EFFECT OF THERAPEUTIC RIDING ON THE COORDINATION OF MOVEMENTS OF DOWN-SYNDROME CHILDREN

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ABSTRACT

Purpose. We examined the effect of therapeutic riding on the development of Down-syndrome children. Examination of walking is appropriate for assessing the coordination of movement and for following the changes. We found therapeutic riding should be considered as a new form of habilitation. Pupils of an auxiliary school participated in therapeutic riding. This raised the question how therapeutic riding affects the development of motion, so we researched it.

Methods. We selected riding and non-riding children and conducted walk analysis one month before and after therapeutic riding to follow the changes in their coordination. We chose to analyse walking. We used four video cameras from four different views. We processed the data by the APAS video analyser system. We used the Dempster model. For the construction of the model we conducted anthropometric measurements. This method made it possible to follow the movements of the selected points of the body in three dimensions. Statistical analysis was based on T-probe.

Results. We found significant differences between test and control groups. In the case of the children who participated in therapeutic riding several parameters were similar to the same parameters of healthy children. Their gait asymmetry and hip-motion asymmetry was decreased. We made several movement analyses of the same group and these data were compared.

Conclusion. According to our results therapeutic riding may be successfully used as an additional therapy for Down-syndrome children and it may present a form of habilitation in cases when other means of therapy are not successful.

Keywords. Therapeutic riding, Down-syndrome, hip - motion asymmetry, asymmetry, coordination of movements.

1. INTRODUCTION

Before the description of the measurements, it must be writes about biomechanics of gait, and Down syndrome Hip

The hip in Down syndrome is retroverted, with excessive external rotation both in flexion and extension, resulting in out-toe gait. Five percent of children with Down syndrome develop a dislocatable or dislocated hip. These children are usually delayed in walking; their hips are hypermobile but not dislocatable until at two to four years of age, the affected hip spontaneously becomes dislocated and relocated. Presenting complains are a click in the hip, an increasing limp or "giving way," and refusal to walk With recurrent dislocation, physical activity diminishes. The dislocations are not painful. If untreated, eventually subluxation or dislocation may become fixed. The recurring dislocated hip is usually treated surgically.

Atlantoaxial Instability

Atlantoaxial instability is an established entity in Down syndrome

It occurs in 10% to 20% of these patients. Atlantoaxial instability in Down syndrome is caused by ligamentous laxity of the transverse ligament that holds the odontoid process close to the anterior arch of the atlas. This instability results in loose joints, where the cervical vertebrae slip forward and the spinal cord is vulnerable to compression.

The neurologic manifestations of spinal compression are fatigue in walking, gait disturbance, progressive clumsiness, incoordination, spasticity, hyperflexion, clonus, and toe-extensor reflex. Onset of neck pain, headache and torticollis are indicative of malposition of the odontoid.

Motor Development and Gait
Children with Down syndrome show a longer period of stance than independent walkers, comparable to that of the supported walking of infants. There is a decrease in hip extension and early hip extension near the end of swing. This is seen as an attempt to make a flatfoot contact instead of the initial heel contact. There is a decrease in ankle sagittal plane rotation, and exaggerated abduction of the swing limb appears to be necessary for foot clearance. There also appears to be a relationship between sitting patterns and gait patterns of children with Down syndrome. Clinical observation suggests that children with Down syndrome usually have excessive external rotation and abduction of the hip, demonstrated by their sitting with widespread legs, and this excessive external rotation and abduction is displayed when they learn to sit. The wide-angled gait is caused by marked hip retroversion, genu valgum of the knee, external tibial torsion, and excessively pronated feet. It has been proven that ambulation performance, including balance and jumping, can be significantly improved in children with Down syndrome with even minimal physical therapy sessions, such as jumping classes. This type of therapy should be encouraged.

Considerations In the Correction of Congenital Deformities

Early detection and treatment of congenital pedal deformities is important in a child with Down syndrome. Since these children are subject to a multiplicity of orthopedic problems, an aggressive program to maintain proper skeletal alignment can significantly decrease the severity of these problems and allow the individual to function much more efficiently. In a report on management of foot and knee deformities in the mentally retarded, Lindsey and Drennan asserted that "proper alignment of the immature foot will frequently decrease the external rotation of the limb and result in development of a more appropriate gait pattern." Rather than being aggressively treated, many of the common congenital deformities, such as metatarsus adductus and tibial torsion, are overlooked because of the patients' many other medical and orthopedic problems, and no treatment is rendered. The treatment modalities used in the correction of congenital foot and torsional abnormalities in the child with Down syndrome are the same that would be used in the normal patient. These include serial immobilization casting, corrective shoes and splints, and surgery. Due to the prolonged excessive ligamentous laxity and the relatively slower foot growth, corrective modalities often are required for longer periods of time in the child with Down syndrome. Immobilization modalities that impede walking, such as plaster casts or restrictive splinting, should be avoided in the older child, since these can further delay the progression of neuromotor development in a child that already will exhibit a significant delay in learning to walk. The use of properly modified corrective shoes should be encouraged when correcting foot pathology in children with Down syndrome who have progressed beyond the states of sitting independently and crawling. Reduction of Out-Toe Gait and Genu Valgum

2. METHODOLOGY

Our work hypothesis was that if riding changes the coordination of movements in these children it will exert effects on their walking as well. Walking requires coordinated work of many muscles, virtually the whole body. Execution of these complex movements requires not only appropriate development of the muscular and the osseous systems but it requires adequate control of movements (e.g. faultless working of flexor and extensor reflexes) as well. We started our examinations (with methods learned from foreign experiences) in Budapest.

Criteria of investigation.Subjects had to have the presence of Down-syndrome and their age had to be in the range of 10-13 years. We examined 30 children, but four of them put out of the groups, because of illness (staying in hospital).

<table>
<thead>
<tr>
<th>Features</th>
<th>Children participating in therapeutic riding</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
<td>Down syndrome</td>
<td>Down syndrome</td>
</tr>
<tr>
<td>Age</td>
<td>10-13 years</td>
<td>10-13 years</td>
</tr>
<tr>
<td>Number of children</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Therapy</td>
<td>Therapeutic riding</td>
<td>Exercises: physioball, sitting up, leg raising on wall-bars</td>
</tr>
<tr>
<td>Duration</td>
<td>1 month</td>
<td>1 month</td>
</tr>
</tbody>
</table>

1 The two examined groups

Subjects of investigation. We selected riding and non-riding children and conducted walk analysis before and after therapeutic riding to follow the changes in their coordination. We chose the gait analysis. The pupils of the auxiliary school were examined by the physician of the school and all of them were advised to participate in our investigation. The parents of the 30 children signed an agreement that they would accept the result of the random drawing that formed the riding and the non-riding groups. While the riding group participated in therapeutic riding the other group did their habitual exercises (as before). The physician of the school advised every child to participate in therapeutic riding. Orthopedic doctors radiographed functional cervical radiogram. The parents of
the children decided whether their child should participate in therapeutic riding or not. Our examination is a comparative study of the two therapeutic methods. Before testing subject signed an informed consent form approved by the Policy and Review Committee on Human Research of Semmelweis University, children’s guardians and school.

**Therapeutic methods.** We analyzed two different methods to compare the effectiveness of rehabilitational techniques. The investigated population was divided into two groups. For the control group (group 1) three times a week 1-1 hour of classical kinesitherapy was conducted. In the test group (group 2) once a week the children were trained by special riding for 15 minutes.

**Type of special riding.** As for some aspects western style riding fits best for therapeutic riding. In case of backward children special attention has to be paid to the safety of the riders during therapeutic riding. This requires increased attention and tolerance of the trainer and unconditional obedience of the horse. Equipment used in western style riding

**Gait analysis.** We made video recordings of the walk of the children one month before and after the therapy. The walk was recorded from four views (front, rear, left and right). The video recordings were processed by the APAS (Ariel Performance Analysis System). This system made it possible to present three dimensional kinematics parameters by the analysis of video recordings made in everyday situations

**Equipment for analysis.** We used four video cameras (type: Panasonic M10) from four different views. Sampling frequency was 50 frames/second (sampling rate 0.02 second) with shutter speed of 1/250 second. We processed the data by the APAS video analyzer system (VCR is Panasonic AG-7350, Computer is AST Bravo 486/25). Digitalization of landmarks was made manually (relative digitalization error 3-5%). The system generated the 3D database with direct linear transformation (DLT). We used the software version APAS rev. 6.73. We made smoothing (noise filtering) through quintal spline algorithm (built in the APAS). 2 The equipment for analysis
The validation system. After setting the cameras calibration was performed. For our investigations we used an eight-point calibration parallelepipedon like cubic structure. After the measurement situation was set and recorded the parallelepipedon was removed so as not to bother the children in moving. The coordinates of the eight control points are in the table. The coordinates of the first point are not zero in all three dimensions because we shifted the coordinates in relation to a virtual origo to enable easier visualization of the data (none of the coordinates fall below zero). The eight points determine the three dimensions of space. The two bolded black marks indicate a 200 cm long section in which the two gait cycle were analysed.

The body model. We used a body model to follow the movements of several points of the body. On processing the data we applied a modified form of the Dempster’s body model that consists of eighteen points and several lines that connect them. The nineteenth point is the centre of mass of the body. The Dempster’s model was modified in the following way. We defined the landmarks, segments, and interconnections of the model. For the construction of the model we conducted anthropometric measurements. The global and local anthropometric data of every child were taken into consideration (segment lengths, relative body masses, radiiuses of gyration). Height and body weight were measured and the partial centres of mass of the body segments were calculated. The final model was constructed after using these data. This method made it possible to follow the movements of the selected points of the body in three dimensions.

3 Control points and the Dempster Body-model

Statistical analysis. The basic of statistical analysis was T-probe. We compared the differences between mean values of parameters of selected groups (length of gait cycle). The equality of standard deviation in the statistical populations was controlled by F-probe
3. RESULTS
Data on the coordination of movements of "riding" and "non-riding" children were compared. The data of only 13-13 children were processed because 2-2 children of the groups could not participate in the second measurement series. In the next section the coordination of movements of 1-1 child from both groups will be analyzed.

The headway (x-axis) motion of both legs of the "riding" child was plotted against time (Figure 4-5). The first Figure shows that the two legs were exposed to unequal loading. The child made shorter steps with the right leg and the foot spent longer time on the ground (the straight sections of the curves are longer). The enclosed areas of the two curves are not equal because of unequal loading. The vertical lines indicate the sections of the curve when both feet are on the ground at the same time (double supporting). Asymmetry of motion can be observed. The right leg of the child was weaker than the left. The second Figure indicates that the influence of riding was that asymmetry of the motion of the two legs decreased (the areas enclosed by the curves are nearly equal) and the speed of walking increased (the duration of double supporting decreased).

The headway (x-axis) motion of both legs of the "non-riding" child was similarly plotted against time (Figure 6-7). The areas enclosed by the curves are not equal due to asymmetric loading. The vertical lines indicate double supportings. Asymmetry of motion is clearly visible. No betterment was observed in the walking technique of these children after the treatment. During the second series of measurements higher speed was observed, but the duration of double supporting showed significant increase. There is a seeming contradiction between the higher speed and the longer duration of double supporting (that slow walking) but this can be construed by the worsening of balance and that this balance is corrected by conscious motory control (longer double supporting). The swing phase of the step became quicker and the resultant of these two factors is higher speed.

Figure A

![Graph A](image)

Figure B

![Graph B](image)
In the next step we analyzed the motion of the hip during walking (Figure 5). The three dimensional motion of the hip before the treatment can be characterized in the following way: the motion is performed more or less in
opposite phase but the left side of the hip moves with much greater amplitude during walking. Asymmetry is clearly visible. The three phases of the healthy motion of the hip (supporting, rolling and pushing off) cannot be found because the hip is stiff.

In Figure the motion of the two hips is compared after therapeutic riding. The two sides moved more symmetrically than before. The shape of the curve changed because one component of the healthy step cycle appeared in the motion of the hips. Figure shows the motion of the hip of a healthy child of similar age. The three phases of motion can be followed and identified (0.5–1.0 sec). Its appearance is like the inverse of the first Figure because a Down-syndrome child does not step on the ground quickly like healthy people do. This difference is compensated with a quick pushing off.

The analysis of the motion of centerogravity shows the balance of the gait. In two dimension measurements (x and z) the centerogravity often moves with bigger amplitude.
Analysis of the motion of the shoulder and the hip axes gives insight into the motion of the spine and the motion of the hip and the shoulder of the same side (Figure 11-13). Before treatment the hips moved stiffly while the shoulders made significant excursions during the step cycle. The stiffness of the hips is compensated with the movements of the shoulders (0.5–1.0 sec). After therapeutic riding we observed that the hips and the shoulders moved in the same phase (the hips and shoulders of the same side moved together) because the turning of the trunk that helped walking. The amplitude of the excursión of the two hips increased and were nearly equal. The hips and shoulders of a healthy child move in the opposite phase. With therapeutic riding a transitional condition was achieved that may be further developed.
6 Motion of the hip and shoulder
Figure A riding child before therapeutic riding
Figure B riding child after therapeutic riding
Figure C of non-riding child before therapy
Figure D non-riding child after therapy
Figure E Normal child
Figure A

-100  0  100  200  300  400
1  8  15  22  29  36  43  50  57  64  71  78  85  92  99  106  113  120  127  134  141

Time

Figure B

-100  0  100  200  300  400
1  8  15  22  29  36  43  50  57  64  71  78  85  92  99  106  113  120  127  134  141

Time

Figure C

-100  0  100  200  300  400
1  5  9  13  17  21  25  29  33  37  41  45  49  53  57  61  65  69  73  77  81  85

Time
7 Velocity of feet
Figure A riding child before therapeutic riding
Figure B riding child after therapeutic riding
Figure C of non-riding child before therapy
Figure D non-riding child after therapy
Figure E Normal child

Analysis of the Velocity of feet was given new information from the asymmetry. The right side is weaker, but after the therapeutic riding the asymmetry is nearer the normal gait. (In normal gait we measured a little asymmetry, but statistically it is non-significant.)

When we compared the "riding" and the "non-riding" groups several considerations had to be taken. For the analysis of the coordination of movements we had to choose a parameter that adequately indicates the occurring changes: improvement or relapse had to be followed by consistent changes of the parameter. The parameter had to give information of the extent of hip-motion asymmetry, asymmetry and balance, altogether: the coordination of movements. The length of the steps is considered to be a parameter of this kind (increase of the length of the steps indicates higher speed, better balance and better coordination of movements). As the motion of a Down-syndrome child is asymmetric we measured the length of steps between two supporting phases of one leg by using the selected points of the body model (in cm). The measurements were performed one month before and one month after the therapy. Means and coefficients of variance were calculated. With dual T-probe we checked whether significant changes can be found in the motion of the two sides. Significant increase was detected in the length of the steps of both legs, which indicates better coordination of movements and decrease of hip-motion asymmetry. We measured the same groups for two years and searched the asymmetry of two sides. There are no differences between the sides, like in healthy children (Figure 14-15).
4. CONCLUSIONS

Thus, as we have shown previously, coordination of movements is controlled by several factors. For the development of motion the extent of asymmetry and muscular atrophy/hypotony have to be diminished and appropriate working of muscles and coordination of movements have to be developed. For this purpose special exercises are used to cure muscular hypotony, to help the establishment of normal muscular tension and help to strengthen the "less developed side" of the children. Our parameters help us to control the changes of motion. As you can see in results, therapeutic riding makes better balance, smaller asymmetry, and hip-motion asymmetry. Last but not least it is important to examine the costs of therapeutic riding and how it compares to the costs of other therapies.

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