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Home-based general versus center-based selective rehabilitation in patients with posterior tibial tendon dysfunction

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Objective: The aim of this study was to compare the effect of home-based and supervised center-based selective rehabilitation in patients with Grade 1 to 3 posterior tibial tendon dysfunction (PTTD).

Methods: The study included 49 subjects diagnosed with PTTD and referred to physiotherapy by an orthopedic surgeon. Subjects were randomly assigned into a home-based rehabilitation (21 cases; mean age: 33.56±17.59) group or center-based rehabilitation (28 cases; mean age: 28.57±14.74 years). The patients in the home-based rehabilitation group followed a home program of cold application, strengthening exercises for the posterior tibial and intrinsic muscles, and stretching in the subtalar neutral position. The patients in the center-based rehabilitation group followed a selective, supervised treatment consisting of the home protocol plus re-education of the non-functional tibialis posterior, proprioceptive neuromuscular facilitation methods, electrical stimulation, joint mobilization and taping techniques. Both groups received appropriate orthotics. All subjects were assessed before and after treatment for pain, muscle strength, foot function index (FFI) scores and specific tests for PTTD.

Results: Statistical analysis showed significant differences between pre- and post-treatment results for pain, first metatarsophalangeal angle, forefoot abduction angle, FFI scores and foot and ankle muscle strengths in the center-based group and for the tibialis posterior muscle strength in the home-based group ($p<0.05$). Intergroup comparison, however, showed no differences between the groups at the end of the treatment program with the exception of posterior tibial muscle strength ($p<0.05$).

Conclusion: Home- and center-based forms of rehabilitation seem to be equally effective in relieving pain and improving functional outcome in patients with Grade 1 to 3 PTTD. A patient-selective, supervised program may provide a better improvement in tibialis posterior strength than home-based rehabilitation.

Key words: Electrical stimulation; orthotic device; posterior tibial tendon dysfunction; treatment protocol.

Acquired pes planus is a frequent chronic foot problem. It is characterized by a flattening of the medial arch of the foot and dysfunction of the posteromedial soft tissues, including the posterior tibial tendon.[1] Posterior tibial tendon dysfunction (PTTD) is the most frequent cause of acquired pes planus in adults. Most frequently seen in middle-age women, its prevalence in the elderly population has been reported as being above 10%.[2] The first publication regarding the pathological conditions of the tibialis posterior tendon was Key's 1953

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study on tendon rupture.[3] The posterior tibial muscle is the primary stabilizer of the medial longitudinal arch; in lifting the medial longitudinal arch with the plantar flexion and inversion movement it locks the midtarsal articulation, stabilizing the hindfoot. As a result, when the middle and posterior foot are stable, the gastrocnemius/soleus muscles can be more effectively activated.[4] When the middle foot cannot be locked in the forward phase of walking, excessive force is applied on the midtarsal joint by the gastrocnemius/soleus, which in its turn causes a collapse of the medial arch and eversion of the subtalar articulation.[5] Imhauser et al. showed that PTTD causes a posterior shift of the center of gravity of the foot and brings an abnormal load on its medial structures.[6] The pathologic process leading to PTTD can develop as a result of degenerative or inflammatory causes or repeated microtrauma. PTTD, in its different stages, can cause rigid structural foot deformities and degenerative changes.[7]

Conservative treatment options are most frequently used for early stages or asymptomatic cases of PTTD, while surgical intervention is reserved for advanced stages, ruptures and chronic disease.[1,5] Among surgical options are tendon transfers, osteotomies, arthrodeses and their various combinations.[8-20] Surgical complications, however, such as infection,[21,22] deep vein thrombosis,[23,24] wound healing problems, nonunion[25,26] and neurological trauma[27] are frequent in patients undergoing surgical reconstruction for acquired pes planus related to PTTD. Other complications specific to the tendon transfer procedure or the soft tissue interventions are described as overcorrection or undercorrection.[1] Therefore, unnecessary surgical procedures should be avoided. Non-surgical treatments concentrate on reducing symptoms and directing force vectors to the correction of the posteromedial foot position. This provides for correct weight transfer, avoids repetitive and worsening trauma, reduces the need for modification of activity, and lessens the patient's problems of shoe selection.[1] Conservative treatment methods include nonsteroidal anti-inflammatory drugs (NSAID),[28] below-knee orthotics in Stage 1 and 2 insufficiency,[4,29-34] different designs of plantar inserts,[30,34-36] and, more rarely, exercise protocols.[4,37] Although cold application and massage techniques have been proposed in a number of publications,[38] the role of physical therapy in the treatment of PTTD remains controversial.[5] It is interesting to observe that a treatment protocol comprising appropriate manual techniques and neuromuscular electrical stimulation has not been listed among the conservative treatment options published to date. Manual techniques should be directed at diagnosis-specific strengthening, stretching, proprioceptive and muscular re-education and neuromuscular electrical stimulation for the weakened posterior tibial muscle to address a problem that involves increased pronation of the hindfoot, shortening of the Achilles tendon in this position, functional insufficiency of the posteromedial structures and dysfunction of the posterior tibial muscle and tendon. There is a need to investigate the effects of individually designed treatment protocols in addition to the conventional conservative treatment methods.

Our study aimed to compare the results of home-based and supervised, selective center-based rehabilitation in PTTD. Our hypothesis was that the results in patients treated by a diagnosis-specific PTTD treatment would be positively different than the results for those patients who were followed by routine treatment at home.

Patients and methods

The study included 56 patients selected according to eligibility criteria from 72 cases who had been referred to our department with PTTD. Patients with any central or peripheral nervous system disorder that could cause musculoskeletal imbalance, weakness, hypertonus or equilibrium troubles were excluded, as were those with a ruptured posterior tibial tendon. Patients were randomly assigned into a home-based rehabilitation group (n=28) and a center-based rehabilitation group (n=28) using simple randomization. Seven patients in the home group were later excluded due to non-compliance with either the recommendations or the follow-up requirements. The patients in the home-based group had an average age of 33.56±17.59 years and average weight of 66.17±8.38 kg. In the center-based group, the average age was 28.57±14.74 years and average body weight was 71.33±12.61 kilograms. The patients in the home-based group received a non-supervised home exercise program, while the patients in the center-based group received a supervised, patient-selective physiotherapy and rehabilitation program, specially designed according to the patient.

All cases were evaluated for PTTD-specific problems, including pain intensity and localization, degree of pes planus, pulley response, presence of edema, Tinel's sign, unilateral and bilateral heel raise test, too many toes sign, and first metatarsal rise test. Those with PTTD at Stages 1, 2 and 3 according to Myerson[39] were included in the study. Table 1 shows the distribution of patients according to PTTD classification. All patients in the study were evaluated before the start of treatment for demographic data, pain intensity on the visual analog scale, manual measurement of muscular strength (posterior tibial, gastrocnemius and soleus, anterior tibial, peroneus longus and brevis, extensor digitorum communis), angular measurements (angle of the 1st metatarsophalangeal and subtalar joints and forefoot abduction angle) and the foot function index (FFI) values of the leg affected by PTTD. The first evaluation was performed at the first visit and the second at the end of treatment for the supervised-rehabilitation group and at the follow-up one month after the start of the study for the home-based rehabilitation group. Both the first and the second evaluations were performed by an investigator unaware of the patients' group allocation and without seeing the results of the first evaluation.

Patients in the home-based group were given individually fitting orthotics, their treatment protocol and an appointment for one month later. The home treatment protocol consisted of 15 minutes of cold application, gastrocnemius/soleus stretching both manually and with a supinator wedge for the foot, rising on tiptoe on one foot and two feet, strengthening of the posterior tibial muscle with Theraband® (The Hygenic Corp., Akron, OH, USA), exercises to strengthen the intrinsic muscles of the foot, and recommendations for appropriate shoes.

The center-based group was given a total of 15 treatment sessions within 3 weeks. The protocol below was applied, with certain variations depending on the specific individual differences among the patients:

- Cold application
- Strengthening of the posterior tibial muscle by repeated contractions, using Theraband® and proprioceptive neuromuscular facilitation techniques,
- Mobilization of the ankle, subtalar and midtarsal joints
- Achilles and plantar fascia stretching
- High-voltage pulsed galvanic current neuromuscular stimulation of the posterior tibial muscle
- Bandaging
- Proprioceptive training
- Individually appropriate orthoses, such as medial arch support, medial wedge or UCBL inserts

The center-based group patients were also given the same home treatment program protocol to be applied at home.

Recorded data were compared between the first and second evaluations for each group and between the two groups at corresponding evaluations. Statistical methods used were the descriptive calculation of the arithmetical mean and standard deviation, and the Mann-Whitney U and Wilcoxon signed rank tests. Error tolerance was set at 0.05.

Results

No significant difference was seen in parameters between the pre-treatment values of the two groups ($p>0.05$), with the exception of gastrocnemius/soleus strength (Table 2). As gastrocnemius/soleus strength is manually measured, it may be qualified as a partially subjective evaluation and therefore it can be said that the groups were homogeneous.

Although there was some quantitative variation between the values before and after the home therapy program within the home group, no significant differ-

Table 1. Distribution of patients by PTTD class.

	Home-based treatment group		Center-based treatment group	
	n	Proportion	n	Proportion
Tenosynovitis	5	23.8%	7	25%
Stage 1	7	33.3%	10	35.7%
Stage 2	6	28.5%	7	25%
Stage 3	3	14.2%	4	14.2%
Total	21	100%	28	100%

Table 2. Intergroup comparison of the pre-treatment values.

	z	p
Age	-0.770	0.441
Body weight	-0.838	0.402
Pain intensity	-0.485	0.627
1st metatarsophalangeal articular angle	-0.847	0.397
Subtalar articular angle	-0.482	0.630
Forefoot abduction angle	-1.846	0.065
Foot function index	0.000	1.000
Tibialis posterior strength	-0.819	0.413
Gastrocnemius strength	-1.411	0.158
Gastrocnemius-soleus strength	-2.519*	0.012*
Tibialis anterior strength	-1.076	0.282
Peroneus longus strength	-0.428	0.669
Peroneus brevis strength	-0.211	0.833
Extensor digitorum communis strength	-1.165	0.244

*$p<0.05$

Table 3. Mean±SD and within-group comparison of values obtained before and after the home treatment protocol.

	Home-based program protocol group (n=21)		
	1	2	z
Pain intensity (cm on visual analog scale)	5.46±3.64	2.86±2.03	-2.806*
1st metatarsophalangeal articular angle	4.31±0.71	4.54±0.52	-1.890
Subtalar articular angle	-1.93±10.69	-0.04±10.47	-0.360
Forefoot abduction angle	3.64±9.71	7.07±5.20	-1.085
Foot function index (mm)	59.28±10.69	48.42±9.71	-1.342
Tibialis posterior strength	4.14±0.80	4.48±0.58	-2.238†
Gastrocnemius strength	4.81±0.50	4.86±0.36	-1.000
Gastrocnemius-soleus strength	4.93±0.27	4.93±0.27	0.000
Tibialis anterior strength	4.58±0.63	4.71±0.47	-1.633
Peroneus longus strength	4.60±0.59	4.64±0.50	-1.000
Peroneus brevis strength	4.64±0.59	4.69±0.48	-1000
Extensor digitorum communis strength	4.43±0.72	4.52±0.60	-1.414

*p=0.05, †p<0.05

ences were seen in the Wilcoxon signed rank test (p>0.05), with the exception of improvement in posterior tibial muscle strength (Table 3). This improvement in posterior tibial strength in the home group patients might be attributed to the effect of the home therapy program strength training.

Significant differences (p<0.05) were seen between the first and second evaluations of the center-based group for all measured values except for subtalar joint angle (i.e. pain intensity, first metatarsal joint angle, forefoot abduction angular measurements, and FFI) (Table 4). Muscular strength evaluations showed a significant within-group improvement from the first to the second evaluation for all measured muscles (p<0.05).

In the inter-group comparison of second evaluation results, only posterior tibial muscle strength was found to be statistically different (p<0.05) (Table 5).

Discussion

Posterior tibial tendon dysfunction is among the most frequent causes of acquired pes planus and progressive impairment of the biomechanical structure of the foot. However, there is a surprising lack of diagnosis-specific treatment protocols. Available literature yields contradictory recommendations for both the conservative treatment of all asymptomatic PTTD cases at all stages and surgery for cases starting at Stage 1.[4,10,11,13,17]

Acquired pes planus due to PTTD can be caused by a soft tissue insufficiency from various sources. When

Table 4. Mean±SD and within-group comparison of values obtained before and after the intensive treatment protocol.

	Center-based treatment protocol group (n=28)		
	1	2	z
Pain intensity (cm on visual analog scale)	6.41±2.29	3.07±1.96	-4.387*
1st metatarsophalangeal articular angle	4.00±1.09	4.51±0.55	-3.241*
Subtalar articular angle	0.14±9.54	-1.43±8.33	-1.225
Forefoot abduction angle	9.57±3.81	7.82±2.87	-3.367*
Foot function index (mm)	52.59±15.40	27.87±10.96	-2.201*
Tibialis posterior strength	3.99±0.75	4.71±0.52	-3.502*
Gastrocnemius strength	4.52±0.70	4.79±0.42	-2.456*
Gastrocnemius-soleus strength	4.39±0.74	4.75±0.44	-2.994*
Tibialis anterior strength	4.79±0.42	4.96±0.19	-2.236*
Peroneus longus strength	4.67±0.56	5.00±0.00	-2.640*
Peroneus brevis strength	4.69±0.52	4.89±0.31	-2.121*
Extensor digitorum communis strength	4.00±1.19	4.58±0.61	-3.213*

*p<0.05

Table 5. Intergroup comparison of parameters measured after treatment.

	z	p
Pain intensity	-0.014	0.989
1st metatarsophalangeal articular angle	-0.112	0.911
Subtalar articular angle	-0.187	0.851
Forefoot abduction angle	-0.620	0.535
Foot function index	-1.500	0.134
Tibialis posterior strength	-2.330*	0.020*
Gastrocnemius strength	-0.549	0.583
Gastrocnemius-soleus strength	-1.373	0.170
Tibialis anterior strength	-1.397	0.162
Peroneus longus strength	-3.329	0.001
Peroneus brevis strength	-1.569	0.117
Extensor digitorum communis strength	-0.389	0-697

*p<0.05

weight transfer in the correct position is not ensured, secondary structural modifications of the soft tissues followed by long-term bone and joint mechanical degeneration may develop.

In this study, we implemented two different treatment protocols, specifically designed for this pathology for patients with Stage 1-3 PTTD. The home therapy protocol of the home group was a more developed version of the routinely recommended exercise package given to patients diagnosed with PTTD. The intensive therapy protocol implemented for the center-based supervised group patients added electrostimulation aiming at muscular function re-education, exercise techniques, joint mobilization, bandaging techniques in the subtalar neutral position and proprioceptive training.

We found a single significant improvement in posterior tibial muscle strength in the home-based group and significant differences in all study parameters, except subtalar angle in the center-based group, from the first to the second evaluation. These findings can be interpreted to mean that the added intensive protocol had a positive effect on treatment (Tables 3 and 4). The significant improvement in the home-based group posterior tibial muscle strength may be related to the home therapy recommendation of the heel raising exercise and the resistance training with Theraband®. The absence of a significantly positive change from pronation to supination in the subtalar joint angle in the center-based group may, in turn, be due to the fact that the second evaluation was too early for same changes to manifest.

Although within-group comparisons indicate the efficacy of the intensive treatment, comparisons between groups only show significant differences in tibialis posterior muscle strength (Table 5). This difference may be attributed to the manual proprioceptive neuromuscular facilitation technique and the high-voltage pulsed galvanic current electrostimulation directly applied to this muscle as a part of the treatment protocol, as both methods aim to achieve a functional contraction by firing more motor units in the muscle. It is also possible that the administration of treatment directly by a physical therapist could have increased the intensity of muscular contraction and motivational power of the exercise program.

We found a positive difference in muscular strength results obtained from the first and second evaluation in both the intra- and inter-group comparisons. However, since muscular strength tests were manually evaluated, their subjectivity reduces the value of these results, although the confirmation of such results by other specific tests and clinical findings should somewhat compensate for this subjectivity.

This improvement in the posterior tibial muscle strength which supports the necessary inversion movement of the hind foot during the propulsion phase that represents the acceleration in walking should support our study's hypothesis. On the other hand, the lack of significant differences in other parameters between the treatment and home-based groups show that individualized home treatment programs designed for individual pathology and symptoms for patients with PTTD may be an alternative to intensive treatment protocols. These results are similar to other results from exercise programs.[4]

The most important limitation of our study was the absence of a control group without any treatment at all or provided with only orthotic support following the diagnosis of Stage 1-3 PTTD. The similar final results in the two groups may be the result of similar efficacy of the components of both treatment strategies. However, non-treatment of patients with a diagnosis of PTTD can be seen as an ethical violation. Additionally, isokinetic methods to record muscle strength, a larger patient group, longer evaluation time and a follow-up of both conservatively and surgically treated patient ratios could have provided better-defined study results and treatment efficacy evaluations.

In conclusion, home- and center-based forms of rehabilitation seem to be effective in relieving pain and improving functional outcome in patients with Grade 1 to 3 PTTD. A patient-selective, supervised program may provide a better improvement in tibialis posterior strength than the home-based rehabilitation. Compared to surgical approaches with their numerous accompanying complications, physical therapy programs are relatively cost-free and restore muscular balance, improve the parameters that cause secondary change and result in a reduction or reversal of PTDD complaints and symptoms.

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Conflicts of Interest: No conflicts declared.

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