P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (RJIF): 5.93
IJPESH 2025; 12(5): 380-383

https://www.kheljournal.com
Received: 09-07-2025
Accepted: 13-08-2025

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Effects of ankle flexibility on propulsion in swimming

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Abstract
The flexibility and movement of the feet are vital factors that directly impact a swimmer's performance and overall efficiency in the water. Without the proper flexibility, swimmers may experience discomfort, difficulty achieving the necessary range of motion, increased drag, and reduced efficiency in the water. Swimming performance relies heavily on effective ankle movements—specifically plantar flexion and dorsiflexion which play a vital role in maintaining both propulsion and balance in the water. The objective of this research was to study how increased flexibility of the ankles (Plantar Flexion), affects the overall speed of a professional swimmer.
Participants: A total of 20 male national level swimmers aged between 14-18 years old, were selected from Sports Authority of India (Delhi) as subjects for our research, and will undergo 6 weeks of ankle flexibility training.
Procedure: Participants underwent timed trials and ankle flexibility measurements pre- and post-test, with a 6-week training interval in between. The plantar flexion of both feet was assessed using a goniometer and swim times were measured using a stopwatch for a 25m distance kick sprint with a kickboard.
Results: Based on the data, the flexibility of the ankles of swimmers after undergoing training were Significant, as the p-values for left foot flexibility ($p=0.0008$) and right foot flexibility ($p=0.0131$) were both below the significance level of 0.05. And, the improvement of the speed of swimmers, measured by the time to complete a 25m Kick Sprint using a kickboard was Not Significant, as the swim times had a p-value ($p=0.4027$) above the 0.05 significance threshold.
Conclusion: A kick sprint with a travel distance of 25m may have not been sufficient to notice any changes in speed even with improved ankle flexibility, but considering extending the travel distance of the test, the swimmers might be able to better utilize their improved flexibility for maintaining speed and efficiency.

Keywords: Plantar flexion, swimmers, ankle flexibility, kick sprint, speed

Introduction

"Swimming, in recreation and sports, the propulsion of the body through water by combined arm and leg motions and the natural flotation of the body". An often-overlooked aspect of athletic performance is ankle flexibility, particularly plantar flexion. In freestyle swimming, the most technically demanding stroke, propulsion relies on the effective synergy between upper-body strokes and lower-body flutter kicks. The flutter kick depends on the flexibility of the ankles to function like a hydrofoil, propelling water backward to generate thrust. Ankle flexibility is influenced by the talocrural joint's anatomy, and the gastrocnemius and soleus muscles enable plantar flexion through the Achilles tendon. A greater range of motion (ROM) allows swimmers to extend their feet into a streamlined position, improving thrust and reducing drag. Limited plantar flexion (<50°) can prompt compensatory movements, ultimately affecting swimming efficiency. To execute effective flutter kicks, swimmers need to swiftly transition between plantar flexion (the downward kick) and dorsiflexion (the upward recovery). Flexible ankles are crucial as they help maintain backward force throughout the kick cycle, while stiffness can obstruct optimal water displacement. The Achilles tendon plays a vital role by storing and releasing energy, which boosts power output. This study set out to explore the role of ankle-driven propulsion by measuring 25-meter freestyle performance in 20 competitive swimmers using a kickboard and a stopwatch. Participants underwent timed trials both before and after a 6-week training period, during which their plantar flexion was evaluated using a goniometer.

Selection of Subjects
The subjects had been selected from Sports Authority of India (Delhi), aged between 14 - 18 years. Total 20 male National level swimmers had been selected by using purposive method of sampling.

Selection of Variables
In the consultation with the experts in the field and literature available or considering the feasibility criteria in mind especially the availability of equipment.
The study will be evaluating:
- Ankle Flexibility - Plantar Flexion
- Swim Time for 25m distance

Selection of Tools
- Goniometer
- Stopwatch
- Fins
- Kickboard
- Resistance Bands
- Foam Roller
- Massage Balls
- Yoga Mat

Criteria of Measure
- 25m Kick Sprint
- Stroke - Freestyle Flutter Kick

Instrument Reliability
- Therapy Plus Goniometer
- Nivia JS - 307 Stopwatch

Test Administration
Participants followed a six-week training protocol and were purposefully assigned to the group. A total of 2 readings were taken of each ankle flexibility of both feet and speed timing of the subjects.
- **Pre - Test:** This group underwent the training intervention for 8 times per week and performed ankle flexibility exercises.
- **Post - Group:** After 6 weeks of ankle flexibility training, final reading was noted for swim time and plantar flexion of both feet.

All the participants involved in the study were carefully monitored through the training program.

Results of the Study
The study evaluated the flexibility of the ankles through plantar flexion and the time taken to swim 25 meters using a kickboard. To test the significance of the observed changes in ankle flexibility and swim time, paired t-tests were performed comparing pre-test and post-test values for each variable.

Table 1: Represents the descriptive statistics of ankle flexibility and swim time

Variable	Pre-Test		Post-Test		P-Value (p =)	Significance
	Mean	Standard Deviation	Mean	Standard Deviation	Pre-Test Vs Post-Test	
Left Foot Flexibility	69.15	6.78446368	70.2	7.0606396	0.000796802	Significant
Right Foot Flexibility	65.1	6.78155393	66.05	7.81681723	0.01307246	Significant
Swim Time (s)	47.535	4.29151856	47.615	4.40481495	0.402659714	Not Significant

The Table 1 presented the descriptive statistics indicating pre-test and post-test mean values, standard deviations, and p-values for left foot flexibility, right foot flexibility, and swim time. The results indicate a significant improvement in both left foot flexibility ($p = 0.000796802$) and right foot flexibility ($p = 0.01307246$), as their p-values are below the 0.05 significance level. However, the change in swim time was not statistically significant ($p = 0.402659714$), suggesting that the intervention did not have a measurable effect on this variable.

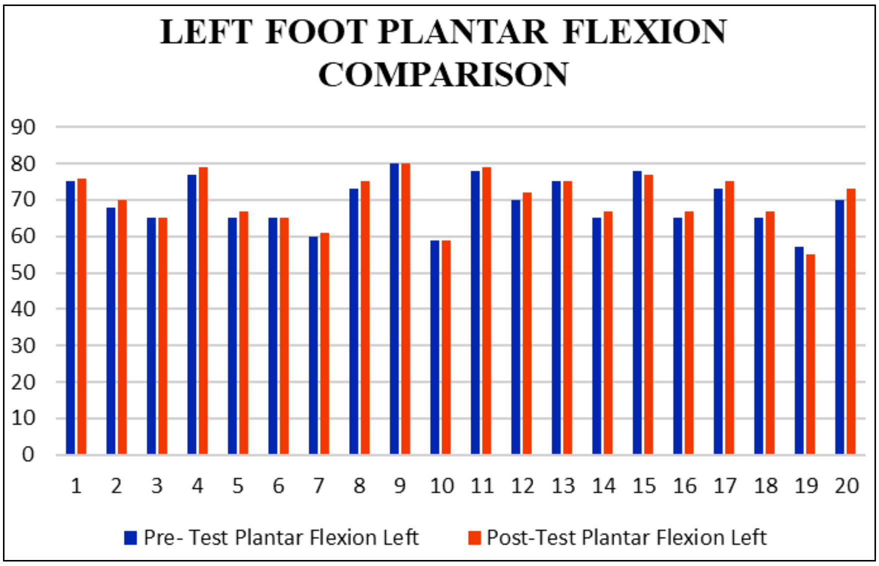

Fig 1: Pre-Test and Post-Test Comparison of Plantar Flexion of Left Foot

Fig. 1 presents the graphical representation of the pre-test and post-test plantar flexion values of the left foot. The X-axis represents the subjects whereas the Y-axis represents the range of motion in degrees. The comparison illustrates a general improvement in plantar flexion after the intervention.

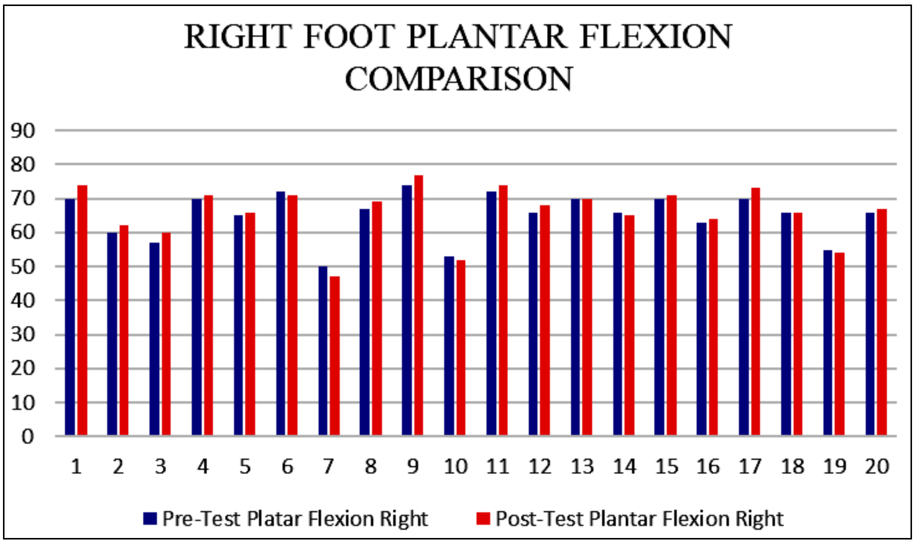

Fig 2: Pre-Test and Post-Test Comparison of Plantar Flexion of Right Foot

Fig. 2 presents the graphical comparison of pre-test and post-test plantar flexion values for the right foot. The X-axis represents the subjects whereas the Y-axis represents the range of motion in degrees. The graph illustrates variations in plantar flexion, with a general trend indicating improvement following the intervention.

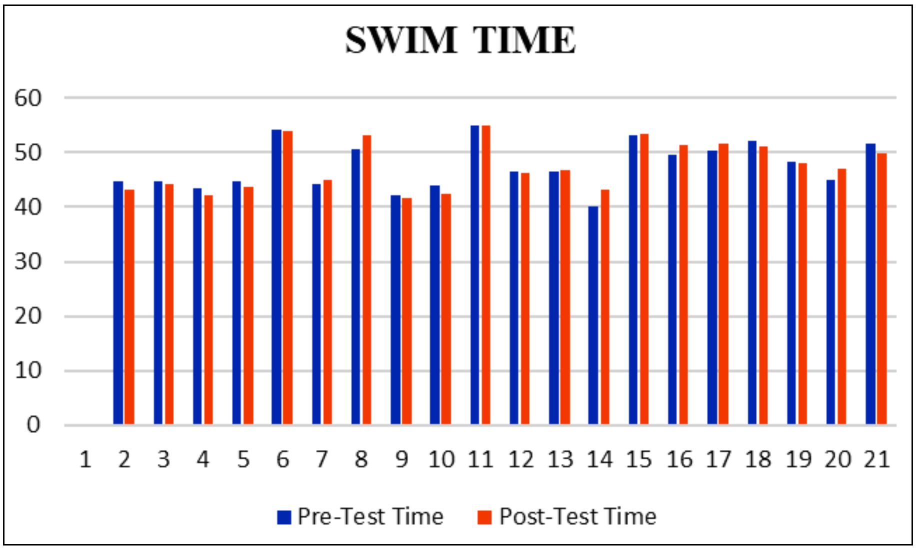

Fig 3: Pre-Test and Post-Test Comparison of Swim Time

Fig. 3 presents the graphical comparison of pre-test and post-test swim times. The X-axis represents the subjects whereas the Y-axis represents the time taken (in seconds) to swim 25m using a kickboard. The graph indicates slight variations in performance; however, the changes were not statistically significant, suggesting minimal impact of the intervention on swim time.

Discussions and Findings

Ankle Flexibility

The results showed a statistically significant improvement in both left and right foot flexibility after the training intervention. The p-values for both feet (left: 0.0008, right: 0.0131) are below the 0.05 significance threshold, confirming the hypothesis that the swimmers' ankle flexibility improved post-training. These findings align with existing literature, which suggests that flexibility training, particularly in the ankle joints, can enhance the range of motion.

Ankle flexibility is crucial for effective swimming, as a greater range of motion, especially in plantar flexion, can enhance the efficiency of the kick. This increased efficiency may reduce drag and improve propulsion by allowing the swimmer to generate more force with each kick. The significant improvements in flexibility suggest that the training regimen used in the study was effective at enhancing the physical capacity of the ankle joint, specifically in terms of plantar flexion.

Swim Time

Despite the significant improvement in ankle flexibility, no statistically significant improvement in swimming time was observed (p = 0.4027). This finding does also crucial for propulsion. While the swimmers showed improved flexibility, their swimming technique or muscle strength might not have progressed to a level that allowed for measurable improvements in speed.

Other Propulsive Forces: In swimming, the arms contribute significantly to propulsion. Since the study focused only on the kickboard technique, the role of arm movement was not included. It is possible that improved ankle flexibility alone is insufficient to produce a noticeable improvement in overall swim times, without the contribution of enhanced arm movements and coordination.

Conclusion

The present study investigated the effects of ankle flexibility on propulsion in swimming by assessing plantar flexion improvements and corresponding changes in 25m kick sprint performance. Findings revealed a significant increase in ankle flexibility for both left and right feet following six weeks of targeted flexibility training. This supports existing evidence that structured mobility exercises can enhance the range of motion of the ankle joint, thereby improving the swimmer's ability to achieve a more streamlined position in the water. Improved plantar flexion is particularly beneficial as it reduces drag, facilitates smoother transitions between kick phases, and optimizes hydrodynamic efficiency.

However, despite these biomechanical advantages, no statistically significant improvement in swim times was observed over the 25m kick sprint distance. This outcome suggests that while ankle flexibility is an important determinant of swimming efficiency, its isolated improvement may not directly translate into measurable gains in short-distance sprint performance. Propulsion in swimming is multifactorial, with arm strokes, core strength, body alignment, and coordination playing equally vital roles. The short sprint distance may also have limited the ability to capture performance benefits derived from increased flexibility. Future research should consider longer swimming distances and integrate flexibility training with strength and technique development to fully explore its impact on competitive performance.

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