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THE EFFECT OF REHABILITATION EXERCISES ON THE GAIT IN PEOPLE WITH DOWN SYNDROME

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Abstract: Objective: The following question was set: Do special exercises decrease disturbances of gait in people with Down syndrome and allow for spacio-temporal parameters closer in values to the variables achieved by healthy people? The research involved 10 persons with Down syndrome, including 9 male pupils and 1 female pupil of the Complex of Special Schools in Cracow, Poland, aged 16-22, with the average age of 17.8±2.69. All the subjects had documented moderate and considerable mental handicap, with the average IQ equalling 37.6±4.29, measured in the Terman-Merrill scale. Background: People with Down syndrome have problems with keeping their balance, both while standing and walking. The dysfunction of lower extremities, manifesting itself in a gait different from the norm of healthy people, releases compensation mechanisms levelling disturbances and leading to unavoidable overloads, and in consequence to the damage of different segments of the locomotor system. Methods: Vicon 250, a computerized system of a three-dimensional analysis of motion, connected with five video cameras working in infrared was implemented to assess the parameters of gait. Results: All the spacio-temporal parameters of gait in people with Down syndrome were significantly improved after the period of rehabilitation, and in the case of step frequency equalled the norm of healthy people. Interpretation. The implementation of additional exercises affects the improvement of the gait parameters of mentally handicapped people, suffering from Down syndrome.

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Key words: Down syndrome - Gait analysis - Improving exercises

Introduction

Physical exercises are of great importance in the rehabilitation of the mentally handicapped, including the ones with Down syndrome. Exercises and different motor activities not only develop physical efficiency, but also advance the level of social maturity of the mentally handicapped [5].

The results of the research of Dyer *et al.* [3] show that people with Down syndrome have problems with keeping their balance, both while standing and walking, which is caused by hypotonia and excessive joint mobility. Apart from disturbed balance, postural reactions conditioning the proper development of posture and motor patterns are also insufficient in people with Down syndrome [4,10,13]. Compared to healthy children of the same age, children with Down syndrome show decreased postural tension in their early development. The development of basic motor activities occurs in this unfavourable situation. Although in a later period of time postural tension increases, some motor dysfunctions created during the period of lowered tension remain unchanged.

The dysfunction of lower extremities, manifesting itself in a gait different from the norm of healthy people, releases compensation mechanisms levelling disturbances and leading to unavoidable overloads, and in consequence to the damage of different segments of the locomotor system [12]. The correction of spacio-temporal parameters of gait in people with Down syndrome through the implementation of rehabilitation exercises seems to be an important physical therapy treatment resulting in improved load of joints, smaller energy cost, and higher level of balance, ergonomic posture, increased general efficiency, and improved global physical fitness.

There is no information in the physical therapy literature on the research assessing the rehabilitation effectiveness of gait in the subjects with Down syndrome, especially on the research carried out with the implementation of Vicon, a computerised system of a three-dimensional analysis of motion. In the research carried out so far, the authors compared spacio-temporal parameters of gait in the subjects suffering from Down syndrome with the gait norm of healthy people [6]. The consecutive stages of analyses presented in this paper concerned the preparation of a set of corrective exercises, their implementation and examination, after a year-long application, and their influence on the parameters of gait in the subjects with Down syndrome. The following question was set: Do special exercises decrease disturbances of gait in people with Down syndrome and allow for spacio-temporal parameters closer in values to the variables achieved by healthy people?

Achieving improved results and getting the gait parameters closer to the norm of healthy people would confirm the usefulness of the set of exercises prepared, and it would convince the persons interested in the matter that due to systematic exercises gait disturbances may be successfully rehabilitated.

Materials and Methods

The research involved 10 persons with Down syndrome, including 9 male pupils and 1 female pupil of the Complex of Special Schools in Cracow, Poland, aged 16-22, with the average age of 17.8±2.69, the average height of 162.3±7.72 cm and the average weight of 68.1±8.70 kg. All the subjects had documented moderate and considerable mental handicap, with the average IQ equalling 37.6±4.29, measured in the Terman-Merrill scale.

Authors took adventage of detaited opinions of school doctor, psychologist and form master to become convinced that involved to the research subjects make possibly homogeneous group. The main condition to be choosen to the experimental group was systematic attendance at obligatory PE classes.

There was carried out an *initial* examination, defining characteristic elements of gait in the subjects with Down syndrome, and the *final* one determining the same gait parameters after a 10-month period of special rehabilitation exercises. *Initial* and *final* examination took place in Biokinetics Laboratory of the Academy of Physical Education in Cracow.

Vicon 250, a computerized system of a three-dimensional analysis of motion, connected with five video cameras working in infrared was implemented to assess the parameters of gait. The gait patterns of the subjects with Down syndrome from the initial and final tests were analyzed and compared with the picture of physiological gait.

Rehabilitation exercises implemented in the experiment:

1. Walking on a 10m-long broad straight line and keeping the balance.
2. Walking on a broad straight line, keeping the balance, and “stepping over” different obstacles placed on the line at different distances one from another.
3. Stepping on small rectangles drawn on the floor on both sides of a straight line.
4. Moving on a strip as broad as the rectangle in exercise 3 above, so that the heel of the forefoot would touch the toes of the back foot.
5. Walking aside, to the right and to the left and putting one foot next to the other.
6. Standing on one leg and raising and lowering the other leg flexed in the knee joint, at first with backing one another up, then without. The same exercise repeated on the other leg.
7. Standing on one’s toes and returning to the initial position.
8. “Cockfighting” while standing on one leg.

9. Rotating around one's axis and stopping at a signal.
10. Maintaining the position of a "stork".
11. Standing on one leg and putting an item under the knee of the other leg, flexed and raised, then the change of the leg.
12. Marching on a straight line (10m-long) and maintaining the proper body posture.
13. Marching on all fours with a pouch on one's head.
14. Running with raising knees high.
15. Walking on the broad side of a gym bench.
16. Walking backwards on the broad side of a gym bench.
17. Walking on a gym bench and avoiding obstacles placed on the bench.
18. Walking on the narrow side of a gym bench.

All the above mentioned exercises were carried out under the supervision of a PT or a PE teacher, 2 times a week within the period of one school year, and each session lasted 45 minutes. Simultaneously with doing rehabilitation exercises, the research group with Down syndrome took part in obligatory PE classes.

Results and Discussion

Historically speaking, in gait there were distinguished some characteristic movements of the segments of the body called gait determinants [11], whose lack or limitation result in the increase of energy expenditure of gait. For example, a simultaneous loss of two gait determinants causes a three-time increase of energy cost [1].

Nowadays, there are also considered other gait factors, allowing for detection of pathological patterns in cooperating links of a bio-mechanism [7,14,15]. Basically, a bio-mechanism can be divided into two functional parts: the locomotor (lower extremities and the pelvis) and the passenger (trunk, head and upper extremities) [9]. Vital interdependencies occur during gait between both parts of the bio-mechanism. This paper shows selected values of important factors affecting the proper work of the locomotor in people with Down syndrome, registered in two research sessions between which the subjects were rehabilitated.

Three-dimensional pelvic angular changes were selected for analysis (Pelvic Rotation, Pelvic Obliquity, Lateral Shift), as well as the angular changes in the hip, knee and ankle joints in the sagittal plane (Hip Flex/Ext, Knee Flex/Ext, Ankle Dorsi/Pla), and the general rotation of the whole lower extremity in a normalised gait cycle (Leg Int/Ext Rotation). The pelvic movements were considered against a moving system of coordinates, connected with the body of the subject, while the remaining angles were defined between the analysed segments of the body.

A comparison was then made with the values of analogous determinants of gait observed in the comparative group of healthy people. The results observed allow to notice objective changes of the motion pattern in people with Down syndrome, its transformation under the influence of implemented exercises and differences with analogous parameters characterising the gait of healthy people.

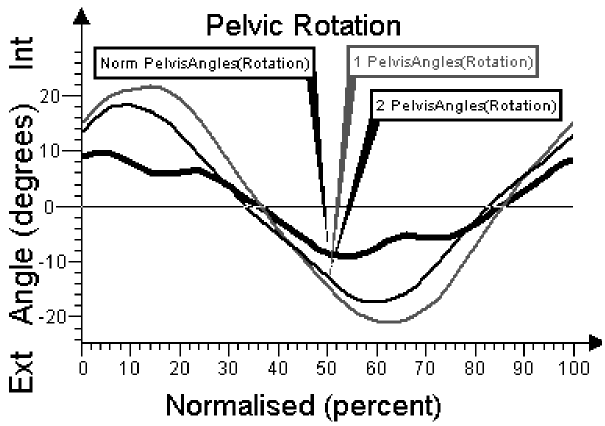

Fig. 1
Pelvic rotation

At the moment of putting the back leg forward, the pelvis follows this motion and moves slightly forward too. It shows rotation in the transverse plane by approximately 9° forward and about 9° backward, which are 18° in total. The motion occurs in both hips. Due to the pelvic movement, the hip of the back leg positions itself in external rotation towards the pelvis and the hip of the supporting leg in internal rotation. The rotation of the pelvis results in elongation of gait.

The analysis of pelvic movements in the transverse plane indicates almost a two times greater range of motion in the subjects with Down syndrome as compared to healthy people. In examination two the pelvic rotation decreases by approximately 6.5° (Fig. 1).

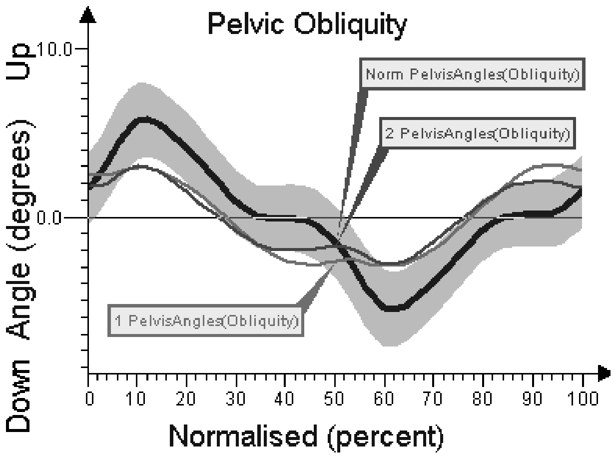

Fig. 2
Pelvic obliquity

At the moment of commencing swing, the pelvis lowers on the back side, which causes a relative abduction on the side of the back leg, and a relative adduction of the hip on the supporting side. The dropping of the pelvis on the back side forces the flexion of the knee joint during the swing phase, which protects the foot against hooking with toes on the surface. Due to the pelvic obliquity, the raising of the body's centre of gravity becomes considerably reduced. A similar angular value was noticed in the subjects, in both initial and final examinations, equalling about 6°. It should be emphasized that in the comparative group the pelvic obliquity reaches values almost two times higher (Fig. 2).

The subjects with Down syndrome show a considerably higher value of the pelvic obliquity in comparison to the comparative group. The pelvic obliquity in the research group (Table 1) was two times higher in examination one (about 85 mm), and in examination two by approximately 40% greater as compared to the results achieved in the comparative group, which causes a significant increase of the amplitude of motion of the centre of gravity aside. In examination two, the value of oscillation decreased by 17 mm on average, which shows to a considerable improvement of the energetics of gait. To sum up, the movements of the pelvis show a tendency towards increasing rotation and movement aside at restricted obliquity in the frontal plane. All the compensations aim at keeping the body's centre of gravity in gait in a line as straight as possible, which points to a tendency to a possibly small energy consumption [2].

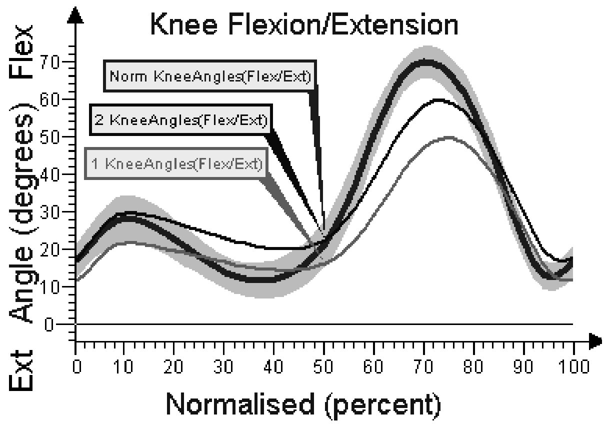

Fig. 3
Angular changes in the knee joints during flexion and extension in the sagittal plane

The flexion of the knee joint in the absorption phase results in lowering of the body's centre of gravity, which causes oscillation towards the vertical axis. The first examination of the subjects with Down syndrome showed considerably smaller values of the knee joint flexion in relation to healthy people, while in the other examination the flexion of the knee joint in the absorption phase increased by 8° (Fig. 3), and the curve of angular changes as for this phase occurred within the norm.

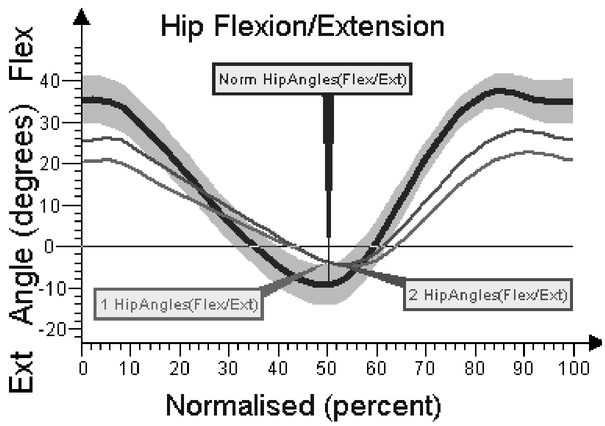

Fig. 4
Angular changes in the hip joints during flexion and extension in the sagittal plane

In the subjects with Down syndrome flexion and extension of the hip joints in the sagittal plane show significantly smaller range of angular changes than in the control group. The restriction of the range of motion reaches 20° in examination one, and 15° in examination two (Fig. 4).

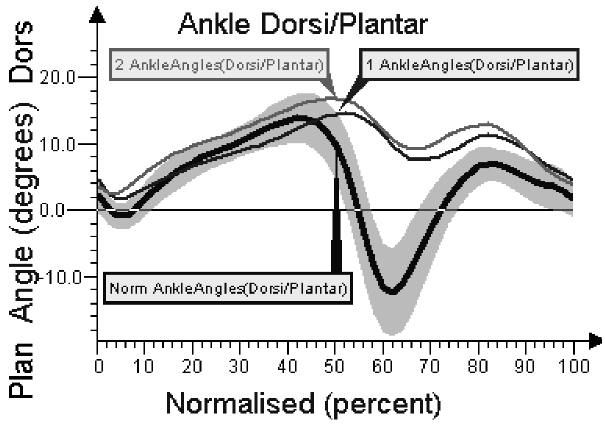

Fig. 5
Angular changes in the ankle joints during plantarflexion and dorsiflexion in the sagittal plane

During the phase of absorption, the foot undergoes dorsiflexion; in the final phase, when it leaves the ground, it quickly moves into the phase of plantarflexion. In the subjects with Down syndrome there was observed a slightly greater, by about 2°, dorsiflexion in comparison to the results of the control group (Fig. 5). The lack of plantarflexion in terminal swing was also noticed. The limitation of movement towards the plantarflexion reached the value of 18°.

The total general range of rotation of the pelvis, of the hip in relation to the pelvis, and the shin in relation to the hip equals approximately 25º [2]. A 63° general rotation was found in the subjects in the first examination, while in the other examination there was noticed a two times greater range of rotation movements of lower extremities and the pelvis in relation to healthy people (Fig. 6). The pelvis had the greatest participation in the general rotation, i.e. from about 42° (examination 1) to 35° (examination 2), while the rotation of the shank remained below the norm (merely 3°).

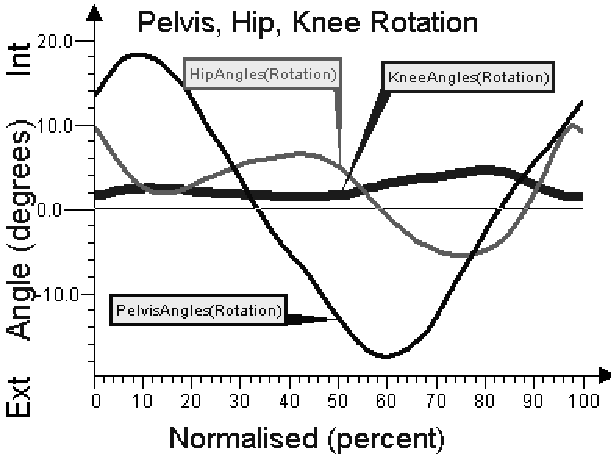

Fig. 6
General rotation of the lower extremity and the pelvis in a w normalized cycle of gait in examination two

Table 1
The range of motion in selected determinants of gait versus the results of the control group

	Pelvic Rotation (deg)	Pelvic Obliquity (deg)	Hip Flex/Ext (deg)	Knee Flex/Ext (deg)	Summary Leg Rotation (deg)	Ankle Dorsi/Pla (deg)	Lateral Shift (mm)
I examination	42.7	5.9	25.8	7.2	63	14.5	85
II examination	35.9	5.8	30.7	9.7	50	16.8	68
Control group	18.4	11.2	44.5	16.6	25	13.8-12.5	44

Table 2
Average spacio-temporal parameters of the subjects with Down syndrome in examination one and two

Spacio-temporal parameters	Down syndrome average I examination	Down syndrome average II examination	Physiological norm average (L and R)
Step length	0.37±0.11 m	0.43±0.12 m	0.69±0.045 m
Cadence	103±25.3 steps/min	114±20.6 steps/min	113±9.68 steps/min
Walking speed	0.64±0.25 m/s	0.83±0.30 m/s	1.30±0.14 m/s
Single support	0.41±0.08 s	0.39±0.059 s	0.47±0.022 s
Double support	0.42±0.31 s	0.32±0.14 s	0.19±0.025 s

To sum up the analysis of spacio-temporal results of gait, one can explicitly say that significant differences in gait patterns were revealed between examination one and examination two in the subjects with Down syndrome, and also between examination one and two and the physiological norm. The implemented exercises resulted in a significant improvement of spacio-temporal parameters as for the length of step, the speed of gait and the phase of single and double support. The frequency of step after the period of rehabilitation was distinctly improved and coincided with the norm of healthy people.

Parker and his co-workers [8] examined the rhythm and length of step in children with Down syndrome and healthy children, and the results showed significant differences in the gait patterns between the two groups. The observed differences concerned step length, shortened stance phase connected with unsteadiness and impossibility of increasing step length. In our examinations we observed similar results in the subjects with Down syndrome. Step length was shorter, both in examination one and two, in comparison to the norm, and the phase of double support was elongated in relation to the physiological norm.

The results achieved clearly encourage introduction of additional exercises improving the parameters of gait in PE classes in special schools, and continuation of further research which would confirm the results achieved and allow to devise even better rehabilitation exercises, geared to the needs of people with Down syndrome.

Conclusions

1. People with Down syndrome show dysfunctions of gait in comparison to the physiological norm.
2. In the determinants of gait there was found restriction of the range of motion in the ankle, knee and hip joints in the sagittal plane, and the pelvis obliquity. The reduction in these determinants is compensated by increased rotation of the pelvis, lower extremities and the pelvis obliquity.
3. The implementation of additional exercises affects the improvement of the gait parameters of mentally handicapped people, suffering from Down syndrome.
4. All the spacio-temporal parameters of gait in people with Down syndrome were significantly improved after the period of rehabilitation, and in the case of step frequency equaled the norm of healthy people.

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