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EFFECTIVENESS OF NORDIC WALKING AND PHYSICAL TRAINING IN IMPROVING BALANCE AND BODY COMPOSITION OF PERSONS WITH DOWN SYNDROME

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Authors' contribution:

A. Study design/planning
B. Data collection/entry
C. Data analysis/statistics
D. Data interpretation
E. Preparation of manuscript
F. Literature analysis/search
G. Funds collection

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Abstract:

Aim. The aim of this study was to evaluate the effects of Nordic Walking training and physical training on balance and body composition in adult people with Down syndrome.

Basic procedures. We enrolled 32 subjects with Down syndrome, aged 25-40 years, with moderate intellectual disability. They were randomly divided into 3 groups: Nordic Walking training group, physical training group and control group with no intervention. Training sessions were held for 10 weeks at a frequency of 3 times a week. Subjects were examined twice: 1 week before training and during the week following intervention. To evaluate balance, we applied the modified Clinical Test for Sensory Integration and Balance (mCTSIB) on the BioSway platform. Evaluation of body composition was performed with the Tanita TBF – 300 Body Composition Analyzer

Results. After training, in the mCTSIB, statistically significant changes were observed only in the Nordic Walking group. In the control group, for this test, no changes were reported. Improvement in body composition was observed after Nordic Walking training while in the control group, deterioration was noted.

Conclusions. The research shows that regular physical activity such as Nordic Walking training has positive influence on the balance of people with Down syndrome. The changes were greater in people participating in Nordic Walking training rather than physical training. Both of the study groups presented improvement compared to the controls.

Introduction

Down syndrome (DS) is a disorder that occurs due to the presence of an additional, 21st autosomal chromosome or its fragment. This was for the first time reported by English Doctor Langdon Down, who distinguished and described a group of people characterised by similar appearance and behaviour [1, 2]. Trisomy 21 – this chromosome is one of the most common pathologies of the human genotype. Recently, an increase has been noted in the percentage of people affected with Down syndrome. According to records kept in the USA, the number of children born with Down syndrome has increased by 31.1% [3]. The frequency of births with trisomy is estimated at 1:700-1:1000, which it is strictly associated with the mother's age and increases along with it [4-6]. People with DS are characterised by phenotypic traits, determined from the early embryonic phase by a different genetic programme. Specific dimorphic features in DS regarding the skin, face, nose, eyes and neck do not have significant impact on functioning of the body. However, apart from these characteristic phenotypic traits, people with DS are at increased risk of diseases regarding the circulatory, respiratory and nervous systems, sensory organs, muscular, osteoarticular, digestive systems and metabolic diseases. Serious organs and system-related defects have major impact on the functioning and psychomotor development among individuals with Down syndrome [5, 7, 8]. An important role in the occurrence of disorders associated with motor disturbances in this group of people is played by ligament-muscular flaccidity as well as muscular hypotonia, resulting in excessive stretchability and joint hypermobility, as well as frequent postural defects. Visual (in 60%) and hearing impairments (in 75%) significantly affect balance control [9, 10].

In addition, there is a high risk of obesity in people with DS, which is a factor that may lead to limitations in motor function. In the examined 18-year-olds, an increase is present in body mass resulting in an increase of Body Mass Index (BMI) in relation to the general population. On average, this takes place in 31% of men and in 36% of women. It has been proved that these disorders have significant impact on the occurrence of motor deficits: problems with maintaining balance, standing and walking [11, 12]. The results of the study indicate that one of the most difficult motor skills for people with Down syndrome is maintaining balance. It has been demonstrated that they have much weaker control than their peers without DS. Numerous studies have proved that adult people with Down syndrome show a greater amplitude of body sway in relation to their peers without DS, suggesting differences in balance control function [13 – 16].

Regular physical activity performed by people with trisomy 21 can significantly affect life expectancy, physical, mental and emotional fitness. Studies were carried out in which a positive effect of physical training was noted on improving physical fitness among people with intellectual disabilities [17, 18]. The proposed rehabilitation programmes, consisting of endurance, strength and balance exercises, significantly influenced improvement of physical fitness, strength, balance while causing a reduction in body mass among people with intellectual disabilities [19]. The available research results allow us to look forward with optimism regarding the improvement of gait and balance using physical activity among individuals with DS.

An attractive and safe form of activity for people with Down syndrome seems to be Nordic Walking (NW) training. Increasing the quadrangle of the support base thanks to using the poles, stabilisation of the exerciser is provided as well as increased stability and balance. The advantage of this type of training is its intensity: activating the upper and lower parts of the muscles of the body while preventing excessive overloading of the movement apparatus. Walking with poles is also an effective form of burning calories and is recommended for people who are overweight. 90% of the muscles of the body are involved in the applying the correct technique, with a small, subjective feeling of effort. Systematic NW training affects the mobility of joints, improves physical fitness and promotes the correction of abnormal posture. In addition, walking with the correct NW technique can affect the improvement of movement functions: gait, balance and performance of everyday activities. The effectiveness of Nordic Walking training in the assessment of physical fitness, gait, balance and exercise tolerance in elderly people has been proved. It was also noticed that regular participation in this type of classes has a positive effect on reducing the risk of falls and assessing quality of life in the studied groups. However, there are no reports on the impact and effectiveness of Nordic Walking training on the balance of people with Down syndrome, assessed using objective methods [20 – 24].

There are still only a few studies evaluating the impact of rehabilitation programmes among adults with DS, and even fewer researchers have addressed the issue of balance and body composition of people with Down syndrome using objective research tools. The available literature lacks comparison of the effectiveness of selected physical activities and there are no specific standards for rehabilitation in this group of people.

The aim of research was to assess the impact of Nordic Walking training and general rehabilitative training on the body balance and composition of people with DS.

Material and methods

The research project was carried out in the years 2016-2017. Consent for carrying out the research was obtained from the Bioethical Committee at the District Medical Chamber in Krakow – opinion No. 69/KBL/OIL/2016.

The study group consisted of 32 adults (16 women and 16 men) with Down syndrome, aged 25-40 years (Tab. 1) with a moderate level of mental disability (IQ 36-51). The subjects were participants of the Occupational Therapy Workshops in Krakow.

The criteria for inclusion into groups were:

- age – 25 years
- moderate degree of intellectual disability (IQ 36-51)

- no health contraindications to physical exercise
- written consent of the subject or legal guardian to participate in the study
- consent of the project supervising doctor for participation in the

The criteria for exclusion from the study were:

- diseases preventing participation in the programme
- taking chronic medication
- lack of written consent of the subject or guardian for participation in research
- simultaneous participation in other forms of rehabilitation

Individuals qualified for the tests were randomly assigned to 3 groups:

- GROUP A (n = 11 people): group undergoing 10-week Nordic Walking training
- GROUP B (n = 10 people): group undergoing 10 weeks of general rehabilitative training
- GROUP C (n = 11 people): control group without therapeutic intervention within 10 weeks

Those qualified for the study, from the moment of its commencement, were obliged to not use other forms of physical therapy for the 10-week period of the experiment. Prior to research, the participants and/or legal guardians of the subjects were familiarised with information on the purpose of the research, methodology and the possibility of resignation from further participation in the project at any stage. The subjects were randomly assigned to 1 of 3 groups according to inclusion criteria. Participants in groups A and B were subjected to 10-week rehabilitation programmes at a frequency of 3 times a week. Training sessions always took place at the same time, in the morning hours (8.00 a.m.-12.30 p.m.). The training for group A was carried out in the area of the Nowa Huta Reservoir Park, at Bednarski Park and Lotników Park by the University of Physical Education in Krakow. Classes for group B took place at the gyms of Occupational Therapy Workshops. The qualified participants were subjected to examination twice, in the week preceding the beginning of the programme and during the week immediately after its completion. Research was carried out in the Biokinematic Laboratory of the Biomechanics Department, University of Physical Education in Krakow, under the same conditions and at the same time of the day, in the morning hours.

Balance assessment

Assessment of the subjects' balance was carried out using the Technomex BioSway balance platform, which is equipped with tensometric sensors that record the pressure of the tested feet on the ground. The BioSway system calculates the position of the center of pressure (COP), which under static conditions, is a projection of the body's center of gravity (COG) on the support plane. The angle of deflection of COG from the zero position is measured at the height of 0.55 of the study participant. The test parameter obtained with the BioSway device test is the sway indicator, which is an objective measurement of the CTSIB results [25 - 27].

The modified Clinical Test of Sensory Interaction on Balance (mCTSIB) was carried out. The mCTSIB test protocol consists of 4 parts:

Test 1 – Open eyes, stable surface: assessment of stimuli from the visual, vestibular and somatosensory systems.

Test 2 – Eyes closed, stable surface: elimination of visual stimuli, assessment of vestibular and somatosensory stimuli.

Test 3 – Open eyes, unstable surface: assessment of the interaction between the somatosensory and visual systems.

Test 4 – Eyes closed, unstable surface: assessment of the interaction between the somatosensory and vestibular systems.

Table 1. Distribution of characteristics in the experimental (gr. A, gr. B) and control groups (gr. C)

Characteristic	Group			ANOVA *p*
	A n=11	B n=10	C n=11	
Age [years]	30.3±2.8	32.2±6.9	32.0±5.21	0.641
Body height [cm]	156.3±6.9	146.5±5.1	152.3±10.2	0.077

Testing procedure. The patient was instructed to maintain a stable, vertical position under different test conditions, with eyes opened or closed. 4 attempts were made, separated by 10 seconds intervals. The test was considered as passed when the subject stood 30 seconds without falling.

Normative ranges of sway index for the conducted MCTSIB test:

1. Eyes open, stable surface: 0.21 - 0.48
2. Eyes closed, stable surface: 0.48 - 0.99
3. Eyes open, unstable surface: 0.38 - 0.71
4. Eyes closed, unstable area: 1.07 - 2.22

Body composition analysis

Body composition analysis was conducted using the TANITA Body Composition Analyzer TBF - 300 device. For all measurements, standard body type was adopted and the results of the previously performed body height measurements and the age of the subject were introduced. The following parameters were evaluated: body mass, percentage of adipose tissue, fat mass, muscle mass and BMI. The measurement was performed to the nearest 0.1 kg.

Therapeutic procedure in the experimental groups

The therapeutic procedure in experimental groups included 10 weeks of training sessions held 3 times a week for 60 minutes. Classes were conducted by a physical therapist, a licensed Nordic Walking instructor.

Therapeutic procedure in the Nordic Walking group (A)

The Nordic walking marching technique was conducted in 30 sessions, lasting 60 minutes. Each class consisted of a warm-up (about 10 minutes), the main part (about 45 minutes) and ended with a warm-down phase (5 minutes). Warming-up was the initial part of training, it was performed in a standing position, and its goal was to prepare the body for increased effort. The subjects performed jumps, side jumps, alternating jumps and squats, using poles. Exercises requiring alternating work of upper and lower limbs were also carried out: alternating foot lift to touch the opposite pole, alternating lift of the knee joints to touch the hand or elbow. Other exercises performed during the warm-up were: wrist, trunk and feet circulating. The main part was the Nordic Walking technique. The warm-down phase consisted of breathing and stretching exercises. The training sessions were conducted with maintained walking intensity progression.

Therapeutic procedure in the group subjected to whole-body rehabilitation training (B)

The training was carried out in 30 therapeutic sessions, lasting 60 minutes. Each session consisted of a warm-up (about 10 minutes), the main part (about 45 minutes) and ending exercises (about 5 minutes). The programme was created on the basis of current scientific reports, and the included exercises were carefully selected in terms of balance training. Classes included general, balance and coordination exercises, range of movement, correct posture, as well as exercises in pairs, relaxing and breathing exercises. Fitball type exercise balls were used. The programme was conducted with increasing difficulty of exercise. The outline of each training session was the same, however, the principle of grading the difficulty of the exercises by increasing the number of repetitions, increasing the pace and modifications of the performed tasks was taken into account.

Methods of statistical analysis

Data are presented as mean values and standard deviation (SD) or median and quartiles (Q1, Q3), depending on the assessment of normal distribution. Normality of distribution was verified on the basis of the Shapiro-Wilk test. Differences between the experimental groups and the control group were evaluated using one-way analysis of variance (ANOVA). Dependent variables were compared using the Student's *t*-test for related variables, and Wilcoxon's test if the assumptions were not met. The significance level of $\alpha=0.05$ was assumed in the analyses. The analyses were performed using the Statistica 12.5 package (StatSoft®, USA).

Results

Modified Clinical Test of Sensory Interaction in Balance (mCTSIB)

Table 2. The mCTSIB test in the group subjected to Nordic Walking training (gr. A)

Testing conditions	Before	After	*p*
OE stable surface	0.73 (0.57-1.13)	0.69 (0.60-1.06)	ns
CE stable surface	1.02±0.26	0.82±0.28	ns
OE unstable surface	1.34 (1.04-2.12)	1.12 (0.86-1.28)	ns
CE unstable surface	3.35±0.74	2.71±0.82	**0.034**

OE – test with eyes opened, CE – test with eyes closed

In the mCTSIB test after rehabilitation, statistically significant changes were noted only in the group subjected to Nordic Walking training. The value of the sway index statistically significantly decreased in the closed eyes test on an unstable surface (Tab. 1). In the remaining groups, no statistically significant changes were noted. In spite of this fact, in the group subjected to general training, a decreasing tendency for the sway index in the balance test was obtained in the majority of conditions, while in the control group, a significant increase in sway rate was observed in all conditions (Tab. 2, Tab. 3).

Body composition analysis

There was a statistically significant decrease in body mass after the Nordic Walking training. In group A, a statistically significant change in the content and body fat mass after exercise was also found. The BMI was statistically significantly lower (Tab. 4). In the group subjected to general-fitness training (gr. B), no statistically significant changes in body composition were observed (Tab. 5). In contrast, in the control group (gr. C), a statistically significant increase in body mass was recorded (Tab. 6).

Discussion

Scientific research and therapeutic experience prove that a very important factor for ensuring effective improvement in people with Down's syndrome is the selection of appropriate physical activity and exercises. This paper attempts to answer the question as to which form of training is the best in improving balance and changes in the body composition among people with Down's syndrome. No publication has been found assessing the impact of Nordic Walking training on balance and body composition in a group of people with DS. However,

Table 3. The mCTSIB test in the group subjected to general training (gr. B)

Testing conditions	Before	After	*p*
OE stable surface	0.97±0.27	0.55±0.19	ns
CE stable surface	1.47±0.64	1.19±0.53	ns
OE unstable surface	1.62±0.66	1.78±0.99	ns
CE unstable surface	3.52±1.32	2.82±1.38	ns

OE – test with eyes opened, CE – test with eyes closed

Table 4. The mCTSIB test in the control group (gr. C)

Parameter	Before	After	*p*
OE stable surface	0.75±0.39	0.79±0.31	ns
CE stable surface	0.86 (0.80-1.24)	0.97 (0.85-1.20)	ns
OE unstable surface	1.27±0.32	1.34±0.35	ns
CE unstable surface	2.92±1.06	3.03±1.10	ns

OE – test with eyes opened, CE – test with eyes closed

Table 5. Body composition analysis after Nordic Walking training (gr. A)

Parameter	Before	After	*p*
Body mass [kg]	69.1±9.8	67.7±9.1	**0.006**
Body fat content [%]	23.47±7.24	22.20±7.46	**0.003**
Fat mass [kg]	16.48±6.26	15.25±6.02	**0.001**
Muscle mass [kg]	50.00±6.99	49.79±6.89	ns
BMI [kg/m^2]	28.42±4.23	27.84±3.97	**0.007**

Table 6. Body composition analysis after general training (gr. B)

Parameter	Before	After	*p*
Body mass [kg]	69.5±5.7	69.5±5.77	ns
Body fat content [%]	30.02±7.16	29.93±7.57	ns
Fat mass [kg]	21.00±5.89	21.00±6.42	ns
Muscle mass [kg]	46.02±4.73	46.05±4.26	ns
BMI [kg/m²]	32.42±2.72	32.43±2.98	ns

Table 7. Body composition analysis in the control group (gr. C)

Parameter	Before	After	*p*
Body mass [kg]	70.5±16.3	71.5±16.3	**0.037**
Body fat content [%]	23.54±8.37	25.51±9.44	ns
Fat mass [kg]	17.73±8.70	18.05±8.49	ns
Muscle mass [kg]	51.91±8.72	48.13±6.03	ns
BMI [kg/m²]	30.49±6.20	30.95±6.44	**0.047**

there are several publications on the impact of a variety of other forms of physical activity on balance. In many experimental studies, it has been shown that physical activity carried out in the form of Nordic Walking training has a positive effect on the health of patients without intellectual disabilities. The positive influence of Nordic Walking has been verified in the rehabilitation of patients with various chronic diseases, Parkinson's, fibromyalgia [28, 29]. Unfortunately, there are no reports in the available literature on the impact of NW training on body balance and composition in people with Down syndrome.

Influence of applied interventions on balance in Down syndrome patients

The assessment of the balance in people with Down syndrome has been the subject of research in numerous scientific publications. Scientific reports point to deficits in postural control among young adults with DS. Studies show that people with Down syndrome demonstrate greater sway in anterior posterior and medial lateral directions with open and closed eyes than in healthy persons [30 – 32].

In the authors' research, balance was assessed using the mCTSIB test. The results of this test, in the group subjected to NW training, show improvement in all tested conditions, however, a statistically significant difference was only obtained in the trial performed with closed eyes on an unstable surface. Analysis of other test results obtained in the measurement with eyes closed suggests that this measurement may be a good indicator of the occurrence of the initial stages of postural stability disorders. The mean value of this parameter in the group of patients after stroke and those bedridden for tinnitus auris and dizziness was more than 4 times higher than the mean in the control group. Under these test conditions, the subject is focused on vestibular stimuli because visual stimuli are inaccessible, and somatosensory ones are disturbed by an unstable medium. Therefore, NW training contributed to the improvement of stability parameters, but probably, both types of rehabilitation support the maintenance of an equivalent level, delaying the progressive imbalance arising with age. In the group subjected to general training, all parameters improved, but they were not statistically significant. Perhaps the lack of significant improvement in the balance test was due to the excessively short time of the intervention, and in the case of general training in adults with DS, the therapeutic effect should be extended. Only a few researchers have attempted to answer the question of whether physical activity improves balance in adults with Down syndrome. The available publications, however, prove that physical activity should be considered as a tool to improve balance in people with DS.

It has been shown that 6 weeks of PRT (Progressive Resistance Training), conducted 3 times a week, has improved balance in children (7-15 years) with DS. The results of the BOTMP (Bruininks-Oseretsky Test of Motor Proficiency) significantly increased from 10.5 to 19.5 in the second test [33]. Other researchers showed improvement in the balance of people with DS under the influence of a 12-week therapeutic intervention, consisting of both plyometric and balance exercises [34, 35]. Interesting results were obtained during a study in which adults with DS (21-30 years) were assigned to 2 groups: subjected to 10 weeks of Taekwondo training and the control, not exercising during the period under examination. Balance was assessed using the mCTSIB test and what is interesting, statistically significant improvement was obtained in both groups during both the open and closed eyes tests. Thus, a significant factor [36] worth paying attention to and which may influence the obtained results seems to be the learning factor [36].

Not even one scientific article has been found regarding the impact of NW training on balance in people with Down syndrome. Nevertheless, there are studies assessing the impact of NW training on balance in older people.

The results of the Nordic Walking training were compared in the group performing a conventional march and in the group performing gymnastic exercises. The training sessions were held 3 times a week for a period of 12 weeks. The balance of the examined elderly group was assessed using functional tests and posturographic examination using a platform with the mCTSIB test protocol. Although there were no significant differences in the values of the sway indicator between groups, there were trends indicating higher walking efficiency using the Nordic Walking technique in the rehabilitation of elderly people [37].

Influence of applied interventions on body composition of Down syndrome patients

Both adolescents and adults with DS are characterised by a lower level of cardiovascular capacity compared to their peers without DS [38, 39]. Studies indicate that they are affected by both clinical symptoms of the disease and sedentary lifestyle. People with DS have a more sedentary routine and spend less time outside compared to their healthy peers [40]. Low levels of physical activity may lead to an increase in obesity and worsening of clinical symptoms [41]. For this reason, the conducted research drew attention to body mass and its changes after training. Bearing in mind the occurrence of significant overweightness as the characteristic clinical feature of Down syndrome, determined inter alia by the set of genes, it was decided to assess whether the proposed activities will have a significant effect on body composition. The hypotonic features of people with Down syndrome cause a delay in achieving milestones and reduced activity since early childhood. Impaired motor skills and difficulties in undertaking activities determine reluctance to participate in games and physical activities as children, which leads to limitations in physical activity. Thus, the vicious cycle results in reduced physical activity, increased body mass and obesity, which, in turn, leads to further reduction in activity [42].

In our study, a significant effect of NW training on weight loss in people with Down's syndrome was noted. The average body mass in group A before training was 69.1±9.8 kg, while after the NW training, it decreased to 67.7±9.1 kg, on average. The percentage of adipose tissue and the mass of adipose tissue also significantly decreased ($p<0.05$). Also, BMI significantly decreased from 28.42±4.23 kg/m^2 to 27.84±3.97 kg/m^2. These changes were not found in the group performing general rehabilitative exercises. In group B, no statistically significant changes were found in body composition analysis. However, in the control group, not subjected to any therapeutic interventions, there was a significant increase in body mass from 70.5±16.3 kg to 71.5±16.3 kg, and an increase in BMI from 30.49±6.20 kg/m^2 30.95±6.44 kg/m^2 ($p<0.05$). This indicates the high effectiveness of NW training in body mass reduction among people with DS, and thus, it is a good tool for the prevention of obesity in this group of people. The increase in body mass and BMI in the control group confirms the necessity for people with DS to regularly participate in physical activity.

In the available literature, there are no reports on the impact of NW training on body composition in people with Down syndrome, however, the effectiveness of NW training on weight reduction has been well proven in various groups of people. Positive training effects have been observed, among others, in obese, adult women. As in our own research, available studies have shown a significant effect of NW training on overweightness in middle-aged women (BMI> 30 kg/m^2). As it turned out, the 12-week training programme, consisting of 3 training sessions a week without dietary intervention, caused a decrease in BMI and improved the values of anthropometric parameters. The mean decrease in body mass was 1.4 kg, and the BMI decreased from 34.2 kg/m^2 to 32.7 kg/m^2 [43].

In conclusion, on the basis of the presented results of our research and observations made during the experiment, it can be assumed that motor rehabilitation carried out in the form of gait training with the Nordic Walking technique has a positive effect on improving the balance of people with DS. This form of activity can be an important part of the rehabilitation process because it contributes to improving physical fitness, preventing obesity and being carried out in the open air can cause improvement in social competences.

Conclusions

1. Nordic Walking training has a positive effect on balance in people with Down syndrome, expressed as a decrease in the sway index during the mCTSIB test, while in the group undergoing general rehabilitative training, such changes have not been recorded.

2. Nordic Walking training causes beneficial changes in the body composition of people with Down syndrome, expressed as a decrease in body mass, fat content, fat mass and BMI, while general training does not cause significant changes in body composition.

Applicative conclusions

Due to the usefulness of the carried out research, the following applicative conclusions were formulated:

1. Incorporation of Nordic Walking training may positively influence the balance of people with Down syndrome.
2. Nordic Walking training is an effective form of preventing obesity among people with Down syndrome, therefore, it is worth including Nordic Walking in everyday, obligatory activity.

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