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Effect of Backward Walking Training on Improves Postural Stability in Children with Down syndrome

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Abstract

Background

Motor intervention plays an important role in reducing the disabilities of Down syndrome (DS). A lack of balance and postural control has created motor problems in DS patients. Therefore, the aim of this study was to examine the effect of backward walking on postural stability of DS patients.

Materials and Methods

Sixteen DS children with 8-10 age range were selected by convenience sampling method and assigned to control and experimental groups. The experimental group performed backward walking training for 8 weeks (2 sessions per week, each session for 25 min). The dynamic postural stability of both groups was examined by Biodex stability system (general balance, medial collateral and anterior-posterior balance indexes) before, during and after the training (pretest, 4th week, 8th week and 18th week). To analyze the data and test the hypotheses, independent t test was used.

Results

The results of this study showed that the three balance indexes in the experimental group was drastically lower than the control group after 8 weeks of backward walking training ($P<0.01$). In addition, significant differences could be observed in balance indexes even 10 weeks after the last session of the backward walking training ($P<0.05$).

Conclusion

It seems that the findings of this study have confirmed the effect of backward walking training on the improvement of postural stability and Syndrome children with 8-10 age range can benefit from this method.

Key Words: Backward walking, Balance, Down syndrome, Postural control, Postural stability.

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1- INTRODUCTION

Down syndrome (DS) is one of the most common chromosome abnormalities accompanied by different physical, mental, behavioral and social disorders (1). Down syndrome is not only diagnosed by facial features, but also some other clinical symptoms such as orthopedic, cardio - vascular, neural - muscular, visual, cognitive and perceptional defects. Studies have shown that the individuals with Down syndrome have difficulties in strength, balance, visual - motor coordination and lateralization (2-5). Existing statistics show that DS happens in 1 to 600-800 successful births which represent this syndrome as one of the most common forms of mental retardation (4). More than 350,000 people in USA suffer from this syndrome (6).

Fall is an important factor of children fatalities which can be the reason for 25-44% of unintentional injuries in children (7, 8). One of the reasons for falls in children is balance impairment and postural sway (9). Postural balance and control is a skill that is integrated by central nervous system using different body systems such as all neuromuscular systems and different parts of the brain. In fact, given the pre-learned motor patterns, central nervous system activates synergic muscular patterns in the limbs through processing the data of vision, vestibular and proprioceptive systems. These muscular patterns create motor strategies through which the individual can maintain balance (2). As a result, balance is comprised of the balance of perceptive, motor and musculoskeletal systems which plays an important role. Balance problems cause DS children to increase their stability limits in their sitting, standing and walking. These children also suffer delayed motion, postural balance and acquisition age of this balance (1). Those factors influencing the reduced balance in DS patients include hypotonia, muscular weakness, small cerebellum and brainstem. Muscular weakness reduces balance during standing and consequently increases the fall risk (6). Muscle strength of these children is 50% lower than mentally retarded children (11). Therefore, it is necessary for these children to appropriately maintain their muscle strength (12). Today different sports and physical activities such as T'ai chi ch'uan, Taekwondo and Pilates are introduced to improve balance and motor control. These sports are suitable for many individuals with different limitations to improve their balance and motor coordination. It should be mentioned that most of these studies were conducted for the adults and cannot be applied to improve balance impairment in children with physical and mental disabilities.

In addition, as most of these activities need special tools and environments due to their specialized nature, patients may face problems to apply them in their daily life. Some researchers have used training such as resistance training to improve impairments in DS children. Tsimaras et al. (2004) used resistance training to improve muscle strength and dynamic balance of DS children. Sayyadi et al. investigated the effect of progressive resistance training on functional balance of DS children. It seems that given a change in lifestyle in the present society and a limitation of motor space for everyone especially DS patients, it is advised to use those types of training which need minimum space, facilities and expertise. In other words, those types of training which everyone can easily apply should be used. Simple physical activity such as backward walking may have beneficial effects on DS children's health especially on their balance and ability of motor control. Some researchers (8) used the effectiveness of backward walking to improve balance and postural stability. Their research showed the effectiveness of 12 weeks of backward walking on static balance of young women. Yang et al. (2007) observed an improvement in walking patterns of patients with stroke after 12 weeks of backward walking training using a walking analysis system. But no researchers have examined the effect of these types of training on balance of DS patients in any age range; therefore, the aim of this study was to examine the effect of backward walking training on postural stability in DS patients (13).

2- MATERIALS AND METHODS

2-1. Study Design and Population

This semi-experimental study was a cross sectional regarding the time and application considering the obtained results. The statistical population consisted of all DS children who were studying in Tehran special schools during October 2013 to January 2014. Sixteen DS boys (8-10 years old) were selected from this population by convenience sampling method and a specialist's confirmation.

2-2. Inclusion and Exclusion criteria

The conditions to participate in this study were as follows: 50 < intelligence quotient < 70 (based on their medical profiles), the ability to stand up, to maintain balance and to walk, no participation in physical activities or physiotherapy treatments so that they could influence their responses to balance tests, no medications that influenced their muscle strength, natural vision and hearing with/without assistive devices, no cardiovascular diseases and no neurologic impairments. The subjects were randomly divided into experimental and control groups. Before the study, parents filled out the written consent form for their children's voluntary participation.

2-3. Measuring tools

Dynamic postural stability, which emphasized a subject's ability to maintain center of balance, was assessed using a Biodex balance system (BSS) (14). BSS has a circular platform that is free to move about the anterior-posterior (AP) and medial-lateral (ML) axes simultaneously (15, 16). The BSS software sampled the deviations in the AP and ML directions at a rate of 20 Hz and calculated the anterior/posterior index (API), medial/lateral index (MLI), and overall balance index (OBI) using the following formulas. It is reported that these indexes are reliable and precise measures for dynamic postural stability (15, 17). The intra-tester reliability of BBS were 0.82 (16) and 0.96 (40), and the inter-tester reliability was 0.70 (16) for OBI.

$$API = \sqrt{\frac{\sum (0 - Y)^2}{N}}$$

$$MLI = \sqrt{\frac{\sum (0 - X)^2}{N}}$$

$$OBI = \sqrt{\frac{\sum (0 - Y)^2}{N} + \frac{\sum (0 - X)^2}{N}}$$

Where; **N** is the numbers of sampling, **Y** and **X** are displacement of COP in the AP and **ML** directions. Thus, OBI, API and MLI represent the subjects' ability to control their balance in all directions, in the sagittal plane, and in the frontal plane respectively (15, 16).

The boys were instructed to walk at a self-selected speed, look straight ahead, and walk as naturally as possible. Each child had finished 3 times of backward walking trial and 3 times of forward walking trials. The walking data of the 3 times had been averaged after being calculated from each trial and analyzed. A whole stride cycle here refers to the phase from one foot contact to the next contact of the same foot, a step refers to the phase from one foot contact to the next contact of the other foot, and a stride length refers to the distance covered by a foot from one contact point to next contact. The balance of the subjects was assessed in four stages:

the **first** assessment was conducted one week before the backward walking training started; the **second** and **third** assessments were carried out after four and eight weeks and the last assessment was performed for both groups 10 weeks after the experimental group finished their backward walking training. The experimental group performed backward walking training for eight weeks, 2 sessions per week, each session 25 minutes on a 30m flat and straight pathway in a hall with proper floor covering. The pace speed and movement rhythm were not analyzed and there were no limitations or obligations to hold head and neck during the training. An individual looked after each subject to protect him on the pathway. Before each session, the subjects performed warm-up for 10 minutes. Control group did not participate in any regular physical activities.

2-4. Data analyses

Also, independent-Samples t-test was used to compare the corresponding balance indexes between experimental and control groups ($P < 0.05$). When significance found, Cohen's effect size (ES) was used to measure the magnitude of the backward walking training effect (18). Two-way analysis of variance (ANOVA) tests, followed by post hoc-test (Tukey's test), were performed to detect differences in kinematic variables between control and experimental groups (between-subject), and gait differences between forward walking and backward walking (within-subject).

Kolmogorov-Smirnov test was used to examine data normality and Levine test was applied to examine the variance homogeneity. 2010 Excel software was used to draw the charts and SPSS-16, Chicago, SPSS Inc. (IL) was used for statistical calculations. A significance level of 0.05 was chosen for all the statistical analysis. The body mass index (BMI) is a value derived from the mass (weight) and height of an individual. The BMI is defined as the body mass divided by the square of the body height, and is universally expressed in units of kg/m^2, resulting from mass in kilograms and height in metres.

$$BMI = weight\ (kg) / height\ (m^2)$$

Weight measurement method: the sample weights were measured via Seca scaled dial (with the accuarcy half -kilogram). The examiner set on zero balance and the subjects were asked to stand in the center with clothing style, so that the weight was distributed in a balanced way between the two legs. Then they were asked to look at faces in a normal exhalation position and stand without movement. In this case, the tester checked the needle and after fixing for three seconds he recorded the read numbers. Height measurement method: The height was measured via Seca scales dial (with the accuracy of a millimeter).

Height meter in height of two meters above the ground was installed on the wall. The subjects were asked to go without shoes, back to the wall stand, So that the back of the leg, buttock muscles, scapula bone and the occipital bone were in contact with the wall. Hands were hanging beside the body and the person was looking at the horizon. Then, the movable handle stadiometer was lowered to the touch the head. Then the subjects were asked to take a deep breath and exhale normally. In that case, the tester looked vertically at the numbers stature and recorder their height.

3- RESULTS

The descriptive statistics of subjects can be observed in **Table.1**. At the beginning of the study and before the application of independent variable, there were no significant differences in body features between the two groups which showed their homogeneity and integration. All participants in this study were in Tehran city that the economic and social situations in terms of those were located. As **Figure.1** shows, three indexes of balance in experimental group was drastically lower than control group after 8 weeks of backward walking training (P<0.01).

In addition, there were significant differences in general balance (P<0.05) and anterior-posterior balance indexes (P<0.01), although the differences in medial collateral balance index (P>0.05) were not significant between the two groups. So that, backward walking training as compared with forward walking (control group) in general balance and anterior-posterior, has achieved a better situation.

Also, the lower values indicate better balance. The difficult levels of the balance tasks for the four tests (pre test, week 4, week 8, week 18) were different, thus they were not comparable among the four tests.

Table-1: Mean and standard deviation (SD) of statistical indexes of age, height and weight in experimental and control groups (n=16)

Variables	Age(yr) Mean ± SD	Height (cm) Mean ± SD	Weight (kg) Mean ± SD	BMI (cm/kg) Mean ± SD
Experimental group	8.6±2.4	127.30±4.22	34.16±14.46	24.75±5.17
Control group	8.9±3.70	126.6±5.64	33.21±9.21	24.66±6.09

SD: Standard deviation; BMI: Body mass index.

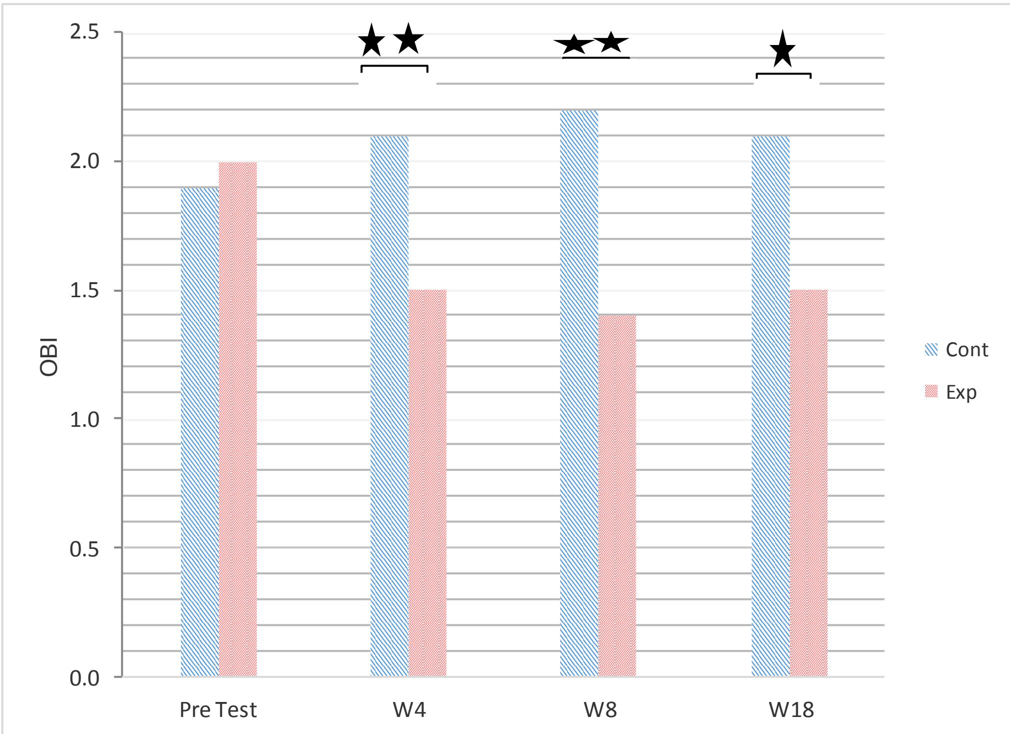

Fig.1: Overall balance index (OBI) of the subjects in control (cont) and experimental (exp) groups (**P<0.01 & *P<0.05).

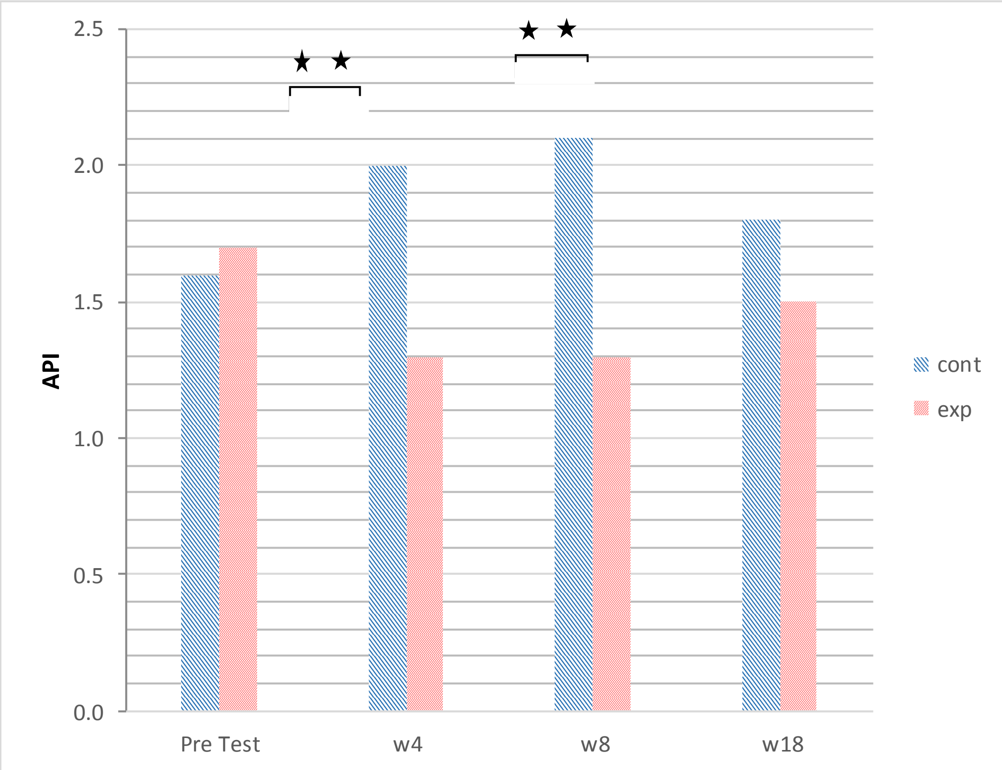

Fig.2: Anterior/posterior index (API) of the subjects in control (cont) and experimental (exp) groups (**P<0.01 & *P<0.05).

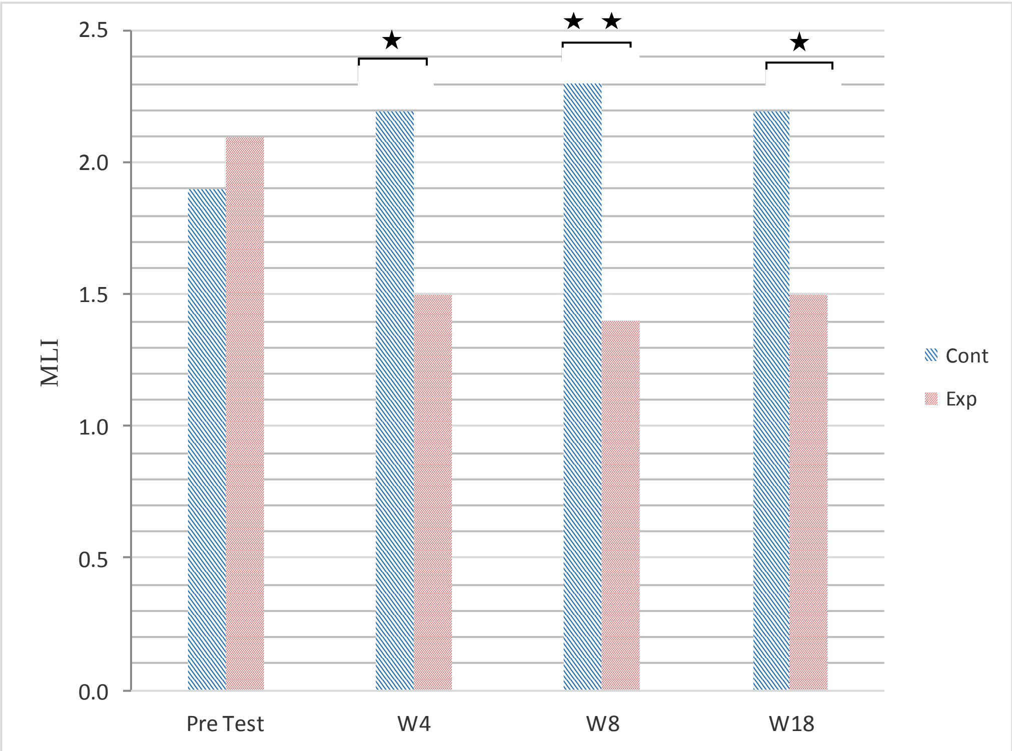

Fig.3: Medial/lateral index (MLI) of the subjects in control (cont) and experimental (exp) groups (**P<0.01 & *P<0.05).

4- DISCUSSION

The results of this study indicated that the balance of the boys had been significantly improved after 8 weeks of backward walking training (**Fig.1**). These results was consistent with findings of Hao and Chen (2011), Zhang et al. (2008), Yang et al. (2005), Galli, Rigoldi, Mainardi (2008) and Deursen et al. (1998). Hao and Chen (2011) in their study showed that the spatial and temporal variables such as travel time, stride length, step rate and step amplitude and angular displacement of the muscles of the lower back walking gait naturally different. This difference resulted from exercises to improve balance, walking backward helps (19). The balance ability, especially in the anterior/posterior direction, was still maintained at a higher level, when the backward walking training program had stopped for 3 months. It is considered that the effect is obvious, when ES is greater than 0.8 (18). Our results are similar to findings by Zhang et al. (2008) and Yang et al. (2005) Zhang et al. (2008) measured and compared static balance abilities of 18 old women (experimental group) before and after 12 weeks Backward walking training with that of 12 old women (control group) without backward walking training using a force plate and an electronic apparatus for single standing test (8, 13, 20). They found that the single leg standing duration of the experimental group was increased and greater than the control group; the fluctuation of gravity center of static standing with eye closed of the experimental group was decreased and less than the control group. Galli et al. (2008) and Yang et al. (2005) measured gait patterns of two groups (control, n=12; experimental, n=13) of patients post stroke using a gait analysis system, and found that after a three-week backward walking training period, subjects of experimental group showed more improvement than those in control group for walking speed, stride length, and symmetry index (13, 37). These findings may be useful for developing balance skills in children with Down syndrome walk back through providing training and creating an active lifestyle among children with Down syndrome.

The exact mechanism through which backward walking training cause improvement of balance and motor control is yet to be fully elucidated. It has been generally assumed that there are many systems within the body that work in concert to move the center of mass (COM) in relation to the base of support (BOS) in a controlled manner when engaged in dynamic tasks (21). There are three primary systems involved for the balancing process: (1) the sensory system (visual, cutaneous and proprioceptive, and vestibular senses), which gives feedback to alter the balance action during a voluntary motor task, (2) the motor system, which creates the coordination movement to maintain balance, and (3) the biomechanical system or musculoskeletal system, which includes the muscles that create the movement torques and the bony and joint frame on which movements are made (21).

All those three systems may be associated with the improvement of balance by backward walking exercise. Children rely more on visual cues than the other sensory cues (22), but children can reweight the three afferent cues since 3 years old in order to maintain balance, and this multisensory reweighting increases with age in children (3). During backward walking, the visual cues doesn't provide the child with the visual information necessary to anticipant ground condition, and motor pattern are unconventional, the boys have to reorganize and adapt the changed information from visual, cutaneous and proprioceptive, and vestibular senses, and then enhance the movement control to maintain dynamic balance (39). It has been reported that prolonged backward walking exercise causes neural adaptations. Schneider, Capaday (23) and Ung et al. (24) found that daily backward walking training progressive induced adaptation of the soleus H-reflex. Van Deursen et al. (1998) suggested that both forward walking and backward walking are mediated by the same central pattern generator (CPG), and only small modifications in the CPG are required in order to produce the different characteristics of each walking mode (25). The reorganization of the muscle synergies or neuromotor control in lower limbs during backward walking might be a possible reason for the improvement of balance by backward walking training. The changes of muscles strength at lower limbs may contribute to the improvement of balance induced by backward walking exercise as well. The contraction modes of lower limb muscles are reversed in backward walking conditions. For example, eccentric contraction of the quadriceps muscle during the loading phase of the forward walking gait is replaced by a concentric contraction during backward walking (26).

Previous studies indicate that strengths of quadriceps and hamstring muscles are increased after backward walking exercise (27). Although we found that backward walking increased balance ability for boys as those old women (20) and patients (13), we still don't know whether the mechanism involved in these boys was same as those old women or patients. The three sensory components of sensor motor control system develop in different periods (38). Function of proprioception seemed to mature at 3 to 4 years of age, but visual and vestibular afferent systems reached adult level at 15 to 16 years of age (41). The boys in this study were only at 7 to 8 years of age. Backward walking is much easier to put into practice. Backward walking also offer benefits especially in balance and motor control ability beyond those experienced through forward walking alone. In comparing with forward walking (FW), backward walking results in the mean electro my graphic (EMG) activity of the lower extremities over the gait cycle (33) which suggests a greater level of energy expenditure during backward walking than the FW. In fact, it has been found that, during backward walking, oxygen consumption and heart rate are much greater than during matched speed forward walking (28, 34), suggesting that backward walking need more metabolic cost, and provide more stimulus to maintain fitness of cardiovascular system. Due to its improvement of motor control ability (13, 20) and reducing impact upon knee joints (35), backward ambulation can be used as a rehabilitation technique for treating patients post stroke (13) and with orthopedic problems, especially those involving knee dysfunction (27, 36).

4-1. Limitations of the study

Among the limitations of the present study was the effect of the program just move on postural control was assessed and in the fields of communication and cognitive study was don't assessed. Also, the effects of the intervention program was only on motor abilities but motor fitness factors such as flexibility, were not assessed. Finally, environmental factors, diet and medications at the time of the test subjects and education sessions that may have an effect on results, not under the control of the investigator.

5. CONCLUSION

This study indicates that Backward walking training on school-aged boys can improve their balance. It has found that there was no difference between control and experimental groups in the kinematics of both forward walking and Backward walking gaits after the Backward walking training. These findings may provide useful information to promote balance ability in prevention of fall injuries through Backward walking training, and promote physically active lifestyle. They may also provide useful information to understand the mechanism of improvement of balance induced by Backward walking training. The present study used eight weeks of backward walking training and the results showed that this training improved the motor function especially dynamic balance of DS children.

As backward walking training need no special equipment, it is suggested that this type of training should be used to improve movement disorders and provide an active lifestyle so that its benefits can be recognized more easily. The participants of this study were selected from DS boys, therefore, it is necessary to have female participants in future studies as well. Also, this type of training can be used to improve balance in other populations.

6- CONFLICT OF INTEREST: None.

7- ACKNOWLEDGMENT

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