DOI prefix: 10.33170, 2024, Vol (17), Issue (3): 2050-2069

Sciences Journal Of Physical Education

P-ISSN: 1992-0695, O-ISSN: 2312-3619
https://joupess.uobabylon.edu.iq/

Gait Analysis using Force Platform analyze child have drop foot

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Abstract

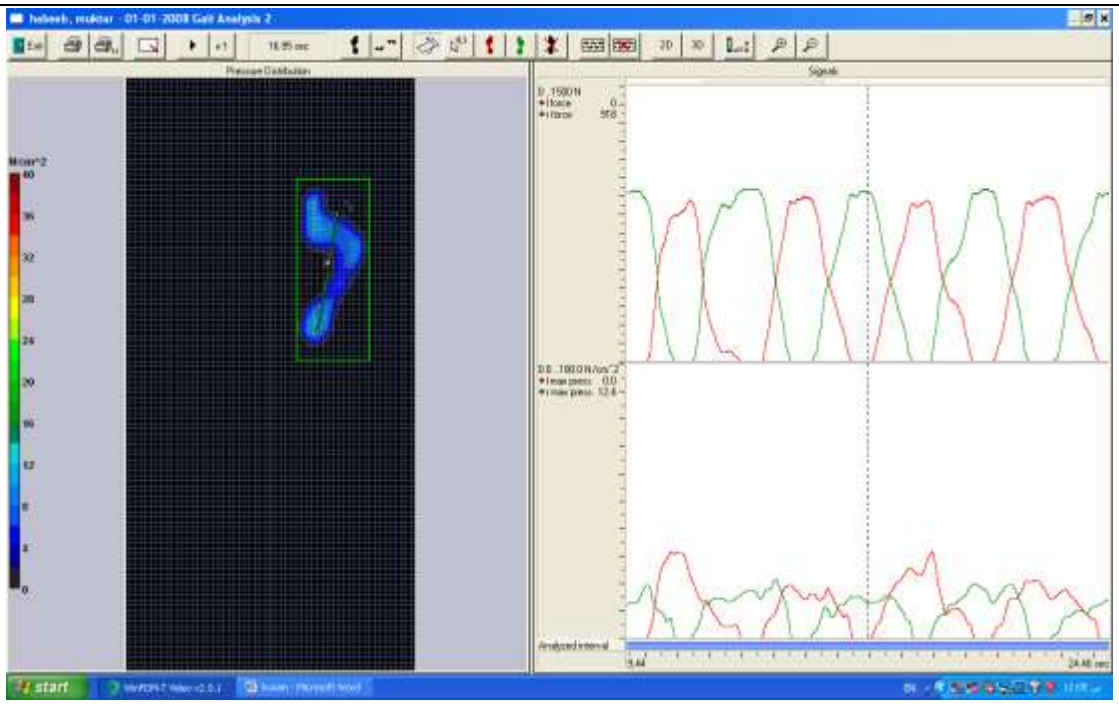
Foot drop, also known as drop foot, is a condition characterized by the inability to lift the front part of the foot, leading to a risk of tripping and difficulty in walking. This symptom is often indicative of underlying neurological, muscular, or anatomical issues, such as nerve damage, motor neuron diseases, or anatomical abnormalities affecting the peroneal nerve and surrounding structures.[1][2] The significance of foot drop lies in its impact on mobility and quality of life, particularly among individuals with chronic conditions like multiple sclerosis, stroke, or traumatic injuries. Effective management of foot drop includes a variety of essential exercises aimed at improving strength, coordination, and mobility. These exercises focus on enhancing dorsiflexion and eversion—the key movements required for safe and effective walking. Rehabilitation strategies often incorporate basic balance exercises, functional and strengthening routines, and stretching techniques to facilitate recovery and maintain independence.[3][4] Furthermore, neuroplasticity-based exercises offer a holistic approach that addresses the interconnections between the muscles, brain, and nervous system, fostering long-term improvements in motor function.[3] Despite the benefits of exercise regimens, individuals may face challenges in adhering to prescribed therapies, particularly due to discomfort from orthotic devices, financial constraints, and psychological barriers such as lack of motivation.[5][6] These factors can impede recovery and necessitate a comprehensive support system that emphasizes consistency and addresses patients' concerns regarding comfort and progress.[7] Thus, an understanding of foot drop, coupled with an informed approach to exercise and rehabilitation, is crucial for enhancing patient outcomes and promoting mobility. In summary, foot drop is a multifaceted condition requiring targeted interventions to manage its underlying causes and improve functional abilities. Ongoing research and clinical practices continue to evolve, emphasizing the importance of personalized rehabilitation programs and the integration of innovative therapies to support those affected by this condition.

https://doi.org/10.33170/jocope.v16i7.3-23

Introduction

In this recerch, pressure distribution measurement platforms called Zebris were used to capture the static and dynamic pressure distribution when the standing and walking of patient during the gait cycle.

Zebris FDM-T series was used in this study. Measurement and analysis of gait patterns for patients can be done with the FDM-T. The FDM-T uses high-quality plates with an integrated sensor matrix to estimate the weight distribution on each foot the aim of this article to correlate the parameters of gait analysis fore child patient 6 years old have drop foot with normal other one 6 years old too and the result shown below .



Figer 1 Test gait analysis for patient with droop foot

Controversies surrounding gait analysis in the context of drop foot primarily re- volve around the interpretation of data and the effectiveness of various treatment modalities. While studies indicate positive outcomes associated with the use of FES and dynamic splinting devices, concerns remain about the variability of individual responses to these interventions and the need for long-term follow-up to assess sustained improvements.[4][7]. As research continues to evolve, the integration of gait analysis into standard care practices is increasingly recognized as essential for

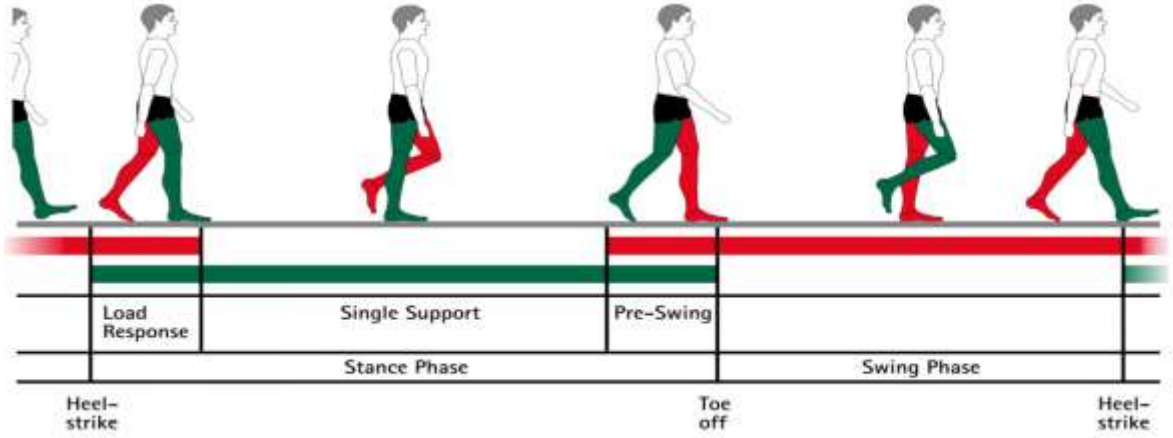
addressing the complex needs of children with drop foot, emphasizing the importance of early intervention and ongoing assessment.[3][8].

Gait Analysis Techniques

Gait analysis is a crucial process used to evaluate and understand human loco-motion, particularly in children with conditions like drop foot. A comprehensive gait analysis typically involves multiple methodologies that together provide a thorough assessment of the child's walking pattern.

the FDM-T stance and the gait analysis system in action. With a high density of calibrated pressure sensors spread out over a 150 x 50 cm area, this force distribution measurement treadmill provides us with more usable information than its initials might suggest. The sensors can fire and collect data repeatedly until the examiner stops the test, giving more data that can be used in this research. With a USB interface, the device connects to a computer and uses a patented technology created by Zebris for accurate data collecting from heel contact until the end of the gait roll-off .

The results of the measurements were displayed on the computer and can be included in the report in color. Over several pages, this report provides a table with significant data, such as stance, swing, double-standing and step-lengths, as well as a direct comparison of both sides [109]. The COP lines are automatically measured on other pages in a report, as well. The force curves are averaged and normalized to 100% of the step cycle on both the left and right sides of the body. Color coded force distributions on images represent roll-off techniques as shown in Figure.



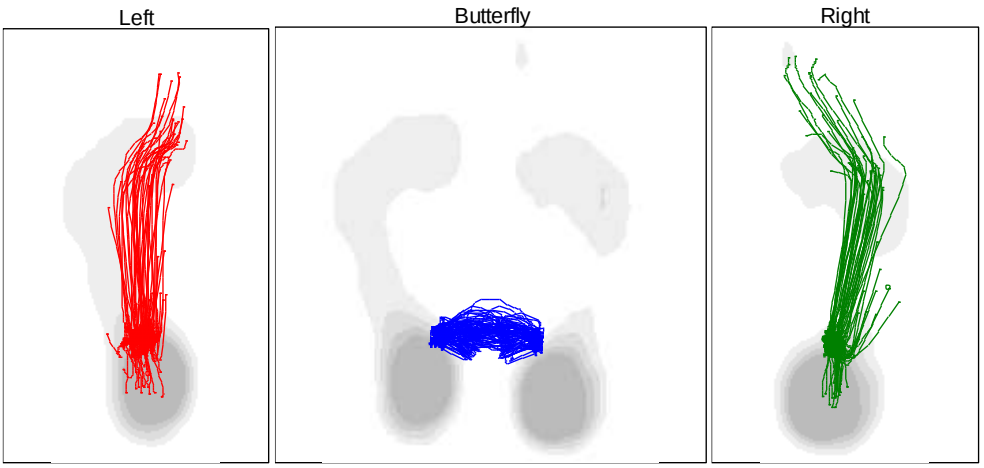
Figer 2 show the cycle gait analysis geven by fdm-t from zebris

Drop Foot

Drop foot, also known as foot drop, is a neuromuscular condition characterized by the inability to lift the front part of the foot, leading to dragging or slapping of the foot during walking.[1][9]. This condition can affect one or both feet and can have a significant impact on an individual's mobility and overall quality of life. It arises from weakness or paralysis of the muscles responsible for dorsiflexion, primarily innervated by the peroneal nerve, which can be affected by various underlying neurological, muscular, or anatomical issues.[2][9].

Butterfly Parameters

	01-01-2008 Gait Analysis	
	Left	Right
Gait line length, mm	167±20	169±27
Single support line, mm	22±5	23±5
Ant/post position, mm	87	
Ant/post variability, mm	5	
Lateral symmetry, mm	-8	
Lateral variability, mm	41	



Figer 3 shown the butterfly for the child

Pressure- and Force Curves

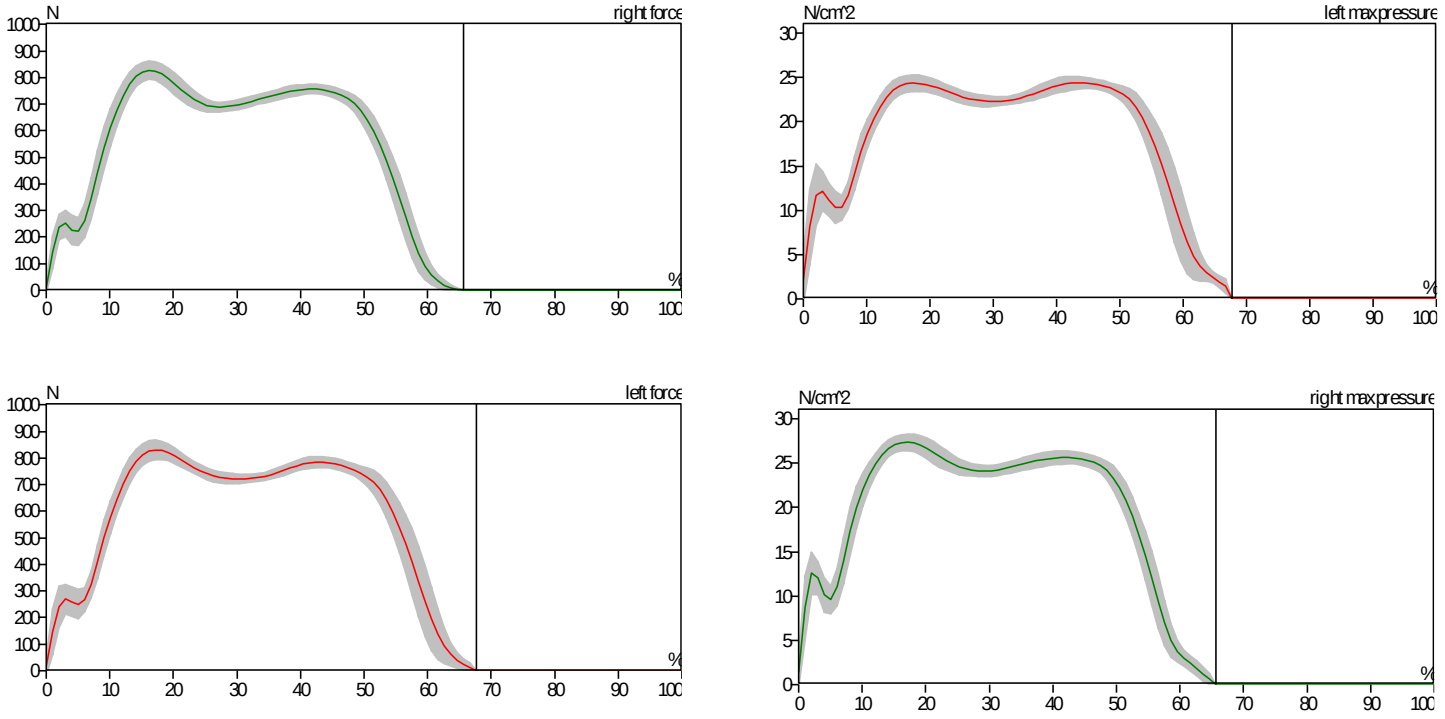
In the diagram “Max Pressure” the averaged and normalized pressure curves are shown. The standard deviation is presented as a grey area. A vertical line seperates the stance- and swing phase.

The force diagram is presented below the pressure diagrams.

Thediagrams shows the average vertical forces. The standard deviation is presented as a grey area. A vertical line seperates the stance- and swing phase.

Report page

The first part of the third report page shows the butterfly diagram. The second part includes the average force- and pressure curves with its standard deviation.



Figr 4 shown the butterfly ,average max pressure and average max force for the child has drop foot case

Project: Demo
Patient: SampleSubject
Record:

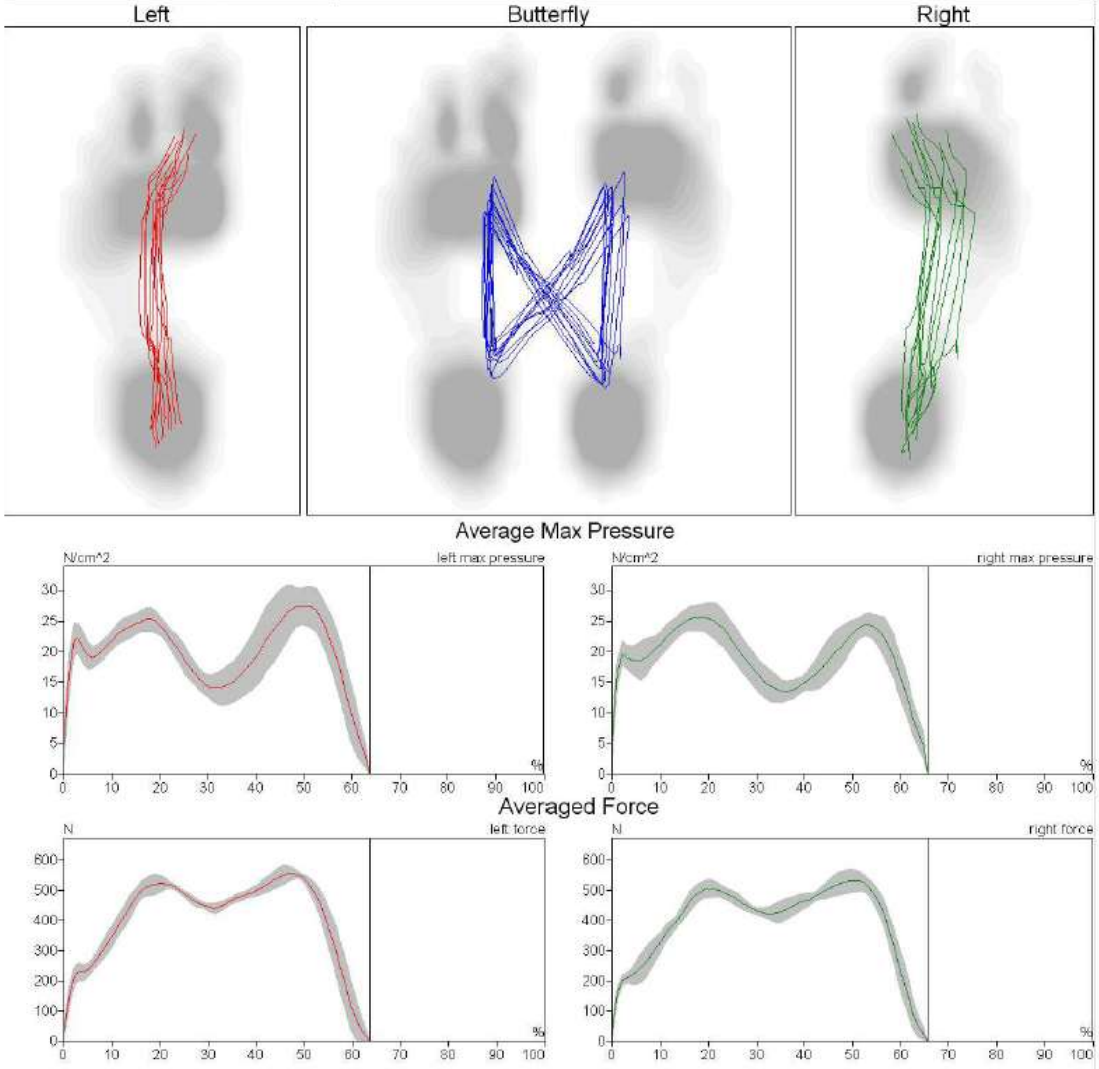
Zebris Gait Report

zebris

Date of meas.: 04.08.2008 16:27

Butterfly Parameters

Parameter, mm	Christina	
	Left	Right
Gait line length, mm	143±8	147±14
Single support line, mm	88±10	89±12
Ant/post position, mm	104	
Ant/post variability, mm	5	
Lateral symmetry, mm	1	
Lateral variability, mm	5	



Figer 5 shown the butterfly ,average max pressure and average max force for the normal case

Causes of Drop Foot

Foot drop can result from several conditions, including systemic neurologic disorders such as Amyotrophic Lateral Sclerosis, Guillain–Barré syndrome, and Charcot–Marie–Tooth disease. These conditions may lead to neuropathy, contributing to the development of foot drop.[10]. Other causes include traumatic injuries to the sciatic or peroneal nerve, which can occur from knee dislocations, fibula fractures, or direct lacerations.[10][1]. Furthermore, conditions like leprosy, vasculitis, and cerebral palsy can also manifest as foot drop due to nerve injury or developmental issues.[10][9].

Symptoms

The primary symptom of drop foot is difficulty in lifting the front of the foot, which may cause the foot to drag or slap against the ground while walking.[2][1]. Other associated symptoms include weakness in the affected leg, numbness or tingling in the foot or lower leg, and an altered gait pattern, often referred to as "steppage gait," where individuals may lift their thigh higher than usual to prevent dragging the toes.[9][3]. Patients may also experience pain or discomfort in the foot or leg, along with loss of balance while walking.[2][9].

Diagnosis

Diagnosis of foot drop typically involves a comprehensive physical examination, review of the patient's medical history, and potentially additional tests such as nerve conduction studies, electromyography (EMG), or imaging scans to assess for structural abnormalities.[2][3][11]. Gait analysis may also be conducted to evaluate the movement dynamics and identify specific functional deficits during ambulation.[3].

Treatment Options

Treatment for foot drop is contingent upon the underlying cause and severity of the condition.

Physical Therapy: Exercises aimed at improving muscle strength and flexibility, as well

as enhancing overall gait and walking abilities.[2][9].

Assistive Devices: The use of orthotic devices, such as braces or splints, can provide necessary support to maintain a more natural walking pattern and prevent the foot from dragging.[2][1].

In cases where the underlying cause can be addressed, such as nerve repair or management of a systemic condition, the prognosis for recovery from foot drop may improve significantly.[11][12]. However, in instances where the damage is irreversible, foot drop may become a chronic condition requiring long-term management strategies.[1][11].

Application of Gait Analysis for Children with Drop Foot

Gait analysis is a critical component in assessing and managing children with drop foot, a condition characterized by the inability to dorsiflex the foot during the swing phase of walking. This analysis involves a comprehensive evaluation of a child's gait mechanics, including the timing and coordination of movements, to identify deviations from typical patterns that may result from foot drop.

Gait Evaluation Techniques

Observational Gait Assessment

The initial assessment often begins with an observational gait analysis conducted in a clinical setting. Clinicians observe the child's walking patterns for signs of foot drop, such as the steppage gait, foot slapping, and abnormal foot positioning,
which may include walking on the side of the foot[8]. These visual assessments are supplemented by a detailed physical examination that focuses on muscle strength, tone, and any structural causes of gait deviations[3].

Instrumented Gait Analysis

For more precise evaluations, instrumented gait analysis is utilized, typically per- formed in specialized gait laboratories. This method involves high-quality video recording and additional technologies such as electromyography (EMG) and force platforms to analyze temporal and spatial gait parameters[3]. These assessments allow for a detailed understanding of how drop foot affects the child's gait, including factors such as walking speed, step length, and gait cycle duration. Furthermore, studies have shown that quantifying asymmetry in gait can lead to improvements in the design of rehabilitation interventions[4].

Role of Functional Electrical Stimulation (FES)

Recent advancements in gait analysis have incorporated the use of functional elec- trical stimulation (FES) devices, such as the WalkAide. This device stimulates the peroneal nerve to enhance dorsiflexion during the swing phase, which is crucial for foot clearance[4]. Research has indicated that using FES not only improves toe clear- ance but also positively impacts gait symmetry and speed over time, as evidenced by a decrease in temporal and spatial asymmetry correlated with increased walking speed[4]. The application of FES, combined with gait analysis, allows clinicians to evaluate both orthotic and therapeutic effects on a child's walking pattern, leading to more tailored rehabilitation strategies.

Research and Developments

Research in the field of gait analysis, particularly for children with conditions such as drop foot, has evolved significantly over the years. A notable study designed by KN, with contributions from KB and JC, examined the efficacy of functional electrical stimulation (FDS) using the WalkAide® device to improve gait mechanics in affected children. This research, conducted in collaboration with the Kessler Foundation and Children's Specialized Hospital, involved a comprehensive data collection process where participants were evaluated at baseline and at three months after continuous use of the device during community ambulation[4].

Functional Electrical Stimulation

The WalkAide device, a commercially available FDS system, employs surface elec- trodes to stimulate the peroneal nerve, facilitating dorsiflexion during the swing phase of gait. The device's operational parameters—frequency (17–33 Hz), pulse width (25–300 μs), and intensity—are customizable, enhancing its efficacy for individual users. This technology utilizes a tilt sensor and accelerometer to monitor leg position, thus optimizing stimulation timing. The compact device weighs approximately 87.9 grams and is secured just below the knee[4].

Gait Analysis Techniques

A rigorous gait analysis was implemented using a 12-camera motion capture sys- tem, capturing kinematic data in the sagittal, frontal, and transverse planes. Each participant completed walking trials under two conditions: with and without the FDS device, which enabled a direct comparison of outcomes. The study's design included randomized conditions to minimize bias, thereby providing more robust data on the effects of FDS on gait abnormalities such as drop foot[4][13].

Advances in Gait Analysis

The advancement in gait analysis technologies, including the integration of plantar pressure mapping, has further refined the understanding of how various forces affect foot function. This objective data aids clinicians in assessing tissue loading charac- teristics, potentially leading to more personalized treatment strategies[6]. Research continues to challenge and expand traditional methodologies, prompting practitioners to adopt innovative approaches that may enhance therapeutic outcomes for children with gait impairments, including drop foot[5][6].

By leveraging cutting-edge tools and methodologies, healthcare providers are better equipped to diagnose and treat gait abnormalities, ultimately aiming to improve the quality of life for affected children[12][3].

Evaluation parameters of Foot Drop in gait analysis

In recent studies assessing the impact of foot drop in children, specific focus has been given to the use of Functional Dynamic Splinting (FDS) as an intervention. The primary aim of these investigations was to analyze the orthotic and therapeutic effects of FDS on children and adolescents, particularly looking at mechanistic and functional outcomes. The studies posited that the use of FDS would enhance toe clearance and improve temporal-spatial symmetry during gait, which are critical parameters for effective ambulation in this population[4].

-Foot rotation (deg) : Angle between longitudinal foot axis and walking direction / plus = outside, minus = inside

-Step width (cm): Distance between left and right heel

-Step Time (sec) : Describes the period in sec. within a gait cycle between the heel contact of one side of the body and the heel contact of the contralateral side

-Stance Phase (percent from gait cycle) : Describes the period within a gait cycle during which the foot has contact with the ground

-Load Response(percent from gait cycle)

Describe the period Load Response within a gait cycle Single Support Time (percent from gait cycle) Describes the period within a gait cycle during which the contralateral foot has no contact with the ground

-Pre-swing(persent from gait cycle) Describes the period pre-swing within a gait cycle

–Swing Phase (percent from gait cycle) Describes the period within a gait cycle during which the foot has no contact with the ground Total Double Support (percent from gait cycle) Describe the period within a gait cycle where both feet have ground contact

–Step Length (cm) Shows the distance between the heel contact of one side of the body and the heel contact of the contralateral side

–Stride Length (cm) · Shows the distance between two heel contacts on the same side of the body

–Cadence (steps/min) Shows the parameter steps/second and is calculated from the reciprocal of the Stride Time

RESULTS

Sagittal Kinematics Figure 6 shows the average sagittal plane kinematics of the parameter of gait analyses for patint ankle joint for the unaffected and affected legs

Parameters

Foot rotation, deg	Left	6.5±2.4	-40 60
	Right	9.6±3.5	-40 60
Step w idth, cm		17±2	100
Step length, cm	Left	15±2	130
	Right	11±3	130
Step time, sec	Left	0.82±0.04	3
	Right	0.87±0.03	3
Stance phase, %	Left	67.6±1.8	100
	Right	65.0±3.2	100
Load response, %	Left	16.5±2.9	100
	Right	16.1±1.5	100
Single support, %	Left	34.9±3.3	100
	Right	32.4±1.8	100
Pre-sw ing, %	Left	16.1±1.6	100
	Right	16.4±2.9	100
Sw ing phase, %	Left	32.4±1.8	100
	Right	35.0±3.2	100
Total Double support, %		32.6±3.4	100
Stride length, cm		27±4	200
Stride time, sec		1.68±0.05	3
Cadence, strides/min		36±1	100

Normative data: 2-5 km/h

Display the results that you analyze and discuss from Table No. 4 that the rate of deviation of the left foot affected by foot drop is more than the rate of deviation of the English foot and I note that the left foot between the feet Francisco and the secretary was 17 + −2 and that the stride length for the left man was 15 with the classic Israeli deviation and the stride length for the left man was 11 with an Israeli deviation of three and that the price of the stride 82 in the line Opoint 82 width in Iraq standard 0.04 and the stride time 87 man with a standard deviation 03 but he seeks the full role of walking was the professional Latin right man for the Jewish man 67.6 with a standard deviation of 1.8 and its ratio to the left man 65. 1 depends on three criteria.2 But at the moment of reliance, the white man succeeded 16 pounds five and the left man 16.1 with a standard deviation of 1.5 was 34.9 in Iraq with a standard deviation 16.1 with one standard deviation between six and I am a man left was 16.4 and the emerging man bright bright white man of the advanced full course no 32.4 of a standard deviation 1.8 for the man knight 35.1 of a caliber three.2

The results proved that improving and expanding the amount of the injured man between the use of the exercises listed and used by the researchers were as auxiliary exercises for the patient to improve the climbing process and cooperation

Essential Exercises for Foot Drop

Ankle Dorsiflexion

How to Do: Sit in a chair with your feet flat on the floor. Keeping your heel on the ground, lift your toes toward your shin.

Repetitions: 10 to 15 repetitions for each foot.

Toe Taps

How to Do: While seated, keep your heels on the ground and lift your toes up and down repeatedly.

Duration: Perform for 1 to 2 minutes or as tolerated.

Heel Walking

How to Do: Stand up and walk on your heels for a short distance. This exercise helps strengthen the muscles responsible for lifting the foot.

Duration: Aim to walk on your heels for about 1 to 2 minutes.

Resistance Band Dorsiflexion

How to Do: Sit on the floor with your legs extended. Place one end of a resistance band around the top of your foot and anchor the other end. Pull your toes towards you against the band's resistance.

Repetitions: 10 to 15 repetitions for each foot.

Calf Raises

How to Do: Stand with your feet shoulder-width apart. Slowly lift your heels off the ground to stand on your toes, then lower back down.

Repetitions: 10 to 15 repetitions.

Seated Leg Lifts

How to Do: While sitting, extend one leg straight out in front of you and hold for a few seconds, then lower it back down.

Repetitions: 10 to 15 repetitions for each leg.

Foot Circles

How to Do: While seated, lift one foot off the ground and draw circles in the air with your toes. Change directions after completing one set.

Repetitions: 10 circles in each direction for each foot.

Towel Stretch

How to Do: Sit with your legs extended. Use a towel to gently pull your toes toward you to stretch the calves and muscles in the foot.

Duration: Hold for 15 to 30 seconds for each foot.

Conclusion

Strengthening the muscles involved in foot movement can significantly improve mobility and reduce the impact of foot drop In a pilot study, outcomes were evaluated in a cohort of pediatric patients with hemiplegia exhibiting foot drop. Initial findings indicated that the FDS could improve dorsiflexion and toe displacement over a period of three months. While the initial walking speed did not show significant improvements—potentially due to participants already ambulating at near-normal speeds—temporal and spatial symmetry between the limbs improved, indicating enhanced bilateral coordination[4]. The improvement in symmetry was noteworthy, as prior research suggested that asymmetry is a significant predictor of walking performance and fall risk[4][14]. The exploratory nature of the investigations highlighted an adaptive effect, where changes in the orthotic outcomes evolved with continued use of FDS. Specifically, it was observed that participants adapted to the device, leading to increased dorsi-

flexion and toe clearance, while temporal and spatial asymmetry was diminished[4]. Interestingly, while temporal asymmetry typically correlates with walking speed in adult populations with hemiplegia, in this pediatric study, the correlation was less pronounced, suggesting that different mechanisms may govern gait performance in children compared to adults[4].

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