

EFFECT OF ANKLE-FOOT ORTHOSES ON GAIT KINEMATICS AND
SPATIOTEMPORAL PARAMETERS IN FOOT DROP USING KINOVEA
VIDEO ANALYSIS

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Author Details**Keywords:**

Foot drop, Ankle-Foot Orthosis, gait analysis, Kinovea, Gait kinematics, spatiotemporal parameters, Ankle dorsiflexion, Functional Mobility.

Received on 24 Apr 2026

Accepted on 06 Jun 2026

Published on 21 Jun 2026

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Abstract**Background**

Foot Drop is a gait disorder where the ankle does not dorsiflex sufficiently during the swing phase of gait leading to toe drag, decreased walking efficiency and an increased risk of falls. Ankle-Foot orthosis (AFOs) is a common orthotic device prescribed to improve foot clearance, gait stability and functional mobility in people with foot drop. Objective measurement of gait is necessary to assess the efficacy of orthotic intervention. Kinovea Software is identified as Low-cost and accessible tool for motion analysis in the clinical setting.

Objective

To assess the impact of Ankle Foot Orthosis on Spatiotemporal parameters and gait kinematics in subjects with foot drop, by means of Kinovea Video analysis.

Methodology

A quasi-experimental pre-test post-test study was carried out on 21 patients with foot drop. Two conditions were assessed: AFO and no AFO. The walking speed, step length, cadence, toe clearance, ankle dorsiflexion angle at initial contact and initial contact type was measured by video analysis using the Kinovea software. The statistical analysis was carried out using paired t-test with significance level $p \leq 0.05$.

Result

The intervention of AFOs resulted in significance improvements in all measured gait parameters. Walking Speed increased from 0.61 ± 0.10 m/s to 0.84 ± 0.11 m/s, step length from 36.55 ± 4.78 cm to 46.32 ± 5.08 cm, cadence from 75.33 ± 7.61 to 88.86 ± 7.66 steps/min, and toe clearance from 0.54 ± 0.27 cm to 1.75 ± 0.32 cm ($p \leq 0.001$). Ankle dorsiflexion at initial contact improved from -

$11.2^\circ \pm 5.43^\circ$ to $0.48^\circ \pm 1.88^\circ$. A substantial shift toward heel-strike gait pattern was also observed following AFO use.

Conclusion

Ankle-foot orthoses significantly improved gait kinematics and spatiotemporal parameters in individuals with foot drop. Kinovea software provides a trustable, accessible and cost-effective method for objective gait assessment and monitoring orthotic outcomes in clinical practice.

INTRODUCTION

Foot drop is a gait abnormality caused by weakness or paralysis of the ankle dorsiflexors muscles, resulting in the inability to adequately lift the forefoot during the swing phase of gait. This condition commonly occurs due to neurological, muscular or peripheral nerve disorders and is associated with reduced mobility, increased risk of falls and diminished quality of life. Individuals with foot drop frequently adopt compensatory gait strategies such as, hip hiking, Circumduction and excessive knee flexion to prevent toe dragging during walking.

The inability to achieve sufficient ankle dorsiflexion affects both kinematics and spatiotemporal characteristics. Reduced walking speed, shorted step length, decreased cadence, inadequate toe clearance and abnormal initial contact patterns are commonly observed in affected individuals. Such gait deviations increase energy consumption and decrease the efficiency of walking which limits functional independence.

AFOs are among the most commonly prescribed interventions for foot drop management. These devices hold the ankle in neutral or a slight dorsiflexed position, allowing for increased foot clearance during the swing phase and a more stable gait. Previous studies have demonstrated the benefits of AFOs in walking speed, gait symmetry, balance, and overall functional mobility in patients with neurological impairments.

Gait assessment is important to evaluate the effectiveness of orthotic intervention. Three-dimensional motion analysis systems are the gold standard for gait evaluation. However, their clinical

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DOI: <http://doi.org/10.5281/zenodo.21256737>

use is often limited by high cost, technical complexity and the need for dedicated facilities. Thus, interest s increasing in low-cost solutions that will allow objective gait measurements.

Kinovea is a free two-dimensional motion analysis software allowing a detailed assessment of movement using video recordings. It is practical tool for clinical rehabilitation settings because it allows frame by frame analysis of joint angles, distances and temporal gait variables. It is affordable and easy to use and is being increasingly used in movements analysis and rehabilitation research.

The aim of this study was to assess the effect of ankle foot orthosis AFO on gait kinematics and spatiotemporal parameters in subjects with foot drop, using Kinovea video analysis. The study also investigated the clinical utility of Kinovea as an objective tool for assessing orthotic outcomes in resource limited health care settings.

Methodology

Study Design

A quasi-experimental pretest-posttest study was conducted to evaluate the effects of Ankle-Foot Orthoses (AFOs) on gait kinematics and spatiotemporal parameters in people with foot drop.

Study Setting and Duration

This study was conducted at district headquarter hospital, Chiniot, Pakistan. Data collection was done over a period of 3 months.

Sample Size and Samplin Technique

21 participants diagnosed with foot drop were recruited using a non-randomized convenient sampling technique.

Inclusion Criteria

- Adults aged 18-65 years with diagnosed foot drop.
- Ability to walk independently or with minimal assistance.
- Established users of Ankle-Foot Orthosis.

Exclusion Criteria

- Severe cognitive impairment.

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- Recent lower-limb surgery within the previous six months.
- Uncontrolled cardiovascular conditions.

Data Collection Procedure

All participants gave written informed consent prior to the collection of data. The participants were walked along 6-m walking pathway under both conditions (with AFO and without AFO). To enhance the reliability of the measurement, each condition was conducted three times. Two video cameras mounted on tripods were positioned perpendicular to the walking direction to record gait in the sagittal and frontal plane. Anatomical landmarks at the hip, knee, and ankle were identified using visible markers. Video recordings were imported into Kinovea Software for gait analysis.

Outcome Measures

The following spatiotemporal and kinematic parameters were assessed: Walking speed (m/s), Step length (cm), Cadence (steps/min), Toe-clearance (cm), Ankle dorsiflexion angle at initial contact (degrees) and Initial contact type (Forefoot, Flatfoot, Heel strike)

Statistical Analysis

Data were analyzed using SPSS software. Descriptive statistics were reported as mean \pm standard deviation. Paired t-tests were used to compare gait parameters before and after AFO application. Statistical significance was established at $p < 0.05$.

Results

Participants Characteristics

A total of 21 participants were included in the study, comprising 11 males (52.4%) and 10 females (47.6%). Participants were between 27 and 69 years of age.

Changes in Spatiotemporal Parameters

The application of AFOs produced significant improvements in all measured spatiotemporal gait parameters. Walking speed increased from 0.61 ± 0.10 m/s to 0.84 ± 0.11 m/s ($p < 0.001$). Step length improved from 36.55 ± 4.78 cm to 46.32 ± 5.08 cm ($p < 0.001$). Cadence increased from

75.33 ± 7.61 steps/min to 88.86 ± 7.66 steps/min ($p < 0.001$). Similarly, toe clearance improved significantly from 0.54 ± 0.27 cm to 1.75 ± 0.32 cm ($p < 0.001$).

Table 1. Comparison of Spatiotemporal Parameters Before and After AFO Application

Variable	Without AFO Mean ± Standard deviation	With AFO Mean ± Standard deviation	P-value	T-value
Walking Speed(m/s)	0.6081 ± 0.10235	0.8371 ± 0.10584	< 0.001	-118.057
Step length(cm)	36.552 ± 4.7822	46.319 ± 5.0785	< 0.001	-90.177
Cadence (steps/min)	75.33 ± 7.611	88.86 ± 7.657	< 0.001	-103.018
Toe-clearance (cm)	0.543 ± 0.2712	1.748 ± 0.3156	< 0.001	-82.520

Changes in Kinematic Parameters

A statistically significant improvement was observed in ankle dorsiflexion angle at initial contact following AFO application. The mean ankle dorsiflexion improved from -11.12 ± 5.43 degrees without AFO to 0.48 ± 1.88 degrees with AFO ($p < 0.001$).

Table 2. Comparison of Ankle Dorsiflexion Angle at Initial Contact

Variable	Without AFO Mean ± Standard deviation	With AFO Mean ± Standard deviation	P-value	T-value
Ankle dorsiflexion angle at initial contact (°)	-11.12 ± 5.427	0.48 ± 1.879	< 0.001	-14.687

Initial Contact Pattern

A marked improvement was observed in initial contact type following AFO application. Before intervention, 71.4% of participants demonstrated forefoot contact and 28.6% demonstrated flatfoot contact, while no participant achieved heel strike. After AFO application, heel strike was observed in 85.7% of participants indicating a substantial normalization of gait mechanics.

Table 3. Distribution of Initial Contact Type Before and After AFO Application

Initial contact type	Pre-AFO (%)	Post-AFO (%)
1) Forefoot	15 (71.4 %)	0
2) Flatfoot	6 (28.6%)	3 (14.3%)
3) Heel strike	0	18 (85.7%)

The findings shows that AFO use significantly improves both spatiotemporal and kinematic gait characteristics in individuals with foot drop. The person was able to walk the steps that were longer and they were able to walk more often. Their Toes were also higher, off the ground. Their ankle was moving better. The way their foot hit the ground was better too. All of this means that the person was able to walk efficiently and get around easier. The walking speed of the person and the step length was also improved. The gait efficiency of the person and functional mobility was also better.

Discussion

The study looked at how ankle foot orthosis affected the way people with food drop walked. It analyzed walking patterns with the use of Kinovea software. The outcomes revealed that the use of AFOs improve the walking speed, step length, cadence, clearance of the toes off the ground, ankle dorsiflexibility and foot placement on the ground after walking these findings validate the effectivity of AFOs for enhancing walking and movement of individuals with drop foot.

AFOs helped to significantly improve walking speed. People with foot drop often walk slowly because they have trouble moving their ankle, are less stable and are afraid of tripping. The AFOs are used

to aid with supporting the ankle during walking. This enhances foot clearance and increases people confidence of walking.

There was the significant change with the AFO use resulting in a really noticeable increase in step lengths. Patients with foot drop often take shorter stride due to the desire to compensate for the feeling of their foot remaining on the floor and for lack of stability. It's a survival mechanism in fact. The AFO aids in returning the ankle to its proper position. It's probably easier to move the leg from this position.

The orthotic intervention results in a considerable improvement in cadence. The higher the cadence, the more efficient the walking and the better the rhythm. Perhaps the added stability of the AFO reduced on the need for those unnatural compensatory movements. There was an increased gait cycle walking confidence. And this confidence is reflected in the numbers. If cadence increases, it means the body is not exerting as much effort to balance the effort and the AFOs are easier to balance.

We saw some of the biggest changes in the toe clearance and across all the data. The sense of this is obvious: if you don't get your toes up, you're a textbook case of foot drop and that's one way people fall. This increase in toe clearance numbers here demonstrates effectiveness of the AFO. They were able to prevent the foot from falling to low in the swing phase. No more toe-drag and well much safer walking. These findings make the importance of orthotics to maintaining people stability and mobility more apparent.

The kinematic data revealed that there was a definite change in ankle initial contact. Participants had excessive plantarflexion (foot on the wrong way down) prior to an intervention. However, with the addition of the AFO, this ankle alignment shifted towards neutral. Just appears more like a natural gait. This additional dorsiflexion at the toe off is important for shock absorption, stability, and efficiency. One would think the change is very subtle on the physical level but on the actual functioning level it can be enormous.

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DOI: <http://doi.org/10.5281/zenodo.21256737>

An improvement was also noted in the type of contact that first occurs on the ground during gait. Prior to the ankle foot orthosis, the participants mostly had forefoot and flatfoot contact patterns. After the AFO application, most people had some level of heel strike which is considered the normal first contact pattern when walking. This study indicates that abnormal foot positioning was corrected and gait mechanics brought back to more typical values with the use of AFO.

This study really indicates the clinical usefulness of the Kinovea software. Simple gait analysis tool. As for gait assessment, the standard is typically 3D motion analysis systems, but they are expensive and required some expertise to be used. Many individuals find it difficult to be able to access. But offers a more viable and inexpensive alternative. It's capable of objectively quantifying gait's kinematics and spatiotemporal aspects. This software is even able to identify meaningful changes associated with treatment. This can make it a good option for clinical rehab. It also comes in handy for orthotics. Especially if you work in environment that doesn't have a lot of resources.

Limitations

There were some limitations to this study. Small sample size. All participants were from one clinical center. This can impact the applicability of the findings to people. We also only looked at the immediate effects of using an ankle foot orthosis. We didn't observe what was going on in the long-term.

Recommendations

Future studies should involve large sample of people and have varying types of participants. This will aid in making it more applicable to all. Long term studies and comparing the different types of AFOs would be beneficial to determine the effects on walking.

Conclusion

We demonstrated in our study that the AFO is indeed useful in improving the walking ability of AFO-users with foot drop. We observed how fast they walked, the length of their steps, and how many steps they took in a minute. There was improved toe clearance. They moved their ankles more

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DOI: <http://doi.org/10.5281/zenodo.21256737>

as the began to walk. These enhancements allow the person to walk efficiently and maintain balance and mobility with an AFO.

We also found that Kinovea 2D analysis software is a tool for assessing how people walk. Easy to use, not costly, and able to measure changes in walking through regular video recordings makes it very useful in clinic and rehabilitation centers that don't have equipment for walking measurement. From our results, we have recommended the use of both AFOs and Kinovea software to assist patients with food drop.

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