



Comparison of the effects of progressive supervised and home program exercise therapy in mild–moderate *hallux valgus*

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Aim: To compare the effects of progressive exercise therapy, performed under the supervision of a physiotherapist and given as a home program in individuals with *hallux valgus*. **Methods:** Participants were randomly divided into two groups. While one group performed the exercises under the supervision of a physiotherapist, the other group did the same program at home. **Results:** The amount of decrease in foot adduction angle, pain level while walking, and right foot navicular height of individuals receiving treatment under the supervision of a physiotherapist were significantly higher. **Conclusion:** The exercise program applied under the supervision of a physiotherapist was more effective in reducing the first toe adduction angle, medial longitudinal arc height, and pain, improving dynamic balance and functional capacity.

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Hallux valgus (HV) is a painful deformity characterized by progressive abduction and pronation of the first phalanx, adduction, pronation and elevation of the first metatarsal, and lateral capsular retraction of the first metatarsophalangeal (MTP) joint [1]. Genetics, age, sex (female > male), laxity, neuromuscular disorders, other foot deformities (e.g., *pes planus*), footwear (high heels, narrow shoes) and excess weight-bearing are the extrinsic and intrinsic factors that may contribute to HV [2,3]. Individuals with HV usually have a chronic onset of severe or deep pain at the MTP joint, which is made worse by ambulation. The frequency, duration and severity of discomfort increase as the HV deformity progresses [4]. The main complaints of these individuals include pain during activity, cosmetic problems, inability to wear the desired shoes and functional limitations [5].

In painful musculoskeletal diseases, fear-avoidance reaction and kinesiophobia develop due to pain. Higher HV deformity degrees were related to higher kinesiophobia symptoms and levels, as well as pain, especially severe and/or moderate HV compared with no and/or mild HV [6]. Greater HV deformity and age were found to predict kinesiophobia and pain intensity. Kinesiophobia and pain intensity seem to play a key role in musculoskeletal disorders prognosis.

In a study conducted on symptomatic individuals with bilateral moderate-to-severe HV, it was shown that walking mobility, balance and postural stability were impaired and the fear of falling increased [7]. Even in asymptomatic subjects with mild HV deformity, single-limb postural stability was negatively affected [8]. It has been suggested that a mild HV deformity should be taken into account in young adults to prevent injury from loss of single-extremity balance, as it is important for the functional state of the lower limb. HV has been associated with a lower quality of life due to increased pain, foot discomfort, disability, functional limitations and perhaps the development of kinesiophobia [9–11].

In the treatment of HV, conservative treatments are preferred at first for symptom control, and if these treatments are insufficient, surgery is considered. Conservative treatments include shoe modification, orthoses, analgesics, ice, medial bunion pads and stretching exercises. It is widely believed that these treatments cannot correct the true deformity, but can only manage the symptoms [4]. Despite the fact that exercise is recommended among conservative

treatments, there are few studies on this subject in the literature, and in most of them, exercise was not applied alone, but in combination with other treatment methods [12–14]. Although it has been shown that exercise increases mobility and reduces pain in individuals with advanced HV [15], reduces the angle in mild-to-moderate HV [16], is effective in preventing and correcting HV deformity in the early period [17], no study was found investigating the effect on static and dynamic balance, functional capacity, quality of life, medial longitudinal arch height and kinesiophobia. In addition, it has been reported that there is a need for research to compare the effects of home exercise therapy with and without the supervision of a physiotherapist in the treatment of HV [18]. For this reason, we aimed to investigate the effects of progressive exercise therapy performed under the supervision of a physiotherapist and given as a home exercise program on deformity angle, pain, kinesiophobia, balance, functional capacity, functionality and quality of life in individuals with HV.

Materials & methods

Participants

This study was designed to compare the effects of progressive exercise therapy, performed under the supervision of a physiotherapist and given as a home program, on adduction angle, pain, functional status, quality of life and kinesiophobia in individuals with HV. Volunteer individuals aged 18–64 years, with bilateral mild-moderate HV (15–40° HV angle), who did not receive physical therapy for HV in the last 6 months, and did not use orthotic devices or dynamic splints were included in the study.

Individuals with rigid HV deformity, obesity (BMI > 30 kg/m²), systemic disease and inflammatory arthritis (rheumatoid arthritis, systemic lupus, diabetes mellitus), neurological disease (e.g., neuropathy), vestibular diseases that may affect balance, history of foot trauma (e.g., fracture of the metatarsophalangeal joint), a history of foot-ankle surgery, and those using NSAIDs or analgesic drugs were excluded from the study.

Before starting the study, individuals were informed and those who volunteered to participate in the study were asked to sign the consent form. After the individuals participating in the study were evaluated, 35 participants were randomized using GraphPad software and the block randomization technique. Seventeen participants applied the exercises with a physiotherapist, while the other 18 were given an exercise brochure and diary and checked by phone once a week.

Referring to the study of Kim *et al.*, the effect size of the HV angle parameter was determined to be $f = 2.01$ [16]. Assuming that the effect size would be large in the study, the sample size required for 95% ($1-\beta = 0.95$) power at $f = 0.8$ and $\alpha = 0.05$ level was calculated as 18 people using G*Power 3.1.9.2 software.

Outcome measures

Individuals' age, gender, height, weight, BMI, dominant leg, frequently worn shoe model and family history of the individuals were questioned. After the sociodemographic information, HV adduction angle, pain and kinesiophobia level, static and dynamic balance, 6-minute walk test, functional status, quality of life, medial longitudinal arch (MLA) height and fatigue level were evaluated. At the end of 8 weeks, the same evaluations were repeated by the same physiotherapist. No participant left the study.

HV adduction angle was evaluated with a goniometer while the individual was standing. The pivot point was placed in the medial projection of the MTP joint, with the fixed arm parallel to the first metatarsal bone and the other arm on the proximal phalanx, and measured from the dorsal aspect of the foot, and the result was recorded [19].

Morning pain, pain when walking with shoes and bare feet, pain when standing with shoes and bare feet, and pain level at night (during rest) were evaluated by a visual analog scale (VAS) (0 = no pain, 10 = unbearable, severe pain).

The Tampa Kinesiophobia Scale was used to assess the participants' level of fear of movement or re-injury. In the scale consisting of 17 questions in total, individuals were asked to mark the scores closest to them using the Likert scale. On this scale, participants get a total score between 17 and 68. A high score on the scale is interpreted as a high level of kinesiophobia [20,21].

Functional status was assessed by static and dynamic balance tests, functional capacity and a foot function index. Static balance was evaluated by using the one-leg stance test, individuals were asked to stand on one leg for 1 min, looking straight ahead, keeping their balance as much as possible. The test was terminated if the subjects made too much postural sway and lost their balance. The time to stand on the right and left foot were measured with a stopwatch, and the averages of three repetitions were taken into account [22]. Individuals' dynamic balance was evaluated with the Y balance test in which they were asked to place their feet at the junction of three measuring

tapes (135° - 90° - 90°), then reach up to the point where they could reach without raising the heel in three directions (anterior, posterolateral and posteromedial). These tests, performed with bare feet, were repeated three-times and the average distance was recorded in centimeters (cm) [23]. The 6-min walk test was used to assess functional capacity. In an area 30 m long, the participant was asked to walk as fast as he could. Care was taken to perform the test with the same shoes before and after the treatment. The total distance walked at the end of the test was calculated and recorded [24]. Foot Function Index is a self-report scale used to evaluate the effects of foot pathologies on pain, disability and activity limitation. The participants were asked to score 23 items with VAS, taking into account their foot condition one week ago. Higher scores indicate more pain, disability and activity limitation [25].

SF-36 was used to evaluate the individuals' general health-related quality of life. It is a 36-item self-report scale to question physical and social functioning, role limitations due to physical and emotional reasons, mental health, vitality, pain and general health perception. Subscales of health are evaluated between 0 (poor health) and 100 (good health) [26].

To measure MLA height with the navicular drop test participants were asked to sit in a chair with back support without shoes and socks. The navicular tubercle was marked on the feet in contact with the ground, and the same level was marked on the paper. Then, the participants were asked to stand up and give equal and full weight to both feet. The level of the navicular tubercle was re-marked on the same paper. The distance between both lines was recorded [27]. The amount of navicular drop between 6 and 9 mm is considered normal MLA, and if it is 10 mm or more, it is considered pes planus.

The general fatigue level of the individuals was evaluated with the VAS (0 = no pain, 10 = unbearable, severe pain).

Interventions

All participants were educated about appropriate footwear (made of soft material, with a wide round toe box, with a normal heel height of 1–1.5 inches). In addition, to increase the awareness of the participants, they were asked to focus on how muscle activation felt during exercise and to perform this activation during daily living activities.

The same exercise program was applied with bare feet 4 days a week for 8 weeks to both groups. The exercise program progressed as recommended in the literature and 30 s rest was given between sets.

After the evaluation, all exercises were shown to the home exercise group and it was ensured that they were applied correctly. In addition, an illustrated and narrative exercise program brochure containing information about exercise position, number of repetitions, contraction time, rest time between sets, frequency and an exercise diary for exercise follow-up were given to the participants. Individuals were checked with a video phone call once a week to motivate them, to answer their questions and to solve the problems that would affect their compliance and continuation. The details of the exercise program, which consists of a warm-up phase, an exercise phase, and a cool-down phase, are given below:

Warm-up phase

Stretching exercises were done with 5 repetitions.

Stretching the intrinsic muscles: participants were asked to place their foot on the opposite knee while sitting. It was stabilized by grasping the heel with one hand, while with the other hand the toes were extended (big toe in abduction) and the foot was dorsiflexed and stretched for 30 s (Figure 1).

Big toe abduction with MTP joint traction: while the force was applied to the bone in the adduction direction from the proximal of the First MTP joint, traction was applied from the distal. In the meantime, the big toe was passively abducted within the pain limits and kept for 30 s (Figure 2).

Exercise phase

These exercises were applied as 2 sets, 10 repetitions. 30 s of rest was given between sets to prevent fatigue. At every 2 weeks, the intensity progressed gradually.

Big toes active extension exercise: by rounding an elastic band around the big toes, proper alignment was ensured and the band was asked to be stretched enough to passively correct the deformity. The feet were asked to move away from each other without moving the heels from the ground. At this time, the extension movement of the big toes was requested while the other toes were on the ground. It was progressed as follows (Figure 3):

- 1–2 weeks: maintaining the position for 5 s while sitting with a yellow elastic band (hip-knee flexed 90°)



Figure 1. Intrinsic muscles stretching.



Figure 2. Big toe abduction with metatarsophalangeal joint traction.



Figure 3. Big toes active extension exercise.

- 2–4 weeks: maintaining the position for 10 s while sitting with a yellow elastic band
- 4–6 weeks: maintaining the position for 10 s while standing with a yellow elastic band
- 6–8 weeks: maintaining the position for 10 s while standing with a red elastic band



Figure 4. Toe spread out exercise.



Figure 5. Short foot exercise.

Toe spread out exercise: in the first stage, active finger extension and abduction were requested from the participants while the heel and metatarsal heads were in contact with the ground. In the second stage, while the other fingers were in extension, the little finger was brought laterally and flexed to contact the ground. In the third stage, while in the second stage position, the big toe was brought into abduction and flexion slowly, and contact with the ground was requested, and these 3 phases were repeated sequentially [16]. It was progressed as follows (Figure 4):

- 1–2 weeks: maintaining the position for 5 s while sitting (hip–knee flexed 90°)
- 2–4 weeks: maintaining the position for 10 s while sitting
- 4–6 weeks: maintaining the position for 10 s while standing
- 6–8 weeks: maintaining the position for 10 s while standing on one leg

Short foot exercise: participants were asked to raise the medial arch by trying to bring the metatarsal heads closer to the heel while standing [18]. Then, they were told to move the toe closer to the heel by sliding the toe without curling the toes and without lifting the heel off the ground. It was requested to pay attention to the proper alignment of the big toe while performing the movement. In the advancement of this exercise, similar to the progression protocol of toe spread out exercises were applied (Figure 5).

Heel raise exercise: it is used to activate the muscles that support the foot and ankle. A sign was placed on the wall at a height of 5 cm from the floor, and the person was asked to raise his heel to a height of at least 5 cm [18]. While



Figure 6. Heel raise exercise.

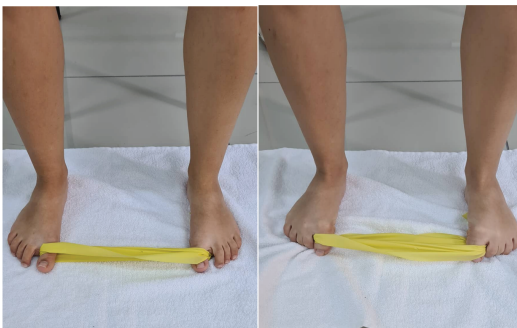


Figure 7. Towel toe curl exercise.

performing the movement, attention was paid to the proper alignment of the big toe (Figure 6). It was progressed as follows:

- 1–2 weeks: maintaining the position for 5 s while standing
- 2–4 weeks: maintaining the position for 10 s while standing
- 4–6 weeks: maintaining the position for 10 s while standing on soft ground
- 6–8 weeks: maintaining the position for 10 s while standing on one leg

Towel toe curl exercise

Participants were asked to place their feet on the edge of the towel on the floor. By rounding the elastic band around the big toe, proper alignment of the big toe was ensured and the band was told to stretch enough to passively correct the position. Next, the towel was grasped with the toes by stretching the toes and dragged forcefully under the feet. In the advancement of this exercise, similar to the progression protocol of toe spread out exercises were applied (Figure 7).

Cool-down phase

Gastrocnemius active static stretching exercise: the participants were asked to place their hands on the wall at eye level, 50 cm away from the wall. The leg to be stretched was brought back, while the knee was straight, and the front leg was flexed. During the test, individuals waited for 30 s with their heel on the ground and this movement was repeated five-times (Figure 8).

Plantar fascia and gastrocnemius stretching exercise: the individual was asked to place both feet on the step and slowly stretch the heel downwards until a stretch was felt in the arch of the foot, waited 30 s, and was repeated five times (Figure 9).

Statistical analysis

Statistical Package for Social Sciences (SPSS) 25.0 software was used for the statistical analysis of the research data. The distribution of socio-demographic characteristics and health status of individuals was determined by frequency analysis. Mann-Whitney U test was used to compare anthropometric measurements, ANCOVA was used to compare adduction angle, pain, balance, 6-minute walk test distance, foot function index, navicular drop



Figure 8. Gastrocnemius active static stretching exercise.



Figure 9. Plantar fascia and gastrocnemius stretching exercise.

test, quality of life, kinesiophobia and fatigue level before and after treatment. A level of $p < 0.05$ was selected to indicate statistical significance.

Results

The distribution of their socio-demographic characteristics was given in Table 1. There was no difference between the two groups in terms of mean age, the percentage of gender, dominant extremity, and family history of HV.

The mean BMI of the participants who did the exercises under the supervision of a physiotherapist was $24.61 \pm 3.23 \text{ kg/m}^2$, and the group that received the home program had a BMI of $25.31 \pm 3.37 \text{ kg/m}^2$, and no statistical significant difference ($p = 0.597$) was found between BMI values.

There was no statistically significant difference between the pre-treatment and post-treatment adduction angle values of individuals in both groups ($p > 0.05$) (Table 2). The right and left foot adduction angle values of the individuals who received treatment under the supervision of a physiotherapist and in the form of a home program were found to be significantly lower than before the treatment ($p < 0.05$). The amount of decrease in right foot

Table 1. Socio-demographic characteristics of the participants.

	Physiotherapist (n = 17)		Home program (n = 18)		χ^2	p-value
	n	%	n	%		
Age, years	43,06 $\pm$ 12,16		39,33 $\pm$ 8,77		-0,892	0,372
Sex						
Female	12	70,59	12	66,67	0,062	0,803
Male	5	29,41	6	33,33		
Dominant lower extremity						
Right	17	100,00	16	88,89		0,486
Left	0	0,00	2	11,11		
Most commonly used shoe model						
Sneakers	3	17,65	9	50,00		
High-heel	4	23,53	3	16,67	-	-
Oxford	2	11,76	3	16,67		
Flat	8	47,06	3	16,67		
Family history of HV						
Yes	13	76,47	13	72,22	0,083	0,774
No	4	23,53	5	27,78		

The assumptions of the χ^2 test could not be met.

adduction angle values ($F = 7.638$; $p = 0.009 < 0.05$; $\eta^2 = 0.193$) and left foot adduction angle values ($F = 7.486$; $p = 0.010 < 0.05$; $\eta^2 = 0.190$) of individuals who received treatment under the supervision of a physiotherapist was significantly higher than the individuals who received treatment in the form of a home program.

In the comparison between the groups, there was no statistically significant difference between the pain values and kinesiophobia levels of both groups before and after the treatment ($p > 0.05$) (Table 3). Post-treatment pain values and kinesiophobia levels of individuals who received treatment under the supervision of a physiotherapist and in the form of a home program were found to be statistically significantly lower than at baseline ($p < 0.05$). The difference between the changes in pain values when walking with shoes ($F = 20.303$; $p = 0.000 < 0.05$; $\eta^2 = 0.388$) and pain values while standing with shoes ($F = 6.134$; $p = 0.019 < 0.05$; $\eta^2 = 0.161$) before and after the treatment under the supervision of a physiotherapist and in the form of a home program, it was found to be statistically significant and the decrease in individuals who received treatment under the supervision of a physiotherapist was higher.

The right leg Y balance test (anterior, posteromedial, posterolateral) (cm) and left leg Y balance test (anterior) pre-treatment values of the individuals who received treatment under the supervision of a physiotherapist were found to be significantly lower than the individuals who received treatment as a home program ($p < 0.05$) (Table 4). It was determined that there was no statistically significant difference between the post-treatment balance values of the individuals who received treatment under the supervision of a physiotherapist and in the form of a home program ($p > 0.05$). Post-treatment balance values of individuals in both groups were found to be statistically significantly higher than before treatment ($p < 0.05$). The increase in the one-leg (right-left) standing test values of the individuals in both groups after the treatment was found to be similar ($p > 0.05$). It was determined that the difference between the changes in the right leg Y balance test (anterior, posteromedial, posterolateral) values of the individuals in both groups before and after the treatment was statistically significant ($F = 8.235$, $\eta^2 = 0.205$, $F = 5.928$, $\eta^2 = 0.156$; $F = 7.452$, $\eta^2 = 0.189$ respectively). The amount of increase in the right leg Y balance test (anterior, posteromedial, posterolateral) values after treatment in individuals who received treatment under the supervision of a physiotherapist were higher than in those who received treatment in the form of a home program. It was determined that there was no statistically significant difference between the changes in the left leg Y balance test (anterior, posteromedial, posterolateral) values before and after the treatment in both groups ($p > 0.05$). It was determined that there was no statistically significant difference between the 6-minute walk test distance and right-left foot function index values of the individuals in both groups. Post-treatment values were found to be statistically significantly higher than pre-treatment values ($p < 0.05$). It was determined that the increase in the 6-minute walk test distance values of the participants who received treatment under the supervision

Table 2. Comparison of the adduction angle values.

Group	Pre-treatment					Post-treatment					Z	p ₃	F	p ₄	Eta ²
	$\bar{x} \pm s$	%95 CI	Range	Z	p ₁	$\bar{x} \pm s$	%95 CI	Range	Z	p ₂					
Right side adduction angle (°)															
Physiotherapist	24.06 ± 6.67	20.63–27.49	16–36	-1.143	0.253	23.12 ± 6.85	19.6–26.64	14–35	-0.910	0.363	-2.889	0.004 [†]	7.638	0.009 [†]	0.193
Homeprogram	21.06 ± 4.21	18.96–23.15	16–32			20.78 ± 3.95	18.81–22.74	16–31			-2.236	0.025 [†]			
Left side adduction angle (°)															
Physiotherapist	22.41 ± 5.97	19.34–25.48	15–34	-1.375	0.169	21.53 ± 6.23	18.33–24.73	14–33	-1.044	0.296	-3.217	0.001 [†]	7.486	0.010 [†]	0.190
Home program	20.11 ± 4.76	17.74–22.48	15–33			19.72 ± 4.78	17.35–22.1	14–32			-2.646	0.008 [†]			

† p < 0.05.

CI: Confidence interval; Eta²: Effect size calculation; p₁: Pre-treatment intergroup comparison; p₂: Post-treatment post-treatment within-group comparison; p₃: Pre-treatment post-treatment intergroup comparison; p₄: ANCOVA.

Table 3. Comparison of the pain and kinesiophobia values of the participants.

Group	Pre-treatment						Post-treatment						Z	p ₃	F	p ₄	Eta ²
	$\bar{x} \pm s$	%95 CI	Range	Z	p ₁		$\bar{x} \pm s$	%95 CI	Range	Z	p ₂						
Morning pain (cm)	Physiotherapist	2.58 ± 1.37	1.87-3.28	0-4.2	-0.447	0.655	1.76 ± 1.06	1.22-2.3	0-3.2	-0.482	0.630		-3.301	0.001 [†]	0.048	0.828	0.001 [†]
	Home program	2.43 ± 1.33	1.77-3.1	0-4.5			1.67 ± 1.11	1.11-2.22	0-4				-3.446	0.001 [†]			
Pain level when walking with shoes (cm)	Physiotherapist	5.74 ± 1.08	5.18-6.29	3.5-7.1	-1.851	0.064	4.04 ± 1.1	3.47-4.61	2.1-5.6	-0.976	0.329		-3.624	0.000 [†]	20.303	0.000 [†]	0.388
	Home program	5.12 ± 0.95	4.65-5.6	4.1-7.3			4.46 ± 0.85	4.03-4.88	3.6-6.8				-3.731	0.000 [†]			
Pain level when walking with bare feet (cm)	Physiotherapist	3.38 ± 1.05	2.83-3.92	1.2-5	-1.404	0.160	2.24 ± 1.38	1.53-2.95	0-4.3	-0.696	0.486		-3.624	0.000 [†]	3.529	0.069	0.099
	Home program	2.89 ± 1.04	2.37-3.4	1.2-4.8			2.06 ± 1.15	1.48-2.63	0-4				-3.595	0.000 [†]			
Pain level when standing with shoes (cm)	Physiotherapist	4.96 ± 0.94	4.48-5.45	3.4-6.7	-0.463	0.643	3.44 ± 0.93	2.96-3.91	2-5.3	-0.678	0.498		-3.626	0.000 [†]	6.134	0.019 [†]	0.161
	Home program	4.69 ± 1.3	4.05-5.34	2.5-7.6			3.81 ± 1.15	3.24-4.38	2-6.4				-3.740	0.000 [†]			
Pain level when standing bare feet (cm)	Physiotherapist	2.91 ± 1.31	2.24-3.58	0-5.2	-0.033	0.974	1.85 ± 1.08	1.29-2.4	0-3.5	-1.308	0.191		-3.367	0.001 [†]	1.324	0.258	0.040
	Home program	3.14 ± 1.45	2.42-3.86	1-6.4			2.36 ± 1.32	1.71-3.02	0-4.4				-3.662	0.000 [†]			
Pain level at rest (cm)	Physiotherapist	2.45 ± 1.56	1.65-3.25	0-5.1	-1.323	0.186	1.45 ± 1.41	0.73-2.18	0-4.3	-1.753	0.080		-3.413	0.001 [†]	0.156	0.695	0.005
	Home program	3.14 ± 1.45	2.42-3.87	1-5.9			2.16 ± 1.22	1.56-2.77	0-4.3				-3.627	0.000 [†]			
Kinesiophobia level	Physiotherapist	31.94 ± 12.89	25.31-38.57	17-51	-1.685	0.092	26.29 ± 10.05	21.13-31.46	17-47	-1.243	0.214		-3.185	0.001 [†]	0.220	0.642	0.007
	Home program	24.33 ± 7.19	20.76-27.91	17-44			20.67 ± 4.86	18.25-23.08	17-37				-2.940	0.003 [†]			

†p < 0.05.

CI: Confidence interval; Eta²: Effect size calculation; p₁: Pre-treatment intergroup comparison; p₂: Post-treatment intergroup comparison; p₃: Pre-treatment post-treatment within-group comparison; p₄: ANCOVA.

Table 4. Comparison of the participants' functional state values.

Group	Pre-treatment					Post-treatment					Z	p ₂	p ₃	F	p ₄	Eta ²
	$\bar{x} \pm s$	%95 CI	Range	Z	p ₁	$\bar{x} \pm s$	%95 CI	Range	Z	p ₂						
One-leg stance test (right) (s)	50.82 ± 6.71	47.37–54.27	38–60	-0.781	0.435	55.29 ± 5.19	52.62–57.96	47–60	-0.186	0.852	-3.308	0.001 [†]	0.364	0.550	0.011	
Home program	52.61 ± 4.42	50.41–54.81	45–60			56.33 ± 3.12	54.78–57.89	50–60			-3.530	0.000 [†]				
One-leg stance test (left) (s)	46.65 ± 7.57	42.76–50.54	35–60	-1.357	0.175	50.65 ± 6.12	47.5–53.8	41–60	-1.821	0.069	-3.138	0.002 [†]	0.381	0.542	0.012	
Home program	50.22 ± 5.66	47.41–53.04	40–60			54.28 ± 3.69	52.44–56.11	47–60			-3.515	0.000 [†]				
Right Y balance test (anterior) (cm)	76.68 ± 14.8	69.07–84.29	53.2–112.5	-2.131	0.033 [†]	81.16 ± 15.61	73.13–89.18	58.7–121.6	-1.650	0.099	-3.622	0.000 [†]	8.235	0.007 [†]	0.205	
Home program	86.2 ± 12.82	79.82–92.58	71–118.3			89.58 ± 14.14	82.55–96.61	70.9–125.4			-3.682	0.000 [†]				
Right Y balance test (posteromedial) (cm)	77.23 ± 14.52	69.76–84.69	51.6–115.8	-2.295	0.022 [†]	79.88 ± 17.58	70.84–88.92	52.3–126.9	-1.898	0.058	-2.821	0.005 [†]	5.928	0.021 [†]	0.156	
Home program	87.51 ± 11.96	81.56–93.46	71.6–114.5			88.66 ± 12.98	82.21–95.11	70.5–119.6			-1.655	0.098				
Right Y balance test (posterolateral) (cm)	70.86 ± 13.84	63.74–77.97	49.3–101.6	-2.195	0.028 [†]	73.36 ± 14.21	66.06–80.67	51.9–106.3	-1.535	0.125	-3.623	0.000 [†]	7.452	0.010 [†]	0.189	
Home program	80.94 ± 10.41	75.77–86.12	65.3–101.6			78.57 ± 19.73	68.76–88.38	12.6–105.1			-1.328	0.184				
Left Y balance test (anterior) (cm)	79.08 ± 14.84	71.45–86.71	58.6–118.2	-2.145	0.032 [†]	82.03 ± 15.59	74.02–90.04	57.9–121.5	-1.947	0.051	-3.528	0.000 [†]	0.052	0.821	0.002 [†]	
Home program	87.66 ± 13.15	81.12–94.19	73.8–119.4			90.78 ± 13.23	84.2–97.36	74.2–121.8			-3.636	0.000 [†]				
Left Y balance test (posteromedial) (cm)	80.26 ± 13.31	73.42–87.1	60.8–112.1	-1.749	0.080	82.76 ± 13.21	75.97–89.56	64.3–114.2	-1.287	0.198	-3.479	0.001 [†]	2.012	0.166	0.059	
Home program	87.08 ± 12.88	80.68–93.49	68.3–116.7			88.57 ± 13.11	82.06–95.09	69.8–118.2			-2.767	0.006 [†]				
Left Y balance test (posterolateral) (cm)	71.77 ± 13.29	64.94–78.6	50.3–98.6	-1.931	0.053	73.48 ± 13.27	66.66–80.3	51–100	-1.683	0.092	-3.196	0.001 [†]	0.891	0.352	0.027	
Home program	80.51 ± 12.61	74.23–86.78	68.1–117.5			81.49 ± 12.43	75.31–87.68	69.4–115.7			-2.156	0.031 [†]				
6-minute walk test distance (m)	377.31 ± 71.21	340.7–413.92	290.9–532	-1.898	0.058	413.46 ± 69.77	377.58–449.33	312.5–568.6	-1.089	0.276	-3.621	0.000 [†]	11.567	0.002 [†]	0.265	
Home program	411.68 ± 50.49	386.58–436.79	328.5–515.5			429.26 ± 53.68	402.57–455.96	335.8–530.6			-3.114	0.002 [†]				
Foot Function Index (right)	269.26 ± 56.82	240.05–298.48	178.94–354	-1.437	0.151	243.88 ± 50.96	217.68–270.08	165.35–326.14	-1.040	0.298	-3.621	0.000 [†]	3.195	0.083	0.091	
Home program	240.47 ± 54.16	213.54–267.4	171.3–367.23			224.67 ± 52.87	198.38–250.96	161.5–347.31			-3.621	0.000 [†]				
Foot Function Index (left)	267.99 ± 55.71	239.35–296.64	178.94–354	-1.469	0.142	242.7 ± 50.39	216.79–268.6	165.35–324.56	-1.007	0.314	-3.621	0.000 [†]	3.948	0.056	0.110	
Home program	239.9 ± 53.37	213.36–266.44	171.3–367.23			224.67 ± 52.87	198.38–250.96	161.5–347.31			-3.621	0.000 [†]				

† p < 0.05.

CI: Confidence interval; Eta²: Effect size calculation; p₁: Pre-treatment intergroup comparison; p₂: Post-treatment intergroup comparison; p₃: Pre-treatment post-treatment within-group comparison; p₄: ANCOVA.

of a physiotherapist was higher ($F = 11.567$; $\eta^2 = 0.265$). There was no statistically significant difference between the changes in the foot function index (right-left) values of both groups before and after the treatment ($p > 0.05$).

There was no statistically significant difference between individuals in both groups in terms of quality of life, navicular drop test, and fatigue values before treatment ($p > 0.05$) (Table 5). While there was no statistically significant difference between the post-treatment navicular drop test and fatigue values ($p > 0.05$), the quality of life value after treatment was found to be significantly lower in individuals who performed the exercises under the supervision of a physiotherapist ($p < 0.05$). It was determined that the fatigue and navicular drop test values of the individuals who received treatment under the supervision of a physiotherapist and in the form of a home program were statistically significantly lower than before the treatment ($p < 0.05$). While the amount of decrease in the navicular drop (right) values of the participants who received treatment under the supervision of a physiotherapist was higher than those who received treatment in the form of a home program ($F = 10.899$; $p = 0.002 < 0.05$; $\eta^2 = 0.254$), there was no statistically significant difference between the amount of change in the quality of life, navicular drop (left), and fatigue values of the participants in both groups before and after the treatment.

Discussion

In individuals with mild-moderate HV deformity, an 8-week progressive exercise program under the supervision of a physiotherapist was more effective in reducing the big toe adduction angle and the level of pain felt while walking and standing with shoes and navicular height, improving dynamic balance and functional capacity. Individuals in both groups completed a total of 24 exercise sessions. While the individuals trained under the supervision of a physiotherapist interacted face-to-face, in the group given as a home program, they were checked by phone and charts once a week. The fact that none of the individuals included in the study dropped out of the study may have resulted from communication with the participant or good compliance with the exercise.

One of the intrinsic factors thought to play a role in the development of HV deformity is the imbalance between Abductor hallucis (AbdH) and Adductor hallucis (AddH) muscle strengths [28], morphological changes in AbdH muscle [29,30], and less activity in AbdH muscle which is demonstrated by EMG study [31]. A systematic study identified scientific evidence of muscle performance impairment in the AbdH and flexor hallucis brevis muscle in individuals with HV deformity [32]. Therefore, it is thought that strengthening the AbdH muscle, especially in the early stages, can correct the HV deformity. Toe spread out exercises and short foot exercises are the most frequently recommended exercises for individual with mild-moderate HV to reduce the deformity and increase the cross-sectional area of the AbdH muscle [17,33]. In a study the effect of exercise alone and combined exercise with rigid taping was compared [12]. Passive abduction of the hallux with the traction of the first MTP joint and active abduction of the hallux exercises were used as exercises for 8 weeks. As a result of the study, it was reported that there was a decrease in both groups, but the exercise treatment group applied together with rigid taping was more effective in reducing the angle. We thought that the decrease in the adduction angle in both groups as a result of the 8-week progressive exercise program and the decrease in the group under the supervision of a physiotherapist may have been because of the exercises (e.g., big toe abduction with MTP joint traction) could have been applied more effectively and accurately.

Foot pain [34], which increases in direct proportion to the HV deformity, usually occurs during activity and negatively affects the functionality of the individual. It was reported that the pain levels of individuals with HV increased more when shoes were worn [35]. In another study, it has been reported that the home program is an effective therapeutic approach that can be used to reduce foot pain since the 2-month home program causes a significant reduction in the level of pain evaluated with modified AFI in individuals with advanced HV deformity [15]. In our study, the level of pain while walking with shoes and standing with shoes in both groups was relatively higher than the pain level in the morning, at rest, and when walking with bare feet and standing with bare feet. While a decrease was observed in all pain level assessments in both groups after the treatment, it was shown that the decrease in the level of pain when walking with shoes and standing with shoes was more in the group performing the exercises under the supervision of a physiotherapist. This decrease may have developed in parallel with the more decreasing adduction angle in the same group.

The level of kinesiophobia increases with increasing HV degree and increasing age [6]. There was no study in the literature investigating the effect of exercise on the level of kinesiophobia in individuals with HV. In our study, which included individuals with mild to moderate HV deformity, we used the Tampa Kinesiophobia Scale to evaluate kinesiophobia. Although the level of kinesiophobia decreased in both groups as a result of the 8-week exercise program, no significant difference was found between the groups. Considering that the major factor that

Table 5. Comparison of participants' quality of life, navicular drop test and fatigue values.

Table 5. Comparison of participants' quality of life, navicular drop test and fatigue values.																
Group	Pre-treatment					Post-treatment					Z	p ₃	F	p ₄	Eta ²	
	$\bar{x} \pm s$	%95 CI	Range	Z	p ₁	$\bar{x} \pm s$	%95 CI	Range	Z	p ₂						
Quality of life	Physiotherapist	78.82 ± 9.31	74.04–83.61	65–95	-1.424	0.155	83.53 ± 9.39	78.7–88.36	74–105	-2.068	0.039 [†]	-1.684	0.092	0.090	0.766	0.003
	Home program	83.33 ± 7.44	79.64–87.03	72–95			89.78 ± 7.96	85.82–93.74	72–105			-2.986	0.003 [†]			
Navicular drop (right)	Physiotherapist	1.19 ± 0.56	0.9–1.48	0.5–2.2	-0.151	0.880	1.04 ± 0.49	0.79–1.29	0.5–2	-0.839	0.402	-2.714	0.007 [†]	10.899	0.002 [†]	0.254
	Home program	1.25 ± 0.63	0.94–1.56	0.5–2.5			1.23 ± 0.63	0.92–1.55	0.5–2.5			-0.447	0.655			
Navicular drop (left)	Physiotherapist	1.16 ± 0.7	0.8–1.52	0.5–2.5	-0.119	0.906	1.08 ± 0.62	0.76–1.39	0.5–2.4	-0.170	0.865	-2.264	0.024 [†]	2.976	0.094	0.085
	Home program	1.12 ± 0.59	0.83–1.41	0.5–2.5			1.09 ± 0.59	0.8–1.39	0.5–2.5			-1.414	0.157			
Fatigue	Physiotherapist	3.44 ± 1.15	2.85–4.03	1–5.1	-0.456	0.648	4.29 ± 1.29	3.62–4.95	2–6	-0.725	0.469	-3.367	0.001 [†]	0.028	0.869	0.001
	Home program	3.03 ± 1.53	2.27–3.79	0–5			3.88 ± 1.47	3.14–4.61	1–5.8			-3.771	0.000 [†]			

[†]p < 0.05.

p₁: Confidence interval; Eta²: Effect size calculation; p₁: Pre-treatment intergroup comparison; p₂: Post-treatment intergroup comparison; p₃: Pre-treatment post-treatment within-group comparison; p₄: ANCOVA.

†p < 0.05.

CI: Confidence interval; Eta²: Effect size calculation; p1: Pre-treatment intergroup comparison; p2: Post-treatment intergroup comparison; p3: Pre-treatment post-treatment within-group comparison; p4: ANCOVA.

plays a role in the development of kinesiophobia is pain, the decrease in the level of kinesiophobia as a result of the progressive exercise training performed with or without supervision may be due to the decreased pain intensity.

Pain that develops in individuals with HV can negatively affect balance [36]. It has been reported that balance is negatively affected by deformation and the risk of falling increases in elderly individuals [37]. Using the one-leg stance test, Kavlak *et al.* [38] reported that HV alone did not affect balance in elderly men. As a result of the study, in which short foot exercises were applied twice a week for 6 weeks in individuals with mild-moderate HV, they reported that exercise was an effective treatment method for static balance [39]. There is no study in the literature investigating the effect of exercise on dynamic balance in individuals with HV. In our study, in which exercises were given mostly in sitting and standing positions, it was observed that the right and left side one-leg standing test increased after the treatment of individuals who received treatment under the supervision of a physiotherapist and in the form of a home program, but there was no difference in the amount of improvement between the two groups. In addition, both groups showed improvement in the right and left leg Y balance test in the anterior direction, and the left leg posteromedial and posterolateral directions. In the comparison between the groups, it was concluded that the exercise program applied under the supervision of a physiotherapist was more effective in all aspects of the right leg Y balance test (anterior, posteromedial, and posterolateral) compared with the home program. This unilateral development may be because the majority of the individuals included in our study had a right-sided dominant leg.

As a result of pain due to HV, the normal gait of individuals may be impaired and functional disability may develop. Long time standing and prolongation of walking distance negatively affect functionality [23]. Studies evaluating functional capacity in individuals with HV are insufficient in the literature. In our study, it was found that there was an improvement in 6-minute walk distance, that is, in functional capacity, in both groups, but the exercise program applied under the supervision of a physiotherapist was more effective than the home program in the comparison between the groups. This result may be due to the fact that the decrease in the level of pain when walking with shoes and standing with shoes is higher in individuals who do the exercises under the supervision of a physiotherapist.

Pain complaints that occur due to deformity in individuals with HV negatively affect the activities of daily living of individuals [40]. The effects of deformity on activities of daily living can be scored with AFI, which questions the pain, strain and disability of individuals with HV in different activities [41]. As the severity of HV deformity increases, AFI scores are negatively affected, as well as functional involvement [9]. There is no study in the literature investigating the effect of exercise on disability and activity limitation in individuals with HV. In our study, which included individuals with mild-to-moderate HV, it was observed that there was an improvement in the total AFI values of the right and left feet in both groups after the 8-week treatment program, but there was no difference between the two groups in the comparison between the groups. This shows us that both supervised and unsupervised exercise programs are similarly effective on disability and activity limitations.

HV has been associated with a lower quality of life due to increased pain, foot discomfort, disability, functional limitations, and perhaps the development of kinesiophobia [9–11]. There is no study in the literature investigating the effect of exercise therapy on the quality of life in individuals with HV. In our study, it was found that there was an improvement in the quality of life of the individuals participating in the home program after the 8-week exercise program, but there was no difference in the comparison between the groups. Due to the current pandemic period, the health-related quality of life of individuals may have been affected. Therefore, although the exercises have a positive effect on the HV angle, pain, and functional status, this may not be reflected in the quality of life. In addition, an 8-week exercise program may not be sufficient time to improve health-related quality of life in individuals with HV.

The AbdH muscle, which is one of the most important structures supporting the MLA, loses its functionality as a result of arch collapse in the tibialis posterior muscle weakness. It has been reported that problems may occur in big toe abduction as a result of dysfunction in this muscle [42]. In our study, the height of MLA was measured with the navicular drop test, and it was observed that there was an improvement in the right and left foot navicular drop test of the individuals who performed the exercises only under the supervision of a physiotherapist. In the intergroup comparison, it was determined that the decrease in the right foot navicular drop test values after the treatment of the participants who received treatment under the supervision of a physiotherapist was higher than those who received treatment in the form of a home program. The greater improvement in MLA height in the group performing the exercises under the supervision of a physiotherapist may probably be due to the more accurate application of the exercises thanks to the feedback from the physiotherapist during the session.

The general fatigue level evaluated by VAS decreased in both groups, but there was no difference between the groups. This may be due to the decreased pain level rather than the decreased fatigue level of the functional capacity, which increased more in the group performing the exercises under the supervision of a physiotherapist.

The limitations of our study can be considered as not questioning the other foot deformities and the duration of wearing frequently used shoe types, not measuring the muscle strength (especially the AbdH muscle), which will provide a better interpretation of the achieved developments, not making any gender discrimination and not questioning the footwear selection at the end of the study. Another limitation of our study was that all assessments and exercises were done by the same physiotherapist.

Conclusion

In individuals with mild-moderate HV deformity, 8-week progressive exercise program under the supervision of a physiotherapist was more effective in reducing the big toe adduction angle and the level of pain felt while walking and standing with shoes and navicular height, improving dynamic balance and functional capacity. As a result, effective conservative treatment on the degree of deformity, pain level, functional status, and kinesiophobia level in individuals with mild-moderate HV was presented to the literature.

The same exercise program was applied to both groups, and although the exercise program applied under the supervision of a physiotherapist was found to be more effective in improving the adduction angle, pain level, and functional status, it was observed that there was an improvement in the group who applied it as a home program. Therefore, this exercise program can be offered as an effective and reliable treatment program for individuals who do not have the opportunity to practice exercises under the supervision of a physiotherapist. Similar to most studies in the literature, individuals with mild-moderate HV were included in our study, and it is recommended to investigate the effectiveness of the same exercise program in individuals with severe HV in future studies.

Summary points

- An effective exercise program was developed for individuals with mild-moderate *hallux valgus*.
- The exercise program was applied 4 days a week for 8 weeks and progressed every 2 weeks.
- With an 8-week progressive exercise program, it is possible to reduce adduction angle, pain and fatigue values, kinesiophobia level and functional limitation, and improve static balance, dynamic balance and functional capacity.
- The exercise program can be offered as an effective and reliable treatment program for individuals who do not have the opportunity to practice exercises under the supervision of a physiotherapist.
- The exercise program applied under the supervision of a physiotherapist was more effective in reducing big toe adduction angle and the level of pain felt while walking and standing with shoes and navicular height, improving dynamic balance and functional capacity.

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Ethical conduct of research

This study was approved by the Eastern Mediterranean University Health Ethics Subcommittee (ETK00-2021-0189). The authors state that they have obtained appropriate institutional review board approval or have followed the principles outlined in the Declaration of Helsinki for all human or animal experimental investigations. In addition, for investigations involving human subjects, informed consent has been obtained from the participants involved.

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