The modelling and experimental research of children with neurological disorders

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1. Introduction

Neurological disorders of children are very serious problem in the modern world. Early detection and appropriate treatment of children with neurological disorders allows to reduce these disorders. Thanks to modern diagnostic methods it is possible to objectively assess such gait parameters, postural stability or the electrical activity of muscles, and also tracking changes of these quantities during the rehabilitation process. Along with the experimental research, the mathematical modeling is also used, which is a supplement to diagnostic and monitoring.

2. Methods

The research was undertaken to determine the forces generated by muscles during the gait of seven healthy children and children with neurological disorders and after the neurosurgery (Table 1) by using a mathematical model of the lower limb and to assess the electrical activity of muscles of these children using a BTS Pocket EMG kit.

Table 1 Research group of seven healthy children and children with neurological disorders

<table>
<thead>
<tr>
<th>Healthy children</th>
<th>Child after the neurosurgery</th>
<th>Child with right-sided hemiparesis 1</th>
<th>Child with right-sided hemiparesis 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age [years]</td>
<td>14-17</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Height [cm]</td>
<td>155-171</td>
<td>164</td>
<td>160</td>
</tr>
<tr>
<td>Weight [kg]</td>
<td>40-60</td>
<td>37</td>
<td>51</td>
</tr>
</tbody>
</table>

The research was conducted in the Silesian Center of Child's Health in Katowice, using an integrated BTS Smart system for three-dimensional motion analysis. The system consists of 6 optoelectronic cameras recording motion with frequency 250 Hz during the measurements, two dynamometric Kistlers platforms, two video cameras, a surface electromyography kit BTS Pocket EMG, passive markers, and a computer with software. Electrical activity of muscles during the gait process was recorded for four muscles (*m. gastrocnemius, m. tibialis anterior, m. rectus femoris, m. biceps femoris*) of both limbs.

Fig. 1 Mathematical model of the lower limb

1 – *SOL m. soleus*
2 – *GAS m. gastrocnemius*
3 – *TA m. tibialis anterior*
4 – *BF l m. biceps femoris caput longum*
5 – *BF s m. biceps femoris caput breve*
6 – *VAS m. vastus*
7 – *RF m. rectus femoris*
8 – *IL m. iliopsoas*
9 – *GMAX m. gluteus maximus*
Identification of the forces generated by the muscles was carried out with the use of the mathematical model of the lower limb [1,2]. Numerical computation is carried out on the basis of the inverse dynamics task. Kinematic quantities describing the motion of the limb and ground reaction forces necessary to perform the calculations are obtained during the experimental measurement using the BTS system. The mathematical model used in the calculation consists of three rigid elements (corresponding to the femoral element, the lower leg and foot) joint into the kinematic chain, loaded with the forces of gravity, inertial force and the forces resulting from contact with the ground and foot. The model includes nine muscle groups responsible for driving and implementing of the movement in the sagittal plane during the gait process (Figure 1). The values of the forces generated by the muscles are determined by the use of optimization methods.

3. Results
Exemplary sEMG results of measurements and numerical calculations are presented for the child after the neurosurgery (Figure 2). Analyzing the results one can observe compatibility between muscle activity during the gait cycle obtained from numerical calculations and sEMG measurements.

![Fig. 2 The raw sEMG signal, filtered, rectified and smoothed (RMS) sEMG signal and muscle forces in relation to the body weight for the child after neurosurgery.](image)

4. Summary
The methodology of experimental and model research, applied in the research work, allows to perform the diagnosis of musculoskeletal system and locomotor function of the subject. Application of calculations by using a mathematical model, allows to determine the loads of musculoskeletal system, enhances and complements the results of experimental measurements.

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5. References