Effects of a Treadmill Walking Program on Muscle Strength and Balance in Elderly People With Down Syndrome

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Background. Longer life expectancy is resulting in increasing numbers of elderly adults with mental retardation. In elderly adults with Down syndrome (DS), the maintenance of muscle strength, endurance, and dynamic balance are important to ensure quality of life and functional independence. The objective of this study was to compare isokinetic leg strength and dynamic balance of aged mentally retarded individuals with DS (n = 16, mean age 63) before and after a treadmill walking program lasting 6 months in comparison with a nonwalking control group (n = 10) with similar physical characteristics.

Methods. Participants in the study undertook leg strength testing on a dynamometer. Parameters measured included peak torque, peak torque % body weight, and average power % body weight. A “timed get-up and go” functional test for dynamic balance was also analyzed and compared prior to and after the treadmill program.

Results. Knee extension and flexion isokinetic strength in elderly individuals with DS showed significant improvement after 6 months of treadmill training. Dynamic balance performance was also significantly improved (p < .05).

Conclusions. Aged adults with DS can significantly improve muscle strength and balance by adopting suitable programs of treadmill walking.

The incidence of mental retardation (MR) of the general population is generally estimated at approximately 3.5%. There are an estimated 200,000 individuals with MR in Israel, including approximately 165,000 with symptoms of mild MR and a further 35,000 with moderate to severe MR. The percentage of aged persons in Israel with mental retardation is steadily increasing, and approximately 5% to 6% of the MR population are adults aged 55 years or older (1). The major reasons for increased life expectancy in this population are attributed to continuing improvements in medical technology and in the quality of health and social care. Increased life expectancy in the MR population enhances the incidence of age-related diseases (2,3). Down syndrome (DS) (trisomy 21) is the most common cause of MR in Israel. Clinical disorders associated with DS and aging include increased obesity, muscle hypotonicity, joint hypermobility, cardiac disease, and cognitive impairments (4–6). The deterioration in physiological status with aging is usually accompanied by a sedentary lifestyle, with decreased mobility and physical activity, resulting in increasing dependence on others (7–9). The ability to maintain an independent lifestyle is of paramount importance for elderly MR individuals.

Approximately 58% of the adults with MR in Israel live in nonfamily settings. Elderly adults with mild to moderate MR tend to be placed in community programs of specialized foster care, consisting primarily of shared apartments with three to five residents, supervised around the clock by trained staff. Medical and rehabilitation services are routinely provided by supplementary staff; however, recreational activities are limited and not often available. Clinical procedures commonly used to determine levels of physical functioning have two main functions: the detection of specific impairments and the identification of individuals with a greater probability of disease than that found in the general population. Various clinical assessment methods, including gait and balance, are widely used to determine general physical functioning and mobility in elderly persons (7). Muscle weakness of lower limbs and poor standing balance are associated with increased risk of falling. Several studies have demonstrated the positive effects of walking training programs on muscle strength, endurance, and balance in elderly people (10). There have been relatively few published reports on the effects of strength training programs in adult individuals with MR, and very little is known about the relationship between muscle strength and functional ability as measured by dynamic balance in elderly adults with DS (11,12). The main aim of the present study was to evaluate the changes in isokinetic leg strength and balance ability and the benefits of a 6-month walking program on improving leg muscle strength of institutionalized elderly MR individuals with DS.
METHODS

Subjects and Design
All participants in the study (n = 26) are residents of a foster home located in Hadera, Israel and have been diagnosed with mild MR requiring minimal supervision for daily activities. Intelligence quotients determined using the Stanford Binet Scale ranged from 56 to 75 ± 5 (13). The age of subjects with mild MR, diagnosed at birth with DS, ranged from 57 to 65 years. The walking group (WG) included 16 adults (10 women, 6 men; mean age 63.5 ± 2; incidence of cardiac disease 14%). The nonwalking control group (CG) included 10 adults (6 women and 4 men; mean age 63.3 ± 4.8; incidence of cardiac disease 16%). The WG and CG were well matched for all recorded physical determinations including height, weight, and body mass index (BMI) (calculated as body weight/height²) with no significant differences in these parameters. All participants were resident in the foster home for at least 4 years and were selected for the study by the in-house physician. Individuals with pre-existing conditions (such as blindness, limb amputation, or severe osteoarthritis) that could interfere with the results or could lead to comorbidity (with non-age–related changes) were excluded from the study. Comorbidity conditions included depression and possible adverse drug reactions. Subjects in the study were not taking drugs, such as sedatives or narcotics, that might have hindered balance or strength performance. Written informed consent was received either directly from subjects or from their legal guardians prior to participation in the study. After receipt of informed consent, participants were asked to refrain from taking medications and from any intense physical activity. Both the walkers and nonwalkers were tested for isokinetic muscle strength and “timed-up and go” (TUAG) performance before and following 6 months of the study. The assessment of strength and balance was performed blindly, with investigators unaware to which group individuals belonged. Approval for the study was received from the Institutional Review Board of the Israel Ministry of Labor.

Experimental Procedures
Knee extension and flexion strength were measured from both sides as previously described (14,15). Testing was performed using a medical isokinetic system (Biodex dynamometer; Medical Systems, Shirley, NY). Familiarization with the equipment and the testing protocol was done in a separate session, and participants showed no resistance. All subjects initially performed 3 minutes warm-up walking at a comfortable speed. After the warm-up, subjects performed five practice repetitions for knee extension and flexion at speeds of 60°/s and 120°/s. Finally, subjects performed three maximal voluntary contractions at a speed of 60°/s and 120°/s (highest peak torque value, Newton-meters) for knee extensors (quadriceps femoris) and flexors (hamstrings). All tests were performed in the sitting position. Data were collected for peak torque (ft/lb) (the greatest single value of three maximal efforts), peak torque percent body weight (ft/lb/kg), and average power (watts) (the expression of work per unit of time).

Balance testing was performed before strength testing to avoid any fatigue that may occur with strength testing. The TUAG test was used to measure the dynamic balance and gait speed (16). The test is a modification of the original “get-up and go” test, in which subjects walk 6 m. Each participant was asked to rise from an armchair, walk 9 m, and return to the chair (total walking distance of 18 m). Times were measured using a manual stopwatch. The target time period to complete this test for older adults with a good level of independence is between 26 and 30 seconds. The procedure was experimentally tested and found to be a highly reliable and valid tool to measure balance function (17).

Walking Training Protocol
Participants in the study were randomly assigned to either the WG or the CG by means of a coin toss. The WG and CG had similar characteristics regarding several health and lifestyle determinants. Five minutes of active stretching exercises were undertaken prior to each walking session and included prolonged and progressive stretching of the Achilles tendon and of the hamstrings and quadriceps muscles. The treadmill program consisted of individually prescribed low-endurance walking at 0% incline as previously recommended (18,19). Participants walked on the treadmill three times per week, for 25 consecutive weeks, initially for 10 to 15 minutes as tolerated and then gradually for as long as 45 minutes as endurance improved. Participants walked at a speed below the threshold of breathlessness but as fast as they could comfortably tolerate, and if necessary participants were allowed to grab the handrails for walking balance adjustments. The participants walked only between 9:30 and 11:30 am indoors under controlled conditions (23°C, 40% humidity). Two monitors stood by the walkers as a safety precaution in case of unexpected dizziness or to prevent a fall. Immediately following the completion of walking, the participant was seated, and heart rate and blood pressure determined. For monitoring purposes heart pulse (1 minute), blood pressure (mm Hg), and respiration rate were recorded before and after each training session. Participants of the control group were instructed not to change current levels of physical activity.

Statistical Analysis
All data were analyzed using a Crunch statistical package (Crunch Software Corporation, Oakland, CA). Means and standard deviations were calculated for all variables. Age, height, weight, BMI, peak torque, peak torque % body weight (%BW), average power %BW, and balance (seconds) were analyzed by multivariate analysis of variance to compare the walking group with the control group. A two-way analysis of variance was used to determine the effects of walk training, gender, muscle, and balance. Reliability of the dependent variables was determined with one-sample independent t tests that were used to compare differences in leg strength and balance pre- and post-training, and 95% confidence intervals of difference were determined. The critical value for statistical significance was assumed at an alpha level <.05.

RESULTS
All participants from the walking group concluded the 25-week gait-training program. After 6 months of treadmill walking at angular velocities of 60°/s and 120°/s, the peak
torque, peak torque %BW, and average power %BW of quadriceps and hamstrings of aged individuals with DS were significantly higher than the prewalking values (Table 1 and 2). Table 3 shows the results of the TUAG test. Times longer than 30 seconds to perform the test may indicate some balance or endurance difficulties and increased risk for falling. The CG and the prewalking WG finished the test in 29.2 and 28.5 seconds, respectively. The WG after training finished this test significantly faster in comparison with their prewalking speeds, needing 9.1% less time (*p < .05). All walking performances improved significantly as a result of the walking program (Table 3). Improvements included better walking duration (+150%), walking speed (+86%), and walking distance (+180%). Mean prewalking distance (km) was 0.31 ± 0.12 compared with the mean postwalking distance of 0.87 ± 0.55; mean prewalking speed (km/h) was 0.72 ± 0.21, and mean postwalking speed was 1.34 ± 0.48; mean prewalking duration (minutes) was 14.1 ± 5.5, and mean postwalking duration was 36.0 ± 7.2.

**DISCUSSION**

Elderly individuals with MR usually have fairly sedentary and inactive lifestyles associated with deterioration in physical health and early onset of age-associated diseases. It is widely believed that the increased morbidity of older adults with DS is due to a large degree to impaired physical development, limited motivational levels, and restricted opportunities to participate in physical activity programs. Regardless of the reasons for the mainly sedentary lifestyle of individuals with DS, further measures need to be investigated on how to improve their physical fitness and aerobic capacities. The introduction of specific exercise programs should be encouraged to promote as healthy a lifestyle as possible and to slow the onset of muscle weakness and deconditioning secondary to inactive or sedentary lifestyles.

Previous studies have reported isokinetic strength of lower limbs in adults with and without MR (20). Sufficient leg strength of institutionalized individuals with DS is essential to permit functional independence for activities of daily living (ADLs) and instrumental ADLs (such as lifting, gardening, and house management). The knee muscles (flexors and extensors) in individuals with DS stabilize and protect the knee during standing, walking, and climbing or descending stairs and provide balance integration.

The main purpose of the present study was to determine the effects of a controlled 25-week walking program on improving leg strength and dynamic balance in a group of elderly individuals with DS. The study clearly demonstrates

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**Table 1. Leg Strength Characteristics (Quadriceps and Hamstrings) of Individuals With Down Syndrome Pre- and Post-Treadmill Walking**

<table>
<thead>
<tr>
<th>Knee Extension</th>
<th>Nonwalking Group (n = 10)</th>
<th>Walking Group, Prewalking (n = 16)</th>
<th>Walking Group, Postwalking (n = 16)</th>
<th>Mean Difference</th>
<th>95% CI of Difference</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women (n = 6)</td>
<td>Men (n = 4)</td>
<td>Women (n = 10)</td>
<td>Men (n = 6)</td>
<td>Women (n = 10)</td>
<td>Men (n = 6)</td>
</tr>
<tr>
<td>Peak torque, Nm or ft/lb</td>
<td>39.2 ± 2</td>
<td>43.5 ± 1</td>
<td>38.2 ± 1</td>
<td>52.2 ± 2</td>
<td>49.4 ± 2*</td>
<td>63.1 ± 2</td>
</tr>
<tr>
<td>Peak torque %BW, %</td>
<td>20.2 ± 5</td>
<td>24.4 ± 6</td>
<td>20.4 ± 1</td>
<td>28.5 ± 6</td>
<td>27.6 ± 5*</td>
<td>38.4 ± 9*</td>
</tr>
<tr>
<td>Average power %BW, watts/kg</td>
<td>17.4 ± 3</td>
<td>42.0 ± 1</td>
<td>17.6 ± 1</td>
<td>47.2 ± 1</td>
<td>60.2 ± 2*</td>
<td>73.6 ± 2*</td>
</tr>
</tbody>
</table>

Notes: Mean difference and confidence intervals (CI) of difference relate to postwalking changes compared with prewalking values. Upper values represent angular velocity at 60°/s; lower values represent angular velocity of 120°/s. %BW = % body weight.

*p < .01.
significant positive improvements in both leg strength and balance. All parameters of leg strength and balance of the participants were markedly improved after the 25-week program of submaximal walking. Walking capacity (speed, duration, and distance) increased progressively from week 1 until week 15, when a plateau was reached and parameters remained fairly constant. The study showed that isokinetic measurements, including mean peak torque, peak torque %BW, and power %BW of quadriceps and hamstrings muscles of old adults with DS, were higher after 6 months of treadmill walking (p < .05). In addition, the walking program significantly improved dynamic balance compared with the prerelative status. It appears that improved knee muscle performance may have played a role in the improvements in subjects’ ability to maintain balance. Results from our study are very encouraging, despite the limitations of the relatively low numbers of subjects tested. As far as we are aware this is the first published study showing a relationship between leg strength and walking functional ability in aged individuals with DS.

The TUAG test is one of the more user-friendly functional assessment tests in the clinic. The TUAG test is used to assess a person’s ability to perform a task that is probably performed many times throughout the day by elderly adults. Adults taking more than 30 seconds to complete the test indicate early fatigue and increased risk of falling and are not considered completely safe to be left alone outside. Poor performance (slower than 30 seconds) may be used to justify therapy intervention as a preventive measure. This test also supplies further information about the participant’s functional ability and rehabilitation requirements (21–23). Individuals with DS improved their scores in this functional test after 6 months of treadmill walking. Prior to the walking program, aged individuals with DS needed significantly more time to complete the test than after the walking program but still finished the test within the normal time frame.

Our study has demonstrated the importance of the duration factor in a walking program for elderly MR individuals with DS, and our methods have helped answer the question of “how much training is enough?” The current program differed from previous studies in that it was based solely on walking components, which may be more acceptable to older adults with MR over a long period than other exercise programs such as resistance training, biking, dancing, or swimming. Increasing the motivation of elderly adults with DS to participate in routine exercise programs is a challenging task; however, all participants in the study enjoyed the treadmill walking, and none withdrew from the study.

These findings clearly support the claim that adoption of an active physical exercise program in relatively inactive elderly persons may be beneficial to health. Such programs of regular physical activity may slow the onset of diseases associated with aging and may also be beneficial in improving self-esteem. The improvements in muscle strength and balance after a walking program may have additional positive health benefits such as reducing risk of falls (23) and encouraging participation in recreational and social activities (24–27).

Although the WG and CG were well matched for most of the variables, there were some subject–control differences. One limitation of the study is that the walking subjects were aware that they were receiving the intervention. Despite the possibility that part of the improvement noted at post-training may have been due to increased attention and motivation, such a confounding factor is nonetheless welcome in this special population.

Conclusions

We conclude that a regular treadmill program can provide distinct benefits for elderly adults with DS and can lead to improvements in leg strength, balance, and walking function. The importance of this improvement is reflected in the potential afforded individuals with DS to increase their daily activities and functional capabilities. The results of the present study are unique in that the relationship reported was between individual muscle and balance performance measurements, as opposed to documenting general debility in nonactive versus active older adults with DS. The data suggest that well-designed walking programs can maintain and even improve leg muscles and balance performance in aged MR individuals.

Acknowledgments

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