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INSTRUMENTED GAIT ANALYSIS AND ORTHOPEDIC MANAGEMENT OF CHILDREN WITH SPASTICITY

ИНСТРУМЕНТАЛЬНЫЙ АНАЛИЗ ПОХОДКИ И ОРТОПЕДИЧЕСКОЙ КОРРЕКЦИИ ДЕТЕЙ СО СПАСТИЧЕСКОЙ ДИПЛЕГИЕЙ

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Clinical gait analysis in this paper is the systemic assessment of human locomotion through objective documentation of gait patterns. The purposes of gait analysis are to document an individual's gait peculiarities and to evaluate the correction treatment of gait abnormalities in patients with spasticity, spasticity being the most common manifestation.

Key words: *motion analysis, gait, spastisity.*

Клинический анализ, описанный в статье, является системной оценкой движения методом объективной регистрации различных характеристик походки. Целью анализа является определение индивидуальных особенностей походки и обоснование лечебного пособия для коррекции нарушений ходьбы у больных спастической диплегией, как наиболее часто встречающейся патологии.

Ключевые слова: *анализ передвижения, походка, спастическая диплегия.*

1. Introduction

Observation has been a useful part in clinical gait analysis in the past. However, observations involving the human eye alone are not very reliable. It is difficult to observe multiple events occurring during locomotion, especially when some of these events can happen within a fraction of a second. There was a need for a system that could measure the motion of human gait. Quantitative gait analysis is an important clinical tool for quantifying normal and pathological pattern of locomotion, and has been shown to be useful for prescription of treatment as well as in the evaluation of the results of such treatment. The data acquired during the clinical gait analysis include relative positions and orientations of body segments, foot-floor reaction forces, temporal-distance parameters, and phasic activity of muscles of the lower extremities.

Symptoms of spasticity lie along a spectrum of varying severity. The symptoms differ from one person to another, and may even change over time in the individual. In spasticity, the muscles are stiffly and permanently contracted. Spasticity child has normal intelligence, near normal upper-extremity function and virtually pure spastic involvement. The pattern of gait in spasticity and total body involved patients are similar in type and differ mainly in the severity of impairment. The typical gait of children is one of flexion, adduction and internal rotation at the hips, and flexion at the knees. The feet usually have a valgus hindfoot and a supinated, abducted forefoot. The children usually walk with a toe-toe or toe-heel gait. In swing phase we can observe that flexion-extension range is significantly constricted. In terminal swing the restriction of full knee extension produces a short step whereas abnormal pre-positioning of the foot sets the stage for instability in stance as soon as the next gait cycle begins. The children with spasticity have mostly spastic muscle problems, and most of the involvement is in the legs, but the children may also have a smaller component of athetosis and balance problems [4].

Joint kinematics includes variables used to describe the spatial and temporal movement of patients with spasticity. These include linear and angular displacement, linear and angular velocities and angular and linear accelerations in the three dimensions.

2. Material and method

Motion analysis was performed using video motion analysis system with eight cameras (Motion Analysis System). The results of three-dimensional accuracy and resolution (static and dynamic) showed that the system has a composite accuracy of $\pm$ 0.14 mm [5]. The experiment was conducted on eight children with spasticity (age range of 8-15 yr.) in Glenrose Rehabilitation Hospital in Edmonton (Canada). Prior to recording the gait patterns, the height, weight, lower limbs length, knee width, and ankle width of each subject were measured. Five sets of gait data were collected over 3 m portion of the 12 m walkway. Gait movement has been detected using passive markers placed on representative points of the subject. Some of them were "static markers", which means that they were used for the static trial only. Markers on the human body were put as follows: two on the Posterior Superior Iliac Spines, one on the Sacrum Bone, two on the Lateral Femoral Condyles, two on the Lateral Malleoli, one on the wrist. Ground reaction forces were collected with two force plates (AMTI) staggered along the walkway. Gait parameters (velocity, cadence, single stance, time, etc.) were calculated for each run using foot switch data. Both right and left limb data were grouped separately. The children with spasticity showed dysfunctions as below:

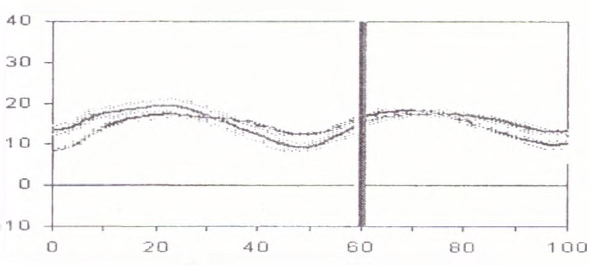
- tight hip flexors, left >right,
- tight hip adductors, left >right,
- hip internal rotation greater than external rotation, more on the left, due to increased femoral anteversion,
- left knee flexion contracture ~ 5°,
- tight hamstrings bilaterally,
- tight gastrocs and soleus, left >right,
- muscle tone (modified Ashworth scale):
- grade 3 hamstrings bilaterally,
- grade 2 left quadriceps and left gastrocs,

- grade 1 right gastrocs, right quadriceps and adductors bilaterally,
- ankle clonus was present bilaterally.

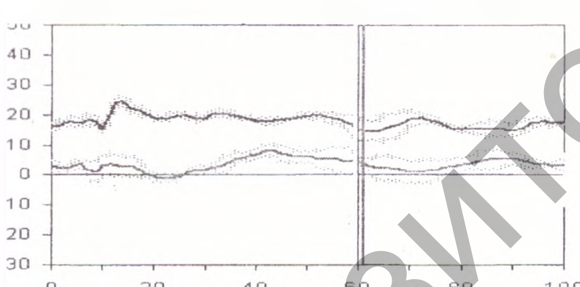
There was weakness in the left hip abductors; hip extensors, hamstrings, and ankle dorsiflexors were weak bilaterally. Velocity was reduced (73% of normal) due to a combination of reduced cadence (90%) and stride length (81%). There was good symmetry in step lengths and toe off times.

3. Results

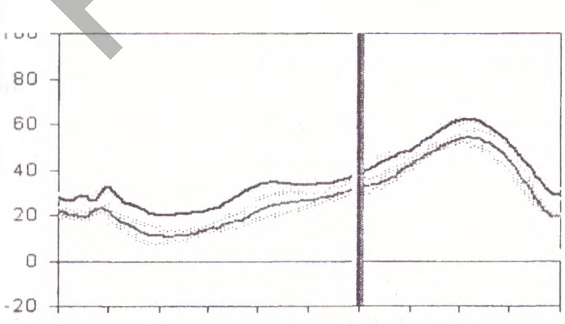
The kinematics data of children with the diagnosis of spastic diplegia are presented in Fig.1-4. There was a double bump in the sagittal plane, which implies a lack of dissociation between the pelvis and femur. In Fig. 1 the kinematics of pelvis is presented. The red line presents the data of right leg, the blue line presents the data of left leg. The green line presents the data for normal patients.

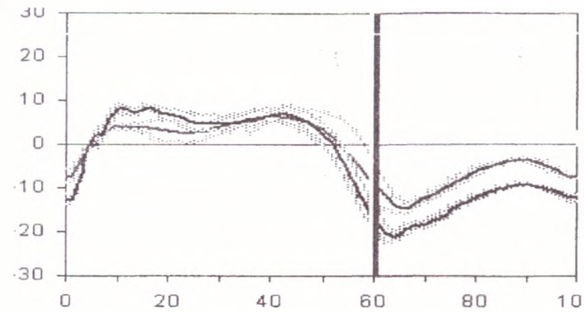


In Fig.2 is presented the kinematics of hip.



There is internal hip rotation on the left. There is the kinematics of knee (Fig.3). Knees are flexed bilaterally at initial contact. Knee position at toe-off is within normal limits. Toe-striking is evident bilaterally. There is reduced dorsiflexion in swing bilaterally. Rapid dorsiflexion due to toe- striking is causing large plantarflexion moments to be created by the gastrocs/soleus. This mechanism creates an associated power absorption/generation wave.





The children had a surgical treatment such as:

- bilateral psoas recessions at the brim,
- bilateral hamstring lengthenings,
- left femoral derotation osteotomy.

Lengthenings were not recommended, for the following reasons: because of the concern that this procedure may encourage a crouched position, due to potential muscle weakness resulting in the lack of ability to generate a plantarflexion moment. The observed lack of heelstrike is likely to be due to the flexed knee position at ic.

4. Conclusion

Gait Analysis is a good tool for the documentation of human movement. This is of particular importance given the current health care climate. Quantification of human motion by the measurement of joint motion, created by and acting upon the body can be precisely recorded and evaluated. These measurements may be coordinated in time to allow comparison between modes of evaluation, creating an accurate assessment of the patients ambulatory ability. It also provides the information from which a treatment recommendation may be made to enhance the subnormal gait patterns evident in these children. A systematic approach of performing routine pre-and postoperative gait analysis can lead to increased comprehension of the mechanics of gait abnormalities. This type of examination will lead to improved treatment decision-making. Although the use of computerized gait analysis is relatively new addition to routine treatment evaluations, it has already had a profound effect on treatment protocols, especially in orthopaedic treatment decision in patients with neuromuscular disorders. Increasing understanding of gait pathomechanics in many different clinical problems has led to more informed treatment decision-making, which is ultimately based on the philosophy of the treating physician.

References

[1] Pauk J., (2002): Identification of human gait model, Conference Proceedings Biomechanics of man, pp.127-129.

[2] Frigo C., et al., (1998) Functionally oriented and clinically feasible quantitative gait analysis method// Medical & Biological Engineering & Computing.- Vol.36, (2).- pp.179-185.

[3] Perry J., (1992): The gait cycle, in gait analysis: Normal and pathological function. Thorofare. NJ. Slack. Inc., pp.3-7

[4] D.H. Sutherland, (1984): Gait disorders in childhood and adolescence. Williams & Wilkins, Baltimore, USA, pp.135-151

[5] Pedotti, A., Ferrigno, G., (1995): Optoelectronic-based systems. Three-dimensional instrumentation, Three-dimensional analysis of human movement, Human Kinetics Publ., Champaign Il. pp.57-77.

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