# Comparison among Three Different Rehabilitation Programs on Outcomes of Patients with Posterior Tibial Tendon Dysfunction

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## Abstract

**Background:** Posterior tibial tendon dysfunction is a chronic, progressive, disabling condition of tendon that adversely affects ankle, foot and lower limb function.**Aim:** Was to compare among three different rehabilitation programs on outcomes of patients with posterior tibial tendon dysfunction. **Subjects and methods:** Research design: Quasi-experimental design was used with a comparative study using parallel-randomized groups (three intervention groups) with absence of control group. Subjects and setting: The study included 60 patients with stage I posterior tibial tendon dysfunction attended to orthopedic department and orthopedic outpatients clinic at Assiut University Hospitals. They randomly assigned into 3 equal groups (20 for each) by using a computer based selection program; group (A) muscle strengthening exercises and cold application, group (B) muscle strengthening exercises, medial arch support insoles and contrast bath, and group (C) muscle strengthening exercises, medial arch support insoles, ankle strengthening exercises and contrast bath. Tools: Patients assessment sheet, visual analog scale, revised foot function index, short musculoskeletal functional assessment questionnaire and exercises adherence logbook. **Results:** Pain level, revised foot function index scores, and short musculoskeletal functional assessment questionnaire scores significantly decreased in all groups after rehabilitation (p. value < 0.01). Group (C) demonstrated most improvement in each category followed by group (B) while group (A) demonstrated least improvement. **Conclusion:** Muscle strengthening exercises, medial arch support insoles, ankle strengthening exercises and contrast bath considered more effective rehabilitation program in reducing pain and improving perceptions of function than other rehabilitation programs. **Recommendation:** Rehabilitation should be considered within the first line of managing patients with stage I posterior tibial tendon dysfunction.

**Keywords**: Patients outcomes; Posterior tibial tendon dysfunction; Rehabilitation programs

## Introduction

Posterior tibial tendon dysfunction (PTTD) is an inflammation and/or overstretching of posterior tibial tendon that connect tibialis posterior muscle to bones of foot. It also can involve the associated ligaments and joints on the medial inner side of the foot and ankle leading to collapse of the medial longitudinal arch of the foot and sometimes ankle deformities occur which become debilitating or disabling in later stages [(1)].

Data on prevalence of PTTD is limited, however, PTTD is estimated to occur in about 3.3% to 10% of population, but this percent is likely to be higher as it can often be poorly recognized. It can occur in women over 40 years, occupations necessitate prolonged standing, limited ankle dorsiflexion, plantar heel spurs, excessive foot pronation, excessive running, athletic, patients with inflammatory arthritis, diabetes, hypertension, obesity, and foot or ankle trauma [(2, 3)].

Posterior tibial tendon dysfunction cause pain and/or swelling in the inner ankle, impaired mobility, instability while walking, toes begin to point outward, poor function and acquired flatfoot deformity. If PTTD left untreated, correction of the flattened foot may require surgery [(4)].

Posterior tibial tendon dysfunction divided into three stages according to Johnson and Strom. Stage I characterized by medial ankle pain, mild swelling, normal but sometimes possibly painful heel rise with no deformity. Stage II characterized by progressive flattening of the medial longitudinal arch with the foot appears flat, inability to rise heel, forefoot abduction and hindfoot valgus malalignment. Stage III includes all signs of stage II with fixed valgus hindfoot deformity accompanied by fixed compensatory forefoot varus [(5)]. Myerson added

stage IV that involves valgus tilt of the joint of ankle within mortise lead to lateral tibiotalar degeneration [6].

Management of PTTD in the early stages (I and II) is typically conservative, aiming to relieve pain and swelling. It mainly focuses on arch supporting devices, non-steroid anti-inflammatory drugs and local strengthening exercises. Surgical management aiming to correct deformity in the late stages (III and IV) and recently to prevent joint and soft tissue destructions in early stages (I and II) that do not respond to conservative treatment [7].

Nursing takes a key role in short and long-term care of patients. Nursing rehabilitation includes positioning and mobilization, supporting patients to independently and to actively perform self-care. Rehabilitation nurses make patients actively participate in the rehabilitation plan [8]. Rehabilitation involved care, education and training that help patients to accomplish the goals of intervention. It enables patients experiencing disability to improve, reach and maintain optimal functioning [9]. Depending on the patients` needs, nurses deliver rehabilitation interventions. In many and different patients conditions, nurses are considered the only professionals who deliver rehabilitation to patients. Basic rehabilitation interventions are delivered to the patients; they are educated and trained in managing disability [10].

**Significance of the study**

Posterior tibial tendon dysfunction is a progressive condition continuum from pain and tendon dysfunction to acquired flatfoot deformity if not treated properly in early stages. Clinical trials for the efficacy of exercises management in PTTD are lacking and exercises prescription parameters are poorly reported in the literature. Some clinical trials suggests that exercises are beneficial in reducing tendon pain and disability but there is no evidence about the best type of exercise used in managing patients with PTTD in early stages. So, this study conducted in an attempt to reduce pain and improve functional ability and identify which rehabilitation program would be most effective.

**Aims**

**General objective**

This study was aimed to compare among three different rehabilitation programs on outcomes of patients with stage I posterior tibial tendon dysfunction.

**Specific objectives**

1. Reduce pain, improve mobility and functional status for patients with stage I posterior tibial tendon dysfunction after rehabilitation programs.
2. Identify the most effective rehabilitation program for patients with stage I posterior tibial tendon dysfunction.

**Research Hypothesis**

The hypothesis of this study included that:

1. Rehabilitation programs would show significant improvements in reducing pain, and improving foot function, mobility and functional status for patients with stage I posterior tibial tendon dysfunction.
2. The results of the rehabilitation program applied for group (C) including muscle strengthening exercises, medial arch support insoles, ankle strengthening exercises and contrast bath would be positively different than the results for those patients in groups (A) muscle strength exercises and cold application and (B) muscle strength exercises, medial arch support insoles and contrast bath.

**Subjects and Methods**

**Study Design**

Quasi-experimental design was used with a comparative study using parallel- randomized groups (three intervention groups) with absence of control group to compare among three different rehabilitation programs on outcomes of patients with stage I PTTD.

**Subjects and Setting**

Patients diagnosed with stage I PTTD were recruited from the orthopedic department and outpatients clinic at Assiut University Hospitals. All eligible patients with stage I PTTD who agreed to participate in the study were included. Sixty adult male and female patients with age ranged from 18 to 65 years old with current complaint of foot and ankle pain and diagnosed with stage I PTTD. Patients were divided randomly into three groups (A, B and C, 20 patients for each) by using a computer based selection program. They randomly assigned to one of the three different rehabilitation programs. Exclusion criteria included pregnancy, rigid foot deformity, previous foot local injection or surgery and neurological, , or other foot pathology.

**-Sample size**

In order to reach (90% power) of study for detection effect size assuming (5% type I statistical error), a sample size of 60 patients to be included as a total number was found to be sufficient. So, this study included 20 patients in each group.

**Tools**

**Tool I: Assessment sheet for patient with stage I PTTD**

It developed by the researchers and included two parts to assess patients demographic and medical data:

Part 1: Demographic data: age, gender, occupation and level of education.

Part 2: Medical data: body mass index, co-morbidities, affected leg and history of foot or ankle trauma.

**Tool II: Visual analog scale (VAS)**

It was developed by **Scott and Huskisson, (1976)** [11] to measure pain intensity. It is a self-reported measure by making a hand written mark on (10 cm) line represents a continuum from "0 to 10". No pain (0), mild (1-3), moderate (4-6) and severe (7-10).

**Tool III: Revised foot function index (FFI-R)**

It was developed by **Venditto et al., (2015)** [12] to give information about foot function as to how foot pain affected patients' abilities to manage daily living activities. It divided into 3 subscales; pain (pain of foot in different situations) included 5-items (range 0-50), disability (difficult in performing various functional activities due to foot problems) included 9-items (range 0-90) and activity limitation (restriction in activities due to foot problems) included 3-items (range 0-30). Scoring of each item is rated on (0 to 10) Likert scale; 0 means no pain/disability and 10 means worst pain imaginable/severe disability to each item. Total score "maximum 170" multiplied by "100" (the total score/ 170×100 = the total FFI-R score %).

**Tool IV: Short musculoskeletal functional assessment questionnaire (SMFA)**

It was developed by **Swiontkowski et al., (1999)** [13] to measure functional status of patients with various musculoskeletal disorders. It consists of mobility, dysfunction and bother indexes. It is a 46-item self-report instrument (34-item for assessment of patients function and 12-item covering how bothered patients are by their symptoms). Each item included in the 34-item of mobility and dysfunction indexes has 5-point response; 1 point = good function and 5 points = poor function. Each item included in the 12-item of bother index has also 5-point response; 1 point = not at all bothered and 5 points = extremely bothered. The lower score indicate better function, mobility, and patients are less bothered by their symptoms while the higher score indicate worse function, mobility and patients are bothered by their symptoms.

**Tool V: Exercises adherence logbook**

It was developed by the researchers to ensure adherence of patients to the rehabilitation programs. It consisted of checklist pages containing the rehabilitation program for 6 months follow up period. Self-reported adherence of each patient in the three groups was recorded as complete adherence = 2, partial adherence = 1 and non-adherence = 0.

**Procedure**

**Ethical considerations**

Before conducting the current research, ethical approval was obtained from faculty of nursing ethical committee and from authorities of Assiut University Hospitals. Oral consent was obtained from each patient to participate in this research after fully explanation to the aim and nature of this research. Patients were informed by researchers that their participation in this research was voluntary and their data would be confidential.

**Tools validity**

The content validity of the used tools was tested for comprehensiveness, relevance, clarity, and appropriateness, it reviewed by five experts (one assistant professor of medical-surgical nursing and one professor and one lecturer of orthopedic and traumatology and 2 professors of rheumatology, rehabilitation and physical medicine in Assiut University). Modifications were done to ensure visibility and clarity of sentences and suitability of the content.

**Tools reliability**

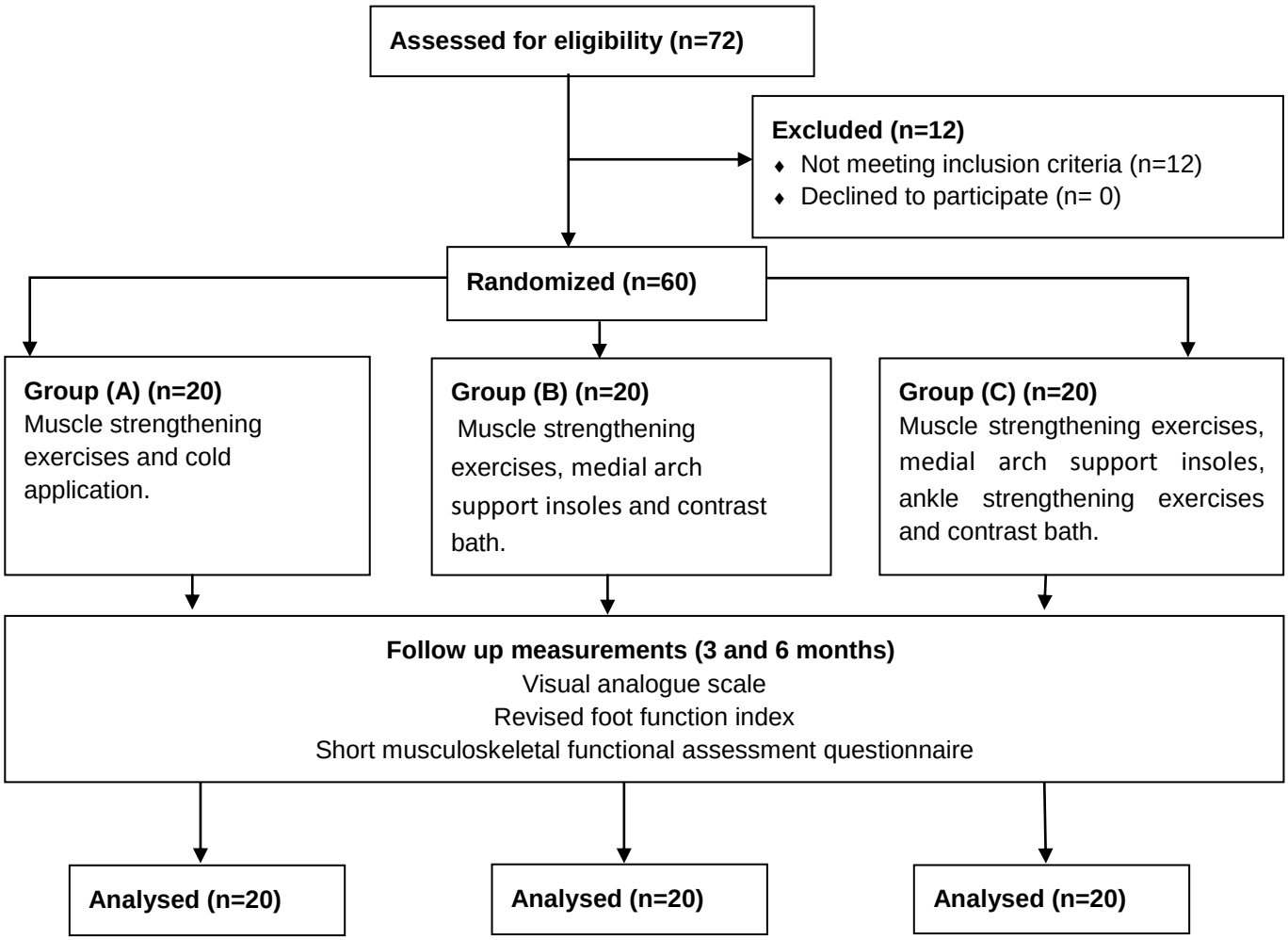
The reliability for VAS (tool II) as assessed by intraclass correlation coefficients was (0.97). The internal consistency for FFI-R (tool III) was (0.95) Cronbach's alpha test. The internal consistency for SMFA (tool IV) was (0.90) Cronbach's alpha test.

**Pilot study**

It was conducted on 10% [6 patients (2 patients from each group)] to ensure the feasibility and applicability of the research tools and the time required to completed. Depending on the results of the pilot study, necessary modifications were performed. The six patients who involved in the pilot study (2 from each group) did not included in the current study sample.

**Fieldwork**

Based on the inclusion and exclusion criteria, patients with stage I PTDD were classified into 3 groups. They randomly assigned into 3 equal groups (20 for each) by using a computer based selection program. They randomly assigned to one of the three different rehabilitation programs.




Flow diagram of study sample recruitment

All groups of patients (A, B, and C) were assessed initially for demographic and medical baseline data (tool I). Also, they were assessed before and after rehabilitation programs for pain intensity (tool II), foot function (tool III), and their functional status (tool IV).

Each tool was taken from 15-30 minutes to fill out by the researchers. After group allocation, all patients were provided with instructions about their allocated rehabilitation program. Patients were informed that muscle soreness in leg was a normal response to exercises

**Rehabilitation Programs (Handout)**

It developed by the researchers guided by **[Nilgun et al. (2012) (14) ; Blasimann et al. (2015) (2) ; Houck et al. (2015)** [(15)] ; **Ross et al. (2018)** [(16)] .It developed in Arabic language to meet patients` needs.

**Group (A)**

-Muscle strengthening exercises of:

-Flexor digitorum longus (2 sets of 15 repetitions, 1-2 times per day).

-Flexor hallucis longus (2 sets of 15 repetitions, 1-2 times per day).

-Tibialis posterior (3 sets of 10 repetitions once per day).

-Foot intrinsic (3 sets of 10 repetitions once per day).

- Cold application for 20 minutes (2-3 times/day).

**Group (B)**

-Muscle strengthening exercises of:

-Flexor digitorum longus (2 sets of 15 repetitions, 1-2 times per day).

-Flexor hallucis longus (2 sets of 15 repetitions, 1-2 times per day).

-Tibialis posterior (3 sets of 10 repetitions once per day).

-Foot intrinsic (3 sets of 10 repetitions once per day).

-Contrast bath for 20 minutes (2-3 times/day).

-Medial arch support insoles.

**Group (C)**

-Muscle strengthening exercises of:

-Flexor digitorum longus (2 sets of 15 repetitions, 1-2 times per day).

Flexor hallucis longus (2 sets of 15 repetitions, 1-2 times per day

-Tibialis posterior (3 sets of 10 repetitions once per day).

-Foot intrinsic (3 sets of 10 repetitions once per day)

-Ankle strengthening exercises (Ankle resistance exercises):

-Elastic band plantar flexion (2 sets of 15 repetitions, 1-2 times per day).

-Elastic band dorsiflexion (2 sets of 15 repetitions, 1-2 times per day).

-Elastic band inversion (2 sets of 15 repetitions, 1-2 times per day).

-Elastic band eversion (2 sets of 15 repetitions, 1-2 times per day).

-Contrast bath for 20 minutes (2-3 times/day).

-Medial arch support insoles.

-All patients received one educational session in the orthopedic department and outpatients clinic at Assiut University Hospitals lasted approximately 40-50 minutes where they informed about the average time of resolution of symptoms (realistic anticipation of rehabilitation program success; 3 to 6 months), and the importance of commitment to the recommended rehabilitation program.

According to their random allocation, wearing suitable footwear (avoid tight and hard footwear), and weight control. Every patient was given a handout of the rehabilitation program according to random allocation.

-All patients informed to do and adhere to the allocated rehabilitation program at home and they encouraged continuing with their rehabilitation program independently. They followed up for 6 months after implementation of the rehabilitation program according to their random allocation. Patients were evaluated at 3 and 6 months in the orthopedic outpatients clinic at Assiut University Hospitals for pain intensity using (tool II), foot function (tool III), and functional status (tool IV) .

-Exercises adherence logbook (tool V) was used to encourage patients to follow and record their commitment to the allocated rehabilitation program. It was recorded by patients, and collected after 6 months-the end of follow up to aid researchers to confirm patients` commitment to the allocated rehabilitation program.

**Statistical analysis**

It was performed with SPSS 20.0 software. Categorical variables were described by number and percent, where continuous variables described by mean and standard deviation. Chi-square test ($X^2$) used to compare between categorical variables. One way ANOVA test (F) used to compare between continuous variables. A two-tailed ($p < 0.05$) was considered statistically significant

**Results**

**Table (1)**: clarified that no statistical significant difference was found among all groups of patients (A, B and C) regarding demographic data (p.value > 0.05). The mean ages of patients were 50.84 ± 9.36, 48.17 ± 6.82, and 49.95 ± 11.73 years, respectively. The majority of patients in all groups were females. All of them were educated and working. Regarding baseline medical data, no statistical significant difference (p.value > 0.05) was found among all groups of patients (A, B and C). The mean body mass indexes of patients were 28.4 ± 4.52, 27.5 ± 9.61, and 28.6 ± 7.24 kilogram, respectively. Fewer percent of them were having diabetes mellitus, hypertension and history of foot or ankle trauma.

**Table (2):** displayed that there was no statistical significant difference among the three groups as regard pain level using VAS before stating the rehabilitation programs (p.value > 0.05). Statistical significant difference (p.value < 0.01) was found among the three groups as regard pain level while group (A) demonstrated the least improvement.

scores after 3 and 6 months of the rehabilitation programs. There was an obvious improvement in pain level scores after 3 and 6 months of the rehabilitation programs among the three groups. However, the improvement was highly in group (C) followed by group (B) then group (A).

**Figure (1):** illustrated that more than one-third of patients in all groups were having swelling along the posterior tibial tendon before application of rehabilitation programs. After application of rehabilitation programs, swelling along the posterior tibial tendon disappeared in all patients in the different three groups.

**Table (3):** showed that no statistical significant difference was found among patients in the three groups before rehabilitation programs regarding their FFI-R mean scores (p. value > 0.05). Statistical significant difference was found among patients in the three groups after 3 and 6 months of rehabilitation regarding pain and disability subcategory mean scores of the FFI-R (p.value < 0.01). The improvement in mean scores was found in the three groups, markedly high in group (C) followed by group (B) then group (A).

**Table (4):** displayed that no statistical significant difference was found among patients in the three groups before rehabilitation programs regarding their SMFA mean scores (p. value > 0.05). There were significant main effects for rehabilitation time, indicating that all groups improved overtime of rehabilitation after 3 months (p.value < 0.01) regarding dysfunction and mobility items of the SMFA scores and after 6 months regarding dysfunction (p.value < 0.001) and mobility (p.value < 0.01) items of the SMFA scores.

Short musculoskeletal functional assessment questionnaire scores decreased in all groups after rehabilitation. Group (C) demonstrated the most improvement in each category followed by group (B) .

**Table (5):** showed that no statistical significant differences were found among all groups of patients regarding their adherence to the rehabilitation programs (p. value > 0.05). The majority of patients in all groups were completely adhering to their rehabilitation programs through their follow up period.

**Table (1): Frequency distribution of demographic and medical data of the studied groups**

| Variables | Group (A) (n=20) | | Group (B) (n=20) | | Group (C) (n=20) | | F/$X^2$ | p. value |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | | |
| **Age (years)** (18-53) | | | | | | | | |
| Mean ± SD | 50.84 ± 9.36 | | 48.17 ± 6.82 | | 49.95 ± 11.73 | | 0.408 | 0.667 |
| **Sex** | | | | | | | | |
| Male | 2 | 10 | 4 | 20 | 1 | 5 | 2.264 | 0.322 |
| Female | 18 | 90 | 16 | 80 | 19 | 95 | | |
| **Level of education** | | | | | | | | |
| Low | 7 | 35 | 3 | 15 | 4 | 20 | 2.703 | 0.609 |
| Moderate | 6 | 30 | 7 | 35 | 8 | 40 | | |
| High | 7 | 35 | 10 | 50 | 8 | 40 | | |
| **Occupation** | | | | | | | | |
| Office work | 6 | 30 | 8 | 40 | 9 | 45 | 2.420 | 0.659 |
| Machinery work | 5 | 25 | 2 | 10 | 4 | 20 | | |
| Manual work | 9 | 45 | 10 | 50 | 7 | 35 | | |
| **Co-morbidities** | | | | | | | | |
| None | 15 | 75 | 17 | 85 | 16 | 80 | 1.668 | 0.797 |
| Diabetes mellitus | 2 | 10 | 2 | 10 | 1 | 5 | | |
| Hypertension | 3 | 15 | 1 | 5 | 3 | 15 | | |
| **Body mass index** | | | | | | | | 0.883 |
| Mean ± SD | 28.4 ± 4.52 | | 27.5 ± 9.61 | | 28.6 ± 7.24 | | 0.125 | |
| **Involved side** | | | | | | | | |
| Right | 9 | 45 | 13 | 65 | 8 | 40 | 2.800 | 0.247 |
| Left | 11 | 55 | 7 | 35 | 12 | 60 | | |
| **History of foot or ankle trauma** | 2 | 10 | 4 | 20 | 3 | 15 | 0.784 | 0.676 |

Chi-square test for qualitative data One way ANOVA test for quantitative data
Non-significant $p > 0.05$

**Table (2): Percentage distribution of pain level using visual analog scale scores for patients before and after application of different rehabilitation programs**

| Visual analog scale (Pain level) | Group (A) (n=20) | | Group (B) (n=20) | | Group (C) (n=20) | | $X^2$ | p. value |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | | |
| **Before rehabilitation** | | | | | | | | |
| No pain (0) | 0 | 0 | 0 | 0 | 0 | 0 | 0.404 | 0.817 |
| Mild (1-3) | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Moderate (4-6) | 8 | 40 | 10 | 50 | 9 | 45 | | |
| Severe (7-10) | 12 | 60 | 10 | 50 | 11 | 55 | | |
| **After rehabilitation (3 months)** | | | | | | | | |
| No pain (0) | 1 | 5 | 1 | 5 | 3 | 15 | 12.408 | 0.015* |
| Mild (1-3) | 15 | 75 | 17 | 85 | 7 | 35 | | |
| Moderate (4-6) | 4 | 20 | 2 | 10 | 10 | 50 | | |
| Severe (7-10) | 0 | 0 | 0 | 0 | 0 | 0 | | |
| **After rehabilitation (6 months)** | | | | | | | | |
| No pain (0) | 4 | 20 | 5 | 25 | 11 | 55 | 9.932 | 0.042* |
| Mild (1-3) | 14 | 70 | 15 | 75 | 9 | 45 | | |
| Moderate (4-6) | 2 | 10 | 0 | 0 | 0 | 0 | | |
| Severe (7-10) | 0 | 0 | 0 | 0 | 0 | 0 | | |

Chi-square test *Significant $p < 0.01$

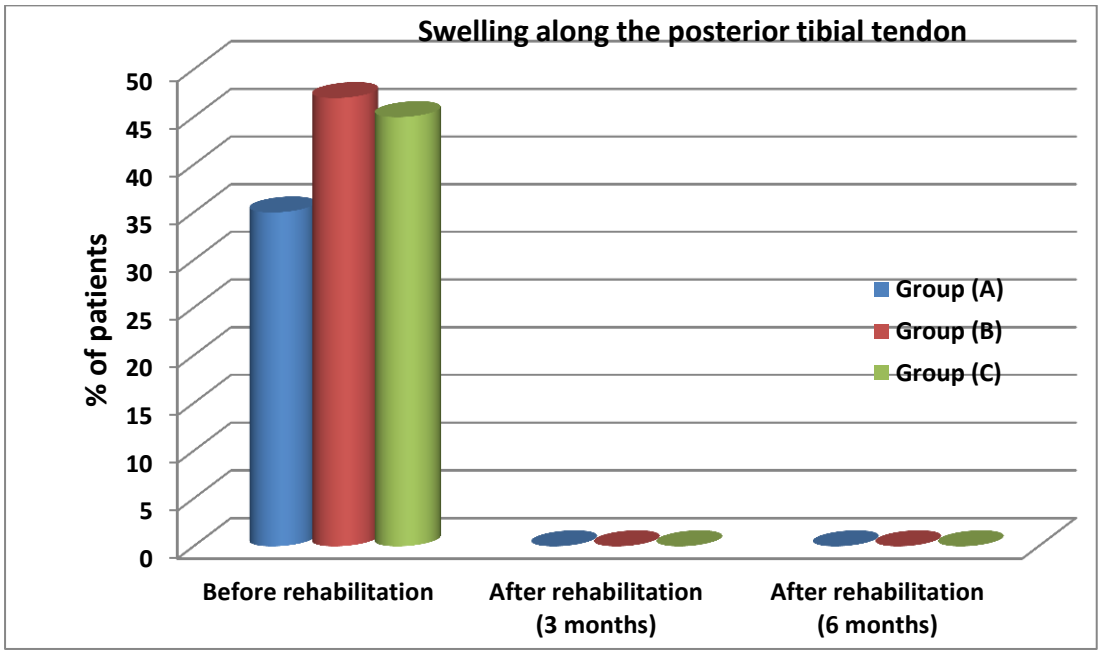



**Figure (1): Percentage distribution of swelling along the posterior tibial tendon for patients before and after application of different rehabilitation programs**

**Table (3): Distribution of revised foot function index mean scores for patients before and after application of different rehabilitation programs**

| Revised foot function index | Group (A) (n=20) | Group (B) (n=20) | Group (C) (n=20) | F | p. value |
|---|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean ± SD | | |
| **Before rehabilitation** | | | | | |
| Pain subcategory (range 0 - 50) | 35.2 ± 16.4 | 33.7 ± 12.9 | 35.8 ± 14.3 | 0.110 | 0.896 |
| Disability subcategory (range 0 - 90) | 37.5 ± 13.8 | 34.9 ± 14.5 | 36.3 ± 11.9 | 0.187 | 0.830 |
| Activity limitation subcategory (range 0 - 30) | 15.0 ± 9.7 | 14.6± 11.2 | 15.2 ± 10.8 | 0.017 | 0.983 |
| **Total** | 29.2 ± 13.1 | 27.7 ± 12.7 | 29.1 ± 12.2 | 0.088 | 0.916 |
| **After rehabilitation (3 months)** | | | | | |
| Pain subcategory (range 0 - 50) | 15.4 ± 13.1 | 14.7 ± 11.4 | 10.1 ± 8.5 | 1.331 | 0.042* |
| Disability subcategory (range 0 - 90) | 20.5 ± 18.4 | 15.1 ± 10.2 | 9.4 ± 7.6 | 3.695 | 0.049* |
| Activity limitation subcategory (range 0 - 30) | 9.8 ± 12.6 | 6.7 ± 7.3 | 5.8 ± 6.9 | 1.017 | 0.598 |
| **Total** | 15.2 ± 14.5 | 12.2 ± 9.7 | 8.8 ± 5.9 | 1.814 | 0.068 |
| **After rehabilitation (6 months)** | | | | | |
| Pain subcategory (range 0 - 50) | 10.6 ± 8.2 | 8.1 ± 5.3 | 5.4 ± 4.9 | 3.400 | 0.040* |
| Disability subcategory (range 0 - 90) | 15.2 ± 10.6 | 10.1 ± 8.4 | 4.2 ± 5.6 | 8.485 | 0.012* |
| Activity limitation subcategory (range 0 - 30) | 7.5 ± 9.6 | 5.9 ± 7.1 | 3.8 ± 5.2 | 1.218 | 0.303 |
| **Total** | 11.1 ± 9.5 | 8.0 ± 6.7 | 5.5 ± 4.8 | 2.985 | 0.059 |

One way ANOVA test *Significant p < 0.01

**Table (4): Distribution of short musculoskeletal function assessment questionnaire mean scores for patients before and after application of different rehabilitation programs**

| Short musculoskeletal function assessment questionnaire | Group (A) (n=20) | Group (B) (n=20) | Group (C) (n=20) | F | p. value |
|---|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean ± SD | | |
| **Before rehabilitation** | | | | | |
| Dysfunction | 20.5 ± 11.8 | 19.7 ± 8.0 | 20.3 ± 10.7 | 0.033 | 0.968 |
| Mobility | 24.6 ± 12.3 | 21.7 ± 10.9 | 23.6 ± 10.2 | 0.348 | 0.708 |
| Bother | 23.5 ± 18.7 | 20.9 ± 14.1 | 20.4 ± 13.9 | 0.224 | 0.780 |
| **After rehabilitation (3 months)** | | | | | |
| Dysfunction | 12.5 ± 7.2 | 10.8 ± 5.9 | 7.6 ± 4.6 | 3.445 | 0.039* |
| Mobility | 15.0 ± 9.6 | 13.2 ± 6.8 | 9.5 ± 2.5 | 3.262 | 0.046* |
| Bother | 14.2 ± 11.1 | 11.4 ± 5.6 | 10.5 ± 4.2 | 1.297 | 0.281 |
| **After rehabilitation (6 months)** | | | | | |
| Dysfunction | 9.8 ± 6.0 | 7.9 ± 4.2 | 4.0 ± 3.8 | 7.706 | <0.001** |
| Mobility | 9.5 ± 7.9 | 7.2 ± 4.6 | 4.0 ± 4.1 | 4.561 | 0.015* |
| Bother | 11.2 ± 8.4 | 9.4 ± 3.5 | 7.0 ± 2.4 | 3.001 | 0.057 |

One way ANOVA test *Significant p < 0.01 **Significant p <0.001

**Table (5): Percentage distribution of patients` adherence to rehabilitation program after 3 and 6 months**

| Adherence to rehabilitation program | Group (A) (n=20) | | Group (B) (n=20) | | Group (C) (n=20) | | $X^2$ | p. value |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | | |
| **After rehabilitation (3 months)** | | | | | | | | |
| Complete adherence | 18 | 90 | 16 | 80 | 15 | 75 | 1.558 | 0.436 |
| Partial adherence | 2 | 10 | 4 | 20 | 5 | 25 | | |
| **After rehabilitation (6 months)** | | | | | | | | |
| Complete adherence | 15 | 75 | 13 | 65 | 14 | 70 | 0.476 | 0.325 |
| Partial adherence | 5 | 25 | 7 | 35 | 6 | 30 | | |

Chi-square test Non-significant p > 0.05

## Discussion

Posterior tibial tendon dysfunction is a progressive disorder continues to deteriorate without treatment. Early detection and intervention help to slow progression. Patients provided with rehabilitation have been shown to have significant improvements. High quality clinical trials about the efficacy of exercises management in PTTD are lacking and exercises prescription parameters are poorly reported in the literature [17]. In the present study, we developed three different rehabilitation programs, specifically designed for patients with stage I PTTD and implemented by patients at home in an attempt to recommend rehabilitation program for patients with stage I PTTD.

The comparison of the characteristics and the baseline medical data of patients in the different groups revealed no statistical significant differences (they were similar). All patients were adult, working and educated. The majority of them were females and overweight. Fewer percent of them were having diabetes mellitus, hypertension and history of foot or ankle trauma.

In this regard, study of **Houck et al., (2015)** [15] reported the same findings regarding characteristics and baseline medical data for patients with PTTD as the majority of the study sample was adult, female and overweight. Recent literature reported higher prevalence of PTTD in females than in males, with no

explanation for this discrepancy. Although diabetes mellitus, overweight and mechanical influences as trauma to the medial ankle reported to contribute to PTTD.

From the researchers point of view, higher prevalence of PTTD in females than in males could be because of the condition in females peaks during perimenopause, hormonal influence [loss of estrogen] could have a role in degeneration of tendons. The same processes which affect changes in bone [collagen I] during menopause may also affect tendons and ligaments, thereby contributing to increased incidence of PTTD in females above 45 years.

In the current study before starting the rehabilitation programs for patients with stage I PTTD, the level of pain obtained from the VAS in all groups were close to each other, no significant statistical difference among them. It was determined high level of pain among patients in all groups. There was significant main effect for rehabilitation time, all groups improved overtime of rehabilitation after 3 and 6 months. More improvement was achieved after 6 months of rehabilitation. Pain level was significantly decreased across all groups after rehabilitation. Group (C) demonstrated the most improvement in pain followed by group (B) while group (A) demonstrated the least improvement in pain. Also, swelling along the posterior tibial tendon was found in some patients before rehabilitation and improved after rehabilitation.

A study of **Ross et al., (2018)** [16] supported the current study which reported that patients with PTTD complain of pain with palpation, pain on tendon loading, swelling along the posterior tibial tendon and impaired function which is considered key features in the clinical presentations of PTTD. Pain and difficulty during various activities that load medial aspect of foot and posterior tibial tendon as single leg heel raise are key clinical features of PTTD.

In the same line, a study of **Hoang et al., (2021)** [18] reported that habitual use of foot orthoses combined with exercises and also exercises alone were clearly found to have better effect on alleviation of pain than wearing foot orthoses only. Active intervention was found to have better efficacy in decreasing pain more effectively than the passive intervention.

A study of **Cook et al., (2016)** [19] stated that the mechanism of effect for outcomes improvements for patients with PTTD following strengthening exercises is understood to be related to the load. It suggested that load through tendon during exercises need to be sufficiently high enough to elicit the physiological changes within tendon. Also, a study of **Malliaras et al., (2013)** [20] suggested that the physiological response to exercises may be greater with eccentric strengthening and heavy-slow resistance due to higher loads applied via tendon during these exercises.

From the researchers point of view, adherence of all patients in the different three groups to the rehabilitation programs through the follow up period (6 months-the end of follow up) resulted in more significant improvements in relieving/reducing pain. Use of insoles in addition to strengthening exercises showed significant pain reduction mechanism in patients of groups (B and C) and this could be mostly related to its supporting function of medial longitudinal arch.

In the present study before starting the rehabilitation programs for patients with stage I PTTD, the FFI-R mean scores were close to each other in all groups, no significant statistical difference among them. It determined increased pain, disability and activity limitation among patients in all groups. There were significant main effects for rehabilitation time, patients in all groups improved overtime of rehabilitation after 3 and 6 months regarding pain and disability subcategories of the FFI-R. Pain and disability were significantly decreased across all groups of patients after rehabilitation. More improvement was achieved after 6 months of rehabilitation. Group (C) demonstrated the most improvement in pain and disability subcategories of the FFI-R followed by group (B) while group (A) demonstrated the least improvement.

In the same line with the finding of the current study, a study of **Nilgun et al., (2012)** [14] displayed that statistical significant differences were found between pre and post rehabilitation programs regarding pain and FFI. Rehabilitation for patients with grade 1 to grade 3 PTTD was effective in relieving/reducing pain and improving functional outcome. Rehabilitation programs provide better improvement regarding tibialis posterior strength, restore muscular balance and reduction/reversal of PTTD complaints and symptoms.

A systematic review who conducted by **Ross et al., (2018)** [16] to determine the effect of strengthening exercises compared with other forms of conservative management for patients with PTTD provide limited evidence to suggest that tibialis posterior strengthening, stretching and orthoses and ankle strengthening, balance and stretching exercises similarly reduce pain, improve mobility and dysfunction for patients with PTTD in the short term compared with no strengthening exercises.

The results of the present study clarified that before starting the rehabilitation programs for patients with stage I PTTD, the SMFA mean scores were close to each other in all groups, no significant statistical difference among them. It determined increased mean scores of the SMFA among patients in all groups. Overtime with continuing adherence of all patients in the different groups to the rehabilitation programs, improvement was achieved after 3 months and more significant improvement was achieved after 6 months and more specifically observed in the mobility and dysfunction indexes of the SMFA. Group (C) demonstrated the most improvement in decreasing disability and improving mobility of the SMFA followed by group (B) while group (A) demonstrated the least improvement.

In the same line with the finding of the current study, a study of **Houck et al., (2015)** [15] reported that a positive effect of the strengthening exercises was observed in the mobility and dysfunction indexes of the SMFA. Gains in ankle muscle strength or improved recruitment of muscles used for mobility might explain these mobility findings, while it may also be possible that increased mobility adversely affects any reduction in pain that might result from the strengthening program.

A study of **Kulig et al., (2009)** [21] supported the present study finding which stated that patients with stage I and II PTTD exhibited significant increase/improvement in function and significant reduction in pain after participation in a three month rehabilitation program that emphasized education and use of orthoses. Simultaneous involvement in exercises which specifically targeted the posterior tibial tendon furthered the improvement. Designing exercises program that strengthening the weakened tibialis posterior musculotendinous is essential for effective management of the early stages of PTTD and in preventing further degeneration. The intensity of a stimulus as exercise required sufficient load and frequency to trigger adaptation.

Also, a study of **Ross et al., (2018)** [16] clarified that tolerance and ability to do the exercises with good/correct form were the criteria for progressing load. Patients in eccentric group were better able to tolerate higher loads during exercises program, optimizing tendon response, and reporting greater improvement in pain, disability and overall foot function. However, were not different between groups.

In this regard, a study of **Cook and Purdam, (2014)** [22] reported that foot orthoses and activity modification help in altering tensile loads; supporting medial longitudinal arch and reducing torque required from tibialis posterior during activities.

From the researchers point of view, adherence of all patients in the different three groups to the rehabilitation programs through the follow up period (6 months-the end of follow up) resulted in more significant improvements in their outcomes overtime; relieving/reducing pain, improve mobility and functional outcomes. Use of insoles showed significant pain reduction mechanism of patients in groups "B and C" and this could be mostly related to its supporting function of medial longitudinal arch. Also, contrast bath used for patients of groups "B and C" helped in decreasing inflammation around the tendon and reducing swelling resulted in more pain relieve/reduction than cold application used by patients of group "A". The overall better improvements observed in all outcome measures of patients in group (C) could be suggested to be as a result of addition of ankle strengthening exercises (ankle resistance exercises) to their rehabilitation program than patients of groups "A and B". These strengthening exercises allowed for quantification of load and constant resistance throughout the exercises. This raised the possibility that the differences in patients` outcomes in the different groups were more dependent on the load.

Also, the researchers point of view supported by other study results which stated that standard management that may prevent the need for surgical intervention include use of orthotic devices and physical therapy. Evidence from clinical management of similar conditions

suggests that active exercises (strengthening exercises) are more effective in leading to fast recovery. Adding strengthening exercises to a normal intervention of orthotic devices is more effective in improving range of symptoms in early stages of PTTD patients than using orthotic devices only [23].

**Study limitations**

The most important limitation of the current study was the absence of control group without any rehabilitation program at all or provided with only orthotic support for the medial longitudinal arch following the diagnosis of stage I PTTD. Patients' adherence to the rehabilitation programs was recorded in the logbook and reported to the researchers by patients and not observed directly by the researchers.

**Conclusions**

The habitual use and adherence to the different rehabilitation programs was clearly found to provide significant effect in alleviation/reduction of pain and swelling, improve mobility and functional outcomes overtime. Moreover, the rehabilitation program that composed of muscle strengthening exercises, medial arch support insoles, ankle strengthening exercises and contrast bath showed more significant improvements than other rehabilitation programs. Managing patients with PTTD in an early stage with the recommended rehabilitation program may delay/prevent progressing to the later stages of the disease and prevent the need for surgical intervention.

**Recommendations**

The current study findings recommended that disseminating the handout of the 6 months rehabilitation program (muscle strengthening exercises, medial arch support insoles, ankle strengthening exercises and contrast bath) for patients with early stage PTTD in the orthopedic and rheumatology, rehabilitation and physical medicine departments in different hospitals as rehabilitation guide. Disseminating the handout should be accompanied by education to patients to describe and explain the content and the importance of the rehabilitation program to improve condition, avoid chronicity and recurrence of symptoms, prevent or delayed progression to later stages of the disease and avoid surgical intervention. Education should be done by qualified health care practitioner; nurses, orthopedic specialist, and/or physiotherapist to ensure patients understanding, awareness and practicing exercises in correct form. Also, follow up is necessary to ensure patients` commitment to the rehabilitation program.

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