Balance Training Reduces Falls Risk in Older Individuals with Type 2 Diabetes

S. Morrison, PhD, S.R. Colberg, PhD, M, Mariano, PhD, H.K. Parson, PhD, A.I. Vinik, PhD

1School of Physical Therapy, Old Dominion University, Norfolk, VA
2Human Movement Sciences Department, Old Dominion University, Norfolk, VA
3Strelitz Diabetes Center, Eastern Virginia Medical School, Norfolk, VA

Corresponding Author:
Dr Steven Morrison
Email: smorriso@odu.edu


This is an uncopyedited electronic version of an article accepted for publication in Diabetes Care. The American Diabetes Association, publisher of Diabetes Care, is not responsible for any errors or omissions in this version of the manuscript or any version derived from it by third parties. The definitive publisher-authenticated version will be available in a future issue of Diabetes Care in print and online at http://care.diabetesjournals.org.
**Objective:** This study assessed the effects of balance/strength training on falls risk and posture in older individuals with type 2 diabetes.

**Research Design and Methods:** Sixteen individuals with type 2 diabetes and 21 age-matched controls (50-75 yrs) participated. Postural stability and falls risk was assessed before and after a 6-week exercise program.

**Results:** Diabetes individuals had significantly higher falls risk score compared to controls. The diabetes group also exhibited evidence of mild-to-moderate neuropathy, slower reaction times and increased postural sway. Following exercise, the diabetes group showed significant improvements in leg strength, faster reaction times, decreased sway and consequently, reduced falls risk.

**Conclusions:** Older individuals with diabetes had impaired balance, slower reactions and consequently a higher falls risk than age-matched controls. However, all these variables improved after resistance/balance training. Together these results demonstrate that structured exercise has wide-spread positive effects on physiological function for older individuals with type 2 diabetes.
Older individuals with type 2 diabetes (T2DM) often exhibit greater impairments in posture and gait and are typically at increased risk of falling (1,2). This study was designed to assess whether T2DM individuals exhibited differences in balance, reaction time and falls risk compared to controls and, to examine the effects of training on these measures.

**RESEARCH DESIGN AND METHODS**

Sixteen T2DM individuals (62.3±5.5yrs; average diabetes duration 15.2±2.4yrs) and 21 age-matched controls (64.7±7.1yrs) participated. Exclusion criteria included: cardiovascular disease, unstable proliferative retinopathy, end-stage renal disease, uncontrolled hypertension and/or participation in balance/resistance training during the previous year. All procedures complied with Institutional Review Board guidelines.

Initial assessment included a complete history, physical examination and full neurologic evaluation that included assessment for somatic/autonomic neuropathy (3). Warm-cold thermal perception, 128Hz vibration perception, touch, pressure and prickling pain perception were evaluated. An overall total neuropathy score was also calculated. The average glycated hemoglobin (HbA1c) for the T2DM group was 7.5%±0.3%. Following screening, a record of previous falls, balance, reaction time and falls risk assessments were completed. Individuals then completed a 6-week, thrice-weekly exercise program followed by post-training evaluations.

Each exercise session consisted of a balance/posture component (e.g., lower-limb stretches, leg, abdominal, and lower-back exercises) and a resistance/strength-training component (e.g., lower/upper-limb exercises performed using strength training machines). Participants performed 1-2 sets of 10-12 repetitions with rests between exercises.

**Falls Risk:** Risk of falling was determined using the long-form Physiological Profile Assessment (PPA). This validated tool (4) assesses vision, sensation, proprioception, lower-limb strength, postural sway/coordination, and cognitive function.

**Simple Reaction Time (SRT):** Participants completed a SRT task where upper-limb (finger) and lower-limb (foot) responses were assessed. Individuals responded to a visual cue by depressing a timing switch. Fifteen trials were completed with each segment.

A repeated measures, generalized linear model was used to assess for group and training effects. Significant effects were further examined using planned contrasts (one-way ANOVAs). Analyses were performed using SAS statistical software (SAS Institute Inc.,) with p<0.05.

**RESULTS**

**Clinical Assessment.** Diabetic individuals exhibited significant differences in total neuropathy scores (left foot F1,35=9.87; right foot F1,35=8.86;p’s<0.05), body mass index (F1,35=22.50;p<0.05) and percent body fat (F1,35=7.11;p<0.05). There were no significant group/exercise differences in blood pressure measurements for either sitting (pre-training: Controls 128.2±3.4/73.4±2.3mmHg, T2DM 133.0±4.2/69.1±2.7mmHg; Post-training: Controls 123.6±2.8/70.7±2.2mmHg, T2DM 130.0±4.6/67.4±3.2mmHg) or standing (Pre-training Controls 125.8±2.8/73.8±2.2mmHg, T2DM 133.4±4.1/72.14±3.3mmHg; Post-training Controls 119.8±2.9/74.6±2.5mmHg, T2DM 127.7±6.0/68.8±3.2mmHg). No significant group/exercise differences were found for the following measures of autonomic function; E:I ratio (Controls 1.13±0.02; T2DM 1.15±0.02), Valsalva maneuver (Controls, 1.25±0.03; T2DM 1.25±0.07), and stand ratio (Controls 1.36±0.16; T2DM 1.48±0.29).
**Falls History.** A significant group difference was found for the average number of falls (\(F_{1,35}=4.44; p<0.05\)) with T2DM subjects experiencing more falls over the past year. No group difference in falls was observed post-training.

**Falls Risk.** As shown in figure 1, T2DM subjects had a significantly higher falls risk score compared to controls (\(F_{1,35}=20.24; p<0.05\)). Following training, both groups exhibited reduced falls risk, but this was only significant for T2DM individuals (\(F_{1,35}=33.03; p<0.05\)). While no age effects were observed, correlation analysis revealed a significant falls risk-age relationship for T2DM group (\(r=0.519; p<0.05\)).

Analysis of the individual PPA measures showed that T2DM individuals exhibited reduced proprioception (\(F_{1,35}=5.89; p<0.05\)), sensation (\(F_{1,35}=5.78; p<0.05\)), and ankle strength (\(F_{1,35}=4.17; p<0.05\)) compared to controls. Following training, a significant group-by-exercise effect was seen for proprioception (\(F_{1,35}=4.54; p<0.05\)), quadriceps (\(F_{1,35}=9.11; p<0.05\)) and hamstring strength (\(F_{1,35}=5.07; p<0.05\)). Planned contrasts revealed that both groups showed improvements in strength and proprioception post-exercise.

**Reaction Time.** There was a significant group difference for hand (\(F_{1,35}=7.22; p<0.05\)) and foot SRT (\(F_{1,35}=9.64; p<0.05\)) with the diabetic group being significantly slower (figure 1). Post-training, a significant improvement in both SRT measures (hand \(F_{1,35}=11.87\); foot \(F_{1,35}=14.52; p's<0.05\)) was found. Planned contrasts revealed that both groups recorded faster hand SRT following exercise. However, only the T2DM group exhibited significantly faster foot SRT post-training.

**CONCLUSIONS**

Normal aging is associated with slower cognitive processing (9), slower postural reactions (10), and decreased muscle strength (11), all of which are essential for optimal balance (7). The current study demonstrated that all older individuals showed a decline in SRT and strength, although the decrement was more pronounced for those with diabetes. The decline in function for older diabetic individuals was further compounded since they had a higher previous history of falls and all exhibited mild-to-moderate neuropathy, the latter being associated with increased falls risk (12). Consequently, the T2DM group was at greater falls risk, confirming the view that increasing age, previous falls history, increased postural sway, and presence of diabetes are major risk factors for falling (1,2,5-8).

Following training, the diabetes group exhibited a significant decline in falls risk, dropping from a mild-to-moderate to a low-to-mild risk of falling. This decline was reflected by improved proprioception and increased hamstring/quadriceps strength. While increasing physical activity can lead to enhanced joint proprioception, a learning effect cannot be ruled out as a contributing factor for the improved lower-limb proprioception. Both groups also demonstrated significant improvements in SRT. The ability to respond quickly to any external perturbation is essential for correcting oneself to avoid possible falls (4,6,10). Unfortunately, many older individuals exhibit slower reaction times (6,9) and are at increased risk of falling since they respond slower under postural situations (10). The improved RT with exercise has obvious implications for individuals at high falls risk to correct themselves during balance-threatening situations. While hypoglycemia could be one reason for slower RT’s for the diabetic group (13), any decreased glucose levels would not explain the significantly improved SRTs seen post-exercise. While
increased strength correlates highly with improved balance and decreased falls risk (14,15), our results show that the benefits of exercise are not limited to muscle function. Rather, training resulted in improvements in a range of falls risk factors, impacting positively on sensory, motor and cognitive processes.

Overall, this study demonstrated that older T2DM individuals are at increased falls risk. Following training, the T2DM group demonstrated improvements in balance, proprioception, lower-limb strength, RT and consequently, decreased risk of falling. The results support the practice of prescribing mild-to-moderate exercise to individuals with type 2 diabetes to alleviate falls risk.

**Figure Captions**

**Figure 1** Changes in the falls risk (a) and average hand and foot simple reaction times (b) between control and T2DM groups. Mean values are shown for each group prior to and following the exercise intervention. Error bars represent one SE of the mean. For the falls risk, significant differences were observed between the groups prior to exercise (*1) and, for the T2DM group only, following training (*2). For the reaction time results, significant differences were observed in the hand and foot RT values between the groups prior to exercise (*3). Following training, the T2DM exhibited a significant reduction in both foot and hand RT values (*4). For the controls, only the hand RT values showed a decrease after training (*5).
REFERENCES


