Relative Efficacy of Ankle Foot Orthosis through Temperospatial Gait Parameters in Crouch Gait: A Critical Analysis on Assistive Health Rehabilitation

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ABSTRACT *Introduction: Lever arm dysfunction is the one of the core problem in crouch gait in diplegic cerebral palsy (CP). Excessive knee flexion along with ankle dorsiflexion leads altered body alignment and increase energy expenditure and cumbersome in walking. The aim of this study was to identify the effectiveness of orthotic device in between knee molded AFO and solid AFO with knee gaiter in diplegic Cerebral Palsy. Case report: Total no of 10 children with diplegic CP diagnosed with crouch gait along with GMFCS II were included in experimental group and 10 normal children included in control group within same age range. Two different Orthotic intervention i.e. Knee molded ankle foot orthosis (KMAFO) and Solid ankle foot orthosis along with knee gaiter (SAFO-KG) were prescribed in experimental group. Adaptation period was set as 4 weeks. Temperospatial parameters were analyzed in control and experimental groups. Discussion: One way ANOVA and post hoc test used for statistical analysis. Temperospatial values of control group serve as reference value of comparison.An improvement meant that the values came closer to normal reference values. Result shows significant difference in KMAFO and SAFO in comparison with control group. Conclusion: This study showed efficacy of KMAFO over SAFO-KG in spastic diplegic CP. The mechanical effects of KMAFO were shown in comparison with control group in term of temperospatial parameters.*

***Key words**: Diplegic Cerebral palsy, Crouch gait, Temperospatial parameters.*

Introduction: Cerebral palsy (CP) is condition of abnormalities of central nervous system,[1]where primary deficit may produce some or all of abnormalities such loss of selective muscle control, dependence on primitive reflex patterns for ambulation, abnormal muscle tone, relative imbalance between muscle agonists and antagonists across joints, and deficient equilibrium reactions.[2] In normal condition, the muscles and ground reaction forces act on skeletal levers to produce locomotion,any abnormalities of lever-arm systems greatly interfere with the child's ability to walk.[2] During the second half of the stance phase, the plantar flexion-knee extension couple mechanism, maintain knee stability.[3]In cerebral palsy, the muscle or ground reaction forces are neither appropriate nor adequate because of muscle contractures, poor selective motor control, or abnormality of the bony lever-arms[2,4,5]and this leads excessive knee flexion or abnormal knee extensor moment during stance phase along with ankle dorsiflexion and shows crouch gait walking pattern.[5-8]
Orthosis plays important role in case of mild to moderate conditions of children with CP [11,12]while bone deformity best corrected by orthopedic surgery.[2,11]As per International Classification of Functioning, Disability and Health (ICF), outcome measures need to set based on patient's perspective, function of device, mobility and participation of patient.[13,14,15] There are no study found related with knee molded ankle foot orthosis or solid AFO along with knee gaiter, although these orthosis are prescribed the case of crouch gait.
The purpose of this study was to identify and compare the effects of solid ankle foot orthosis along with knee gaiter (SAFO-KG) and Knee molded AFO (KMAFO) on walking in children with spastic diplegic CP (GMFCS II[9,10]) who demonstrate excessive ankle dorsiflexion motion during stance phase through temperospatial parameters.

Case report: 10patients (6 male and 4 female) diagnosed with diplegic CP (GFMCS II) were included in study. The mean age was 6.34 ±2.31years. A control group of ten healthy subjects were includedin the study. The group (5male and 5female) had a mean age of 6.87±2.2 years, mean height of 119.29±11.76 cm and a mean weight of 23.13±5.53 kg. (Table 1)Two type of orthotic intervention were used, Solid Ankle Foot Orthosis along with Knee Gaiter (SAFO-KG) and Knee Molded Ankle Foot Orthosis (KMAFO). (Figure no.1) Adaptation period was 4 weeks to adapt each type of orthosis.

Table 1: Patient information sheet

Experimental group			Control group		
Patient identification	Age (years)	Sex	Patient identification	Age (years)	Sex
1	4	M	1	5	M
2	5.6	M	2	5.5	F
3	7	F	3	4.8	F
4	5	M	4	10.9	M
5	4	M	5	6	F
6	4.3	F	6	9	M
7	9	F	7	4.5	M
8	11	M	8	9	M
9	6	M	9	8	F
10	7.5	F	10	6	F
Total =10	**Mean=6.34±2.31**	**M=6, F=4**	**Total =10**	**Mean=6.87±2.2**	**M=5, F=5**
(M= Male, F= Female)					

Figure no1: Cerebral palsy child wearing a) Solid Ankle foot Orthosis with knee gaiter and b) Knee Molded Ankle foot Orthosis design.

10 meter walkways were prepared for data collection purpose. Patients were asked to walk at a self-selected speed over walkway. Three trails were taken for each patient. 10 minutes interval was provided in between each trail.After first adaptation of 4 weeks of SAFO-KG, data was taken. After second adaptation of 4 weeks, next data was taken with KMAFO by following same process. Data of three trials under each orthosis were averaged for each patient. Temporo-spatial parameter stride length, step length, step width, step time and cadence were taken out from each trail.An improvement meant that the values came closer to normal reference values.

Result: Temperospatial parameters stride length and step length increased significantly when compared with KMAFO walking with SAFO-KG. There was no much significance difference in between step width in between experimental groups. Mean valve of stride length of right leg was 57.78 ±1.59 and left side was 57.9±1.37 in control group whereas 47.73±1.31(R), 47.6±1.35(L) reported in SAFO-KG and 52.98±2.16(R), 52.99±2.06 in KMAFO. Step length was marked in control group as 27.72±1.27 whereas 23.81±0.66 in SAFO-KG and 25.7±0.92 in KMAFO. Cadence was marked 68.27±4.14 in control group, 58.3±0.90 in SAFO-KG and 67.44±1.89 in KMAFO. Statistical analysis was performed using a one-way analysis of variance (ANOVA) for repeated measurements to test the means of the conditions within the patient group.

Statistical significance was set at $P \leq 0.05$ and after the analysis P valve shows significant difference. Result shown in Table no 2 stated that there were significant differences reported in KMAFO and SAFO-KG during comparison in between Control groupAn improvement meant that the values came closer to normal reference values. Here data of KMAFO shows nearby valve with control group except the valves of step width. Huge difference was shown in SAFO-KG values.Post hoc analyses were applied to finding patterns or relationships between sampled populations and the Bonferroni method was used as post hoc test.

ANOVA(Stride length R)					
MEAN					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	**505.553**	**2**	**252.777**	**88.115**	**0**
Within Groups	**74.587**	**26**	**2.869**		
Total	**580.14**	**28**			

ANOVA(Step length)					
MEAN					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	**76.552**	**2**	**38.276**	**39.548**	**0**
Within Groups	**26.132**	**27**	**0.968**		
Total	**102.684**	**29**			

ANOVA(Stride length L)					
MEAN					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	**530.782**	**2**	**265.391**	**100.63**	**0**
Within Groups	**71.208**	**27**	**2.637**		
Total	**601.99**	**29**			

ANOVA(Step width)					
MEAN					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	**214.056**	**2**	**107.028**	**97.588**	**0**
Within Groups	**29.612**	**27**	**1.097**		
Total	**243.667**	**29**			

ANOVA(Cadance)					
MEAN					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	**611.47**	**2**	**305.735**	**42.738**	**0**
Within Groups	**193.151**	**27**	**7.154**		
Total	**804.622**	**29**			

Table no 2: One way ANOVA were applied to test the means of the conditions within the patient group to compare Stride length (Right side), Stride length (Left side), Step length, Step width and Cadence. This result clearly shows that there were significant differences reported in KMAFO and SAFO-KG during comparison in between Control group.

Discussion: The purpose of this study was to identify and document the effect of the two types of AFOs on gait function in patients with diplegic CP with GMFCS II[9,10]. We found that the KMAFO altered couch gait walking in compared with solid AFO with knee gaiter.The KMAFO successfully controlled excessive knee flexion and dorsiflexion of ankle joint that provide posterior directed force of knee joint to maintain required extension position of knee.

Effect of KMAFO was also supported by Lucareli et.al.,[21] who explained efficacy of floor reaction ankle-foot orthosis in children with cerebral palsy. While some study documented that only use of Solid AFO could not provide any significance alteration in knee flexion position. Radtka et al,[19] and Rethlefsen et.al,[20] also not found any significant changes in knee flexion during mid-stance of gait when solid AFOs were worn. Carmick[17], Able et.al[18]and Carmick[22]reported,disadvantage of the solid AFO as it limit of normal movement of the tibia forward progression and results in decreased ankle dorsiflexion and early heel rise in stance. Different type of FRAFO and Anterior AFO designs were reported in research papers[8,16,17,21,23]such as Saltiel ankle foot orthosis and others. In this study when experimental group was walking with SAFO-KG, by keeping ankle in neutral lock position and knee in extension position. FRAFO also provide knee extension moment but it is very difficult to use this orthosis in bilateral condition, and does not prevent equinus in swing phase of gait[21]while KMAFOcan be used bilaterally and provides swing phase stability. Few patients complain about back pain too. Here as both ankle and knee in locked, sitting discomfort was also reported.

No clinical studies have found on showing knee molded AFO or the effectiveness of solid AFO with knee gaiter in children with CP and hence our study could not be compared. Most studies discussed in this paper are based on solid or articulated ankle-foot orthoses or FRAFO. This study also found lacking in documentation on clinical cases where different types of orthotic intervention were provided to patient in general clinical practice. For future studies, it would be mandatory to elaborate the area of search with different type of orthotic interventions and correlate these results with existing studies.

Conclusion : This study illustrates the beneficial effect of KMAFO on comparison with SAFO- KG on children with CP with excessive knee flexion and ankle dorsiflexion problems. Knee molded ankle-foot orthoses (KMAFO) were effective to improve the knees flexion in children with spastic cerebral palsy.

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