Forefoot Gait Retraining as an Intervention for Patellofemoral Pain: A Critically Appraised Topic

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Abstract

Context: Running is a popular and accessible athletic activity, but many individuals are deterred by the pain and injury associated with it. Gait retraining, particularly transitioning to a forefoot strike (FFS), has gained popularity as an intervention for patellofemoral pain, a common running-related injury. This critically appraised topic aims to investigate the impact of running gait retraining to FFS patterns on the management of patellofemoral pain.

Methods: A computerized search was conducted in October 2023, focusing on terms related to patellofemoral pain, gait, and forefoot. Inclusion criteria encompassed articles from the last 10 years, studies with human subjects, randomized control trials, those including forefoot gait retraining, and a running population. Exclusion criteria comprised non-randomized trials, studies measuring other indicators of patellofemoral pain, and studies focusing on gait retraining types other than forefoot running. Three relevant studies were identified, each with different intervention protocols. These articles were critically appraised via the Physiotherapy Evidence Database (PEDro) scale resulting in a score of 7/10 for dos Santos et al.[1], 5/10 for Roper et al.[2], and 5/10 for Wang et al.[3]

Results: Dos Santos et al.[1] and Roper et al.[2] used various gait retraining techniques with reinforcement through standardized phrases and mirror feedback, while Wang et al.[3] introduced minimal shoes for forefoot striking. The outcome measures varied, with a focus on kinematic outcomes and patellofemoral pain indicators such as VAS scores, AKPS, and LEFS. The findings demonstrated a reduction in pain and positive changes in kinematic variables for FFS gait intervention, with values exceeding minimal clinically significant differences.

Conclusions: Gait retraining to FFS was effective in reducing patellofemoral pain symptoms and improving function. However, the improvements were not consistently accompanied by significant kinematic differences. These findings suggest that this intervention can reduce running-related knee pain and patellofemoral joint loads, decreasing the risk of patellofemoral pain syndrome.

Clinical Scenario and Clinical Question

Clinical Scenario

Running is one of the world's most accessible athletic activities. Unlike other sports that require a series of equipment, running only necessitates a pair of shoes. It is no wonder millions of people flock from road race to road race, around the world.[4] However, despite the ease of entry there is a large barrier in the uptake of running as a hobby. Simply being that running can hurt. This hurt can come from the mental toll of pushing through the perceived limitations of one's body, to overcoming the stress created by the physiological response from the brain trying to reestablish equilibrium, to the very real musculoskeletal pain imposed by the demands of running.[5] In order to decrease this barrier to entry it is imperative that research is continually conducted with the purpose of reducing the incidence of pain and injury in running.

One such intervention that has found popularity in recent years is gait retraining. Specifically gait retraining for patellofemoral pain. Patellofemoral pain is one of the most common incidences of injury within the physically active.[6] If gait retraining is truly effective in the prevention of patellofemoral pain this could be an incredible resource for health care professionals treating patients with chronic patellofemoral pain. Therefore, this critically appraised topic seeks to assess the efficacy of gait retraining to forefoot striking (FFS) on patellofemoral pain.

Focused Clinical Question

What are the impacts of running gait retraining to forefoot strike (FFS) patterns on the management of patellofemoral pain syndrome

Search Strategy

A computerized search was completed October 2023 (Figure 1).

Terms Used to Guide Search Strategy:
- **P**atient/Client Group: Patellofemoral pain, patellar tendinitis
- **I**ntervention: Gait, forefoot
- **C**omparison: No terms listed (compared to heel strike or other intervention)
- **O**utcomes: No terms listed (Pain, recovery, reduction in symptoms)

Sources of Evidence Searched:
- CINHAL Ultimate
- SPORTSDiscus
- PubMed
- MEDLINE Ultimate

Inclusion Criteria:
- Limited to articles written in the English Language
- Limited to articles written in the last 10 years (2013-2023)
- Limited to studies with human subjects
- Limited to randomized control trials
- Limited to studies that included forefoot gait retraining
- Limited to running population

Exclusion Criteria:
- Research not conducted as a randomized trial
- Studies that focused on other gait retraining types while excluding forefoot running
- Studies that did not include patellofemoral indicators
- Studies with no intervention

*Liberty University Runners Demonstrating an FFS gait pattern. Photo by Tanner Bohan

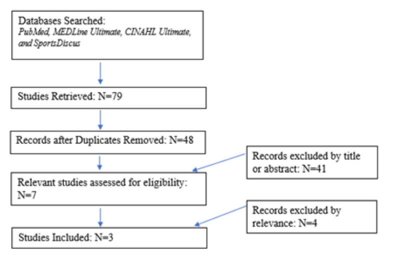

Figure 1 Search Strategy

Table 1 Results of PEDro Scale[9] for Each Article

	Dos Santos et al.[1]	Roper et al. [7]	Wang et al.[3]
1. Eligibility Criteria specified (yes or no)	Yes	Yes	Yes
2. Subjects randomly allocated to groups (yes/no)	Yes	Yes	Yes
3. Allocation was concealed (yes/no)	Yes	No	No
4. Groups similar at baseline (yes/no)	Yes	No	Yes
5. Subjects were blinded to group (yes/no)	No	No	No
6. Therapists who administered therapy were blinded (yes/no)	No	No	No
7. Assessors were blinded (yes/no)	No	No	No
8. Minimum 85% follow-up (yes/no)	Yes	Yes	Yes
9. Intent to treat analysis for at least 1 key variable (yes/no)	Yes	Yes	Yes
10. Point measurements and variability reported	Yes	Yes	Yes
11. Point measurements and variability reported (yes/no).	Yes	Yes	Yes
Overall Score (out of 10)	7/10	5/10	5/10

Note: Item 1 was not included in overall score *PEDro - Physiotherapy Evidence Database

*Liberty University Runners Demonstrating a RFS gait pattern. Photo by Tanner Bohan

Table 1: Characteristics of Included Studies.

	dos Santos et al.[1]	Roper et al.[2]	Wang et al.[3]
Study Design	Randomized Case Trial	Randomized Control Trial	Randomized Control-Trial
Participants	18 runners (9 Male, 9 Female) between the ages 18 and 35. Runners had to be rearfoot strikers who run at least 15km a week who experience patellofemoral pain with no history of trauma.	16 recreational runners; with self-reported patellofemoral pain of at least 3 but no more than 7 out of 10.	30 healthy male recreation runners, with an inclination for rearfoot strike; weekly running distance > 20km; free from lower extremity injuries within 3 months
Interventions Investigated	Participants were randomized into 3 gait retraining groups forefoot landing, 10% step rate increase, and forward trunk lean. Each group completed 8 sessions of retraining on a treadmill with a progression of running time from 15 -30 min. Verbal instructions on keeping the running pattern were decreased as the sessions lengthened. Runners wore their own shoes and were instructed not to run outside of retraining sessions.	Control Group: Run time progressed from 15 to 30 min. over 8 sessions. Running would be conducted in front of a mirror with no verbal cues that aided in gait retraining. They only received encouragement. They would be retested after each training session and one-month following. Experimental Group: Run time progressed from 15 to 30 min. over 8 sessions. Running would be conducted in front of a mirror with real time feedback on their adherence to a fore foot strike. They would also be told scripted statements such as "run on your toes." Feedback would decrease periodically after the fourth session.	Control Group: Wear experimental vests, shorts, and socks. 5-min. Warm-up at 12km/h; 5-min rest. Change into minimalist shoes. Maintain original strike pattern at self-selected speed with moderate intensity, training sessions lasted for 5-48 minutes across 12 weeks. Experimental Group: Wear experimental vests, shorts, and socks. 5-min. Warm-up at 12km/h; 5-min rest. Change into minimalist shoes. Adjust strike pattern to utilization of the metatarsal ball of the forefoot to strike first. Training at self-selected speed with moderate intensity, training sessions lasted for 5-48 minutes across 12 weeks.
Outcome Measures	Knee ROM Patellofemoral joint contact force Patellofemoral stress Ankle ROM Hip and Trunk ROM Pain Score (VAS, LEFS and AKPS) Lower Leg Muscle Activity	Knee Flexion, Knee ROM Ankle Flexion, Ankle ROM Knee Extensor Moment Plantar flexion moment Patellofemoral joint contact force Patellofemoral stress Achilles Tendon Force Pain Score (VAS)	Maximum Knee Flexion Angle Foot Strike Angle Peak Knee Extension Moment Patellofemoral Joint Contact Force Patellofemoral Stress
Main Findings	Regardless of group there was a 54% reduction of worst knee pain after training and 75% reduction after the 6th month follow-up measurement. The greatest change occurring in the forefoot intervention group. This change exceeded the minimal clinically important difference, indicated clinical relevance. Change in the VAS exceeded 2 and AKPS exceeded 10 both meeting MCID standards for FFS. No clinically significant difference was found in the kinematic differences between groups.	There was a statistically significant effect found in the change in Knee flexion at initial contact, Knee abduction at initial contact, Ankle flexion at initial contact, ankle ROM, Patellofemoral joint contact force, Patellofemoral stress, Achilles Tendon Force, and Pain. Change in VAS of 4, Patellofemoral joint contact force changed by 0.82 and patellofemoral stress by 1.9 MPa.	The foot strike angle of the experimental group decreased by 10.2° while no change was noted in the control group. Peak Knee extension moment decreased by 13.8% in the experimental group. Peak patellofemoral joint stress decreased by 13.3% in the experimental group and no change was noted in the control group. Neither group experienced a change in patellofemoral joint contact force. There was no development of knee pain during the intervention period.
Level of Evidence	1b	1b	1b
Validity Score	PEDro 7/10	PEDro 5/10	PEDro 5/10
Conclusion	Forefoot landing, increase step rate by 10% and forward trunk lean running techniques were able to reduce patellofemoral pain symptoms and improve function after a 2-week of supervised gait retraining and the benefits were maintained in the 6-month follow-up. However, the clinical improvement was not accompanied with significant kinematic differences.	"The findings suggest that gait retraining by transitioning from RFS to FFS results in significant increases in knee flexion, knee abduction, and ankle plantarflexion at initial contact, and ankle range of motion throughout the loading response, as well as significant reductions in reported knee pain. This also suggests that transition to the use of an FFS running gait may reduce running-related knee pain."	A 12-week gait retraining from rear-foot running to fore-foot running can effectively decrease patellofemoral joint loads without altering running speed. Thereby reducing the risk of patellofemoral pain syndrome.

* ROM – Range of Motion; VAS – Visual Analog Scale; AKPS – Anterior Knee Pain Scale; LEFS – Lower Extremity Functional Scale; MCID – Minimally Clinically Important Difference; FFS – Forefoot Strike; PEDro – Physiotherapy Evidence Database; RFS – Rearfoot Strike.

Results of Search & Clinical Bottom Line

Results of the Search

Three relevant studies were located using these search terms (Figure 1). Validity of the selected studies was determined using the PEDro Scale (Tables 1 and 2).

Intervention protocols varied among the three studies to some degree, some studies paired the use of minimalist shoes with gait retraining, while other studies focused on a pure comparison of the forefoot to rearfoot gaits or even other modifications. In studies by Roper et al.[7] clinicians reinforced FFS through the utilization of standardized phrases and mirror feedback in front of the participant. While the study by dos Santos et al.[1] and Wang et al.[3] were more focused on gait intervention via verbal instruction. Dos Santos et al.[1] also conducted interventions in stride rate and length in comparison to FFS, making comparisons based on baseline measurements rather than against a group with no intervention.

The studies differ slightly in their measurement of outcomes, dos Santos et al.[1] and Roper et al.[7] measure multiple kinematic outcomes in addition to direct measurements for patellofemoral pain utilizing the visual analog score (VAS), anterior knee pain scale (AKPS), Lower Extremity Functional Scale (LEFS). While the study by Wang et al.[3] only measured kinematic outcomes specifically patellofemoral joint contact force (PFCF) and patellofemoral stress (PFS) as these are indicators of developing patellofemoral pain syndrome.[8] Dos Santos et al.[1] measured pain values that exceeded minimal clinically significant differences (MCID) pre- and post- intervention for reductions in VAS of greater than 2 and an increase of greater than 10 in AKPS. Roper et al.[7] measured a VAS decrease of 4 and also had MCID register in reduction of PFS and PFCF. Wang et al.[6] required participants to be pain free before starting the training and experienced no development of knee pain in the experimental group as well as a 13.3% reduction in Patellofemoral Stress.

Clinical Bottom Line: Strength of Recommendation

There is Grade B evidence that the FFS intervention for patellofemoral pain syndrome improves pain and reduces mechanisms for injury such as PFCF and PFS in runners.[10] All three included studies were randomized trials, allowing for greater determination of causal relationships. However, one study did not include a control group which limits the ability to link the kinematic relevance to the intervention. Clinicians should consider incorporating this intervention for patients who participate in running while experiencing patellofemoral pain. However further research should be conducted using larger cohort randomized control trials and meta-analyses to determine if there is truly a kinematic link between the PFCF and PFS with regards to pain and to determine the clear benefit of the intervention.

Future Work

Based on the results of the three randomized trial studies included in this CAT, clinicians who utilize an FFS gait intervention for the treatment and prevention of patellofemoral pain, have demonstrated positive patient outcomes.[1,3,7] Although these studies demonstrate positive results for the FFS intervention with regards to patellofemoral pain additional research is necessary to ensure the change of impact loading does not cause cascading effects in other areas of the kinetic chain. These studies have demonstrated a high degree of long-term reduction in pain with post treatment follow ups, however further research should also explore the interventions effectiveness in more specific populations such as collegiate or high school runners. Finally additional studies should examine the effect of FFS gait intervention on athletes in sport specific activities beyond uniplanar running. This CAT should be reviewed and renewed in 2 years.

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Acknowledgments

The authors declare no bias towards the study or conflict of interest.

****Special thank you to Dr. Robert J. Bonser and Dr. John G. Coots for being faculty sponsors on this CAT Research Presentation****