lower muscle strength than those with mild deformity. Correspondingly, a significant difference was found between deformity severity and FFI scores, with higher deformity severity associated with increased pain, greater disability, and more pronounced limitations in daily activities. Furthermore, significant correlations were observed between the FHL and EHL muscle strength of the affected foot and FFI scores, indicating that reductions in muscle strength are linked to increased pain, disability, and activity limitations. These findings highlight the importance of considering changes in the FHL and EHL muscles when designing rehabilitation programs, suggesting that targeted strategies and exercise interventions aimed at strengthening these muscles may help alleviate functional limitations associated with hallux valgus. Given that this study is the first of its kind on this topic, further research is warranted to confirm and generalize these results.

Ethics Committee Approval: Ethical approval for the study was obtained from the Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee (23.11.2023 – Decision No: 09-042).

Informed Consent: They were assured of the confidentially of their data, and they signed an "Informed Consent Form" indicating their voluntary participation in the study.

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