Abstract. [Purpose] The aim of the study was to assess the effect of an 8-week balance exercise program for enhancement of gait function on temporal and spatial parameters of school aged children with intellectual disabilities. [Subjects] Forty young people with intellectual disabilities were assigned either to the balance exercise program for enhancement of gait function group (BG group, n=19) or the control group (n=21). [Methods] The BG group attended an 8-week balance exercise program for enhancement of gait function consisting of two sessions a week. Gait was assessed using temporal and spatial parameters. [Results] The balance exercise program resulted in significant improvements in participant performance in temporal and spatial parameters. [Conclusion] A balance exercise program for enhancement of gait function can be an effective intervention for improving functional outcomes and can be recommended as an alternative mode of physical activity programming for improving balance and gait.

Key words: Balance exercise, Gait, Intellectual disability

INTRODUCTION

Motor problems have been reported as common in persons with intellectual disabilities since intellectual disabilities are conditions that affect cognitive and motor functions. Intellectual disabilities negatively affect the life of a person with disability also by decreasing their motor function, which is manifested by poor visual and motor coordination, limited precision of movements, inhibition, and difficulties in learning new forms of activities. Alongside impairments in cognitive and motor function, individuals with intellectual disability also have lower levels of physical fitness at all stages of life due to inactive ways of life.

A pervasive feature of motor skill performance in children with intellectual disabilities that persists in adulthood is the slowness of movement. In general, although children with intellectual disabilities learn to walk, to reach and to grasp objects, to feed themselves, and to perform many other fundamental skills, their movements lack in precision and appear poorly coordinated and less efficient than the movements of normally developing children. Persons with intellectual disabilities are worse at performing motor tasks that require a combination of two activities; they also often have difficulties in developing praxis skills. Additionally, disturbed body sensibility and poor spatial orientation considerably decrease the levels of static and dynamic balances, which is manifested by awkward movements and increases in the risk of falls.

Falls resulting in injury are very common in individuals with intellectual disabilities. Balance and gait problems are well-established risk factors for falling. Some studies have indicated that persons with intellectual disabilities have a relatively high fall rate and an increased risk of fall-related injuries. For example, persons with intellectual disabilities are more at risk of fall-related fractures because of low bone mineral density. The rate of hospitalization because of an injury is twice as high in persons with intellectual disabilities compared with the general population, with most of the injuries being caused by falls. A good understanding of the nature of balance and gait problems and their role in the causation of falling in persons with intellectual disability may help to develop intervention strategies to prevent falls and injuries.

In the general population, there is convincing evidence showing that exercise programs are effective, not only to improve balance, gait, and muscle strength capacities, but also to reduce the number of falls. Such evidence is currently lacking for persons with intellectual disabilities.

Therefore, the aim of our research was to determine whether and to what extent application of different planned activities, e.g., a specific exercise program, could assess the
effects of a balance exercise program for enhancement of gait function on temporal and spatial parameters in young people with intellectual disabilities.

SUBJECTS AND METHODS

The experiment was performed with a total of 42 participants with mild intellectual disabilities, who were students of a G special-education school in Gungyi-do, Korea. Participants were excluded if they had musculoskeletal impairments, such as the inability to walk independently, neurological impairments, or vision impairment. Individuals who participated in less than 80% of the training program and who were unable to perform follow-up tests were also excluded.

All experimental protocols and procedures were explained to each subject and approved by the institutional review board of Sahmyook University, Korea. All subjects provided written informed consent prior to study enrollment.

Forty-two subjects who met the inclusion criteria were randomly divided into two groups, namely, the balance exercise program for enhancement of gait function group (BG group, n=21) and control group (n=21), using Random Allocation Software (version 1.0)[15]. However, two subjects in the BG group were excluded because their program participation rates were less than 80%. Accordingly, the study cohort comprised 40 subjects: 19 in the BG group and 21 in the control group (Table 1).

The participants trained for 8 weeks. Evaluations were performed twice, a week before the program started and a week after its completion. Demographics and gait parameters were assessed by two different examiners. Evaluations were measured by an assessor who was blind to the study details.

The BG group participants received 40 minutes of balance training supervised by a school therapist that combined progressive balance and functional gait training twice a week for eight weeks. The members of the control group did not receive any form of balance training.

This balance exercise program was designed based on a previous study of training that has been shown to improve balance and gait[10]. The exercise was conducted twice a week for 8 weeks. School therapists conducted the balance and gait training. The balance exercise program was carried out for 40 min. The program included warm-up movements followed by the balance exercise program (i.e., toe-to-heel walk, tandem standing, side walking, walking backward, with eyes opened versus closed). Balls, foams, balloons, bands, sticks, and scarves were used in conjunction with the dynamic exercises. In addition, general dynamic activities such as dancing, rolling a ball, pushing, pulling, lifting, catching, and throwing were practiced in each session.

Temporal and spatial gait parameters were assessed using an electronic pressure-sensitive walkway (GAITRite, CIR Systems Inc, Sparta, NJ, USA, 2008). The subjects were asked to walk at their usual speed on the GAITRite walkway (5 m length, 61 cm wide, 0.6 cm high) without shoes. This test was repeated 3 times, and the results were averaged. We assessed spatial and temporal parameters using computer analysis (GAITRite GOLD Version 3.2, CIR Systems Inc, Sparta, NJ, USA, 2008).

Subjects practiced walking without paying attention to the board, practiced keeping their eyes straight ahead, and practiced swinging their arms naturally. Then, the participants were instructed to walk at a comfortable pace, as if they were walking down the street. Subjects began walking at a starting position 3 m before the beginning of the mat and continued walking for 3 m beyond the end of the mat. This enabled us to record steady-state gait without the effects of gait initiation and termination. Values obtained during 3 trials were averaged for analysis.

The temporal parameters measured were velocity, cadence, step time, and stride time. The spatial parameters included step length and stride length.

Statistical analyses were performed using the SPSS version 19.0 software. The Shapiro-Wilk test was used to test the normal distribution of all parameters. Differences in continuous variables between groups were tested using the two-sample Student’s t-test, and within group differences were tested with paired Student’s t-test. Differences in categorical variables were analyzed using the χ² test. P values less than 0.05 were considered statistically significant.

RESULTS

Table 2 summarizes the findings for temporal gait parameters over the 8 weeks of the study. The temporal gait parameters were assessed using velocity, cadence, step time, and stride time.

The temporal gait parameters in all conditions showed significant improvement in the BG group (p<0.05) but nothing significant in the control group.

Table 3 summarizes the findings for spatial gait parameters over the 8 weeks of the study. The spatial gait parameters were assessed using step length and stride length.

The spatial gait parameters in all conditions showed significant improvement in the BG group (p<0.05), but nothing significant in the control group.
In this study, cadence showed a significant decrease, 3.4% in the BG group. The persons with intellectual disabilities displayed a higher cadence, and therefore, the results of this study are meaningful.

**DISCUSSION**

This study was performed to evaluate the effects on spatiotemporal gait parameters with an application of a balance exercise program for enhancement of gait function in young people with intellectual disabilities.

The results of this study showed that balance training for enhancement of gait function may be effective in encouraging temporal gait parameters of young people with intellectual disabilities. Moreover, the spatial gait parameters also showed significant improvement in the BG group.

A number of gait analysis studies in persons with intellectual disability have recently reported differences in the spatiotemporal characteristics of gait in persons with intellectual disabilities compared with controls. The persons with intellectual disabilities including Down syndrome displayed lower gait function, lower gait velocity, higher cadence, shorter step length, and larger step width\(^{17}\). In the present study, the young people with intellectual disability showed lower gait functions at baseline, but their gait functions showed significant improvement after training.

Temporospatial gait parameters are now used to assess the abilities of the lower extremities and to represent changes in gait pattern as quantifiable values after an intervention\(^{18}\). The gait functions are important requirements for independent activities of daily living, and therefore, gait speed is an important indicator of walking disability. In this study, gait velocity showed a significant improvement, 31%, in the BG group. Angola-Barroso et al.\(^ {19} \) found that the gait velocity significantly increased in Down syndrome after treadmill gait training. Since Verghese et al.\(^ {20} \) reported that a 10 cm/s decrease in velocity is equivalent to a 10% loss of mobility in daily life, the 31% improvement observed in velocity in the BG group shows that training enhanced subject independence.

In this study, cadence showed a significant decrease, 3.4% in the BG group. The persons with intellectual disabilities displayed a higher cadence, and therefore, the results of this study are meaningful.

**Table 2.** Changes in temporal gait parameters

|                         | BG group (n=19) | Control group (n=21) |
|-------------------------|----------------|---------------------|
| Velocity (cm/s)         |                |                     |
| Pre                     | 0.91 ±0.19\(^ a \) | 0.89 ± 0.22         |
| Post                    | 1.19 ± 0.31    | 0.94 ± 0.29         |
| Pre-Post                | 0.28 ± 0.31\(^ * \) | 0.04 ± 0.32         |
| Cadence (steps/m)       |                |                     |
| Pre                     | 134.71 ± 8.28  | 134.51 ± 8.41       |
| Post                    | 130.19 ± 8.83  | 135.31 ± 6.48       |
| Pre-Post                | −4.52 ± 2.64\(^ * \) | 0.80 ± 8.48         |
| Step time (seconds)     |                |                     |
| Pre                     | 0.57 ± 0.04    | 0.55 ± 0.04         |
| Post                    | 0.56 ± 0.03    | 0.56 ± 0.13         |
| Pre-Post                | 0.02 ± 0.02\(^ * \) | 0.00 ± 0.05         |
| Stride time (seconds)   |                |                     |
| Post                    | 1.13 ± 0.07    | 1.12 ± 0.07         |
| Pre-Post                | −0.04 ± 0.04\(^ * \) | 0.01 ± 0.10         |

Values are expressed as means ± SD. * Values are significantly different between before and after the intervention.

**Table 3.** Changes in spatial gait parameters

|                         | BG group (n=19) | Control group (n=21) |
|-------------------------|----------------|---------------------|
| Velocity (cm/s)         |                |                     |
| Pre                     | 0.50 ±0.09    | 0.49 ± 0.12         |
| Post                    | 0.64 ± 0.16   | 0.52 ± 0.14         |
| Pre-Post                | 0.14 ± 0.03\(^ * \) | 0.03 ± 0.14         |
| Cadence (steps/m)       |                |                     |
| Pre                     | 1.02 ± 0.18   | 1.00 ± 0.24         |
| Post                    | 1.30 ± 0.32   | 1.05 ± 0.30         |
| Pre-Post                | 0.28 ± 0.29\(^ * \) | 0.05 ± 0.32         |

Values are expressed as means ± SD. * Values are significantly different between before and after the intervention.

The normal ranges of velocity and cadence for males between 15 and 17 are 1.03–1.75 m/s and 96–142 steps/min, respectively, and for females, they are 0.92–1.64 m/s and 100–144 steps/min, respectively\(^ {21} \). Although 33% of the experimental group was in the normal velocity range before training, this increased to 71% after training. In terms of cadence, 92% of the subjects in the experimental group were in the normal range before training, but all were within the normal range after treatment.

In this study, we assessed spatial gait parameters by stride length and step length. Previous studies reported that persons with intellectual disabilities showed shorter step lengths and shorter stride lengths compared with the control group. A short stride length and wide step width lead to a high cadence and instability. Ulrich et al.\(^ {22} \) and Wu et al.\(^ {23} \) also noted improvement of walking pattern and increasing step length and stride length compared with the control group.

Because few studies have reported trainability of gait capacities in persons with intellectual disabilities, it is very meaningful that this study suggests trainability of gait capacities in persons with intellectual disabilities. The balance exercise programs used in our study consisted of dynamic balance exercise, dynamic exercise, and dynamic activity. Our program was modified from that applied in adults with mild intellectual disabilities by Carmeli et al.\(^ {16} \).

They suggested that their program improved psychological perception and dynamic balance. Brosse et al.\(^ {20} \) reported that physical activity affects brain function as a result of its facilitation of neurotransmitter chemicals such as dopamine and serotonin in the CNS. These factors may explain the mechanism by which a balance exercise program can affect youth with intellectual disabilities.

Previous studies have reported the risk of falling and falling injuries in elderly with intellectual disabilities, and some studies have indicated an increasing fall risk in elderly individuals with intellectual disabilities\(^ {25} \); therefore, development of appropriate, feasible, and reasonable interventions for persons with intellectual disabilities is required in rehabilitation for young people with intellectual disabilities in the future.

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