BIOMECHANICAL CHARACTERISTICS OF FUNCTIONALITY OF THE CERVICAL SPINE IN CASES OF ROTATORY SUBLUXATIONS OF C1-C2 VERTEBRAE IN CHILDREN

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ABSTRACT — The aim of the work is to review with the help of motion capture system the biomechanical characteristics in children who suffer recurrent rotatory subluxation of C1–C2 vertebrae. Subjects of the study were adolescents with a recurrent subluxation of a cervical spine (5). The control group consisted of 22 conditionally healthy adolescents. The study was carried out with the help of "Vicon Motion Capture" motion capture system as well as the AMTI stabilometric system. An individual three-dimensional skeletal model was constructed for each subject that allowed studying the volume of movements of the cervical spine in the stepping cycle. The analysis of digital data, which were presented in the form of diagrams in the Vicon Polygon program, was carried out. There were revealed the changes in the dynamics of rotatory movements of the cervical spine in a single-stage. The data analysis and monitoring of the dynamics of indicators with the use of the innovative motion capture system Motion Capture will allow improving the accuracy of diagnostics and effectiveness of therapeutic measures.

KEYWORDS — motion capture, motion capture system, biomechanics of movements, acute torticollis, rotatory subluxation of C1–C2 vertebrae.

INTRODUCTION

Biomechanical investigation in applied medicine is the field where anatomic-functional distinctions of the skeleton of the growing body are revealed. Fundamental and applied investigations provide opportunities that are used for this purpose and the implementation of modern computer-aided systems gives the essential perspectives.

Nowadays the developed countries have the standards of biomechanical investigations that require the video-analysis of the motion to be made. The innovative methods of motion capture are being introduced due to this fact. It allows having the absolute digital characteristics of linear and angular kinematics of limb joints to be studied, the skeleton in general and the character of walking. The analysis of the findings can both indicate the characteristic features of the skeleton and reveal the diagnostic and prognostic index in different diseases of locomotor apparatus.

The syndrome of acute torticollis which arises from the displacement in segment C1–C2 is often observed in the infant orthopedics surgery. Most children have recurrent pathology and it is combined with hypermobility of different joints and it can be the system dysplasia of connective tissue (SDCT). System dysplasia of connective tissue (SDCT) is an abnormal development of a child which arises from the genetically determined development disorder of peridesmium during prenatal and postnatal periods which results in underdevelopment of different organs and systems. [1, 2]. The prevalence proportion of SDCT in population varies from 48, 5% to 80% [4, 3, 5].

The children population with the above pathology is increasing and it initiates to search the etymological factors as well as the anatomic–physiologic factors with the help of modern technologies.

The publications devoted to the investigation of the change in the motor function of unstable cervical spine where the modern method of motion capture is used have not been found in the resources available.

Objective: to obtain the biomechanical characteristics of the motor function of cervical spine in the gait cycle of children with the recurrent incomplete dislocation of C1–C2 vertebrae with the help of *motion capture*.

MATERIAL AND METHOD

The target was 5 adolescent girls (8–11 years old) with recurrent incomplete dislocation of cervical spine. The model study was performed on 22 healthy female infant and adolescent subjects. The research was performed in the follow-up mode during the gait. Plug-in-gait Fullbody model was used in the research. The subjects were offered to make the sequence of 7 goings on the force platform. The monitoring of biomechanical parameters was performed using the systems of capture and of movement analysis Vicon (Vicon, Oxford, Great Britain) which include 10

IR cameras Vicon N40, two-section force platform AMTI (model OR6-5-1000, Watertown MA, USA) and software Vicon Nexus and Vicon Polygon. The research subject was the angles of flexion-extension, lateroflexion and the rotation cervical spine.

RESULTS

Under normal condition the movements in the sagittal plane (flexion-extension) are characterized by two highest points of maximum value of flexion: one is in the stance and one is in the swing phase. The highest maximum is shown in the swing phase when the bodyweight is held on the contralateral limb (76% of cycle time). The highest maximum of flexion in the stance coincides with the swing of the contralateral limb (26% of cycle time).

Consequently, the maximum value of the flexion in the gait cycle corresponds to the stages of single support; herewith the maximum value of flexion conforms to the stage of single support of contralateral limb. In the gait cycle of the study group two maximum values of flexion were differentiated. However, their beginning happens by 15% of time cycle earlier than in the norm (in the stance it is 15% of time cycle, in the swing phase it is 59%). In the stance the decay of flexion amplitude (in the norm it is 1,18° ± 0,26, in the study group it is 0,44° ± 0,13) is observed but in the swing phase the increase of flexion amplitude (in the normal condition it is 0,38° ± 0,23, in the study group it is it is 0,99° ± 0,33) is observed. During the whole gait cycle the angle of flexion is increasing; in the stance it increases by 3,98° ± 0,45, in the swing phase it increases by 3,31° ± 0,58.

In the normal condition there are two highest points of maximum values of lateroflexion in the stance and in the swing phase. In the stance these maximum values go to the beginning (10%) and the end of the single-support phase (40%). In the swing phase the maximum value of lateroflexion conforms to the beginning (10%) and the end of the single-support phase (40%). In the swing phase the maximum value of lateroflexion conforms to the beginning of the phase the toes of the "leader" foot are losing contact with the support — 60%) and the upright stance of the lower leg of the "leader" leg which in turn correspond to the beginning and the end of the single-support phase of the contralateral leg. The minimum values of lateroflexion conform to the middle of the single-support phase (75%). The study group demonstrates the increase of the total amplitude of lateroflexion 0,23° ± 0,12 with the respect to the norm (Fig. 1). In general, the increase of lateroflexion to the left by 1,05° ± 0,36 was observed in the stance and the swing phase.

In the normal condition the gait cycle demonstrates one highest point of equal maximum values of rotation in each phase. These highest points are in the middle of single-support phase in the stance (30%) and in the swing phase (75%). In the stance the rotation of the cervical spine is directed to the leg responsible for the transfer. The initiation of the gait cycle is usually considered to be the moment of the initial contact of the *leader* foot with the support plate. Then the phase of the "leader" foot support follows (0–60% of the gait cycle). In this phase the rotation is directed to the transferring foot. The phase of its transference starts since the toes of the leading foot lose contact with the support (60%). In this phase the rotation is directed to the leading foot.

The corresponding peaks of maximum values of the rotation in the single-support phase are observed in the study group. However, on contrast to the norm group the decay of rotation movement amplitude takes place. In comparison to the norm the decay of rotation angle to both sides by 1,44° ± 0,38 is observed.

The study group demonstrated the change in the dynamics of rotation movements in the single-support phase. In contrast to the norm group where the rotation value in the single-support phase towards the foot responsible for the transfer was increasing smoothly, the study group demonstrated the highest points of rotation towards the support foot in the beginning and the end of the single-support phase.

CONCLUSION

1. The method of motion capture allows obtaining the distinctive biomechanical characteristics of gait among children with malfunction of cervical spine.

2. The study group demonstrated the changes in kinematic parametres in comparison to the data obtained in the norm group. The monitoring survey of the changes in the parametres in comparison to the data obtained in the norm group allows evaluating the function of cervical spine which in return increases the accuracy of diagnostics and the efficiency of treatment.

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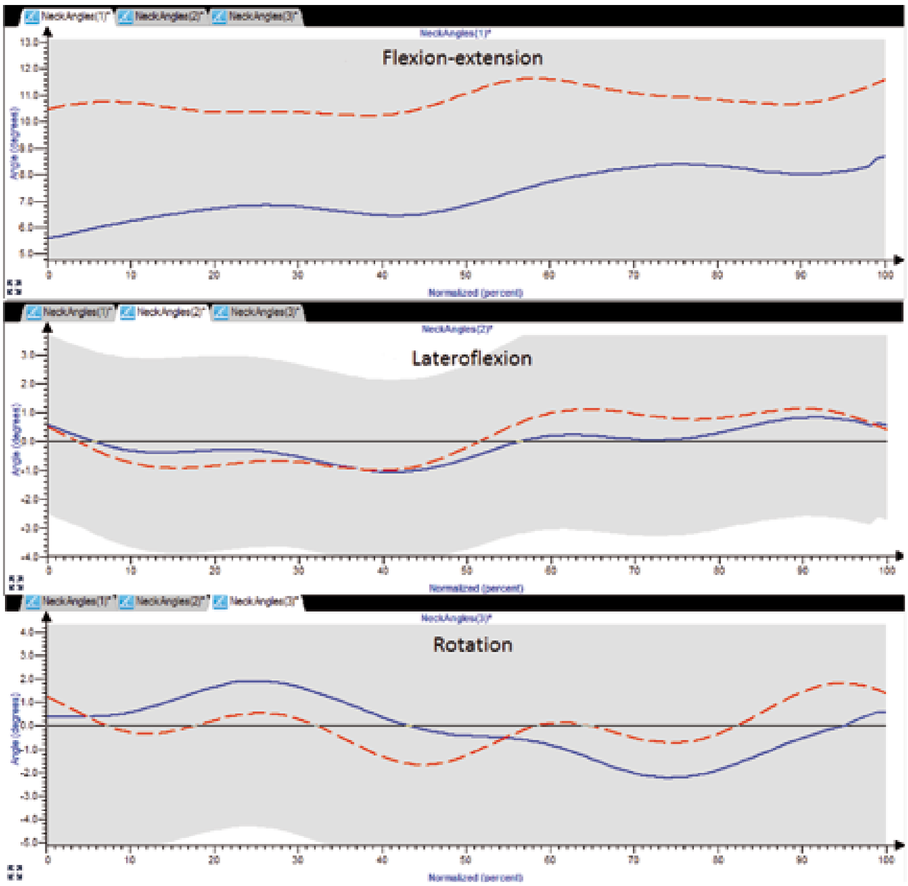

Fig. 1. The range of motion of cervical spine in the gait cycle (blue curve – norm group, red curve – the study group)

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