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A Descriptive Study on Assessment of Functional Status in Cerebral Palsy Patients Using Knee Ankle Foot Orthosis

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Abstract

Background: Cerebral Palsy (CP) is the most prevalent motor disability in childhood, arising from abnormal brain development or damage, affecting muscle control. Knee Ankle Foot Orthoses (KAFO) is a lower limb orthosis extending from foot plate to thigh level, designed to support weakened leg muscles and stabilize knee and ankle joints, potentially halting deformity progression or rectifying flexibility. This study aims to elucidate the functional status of lower limb CP patients utilizing KAFO.
Aims: This study aimed to describe the functional level of lower limb CP patients wearing KAFO.
Methods: Informed consent was obtained, and data of 110 cerebral palsy patients were collected using non-random consecutive sampling. Patients were divided into two groups: one with 80 patients utilizing KAFO with 4PPS (four-point pressure system), and the other with 30 patients not using KAFO with 4PPS. Observational gait analysis was conducted, and subjective and objective details were recorded on a specially designed questionnaire. The OPUS scale evaluated the functional status of CP patients, and statistical analysis employed chi-square tests to examine the role of KAFO in their functional status using SPSS version 21.0.
Results: Statistical analysis revealed a significant relationship between total functional score and KAFO use. Among the 80 KAFO users, 71 patients scored >40, while 9 scored <40. In the non-KAFO group, 28 patients scored <40, and 2 scored >40. KAFO users exhibited higher total functional scores, indicating improved functionality and independence in daily activities ($p<0.05$).
Conclusion: The study concludes that KAFO utilization enhances the functional status of cerebral palsy patients, facilitating independent engagement in daily activities. Comparison of total scores between KAFO users and non-users underscores the association between functional improvement and KAFO use.

Keywords:
Cerebral palsy, Knee Ankle Foot Orthosis, Ankle Foot Orthosis, Point Pressure System, Equinus Foot Deformity.

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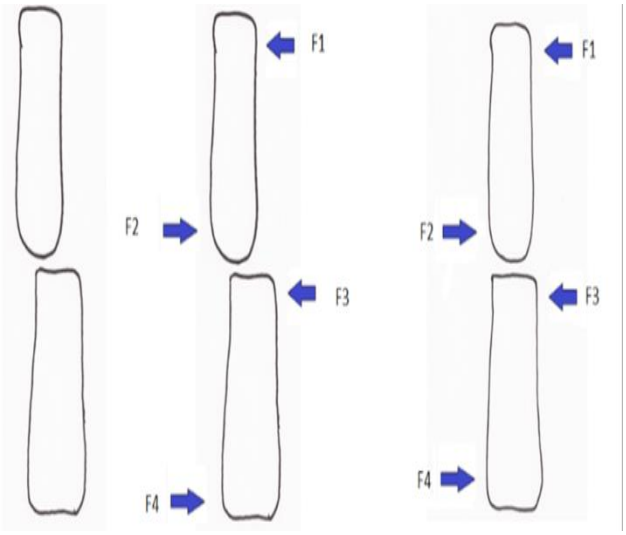
Introduction

Orthoses can be simply defined as devices applied externally to support or improve the function of weakened body parts (Yan et al., 2015). They are also utilized to prevent the exacerbation of fixed deformities and correct flexible deformities, such as reducing contractures in cerebral palsy patients (Chan & Miller, 2014). Knee Ankle Foot Orthoses (KAFO) is a type of lower limb orthosis that extends from the footplate to thigh level. It comprises four main components: the thigh shell, AFO (ankle foot orthosis), knee joint, and metal uprights. KAFOs are long leg orthoses designed to assist weakened leg muscles and stabilize the knee and ankle joints. There are two types of knee joints used in KAFO braces: the drop lock knee joint, which is manually controlled, and the stance-controlled knee joint, which automatically locks the knee during specific phases of gait (Andrysek et al., 2017).

Both types of KAFO serve similar functions; the primary difference lies in the force delivery system. In conventional types, forces are delivered through transverse straps, while in plastic molded designs, plastic sections fulfill this role (Shivers & Day, 2024). Regardless of design, the shoe remains a crucial component of the biomechanical system. In cases where ankle control is unnecessary, a free motion ankle joint is utilized, or trimlines at ankle level are positioned posterior to the malleoli (Wright & DiBello, 2020). However, Cerebral Palsy (CP) patients with knee deformities often experience impaired ankle or foot function, necessitating KAFOs with appropriate ankle control joints or trimlines positioned anterior to the malleoli to control ankle motion (Nouri et al., 2023).

The biomechanical principles of KAFO design aim to promote control, correction, stabilization, or dynamic movement. Key considerations in KAFO design include forces at the interface between orthotic material and skin, degrees of freedom of each joint, number of joint segments, neuromuscular control of each segment, material selection for manufacturing, and the activity level of the patient (Kempfer et al., 2022).

All orthotic designs are based on three relatively simple principles: the pressure principle, equilibrium principle, and lever arm principle (Ramachandran et al., 2018). Balanced force systems are employed to control joint motion, with forces acting parallel to each other (Mahmoudi et al., 2019). These forces follow the first-class lever system, where forces are applied on opposite sides of the fulcrum or point of rotation. In the three-point pressure system, one force is applied proximally at the tibia, another distally at the foot, both acting in the same direction (Dessery et al., 2014). A third force is applied at the ankle in the opposite direction to the proximal and distal forces, counterbalancing the other two. Most orthoses utilize the three-point loading system to control specific planes and directions of motion (Dvorznak et al., 2006).



Material and Methods:

A cross-sectional survey was conducted at the Rehabilitation Center of Benazir Bhutto Hospital from July 2021 to July 2022. Data were collected from patients using the OPUS questionnaire after obtaining written consent due to ethical considerations. All work was conducted under the supervision of orthotists and prosthetists. The study included 110 cerebral palsy patients, comprising 31 females and 79 males, with spastic-type CP and knee, ankle, and foot deformities. Patients were divided into two groups: users and non-users of KAFO. Among female patients, 10 were non-

users and 21 were KAFO users, while among male patients, 59 were users and 20 were non-users. Total functional scores of both groups were compared. Statistical analysis was performed using SPSS version 21.0, with data entered into an Excel spreadsheet, tabulated, and subjected to statistical measures such as chi-square and frequency distribution.

Results

The statistical analysis was conducted with the assistance of SPSS version 21.0. For this purpose, the data were entered into an Excel spreadsheet, tabulated, and subjected to statistical analysis. Various statistical measures, such as chi-square and frequency distribution, were employed to analyze the data. A total of 110 patients were included in the sample: 80 were utilizing KAFO with 4PPS, among whom approximately 71 patients had a total score >40, while 9 patients had a total score <40. The remaining 30 patients were not using KAFO, with 28 of them having a total functional score <40 and 2 patients having a total functional score >40. Statistical analyses revealed a significant relationship between the total functional score and KAFO use, indicating that KAFO users had a higher total functional score compared to non-users. The utilization of KAFO with 4PPS enabled cerebral palsy patients to independently perform most of their daily living activities (p<0.05).

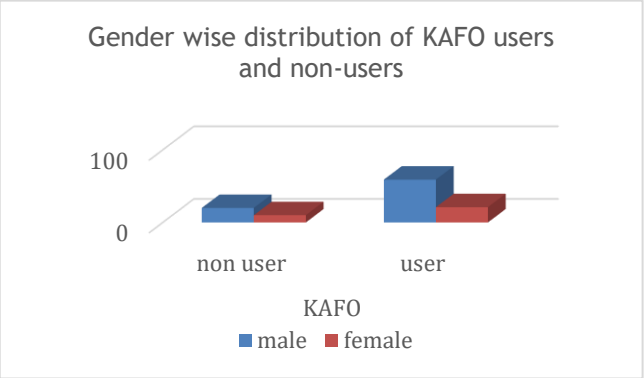
Table1:
Cross Tabulation Functional Score for 2 groups

			Total functional score		Total
			<40	>40	
KAFO users	No	Count	28	2	30
		Expected count	10.1	19.9	30.0
	Yes	Count	9	71	80
		Expected count	26.9	53.1	80.0
Total		Count	37	73	110
		Expected count	37.0	73.0	110.0

Table 2. Gender wise distribution of KAFO users and KAFO non-users

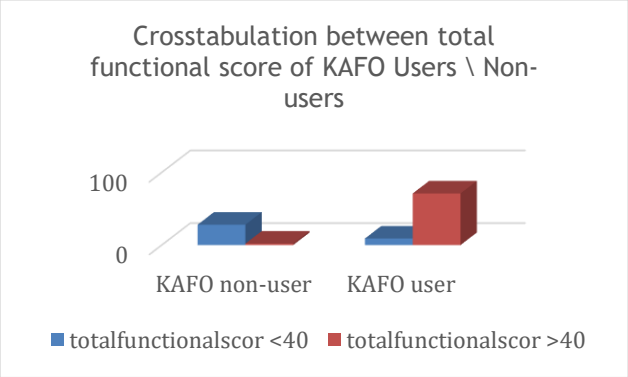
		Gender		Total
		Male	Female	
KAFO users	no	21	10	30
	yes	59	21	79
Total		79	31	110

Figure 3. Gender wise distribution Gender wise distribution of KAFO users and KAFO non-users



The study was conducted on 110 cerebral palsy patients, comprising 31 females and 79 males. Among the female patients, 10 were non-users of KAFO, while 21 were users.
Among the male patients, 59 were users, and 20 were non-users. The chi-square p-value, being less than 0.05, indicates a strong association between KAFO usage and total functional score.

Figure 4. crosstabulation between total functional score of KAFO users and non-users



Discussion

In this study, the functional status of cerebral palsy patients currently rehabilitated with knee ankle foot orthosis (KAFO) was assessed to determine the impact of KAFO on their functional abilities. Consistent with previous research by (Caliskan Uckun et al., 2014), it was observed that KAFO use was associated with improved functional status among cerebral palsy patients.

The study included both KAFO users and non-users, with their functional status evaluated separately using the OPUS survey. Despite the heterogeneous nature of the sample, comprising 31 females and 79 males aged between 2.5 to 13 years, the analysis revealed a significant association ($p < 0.05$) between total functional score and KAFO use. This underscores the positive impact of KAFO on enhancing functional status among cerebral palsy patients.

However, the lack of significant associations between functional score and gender, as well as age, suggests that factors other than these demographic variables might play a more crucial role in determining functional outcomes among cerebral palsy patients utilizing KAFO. Further exploration into these factors could provide deeper insights into optimizing rehabilitation strategies tailored to individual patient needs.

The findings of this study align with previous research investigating the effectiveness of orthotic bracing for cerebral palsy rehabilitation. For instance, studies by (Bhave et al., 2019) and (Maas et al., 2014) indicated that orthotic interventions, including static KAFO, can effectively reduce deformities and improve functional outcomes in cerebral palsy patients. However, variations in the type of orthotic intervention and its effects on mobility highlight the importance of selecting the most appropriate orthotic device based on individual patient characteristics and rehabilitation goals.

Moreover, research by (Andrysek et al., 2013) and (Maas et al., 2014) emphasized the importance of considering factors such as wearing time and the design features of KAFO in optimizing functional outcomes. The efficacy of KAFO in improving functional scores, as observed in this study, underscores its role in facilitating independent engagement in daily activities for cerebral palsy patients.

Overall, while this study contributes to the growing body of evidence supporting the effectiveness of KAFO in improving functional outcomes among cerebral palsy patients, further research is warranted to explore additional factors influencing rehabilitation outcomes and to refine rehabilitation protocols for optimizing patient-centered care.

Conclusion:

Based on the results of this study, it is concluded that the use of KAFO improves the functional status of cerebral palsy patients, enabling them to perform most of their daily living activities. The total scores of both groups—KAFO users and non-users—were compared using SPSS software, revealing an association between functional score and KAFO use.

For future recommendations, further research could explore the long-term effects of KAFO usage on the quality of life and functional independence of cerebral palsy patients. Additionally, investigating specific factors such as duration of KAFO use, frequency of wear, and adjustments in design could provide valuable insights into optimizing the effectiveness of KAFO interventions. Moreover, longitudinal studies could shed light on the sustainability of functional improvements over time and guide the development of personalized rehabilitation strategies for individuals with cerebral palsy.

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