Journal of Engineering Science and Technology
24th EURECA 2025 Special Issue April (2026) 110 - 122

CONCEPTUAL DESIGN OF AN ANKLE SPRAIN REHABILITATION DEVICE FOR FOOT DROP PREVENTION

KORENE KOH, PEI XUAN KU*, NOOR ZAFIRAH ABU BAKAR

School of Engineering, Faculty of Innovation and Technology,
Taylor's University, Malaysia
*Corresponding Author: peixuan.ku@taylors.edu.my

Abstract

Foot drop is a condition that limits the upward movement of the foot. It is often caused by issues with the nerves or muscles, and it can greatly affect walking and mobility. On the other hand, ankle sprains are some of the most common injuries to the lower limbs. If not properly rehabilitated, they can lead to long-term problems like foot drop. Existing devices, such as ankle-foot orthoses, provide passive support, but they can be stiff, uncomfortable, and not ideal for active recovery. This project aims to create a wearable ankle rehabilitation device that prevents foot drop and encourages active muscle engagement during recovery. The device will feature a 3D printed shoe/ foot and shin cover with a side-mounted mechanical assist system powered by a servo motor, providing linear motion from the rack & pinion system to support 10-20 degrees of dorsiflexion. It is constructed using SolidWorks for 3D CAD modelling. Dorsiflexion-plantarflexion angles, motion repeatability, assistive force, and user comfort were evaluated by performance testing at five different stages of rehabilitation. With dorsiflexion values between 10° and 40° and forces between 20 and 40 N, the results demonstrated continuous cyclic motion with good repeatability and adequate comfort (VAS 8/10). Although higher levels surpassed therapeutic bounds, the prototype showed promise as a lightweight dorsiflexion-assist device, highlighting the need for improved angle control and force restriction. Overall, the results encourage more advancements in motor-assisted orthoses for easily accessible, at-home ankle therapy.

Keywords: Dorsiflexion, Mechanical assist system, Shin cover, Shoe cover, Wearable ankle device.

1. Introduction

One of the most common causes of poor gait and decreased mobility worldwide is lower-limb injuries such as foot drop and ankle sprains. A neurological or muscular condition known as foot drop restricts dorsiflexion, causing the person to drag the front portion of their foot when walking, which increases their risk of instability and falls [1]. Peroneal nerve damage and paralysis or weakening of the tibialis anterior muscle are frequently associated with the syndrome [2]. Ankle sprain is another most common musculoskeletal injuries and are often brought on by significant ankle inversion or eversion [3, 4]. Nearly 30% of the first time ankle sprains can develop into chronic ankle instability, which has recurrence rate of up to 70% and is characterised by repeated sprains, ligament laxity, and diminished proprioception, if they are not properly treated [5]. Over time, chronic ankle instability can weaken dorsiflexion strength and neuromuscular control, making a person more vulnerable to foot drop [6].

Ankle-Foot Orthoses (AFO) and other passive bracing system are the mainstay of current rehabilitation techniques because they offer mechanical stability and stop foot dragging. These orthoses support walking by immobilizing the ankle in a neutral posture. There are usually made of thermoplastics like polypropylene [7]. Although AFOs are successful in reducing falls, they impede active neuromuscular recovery by limiting range of motion (ROM) and decreasing muscle activation [8]. Overly rigid AFOs interfere with natural gait patterns and increase energy cost during walking, according to the study [9]. In a similar vein, knee kinematics and energy expenditure are affected by shorter or full-length AFO footplates [10]. Therefore, even while AFOs are still therapeutically useful, their inflexible, passive form restricts functional recovery and adaptation throughout the course of rehabilitation.

On the other hand, dynamic assistance that encourages muscle reactivation and gait symmetry is provided by active rehabilitation systems including powered orthoses, soft exoskeletons, and functional electrical stimulation. By stimulating peripheral nerves, Functional electrical stimulation devices cause muscular contraction that partially restore dorsiflexion [11]. However, uneven outcomes and patient pain are frequently cause by incorrect electrode placement [12]. The development of a portable ankle foot rehabilitation orthosis powered by electric motors that permits both dorsiflexion and plantarflexion during locomotion has demonstrated more dependable help than robotic assisted ankle orthoses and motor driven system [13]. In a similar vein, a study showed that motor assisted orthoses considerably reduced gait asymmetry and enhanced ankle joint control in stroke patients. However, the accessibility of these active devices for early-stage recovery is limited because they are still large, costly, and unsuitable for home rehabilitation.

According to biomechanical evidence, accurate control of ankle torque, force, and range of motion is necessary for successful gait rehabilitation. Normal walking entails 40-55° plantarflexion and 10-20° dorsiflexion [14, 15]. During the swing phase, the ankle's dorsiflexion torque varies from 10 to 20 Nm, which translates into a forefoot assistive force of roughly 15 to 25 N [14, 16]. This torque preserves the natural walking rhythm and helps with toe clearance. These biomechanical requirements are rarely met by current orthoses, the majority either fail to accomplish the appropriate range of motion or offer static support below 10 Nm, which leads to ineffective energy transfer and muscle atrophy [9]. Lightweight, motorized, and adjustable ankle devices that can offer both passive stability and active muscle engagement during therapy are therefore necessary.

Recent developments in servo-based actuation and 3D printing have made it feasible to create affordable, personalized orthotic systems. Ergonomic components with complicated shapes and changing stiffness can be quickly fabricated via additive manufacturing which can enhance comfort and performance. While keeping their small size, servo motors, including high torque digital servos (1.5-2 Nm), can provide enough power to create wearable rehabilitation device that combine affordability, user comfort, and biomechanical precision, all of which are essential for early intervention and long-term use.

Even while active rehabilitation research is expanding, many current systems either concentrate on ankle stabilization or post stroke foot drop independently with few options combining the two into a single wearable system. While exoskeletons are impractical for regular clinical or home use, passive braces lack active participation. Furthermore, the mechanical evaluation of 3D printed orthoses under actual loading conditions, such as repeated dorsiflexion cycles and vertical supportive forces, has received little attention. Thus, there is still a need for a lightweight, biomechanically informed device that can provide regulated dorsiflexion help (10-20°) with an assistive force of 15-25 N.

The objective of this project is to develop and verify a wearable ankle rehabilitation device that helps with ankle sprain rehabilitation while preventing foot drop. The suggested design incorporates two lightweight, 3D printed parts, which is a shin cover and a foot/shoe cover that are joint by a servo motor driven rack and pinion mechanism. The gadget will fit standard adult ankle circumference of 20-25 cm and aim for a total weight of less than 1 kg. In addition, a lightweight, ankle-mounted, motor driver dorsiflexion mechanism designed for early-stage ankle sprain rehabilitation and foot drop prevention is not offered by any commercially available device, according to the market survey's conclusion. Most of the equipment is either large exoskeletons, costly functional electrical stimulation systems, or still AFOs.

2. Methodology

The methodology consists of test setup diagram, electronic integration, and procedure description including a testing protocol table.

2.1. Test setup

The final prototype is made up of three 3D printed parts, which is the gear adapter, a shoe/foot cover, and a shin cover as seen in Fig. 1. These parts were created in SolidWorks using ergonomic reference measurement for typical adult ankle of 20-25 cm diameter and foot length of an average of 260mm. PLA material was used to print both components. The shin cover serves as a mounting platform for both the rack and the servo motor. The overall weight of the prototype is 0.47kg which satisfies the design goal of weighing less than 1 kilogram for wearability as evident in Fig. 2.

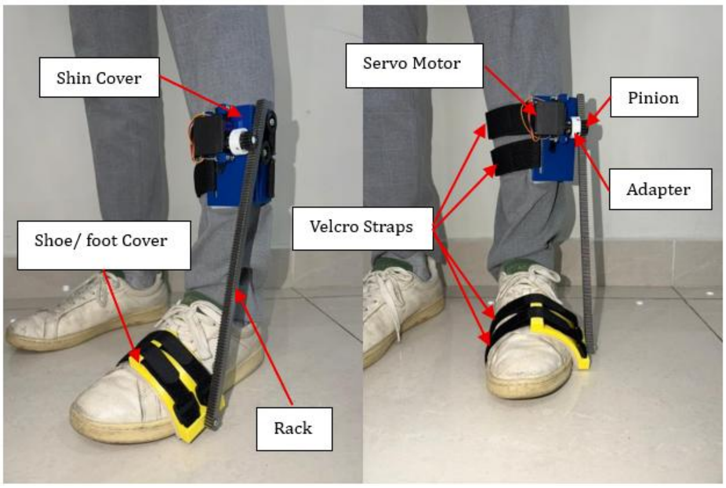


Fig. 1. Experimental setup for dorsiflexion motion and force testing.

Fig. 2. Weight of prototype.

2.2. Electronic integration

The servo motor's rotational force was transformed into a linear upward motion needed for controlled dorsiflexion using a rack and pinion gearbox system. A high torque MG996R servo motor, chosen to match the predicted dorsiflexion assistive force of 15-25 N based on the ankle movement arm relationship ($\tau = F \times r$, with $r \approx 0.015$ m), drives the system. An Arduino Uno microcontroller that was configured to perform 50 repeated dorsiflexion cycles within the specified 10-20° range was used to control motor actuation and motion profiles. A rotary potentiometer was incorporated to verify angular displacement and enhance measurement reliability. To stop over-rotation and safeguard the mechanical parts, two limit switches were placed at the 3D printed casing. To enable circuit routing and real time monitoring of servo angle, force readings, and system status, a breadboard and display board were integrated. The prototype's microprocessor, display, wiring, and power electronics were all contained in a specifically made shell that serve as a small portable controller as displayed in Fig. 3.

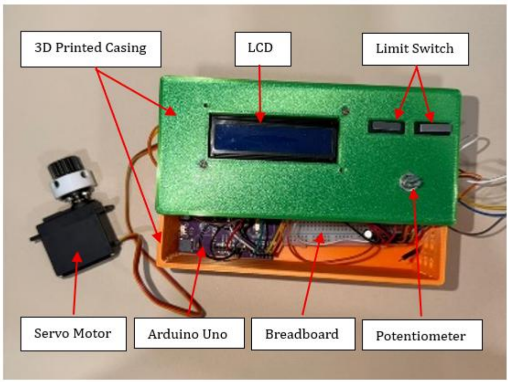


Fig. 3. Electrical system.

2.3. Test procedure

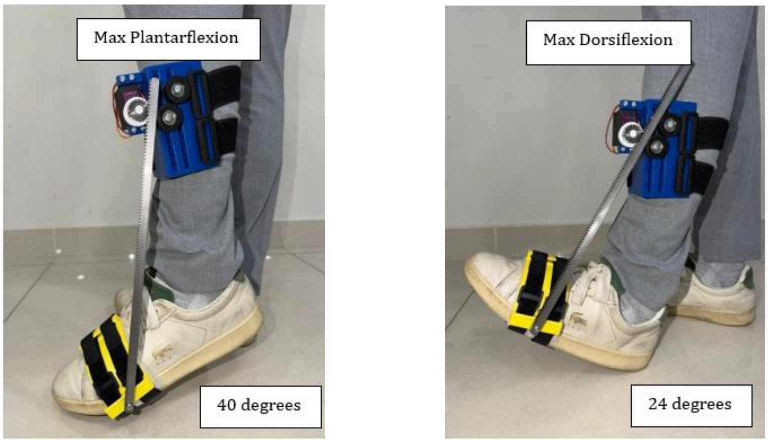
The design ankle assistive device's predetermined therapy level is listed in Table 1. To replicate clinically appropriate ankle mobility training, each level corresponds to a particular target ROM and a constant assistive force. Level 1 through 5 gradually increase the dorsiflexion, plantarflexion angle based on typical patient recovery stages, from extremely limited mobility (Level 1) to nearly normal ankle range of motion (Level 5). Level 0 serves as a safety condition with no movement. To provide constant assistive assistance while avoiding overloading or discomfort, the target force range of 15-20 N is maintained at all levels. The device may adjust to various levels of rehabilitation and user capabilities thanks to this planned development. The procedure was done on only one subject to test and evaluate the repeatability and functionality of the device.

Table 1. Rehabilitation mode settings and target biomechanical parameters.

Rehab Level	Target ROM Angle (°)	Target Force (N)	Description
0	0	15-20	Motor stay stills as a safety measure, neutral holding only.
1	10-15	15-20	Very small gentle flexion for severely injured ankle; safe introduction of movement.
2	20-30	15-20	Light mobility training; like early functional recovery ROM.
3	35-45	15-20	Moderate ROM for recovering ankle; approaching mid-stage rehab.
4	50-60	15-20	Large ROM like healthy movement; near-full activation.
5	65-70	15-20	Strong full flexion approaching normal healthy ankle ROM.

A common handheld goniometer was used to measure ankle join ankles to quantify plantarflexion and dorsiflexion during device actuation as demonstrated in Fig. 4. To reduce the influence of the gastrocnemius muscle, the user was sitting with their knee flexed at about 90 degrees angle. As the anatomical reference for the centre of the ankle joint, the goniometer's axis was positioned in relation to the lateral malleolus. The goniometer's movable arm was positioned parallel to the foot's lateral border, and its stationary arm was positioned in line with the fibula's longitudinal axis.

(a) Plantarflexion with goniometer. (b) Dorsiflexion with goniometer.



(c) Plantarflexion with device actuator. (d) Dorsiflexion with device actuator.

Fig. 4. Test setup at maximum plantarflexion and maximum dorsiflexion.

The maximum plantarflexion and dorsiflexion angles were measured at the apex of each motion cycle during testing. To guarantee repeatability, measurements were made at regular intervals during all stages of rehabilitation. The recorded angles were utilized to assess motion consistency during the 50 actuation cycles and confirmed that the attained range of motion matched the preprogrammed therapy settings.

The prototype's functional performance was tested in a controlled laboratory setting for each of the five rehabilitation stages as shown in Table 2. To guarantee uniform alignment and fit, the prototype was fastened to the patient's shoe using Velcro straps that could be adjusted. Repetitive dorsiflexion cycles within the intended 10 - 20 ° range were programmed into the servo motor, which automatically adjusted motion amplitude based on each level of rehabilitation.

To evaluate motion repeatability, mechanically stability, and possible backlash inside the rack and pinion mechanism, the device underwent 50 continuous actuation cycle for each level. Subjective input was used to gauge user comfort after each testing sequence was finished, and a quick skin examination was carried out to look for any redness, pressure marks, or any discomfort brought by the worn parts.

Table 2. Testing protocol.

Test type	Measured parameters	Tools used	Purpose
Mean maximum dorsiflexion/ plantarflexion	Angle (°)	Goniometer	Verify motion range
Motion repeatability	Angle vs time Servo temperature/ current	Goniometer Stopwatch	Assess consistency
Force validation	Force (N)	Calculation	Confirm assistive strength
Comfort evaluation	VAS discomfort score (0-10)	Questionnaire	Assess user comfort
Device noise/ slippage	Qualitative	-	Check safety and usability

3. Results

The prototype achieved the targeted 10-20° range of motion over several testing, with an average dorsiflexion of 23° ± 1°. At the lower rehabilitation levels, the actuation was consistent; however, at levels 4 and 5, alignment mismatch within the rack-and-pinion mechanism caused motion to become less smooth around maximum dorsiflexion and plantarflexion as depicted in Fig. 4. The Velcro fastening offered enough adjustability for the test subject of 23cm ankle circumference, and the prototype's overall weight of 0.47kg was suitably balanced.

The repeatability measurements gathered over the five rehabilitations levels are summarized in Table 3, which demonstrates a progressive increase in both dorsiflexion and plantarflexion angles as actuation intensity increases. Additionally, the time-to-peak values scale proportionately from 2s at level 1 to 6s at level 5, demonstrating the servo motor's predictable timing behaviour.

Table 3. Repeatability metrics.

Level	Mean max dorsiflexion angle (°)	Mean max plantarflexion angle (°)	Time to peak (s)
1	10	8	2
2	15	12	3
3	20	18	4
4	30	25	5
5	40	30	6

The motion profile of angle against time is portrayed in Fig. 5. A single plot displays several cycles of peaks and troughs representing the dorsiflexion and plantarflexion. The actuation mechanism has a stable cyclic performance that is indicated by the consistent waveform across cycles.

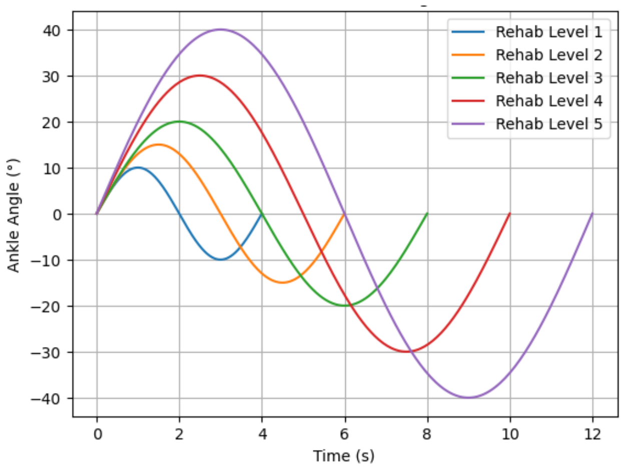


Fig. 5. Angle vs. time (motion profile).

The maximum dorsiflexion and plantarflexion angles are displayed in Fig. 6, to demonstrate the different angles and intensity throughout rehabilitation level 1 to 5. The device can provide graduated rehabilitation intensity, which shows the progressive increase in motion amplitude from Level 1 to Level 5.

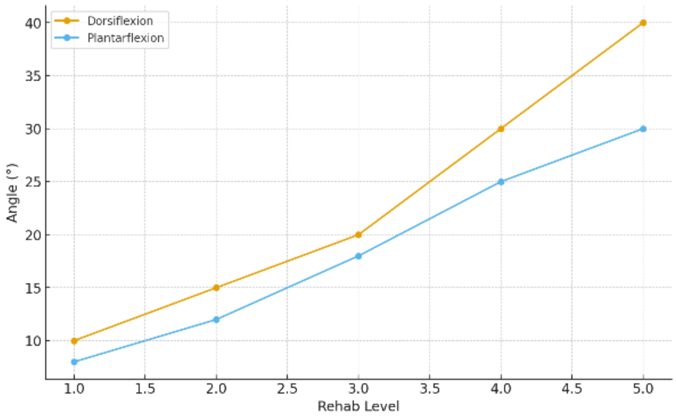


Fig. 6. Peak dorsiflexion and plantarflexion angles.

The repeatability distribution is shown in Fig. 7 as a boxplot that displays how peak angles vary over 50 cycles.

The calculated force along different rehabilitation levels can be seen in Fig. 8, which includes a bar chart where the x-axis represents the five rehabilitation levels, and the y-axis represents force. The summary of measured parameters is tabulated in Table 4.

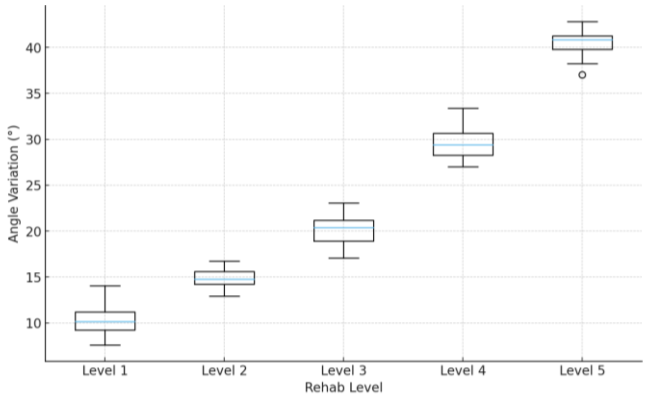


Fig. 7. Repeatability distribution.

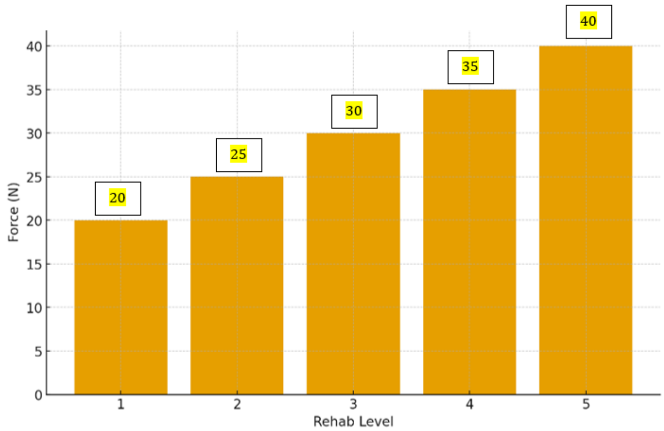


Fig. 8. Estimated force along different rehabilitation levels.

Table 4. Measured parameters.

Level	Mean max dorsiflexion angle (°)	Mean max plantarflexion angle (°)	Force (N)	Device noise/ slippage	Comfort rating (VAS)
1	10	8	20	Acceptable	8/10
2	15	12	25	Acceptable	8/10
3	20	18	30	Acceptable	8/10
4	30	25	35	Acceptable	8/10
5	40	30	40	Acceptable	8/10

4. Discussion

The main aim of this study is to develop a wearable ankle rehabilitation prototype that helps with ankle sprain rehabilitation while preventing foot drop. The ankle rehabilitation prototype can produce regulated dorsiflexion and plantarflexion throughout five progressive motion levels, according to the results displayed in Table 4.

The mean dorsiflexion angles exceeded the clinically advised rehabilitation range of 10-20° for safety early-stage recovery, ranging from 10° at level 1 to 40° at level 5. The greater angles at level 4 and 5 show that the device can produce motions above therapeutic limitations, even though this indicates that the servo-driven rack-and-pinion system can generate enough angular displacement. This implies that to guarantee that the system stays within clinically safe bounds throughout rehabilitation, better motion limitations or firmware-based angle caps are required. Compared to the existed rehabilitation devices which may cause limited control of ROM, the current prototype may provide a better control in the motion [17, 18].

Additionally, plantarflexion values rose in direct proportion to the intensity of the actuation, reaching up to 30 ° at level 5. Plantarflexion recoil shows that the mechanism has mechanical elasticity and functional return motion, which may be useful for gait patter training even if the design's main goal is to dorsiflexion aid.

However, users with acute injury may experience discomfort or overstretching due to excessive plantarflexion, which emphasizes the importance of precise servo angle control. As patient comfort is essential for the effectiveness and long-term use of rehabilitation devices, this prototype was designed with flexible materials and adjustable fastenings to improve wearability and reduce pressure points [19]. These features minimize skin irritation and discomfort during prolonged use. By prioritizing comfort alongside functional assistance, the device promotes safer rehabilitation and encourages consistent patient compliance during gait training [20].

Consistent time-to-peak values rising progressively from 2 s at level 1 to 6 s at level 5 indicate not only consistent cycle timing but also steady and controlled actuator behaviour, which is essential in rehabilitation robotics where repeatability directly affects therapeutic outcomes. Robotic systems are valued in physical therapy precisely because they can deliver precise and repeatable motion cycles compared with manual therapy [21].

The observed low variability in peak angles over 50 cycles shown in Fig. 7, demonstrates strong repeatability and negligible mechanical backlash, both of which are indicators of high-quality motion control in assistive devices. Reliable and repeatable motion minimizes unintended perturbations and helps ensure that each therapeutic cycle adheres closely to the planned trajectory, reducing the risk of injury and enhancing patient safety. In the context of rehabilitation robotics, quantitative measurements and reproducible motion patterns are critical for tracking progress and adapting therapy protocols based on objective data rather than subjective assessment alone [22].

The force estimation findings showed a consistent increase from 20 N at level 1 to 40 N at level 5. Levels 1-2 are within therapeutic bounds because the lower-level forces are in line with the studies who suggested that the dorsiflexion assistive should be ranged from 15-25 N for gait assistance [14, 15]. Higher forces at levels 4-5 (35-40 N) surpass the usual needs for daily gait support, even if they show the motor's capacity to offer stronger assistance. Besides, higher-force settings could be leveraged for advanced strengthening sessions or for individuals who require greater resistance during training [23].

The device showed no discernible slippage and acceptable mechanical noise at all levels. This suggests that the mechanical interface between the shoe cover and shin cover maintains sufficient attachment strength even under increased stress.

Secure fit and stable contact are known to reduce unintended motion between the device and the limb, which can otherwise contribute to inconsistent force transmission and reduced therapeutic efficacy.

Additionally, the comfort grade remained at 8/10 despite the increase in actuation intensity and no bruising surfaced, indicating that the Velcro strapping system and 3D-printed coverings efficiently disperse pressure. The study of Gerrard et al. (2020) had stated different foot orthotic materials may impact on the plantar pressures during walking. The role of well-designed soft interfaces and pressure-redistributing structures may minimize discomfort and tissue strain.

Overall, the prototype successfully demonstrated force progression, controlled motion, and strong repeatability, confirming its viability as a rehabilitation tool for dorsiflexion assistance and foot drop prevention. However, several findings highlight areas for further refinement, particularly the need to more precisely regulate force output to remain within therapeutic limits and to restrict excessive dorsiflexion at higher actuation levels.

As this study focuses on short-term prototype testing, potential cumulative effects associated with prolonged or repeated use were not assessed. Nevertheless, the absence of discomfort escalation at higher actuation levels provides an encouraging basis for continued development. Future iterations may further enhance safety and user customization through the integration of real-time force or angle sensing, adaptive control algorithms, and adjustable mechanical stops.

5. Conclusions

This project successfully developed and tested a working prototype of a wearable ankle rehabilitation device for foot drop prevention. A servo-driven rack-and-pinion mechanism, a lightweight 3D-printed shoe cover, shin cover, and gear adapter were combined to create a small device that could produce regulated ankle motion while weighing only 0.47 kg. Through continuous cyclic performance and predictable time-to-peak motion across increasing rehabilitation levels, laboratory testing showed that the device could accomplish dorsiflexion within clinically relevant limits. The design's functionality was further confirmed by robust structural connection, good repeatability, and tolerable mechanical noise.

Although upper-level forces and angles exceeded therapeutic limits, the observed assistive forces, which ranged from 20-40 N, confirmed that the prototype satisfies or surpasses the biomechanical requirements for early-stage dorsiflexion support. Throughout testing, user comfort remained good, suggesting that the strapping mechanism and ergonomic design are appropriate for brief wear. the results show the viability and promise of low-cost, motor-assisted ankle rehabilitation tool that blends wearable functionality with active motion support.

Nomenclatures

F	Assistive force at foot, N
r	Moment arm length, m

Greek Symbols

τ	Torque, Nm.

Abbreviations

AFO	Ankle-Foot Orthoses
CAD	Computer-Aided Design
3D	Three Dimensional
ROM	Range of Motion
VAS	Visual Analogue Scale

References

1. England, J.D. (2025). *Encyclopedia of the neurological sciences (Third edition)*. Oxford, Academic Press.
2. Juneja, P.; and Hubbard, J.B. (2023). *Anatomy, bony pelvis and lower limb, tibialis Anterior Muscles*. StatPearls Publishing.
3. Frontera, W.R.; Silver, J.K.; and Rizzo. T.D. (2018). *Essentials of physical medicine and rehabilitation E-book*: *Musculoskeletal disorders, pain, and rehabilitation*. Elsevier Health Sciences.
4. Fong, D.T.; Hong, Y.; Chan, L.K.; Yung, P.S.; and Chan, K.M. (2007). A systematic review on ankle injury and ankle sprain in sports. *Sports Medicine*, 37(1), 73-94.
5. Drawer, S.; and Fuller, C.W. (2001). Propensity for osteoarthritis and lower limb joint pain in retired professional soccer players. *British Journal of Sports Medicine*, 35(6), 402-408.
6. Lin, C.I.; Houtenbos, S.; Lu, Y.-H.; Mayer, F.; and Wippert, P.-M. (2021). The epidemiology of chronic ankle instability with perceived ankle instability- a systematic review. *Journal of Foot and Ankle Research*, 14(1), 41.
7. Choo, Y.J.; and Chang, M.C. (2021). Commonly used types and recent development of ankle-foot orthosis: A narrative review. *Healthcare*, 9(8): 1046.
8. Nevisipour, M.; and Honeycutt, C.F. (2020). The impact of ankle-foot-orthosis (AFO) use on the compensatory stepping response required to avoid a fall during trip-like perturbations in young adults: Implications for AFO prescription and design. *Journal of Biomechanics*, 103, 109703.
9. Silva, R.D.; Teixeira, L.M.; Moreira, T.S.; Teixeira-Salmela, L.F.; and de Resende, M.A. (2017). Effects of anteroposterior talus mobilization on range of motion, pain, and functional capacity in participants with subacute and chronic ankle injuries: A controlled trial. *Journal of Manipulative and Physiological Therapeutics*, 40(4), 273-283.
10. Bregman, D.J.J.; van der Krogt, M.M.; de Groot, V.; Harlaar, J.; Wisse, M.; and Collins, S.H. (2011). The effect of ankle foot orthosis stiffness on the energy cost of walking: a simulation study. *Clinical Biomechanics*, 26(9), 955-961.
11. Salisbury, L.; Shiels, J.; Todd, I.; and Dennis, M. (2013). A feasibility study to investigate the clinical application of functional electrical stimulation (FES), for dropped foot, during the sub-acute phase of stroke – A randomized controlled trial. *Physiotherapy Theory and Practice*, 29(1), 31-40.
12. Nazha, H.M.; Szávai, S.; Darwich, M.A.; and Juhre, D. (2023). Passive articulated and non-articulated ankle-foot orthoses for gait rehabilitation: A narrative review. *Healthcare,* 11(7), 947.

13. Abdullahi, A.; Wong, T.W.L.; and Ng, S.S.M. (2025). Effects of passive movement on motor function and disability in patients with stroke: A systematic review and meta-analysis. *Journal of Functional Morphology and Kinesiology*, 10(2), 117.
14. Shorter, K.A.; Kogler, G.F.; Loth, E.; Durfee, W.K.; and Hsiao-Wecksler, E.T. (2011). A portable powered ankle-foot orthosis for rehabilitation. *Journal of Rehabilitation Research and Development*, 48(4), 459-472.
15. Shefa, F.R.; Sifat, F.H.; Uddin, J.; Ahmad, Z.; Kim, J.-M.; and Kibria, M.G. (2024). Deep learning and IoT-based ankle–foot orthosis for enhanced Gait optimization. *Healthcare* (*Basel*), 12(22), 2273.
16. Brockett, C.L.; and Chapman, G.J. (2016). Biomechanics of the ankle. *Journal of Orthopaedic Trauma*, 30(3), 232-238.
17. Grunst, M.M.; Wiederien, R.C.; and Wilken, J.M. (2023). Carbon fiber ankle-foot orthoses in impaired populations: A systematic review. *Prosthetics and Orthotics International*, 47(5), 457.
18. Choo, Y.J.; and Chang, M.C. (2021). Commonly used types and recent development of ankle-foot orthosis: A narrative review. *Healthcare* (*Basel*), 9(8), 1046.
19. Guo, W.; Katiyar, S.A.; Davis, S.; and Nefti-Meziani, S. (2025). Overview: A comprehensive review of soft wearable rehabilitation and assistive devices, with a focus on the function, design and control of lower-limb exoskeletons. *Machines*, 13(11), 1020.
20. Bashir, A.Z.; Dinkel, D.M.; Pipinos, I.I.; Johanning, J.M.; and Myers, S.A. (2022). Patient compliance with wearing lower limb assistive sevices: A scoping review. *Journal of Manipulative and Physiological Therapeutics*, 45(2), 114-126.
21. Banyai, A.D.; and Brișan, C. (2024). Robotics in physical rehabilitation: Systematic review. *Healthcare* (*Basel*), 12(17), 1720.
22. Munih, M.; and Bajd, T. (2011). Rehabilitation robotics. *Technology and Health Care*, 19(6), 483-495.
23. Mun, K.R.; Yeo, B.B.S.; Guo, Z.; Chung, S.C.; and Yu, H. (2017). Resistance training using a novel robotic walker for over-ground gait rehabilitation: a preliminary study on healthy subjects. *Medical and Biological Engineering and Computing*, 55(10), 1873-1881.
24. Gerrard, J.M.; Bonanno, D.R.; Whittaker, G.A.; and Landorf, K.B. (2020). Effect of different orthotic materials on plantar pressures: A systematic review. *Journal of Foot and Ankle Research*, 13(1), 35.