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CASE REPORT

Comparison of Molded and Conventional Orthosis during Ambulation for Adolescent with Myelomeningocele

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ABSTRACT

Varying diversities of involvement in adolescent with myelomeningocele make orthotic prescription, evaluation, and fitting highly challenging. A school-going 14-year-old boy presented with extensive weakness and kinematic alterations of both lower limbs and spine. Planovalgoid foot, calcaneal deformity of ankle, knee flexion, anterior pelvic tilt, rotation, and frequent hip dislocation of left side were noticed on examination. Gait comparisons were made between walking with bare foot and with conventional and molded orthosis with auxiliary crutches. Kinetic and kinematic parameters were studied in gait lab by force plate (BTS P-6000) and cameras with reflective markers (BTS SMART-DX 6000). Molded orthosis was found to improve all gait parameters except cadence and walking velocity; however, diversity in the results was observed. Though both variants were effective, a follow-up is necessary to finalize the best orthotic solution for the individual subject.

Keywords: Adolescent, Comparison, Gait, Myelomeningocele, Orthosis.

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INTRODUCTION

Subjects with myelomeningocele present with a spectrum of impairments, but the primary functional deficits are lower limb paralysis, sensory loss, bladder and bowel dysfunction, and cognitive dysfunctions. Most individuals need the help of orthoses, which stabilize joints with inadequate muscle control, prevent progression of deformity, and provide weight bearing on limbs for both physiological and psychological benefits.[1] Many children with myelomeningocele use lower extremity orthoses, mostly ankle–foot orthoses (AFOs) or knee–ankle–foot orthosis (KAFOs), for ambulation and socialization. Unlike younger children, who can be sufficiently braced to allow for walking, the problems are accentuated for teenagers because of their added body weight, greater limb length, and the subsequent increase in energy demand during walking.[2] For these reasons, a significant number of teenagers stop walking.[2,3] Varying diversities of involvement in adolescent myelomeningocele result in conflicting outcome measures in orthotic management. There is a desperate need for higher quality studies to be produced regarding bracing the lower extremity in children with myelomeningocele.[4] The KAFOs are less frequently used in these populations, and very few publications found report on the efficacy of this modality of orthotic management.[2,4,5] Few reviews or systematic analyses have been published that analyze the efficacy of assistive devices on the walking ability of ambulant adolescents with spina bifida and differentiate between the effects of treatments on gait parameters, walking capacity, and walking performance.[5] In addition, no literature has been found to compare different variants of orthoses (molded and conventional) with barefoot conditions. In this report, we present a case of an ambulant adolescent case of myelomeningocele, who received orthoses and was compared with different bracing conditions.

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CASE REPORT

A 15-year-old school going boy weighing 93.6 kg, 1.58 m height, and diagnosed as lumbosacral myelomeningocele with hydrocephalous reported to our institute in 2015, with a chief complaint of difficulty in ambulation. He was the first born male child and was operated for excision and repair of myelomeningocele and right ventriculoperitoneal shunts in 2002. He had bilateral congenital talipes equinovarus, which was operated in 2003. On examination, it was observed that there was some degree of motor and sensory loss. Motor paresis was asymmetrical. Flaccid paraparesis was noticed. Evaluation of range of motion

Fig. 1: Standing posture of subject showing different abnormal kinematic alterations

and strength revealed variable hip flexor and hip adductor strength. There was absence of active hip extension, abduction, and partial knee and ankle movements were present. Excessive hip external rotation and flexion, knee flexion, ankle calcaneo plano valgoid and increased lumbar lordosis were noticed (Fig. 1). There was frequent hip dislocation on left side, no apparent leg length discrepancy was observed. Other problems identified were kinematic alterations in the trunk, pelvis, hip, knee, and ankle in all three planes, anterior pelvic tilt, pelvic rotation, and lack of sensation of lower limb and circumductory gait.

The subject had received physiotherapy earlier, and the exercise program was modified from time to time. He was earlier using

- Left conventional KAFO with drop lock knee (KDL) with ankle reverse 90* foot drop stop (FDS) and knee cap and
- Right AFO with ankle reverse 90* FDS with a pair of surgical shoes.

Based on our assessment and evaluation, a new variant of orthosis was planned with an intent of

- Reducing energy expenditure of gait by limiting excessive body movements
- Providing better standing balance and maintaining good posture
- Supporting muscular imbalances
- Weaker quadriceps in addition to heavy weight of upper body produce increased stress on lower limb muscles to control and balance, especially in long-duration activities.

Accordingly, he was prescribed with left KAFO (molded) with KDL with knee cap and right AFO (molded) with pair of sports shoes (flat sole) and a pair of auxiliary crutches. The ankle was made sufficiently rigid and proper reinforcements were provided at appropriate areas to support the weight of subject.

The aim of this case report was to compare between the three walking conditions, i.e., walking with bare foot, conventional, and molded AFO/KAFO (Fig. 2) in terms of their kinetic and kinematic parameters. The force platform (Version BTS P-6000) and high-definition optoelectronic camera with reflective markers (BTS SMART-DX 6000) were used for kinetic and kinematic data in our gait lab (Fig. 3). Physiological cost index (PCI) was used to quantify energy expenditure of ambulation.

Some protocols were maintained for clinical trial of our subject. Resting and walking heart rates were measured to check for any exhaustive conditions. There was a pause period between subsequent trials, so that the baseline heart rate is achieved. Subject was advised to walk in his self-selected walking speed over a span of 10 m. He was not aware of the location and position of force platform on the walking surface. Walking with assistance of auxiliary crutches was encouraged. Data were recorded under normal conditions on level surface

Fig. 2: Subject in three different walking conditions in gait lab

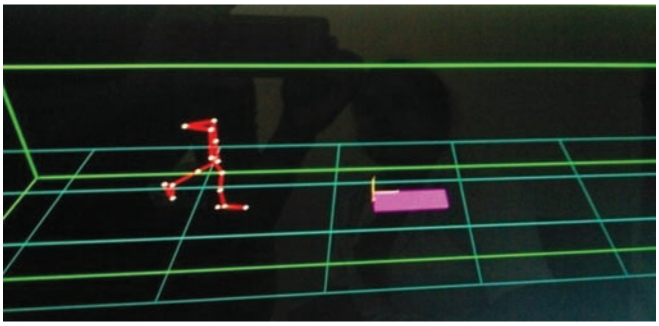


Fig. 3: Force platform and reflective markers

walking. Selection of experimental intervention was randomized to avoid biasness.

The molded orthosis was better in controlling excessive external rotation and valgus thrust, maintaining initial contact and toe out, increasing step and stride length, and better toe clearance than in conventional and barefoot conditions (Table 1). In addition, standing angles were improved and frequent hip dislocation was prevented by molded orthosis. However, cadence and walking velocity were increased in conventional orthosis than in its molded counterpart. The PCIs for bare foot, conventional, and molded orthotic interventions were found to be 0.72, 0.61, and 0.37 beats/m respectively.

DISCUSSION

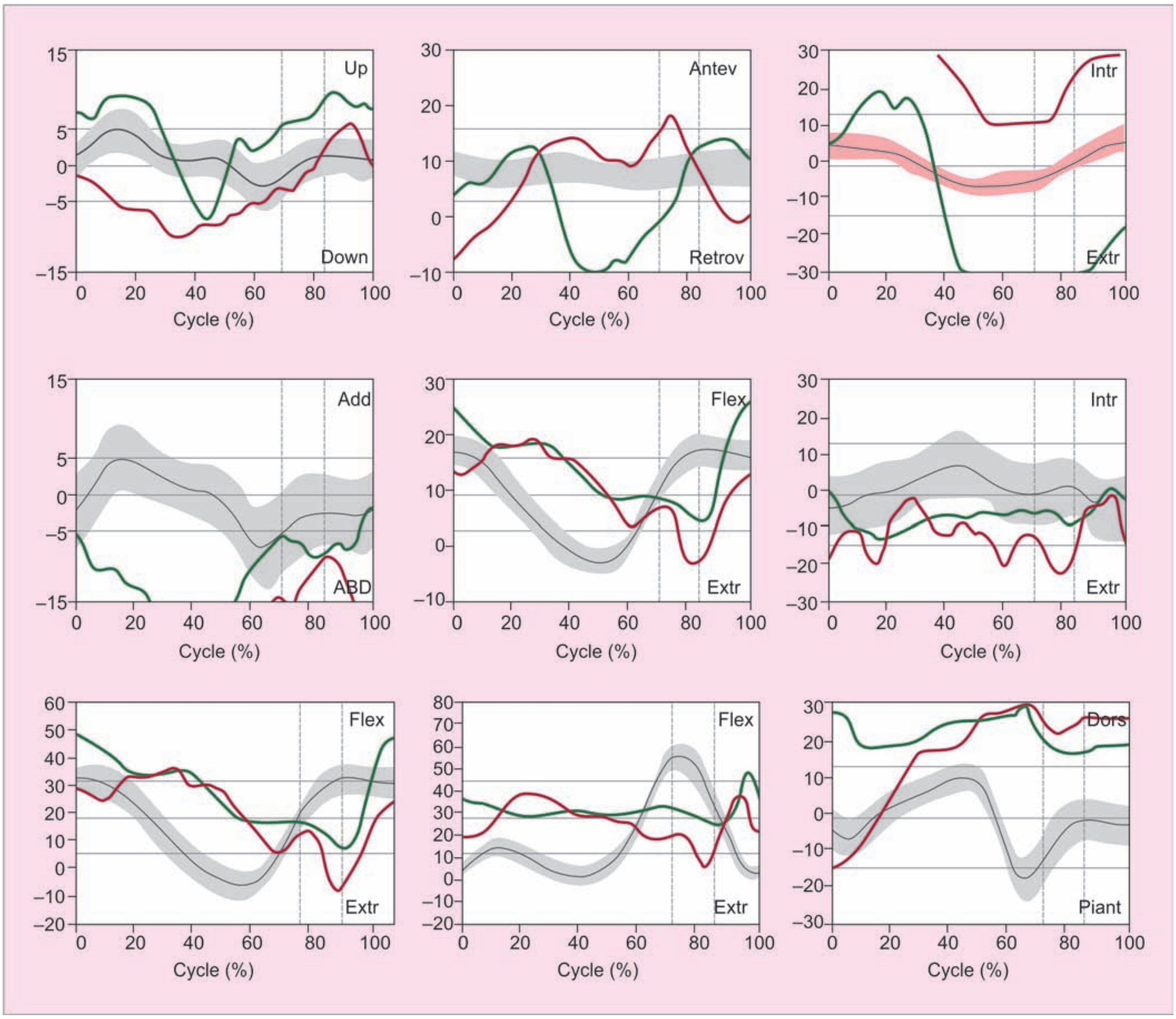
The entire article's discussion hinges on the accurate assessment and description of this boy's functional level and derived walking potential in order to have a meaningful discussion on gait analysis and what type of orthosis will most benefit him. It is a well-agreed fact that with poor active hip flexion, the wisdom of trying to achieve ambulation in adolescent myelomeningocele is debatable.[6] The subject, in our case with heavy weight, tried to propel himself by exaggerating pelvic and spinal motions supported by orthosis and auxiliary crutches. Use of crutches enables the subject to transfer some weight to upper extremities, which minimally decreases the demand on lower limb musculature and orthosis. This allows him to maintain functional ambulation with a closer to normal gait pattern. Earlier studies also found the use of crutches beneficial for subjects with low lumbar or sacral myelomeningocele in addition to orthosis.[7]

In children, much like the child in this case study, with a lower lumbar or sacral level involvement, orthoses are used due to weak hip extensors, abductors, dorsi-flexors, and plantar-flexors. There may be two causes for this boy's crouch gait. The first is likely due to his calcaneus feet that dorsiflex the ankle and cause the ground reaction force to pass behind the knee joint, causing the knee to flex. The second reason is the external torsion of the lower limbs that contributes to the lever-arm dysfunction leading to the first problem. That is why the treatment of crouch gait in this patient is to prevent the ankle to dorsiflex excessively and reduce the external rotation of the limb. While the conventional orthosis may be able to sufficiently immobilize the ankle, it is obvious that the molded orthosis will be far more superior in controlling the rotation of the limb due to its accurate fitting to the patient's limb. Orthoses for these types of subjects include KAFO, AFO, or supramalleolar orthotic. The intent of this case study was not only to check for the efficacy of lower limb orthoses in adolescent myelomeningocele, but also to compare between different orthotic variants. It results in significant improvements in sagittal plane

Table1: Results of kinetic and kinematic data

			Barefoot		*Conventional*		*Molded*	
	Parameters	*Normal*	*Left*	*Right*	*Left KAFO*	*Right AFO*	*Left KAFO*	*Right AFO*
Temporal parameters	Stance time(s)	0.65	0.42	1.42	1.79	1.81	1.07	1.16
	Swing time(s)	0.44	0.98	0.44	0.68	0.5	0.87	0.54
	Stance phase (%)	58.98	21.38	53.66	72.5	56.22	45.31	33.14
	Swing phase (%)	40.03	15.06	10.98	27.79	20.66	30.2	15.59
	Mean vel. (m/s)	1.2	0.1	0.1	0.3	0.3	0.2	0.2
	Cadence	114	18.4	18.4	37.2	37.2	25.5	25.5
Spatial parameters	Stride length (m)	1.36	0.31	0.34	0.43	0.40	0.45	0.38
	Step length (m)	0.62	0.06	0.25	0.27	0.15	0.30	0.17
	Step width (m)	0.08	0.07	0.07	0.15	0.15	0	0
Standing angles	Pelvic obliquity (deg)		–4.9	4.9	4.2	–4.2	8	–8
	Pelvic tilt (deg)		12.6	12.6	26.5	26.5	34.8	34.8
	Hip Ab–Ad (deg)		–17.8	–9.9	–10.5	–18.4	–4.3	–22.9
	Hip F–E (deg)		21.9	22.8	24.6	36.8	38.9	47.4
	Knee F–E (deg)		35.3	29.5	24.1	32.8	16.6	35.8
	Ankle D–F (deg)		59.7	30.7	34.5	26.7	8.2	22
	Foot progress (deg)		22.5	–8	20.7	–9.8	14.1	–11.2

Ab: Abduction; Ad: Adduction; F-E: Flexion-Extension; D-F: Dorsiflexion

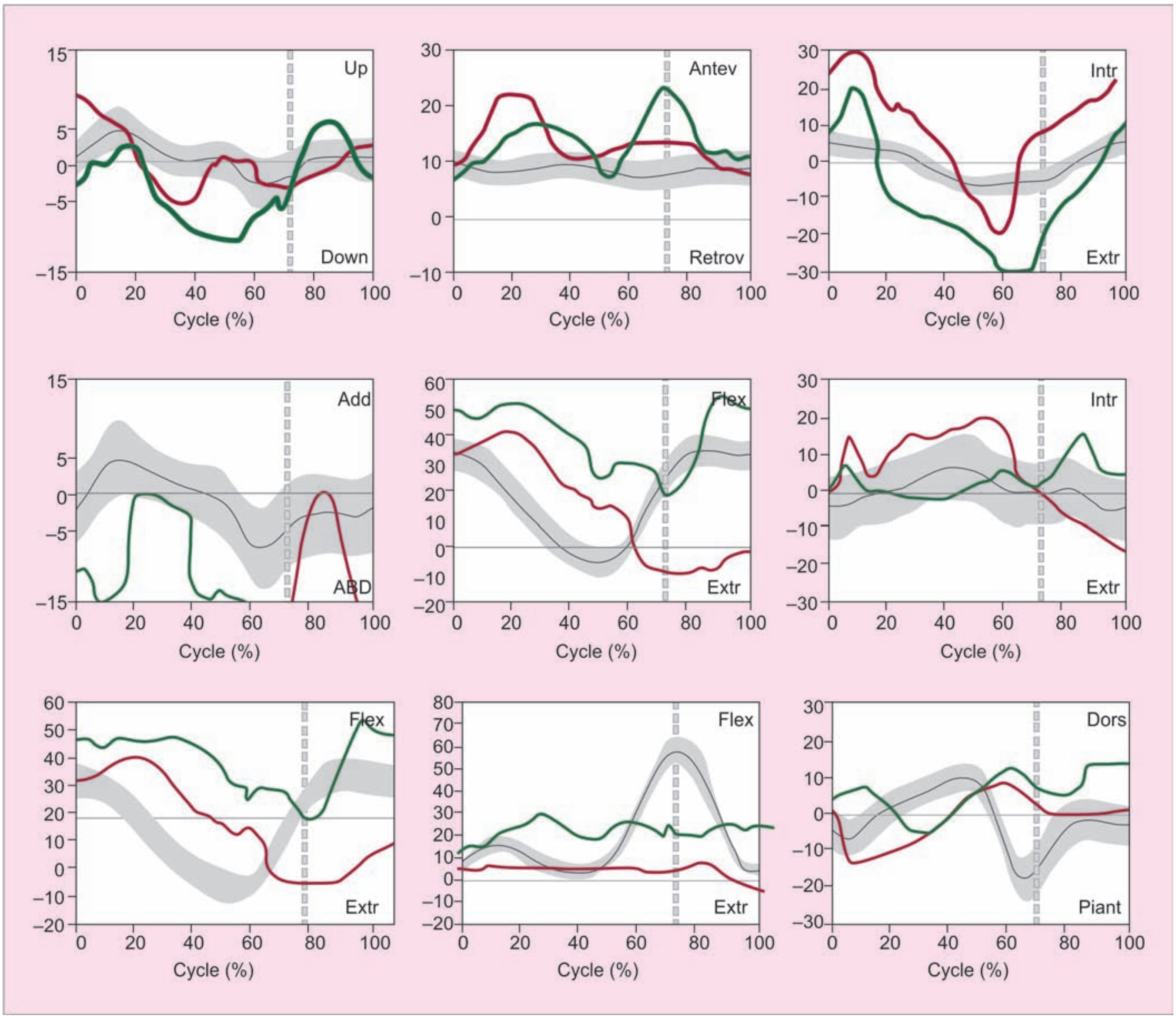


Graph 1: Graphical representation of kinetic parameters: Barefoot

function with reductions in excessive ankle dorsiflexion, increases in peak plantar flexor moment, and reductions in crouch and knee extensor moments, which are more evident from molded orthosis than its conventional counterpart (Graph 1 to 3). Some of the earlier reports have revealed that use of orthosis leads to an improvement in gait parameters, minimized gait deviation, and reduced energy consumption.[8] Temporal–spatial gait parameter revealed that walking speed was faster with orthosis, stride length improved significantly, and double support time was decreased. Hip flexion at initial contact was increased. Ankle kinematics were unchanged, but ankle power generation showed a significant improvement. Increased ankle power generation results in improved hip flexion and stride length, which contribute to increased walking speed. The stability conferred by the orthosis is reflected in the reduced time spent in double support, which is well supported by earlier researches.[8,9] In another study, authors reported that AFO stabilizes the ankle–foot complex, but improved knee motion, knee–extensor activity, and ultimately walking efficiency may be compromised.[10]

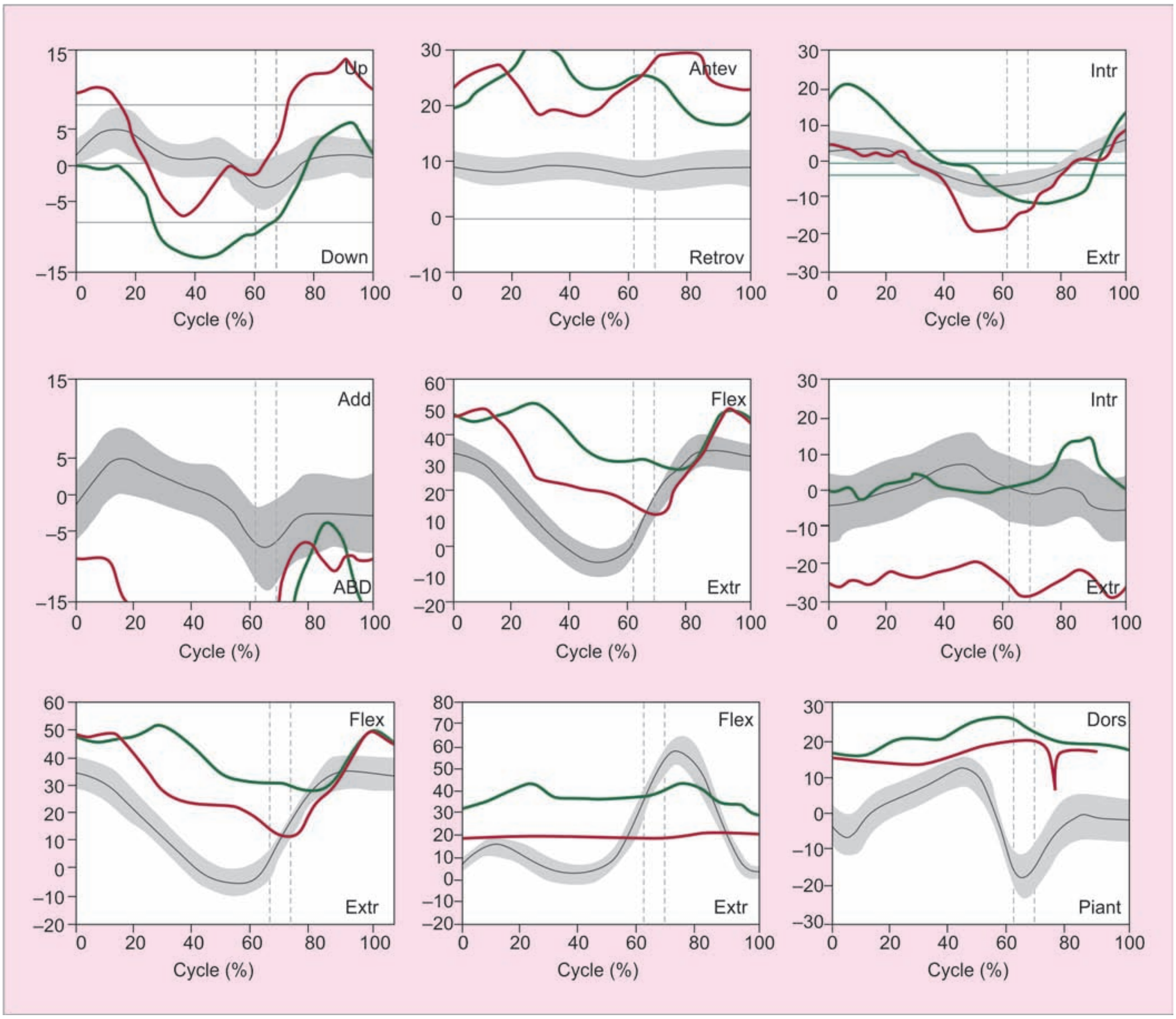
Subject has chosen self-select walking speed, and the use of orthosis helped to control their vertical and horizontal centers of mass excursions to improve kinematics and conserve energy. Earlier report also demonstrates that self-selected walking velocity at which many of these children consider comfortable and stable may be predicated on an optimal center of mass movement that approximates the magnitude observed in normal gait.[11]

The reported shift of the kinematics and kinetics data toward normality is thought to indicate the biomechanical efficacy of the orthotic intervention, but this depends on the design of the orthosis.[12] The lack of information on the type, design, and biomechanical alignment of the



Graph 2: Graphical representation of kinetic parameters: Conventional

various lower limb orthoses, therefore, makes it difficult to apply this information in clinical practice. Achieving an adequate level of orthotic intervention without overbracing is a delicate balancing act and requires an individualized and multifactorial approach. We have reviewed our subject to assess the factors that influence the use of the two types of orthoses as well as their relative merits and limitations. In the literature, no direct comparison was foundbetween molded and conventional orthoses in terms of kinematics and kinetics of gait and measuring energy expenditure. However, in our case study a mixed result was found. Except cadence and walking velocity, molded orthosis improved all other parameters compared with the conventional one. Since cadence multiplied by step length results in walking velocity or speed, the increased cadence in previously acquainted conventional orthoses resulted in increased walking velocity though the difference is not significant. Molded orthosis offers better design, stronger support, increased durability, and improved cosmesis. It is desirable for the materials to conform to the body shape and absorb or store elastic energy that can be returned during the gait cycle. In molded orthosis, a system of 3- or 4-point force control systems was used to provide orthotic control contrary to point forces in conventional one. The efficacy of an orthosis in controlling or correcting motion is influenced by the distance between the joint axis and the point of force application. The contour of the orthosis and the degree of tightness of the straps necessary to secure the orthosis determine the magnitude of the forces and pressures applied to the soft tissues. At the patient–orthosis interface, stability and comfort are achieved by having the force distributed over a large area to reduce pressures, which is evident in a molded one. The above-cited reasons may have resulted in improved parameters in molded orthosis compared with conventional design.



Graph 3: Graphical representation of kinetic parameters: Molded

The oxygen cost of walking is widely used as a measure of gait efficiency.[13] The PCI data revealed that the molded orthosis resulted in less energy-consuming gait. The reported reduction of the oxygen cost of walking as the result of wearing an AFO or KAFO or using crutches indicates a more efficient gait and could result in decreased fatigue and increased levels of daily physical activity. Moreover, the subject response was he was feeling comfortable while walking with molded orthosis than conventional and barefoot walking. This may be due to the fact that the conventional orthosis is 0.5 kg heavier than molded ones, and it's a well-understood fact proven by earlier researches.[14] The difference in PCI values between bare foot and orthotic invention may be due to limitation of exaggerated motions and minimal displacement of center of gravity while using orthosis.[8] Molded orthosis was made sufficiently rigid for sustaining the heavy weight of subject which stabilized all joints, controlled unwanted motions, and resulted in energy-consuming gait compared with the conventional one. The results of an earlier report suggest that patient energy cost might be reduced by the proper choice of orthotic stiffness.[15]

However, being a single case study analysis, it has been subject to a number of criticisms, the most common of which concern the inter-related issues of methodological rigor, researcher subjectivity, and external validity. It would be beneficial if the study were of a higher quality and included more statistical analysis; however, this study demonstrates the desperate need for higher quality studies to be produced regarding bracing the lower extremities in children with myelomeningocele.

CONCLUSION

It can be concluded that in children with lower lumbar level myelomeningocele, the use of orthoses can help improve sagittal gait kinematics and increase walking speed and kinetics of lower limb joints more so than without the use of orthoses. Though molded orthosis is a better option than its conventional counterpart in low lumbar myelomeningocele, a follow-up is necessary to check the best orthotic solution for the individual subject. Further research should include outcome measures of walking capacity and performance and a test-specific hypothesis regarding the design of the orthosis or their combination.

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