A Combined Strength and Balance Exercise Program to Decrease Falls Risk in Dialysis Patients: A Feasibility Study

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ABSTRACT

Bennett PN, Breugelmans L, Chan D, Calo M, Ockerby C. A Combined Strength and Balance Exercise Program to Decrease Falls Risk in Dialysis Patients: A Feasibility Study. JEPonline 2012;15(4):26-39. People suffering end-stage kidney disease receiving hemodialysis have a greater risk of falling and suffering debilitating injuries. The purpose of this study was to examine the feasibility and impact of a combined strength and balance exercise intervention on falls risk in hemodialysis patients. Twenty-four adults (mean age = 67.8 yrs) from two Australian outpatient hemodialysis clinics completed the intervention. Falls risk was measured using the Physiological Profile Assessment (PPA). There was a significant reduction in the median overall falls risk z-score from 1.67 to .52 (z = -3.11, P<.008; r = .45). Median reaction time improved from .30 to .26 sec (z = -2.86, P<.008; r = .41). A strength and balance intervention to reduce the falls risk for dialysis patients is feasible and may reduce falls risk for at-risk patients.

Key Words: Dialysis, Exercise Physiologist, End Stage Kidney Disease, Falls
INTRODUCTION

People suffering end-stage kidney disease (ESKD) require dialysis or kidney transplantation to maintain life. The average age of this population is increasing. For example, the number of hemodialysis patients in the United States aged 65 to 74 has increased 28% since 2000 with an increase of 37% among those 75 yrs of age (51). Similarly, in our Australian population, 70% of all hemodialysis patients are over the age of 55 yrs (39). Increasing age is strongly associated with increased falls risk (22).

Increased risk of falls and falls-related injury in the aging general population include weakness, poor balance, poor gait, poor vision, limited mobility, cognitive impairment, poor physical function, and postural hypotension (16,43). Such risk factors are common in hemodialysis patients, given that many of them are frail (17) and suffer co-morbidities such as diabetes (51), anemia (38), visual impairment (6), depression (12), sleep disorders (19), hypotension (9,41), neuropathy (36), and bone disease (4,48). In addition, the rapid fluid and electrolyte shifts associated with the hemodialysis treatment can further contribute to risks of hypotension and syncope (30,40). Hemodialysis patients take on average nine medications (12), and are more likely to be prescribed antidepressants, narcotics, and hypnotics (13,15).

Until recently, falls among hemodialysis patients had received little attention. Recent literature confirms that older people receiving hemodialysis have a significantly greater risk of falling than the age-equivalent general population (8,42). While 30% of people over the age of 65 will fall each year, 47% of hemodialysis patients under and over 65 yrs of age will fall (9). Furthermore, severe falls that result in radiological-confirmed fractures (23) are common in hemodialysis patients (1) because of renal bone disease that contributes to the increase in fracture risk (48) and the associated increase in morbidity and mortality (53). Fifty-four percent of falls-related admissions in people on dialysis are diagnosed with fractures (42) and over 50% suffer a falls related fracture prior to commencing a dialysis program (53). This falls injury rate is four times that of age-matched populations (24) with post hip fracture mortality doubled for people in the dialysis population compared with the non-dialysis population (24).

Since exercise interventions targeting both strength and balance in the non-dialysis population have been successful in reducing falls risk through physical therapy (27,36), it is reasonable to expect similar results in the dialysis population (20,48). Yet, it remains unclear as to whether these interventions reduce falls risk in the hemodialysis population. The aim of this pilot study was to explore and assess the feasibility of such an intervention in the dialysis setting to inform the development of future research in this area. In particular, this included identifying the proportion of eligible persons who consented to participate, tracking the flow and attrition of participants over time, examining effect sizes, and calculating sample size for a future study (7).

METHODS

Subjects

Approval for this study was obtained from the hospital’s Human Research Ethics Committee. All subjects provided an informed consent. Participant selection was a two step process. In Step 1, the participants were recruited from two satellite hemodialysis centers located in one Australian city. Subjects were eligible for inclusion if they: (a) suffered ESKD; (b) had been receiving hemodialysis for more than three months; and (c) were aged 18 yrs or more. They were excluded...
from the study if they had partial or total blindness, lower limb amputation, were unable to understand spoken English, hospitalized in the month prior to study commencement, were cognitively impaired, and/or were unable to ambulate independently.

This was a feasibility study (not a controlled trial), so we added a second inclusion criteria step in order to target the intervention to those who were most likely to provide information regarding the feasibility of the project (i.e., those at high risk). We considered that if the intervention exercise program was feasible for those at higher risk it would logically be feasible for other lower risk participants. Thus, Step 2 of the selection process included those people with a high risk of falling. We based our high falls risk definition on the Short Form Physiological Profile Assessment (PPA) (32), the primary outcome measure in this study. We undertook a falls assessment using the PPA and compared the potential participant's overall falls risk with that of their comparative normative age group. If the participants were at a higher risk, they were eligible for inclusion in the intervention. Alternatively, if any of the five PPA component z-scores was lower than -1 compared to normative data for people aged 60 yrs and over, they were also eligible for inclusion in the intervention.

**Primary Outcome Measure**

Falls risk was measured using the five item Short Form Physiological Profile Assessment (PPA) (32). The measures used were: (a) edge contrast sensitivity, which requires identification of the orientation of a line separating two semicircles of differing contrast; (b) hand reaction time using a computer mouse or button press system; (c) knee joint proprioception using a joint matching test; (d) a lower limb (maximal quadriceps) strength test; and (e) postural sway when standing on foam (32). These five items were identified by the PPA developers as being the most important items for discriminating between fallers and non-fallers in both institutional and community settings (33,35).

Data for the five PPA components were entered into a web-based computer software program that generated a comprehensive report for each individual. Based on the weighted scores of the five independent PPA components, the software program calculated the overall falls risk z-score for an individual, which was standardized for age and gender and derived from discriminant function analysis of data from large-scale studies. (32). Lower scores in proprioception, reaction time, postural sway, and overall falls z-score signified lower falls risk, while higher scores in contrast sensitivity and lower limb strength signified lower falls risk. All assessments were conducted by a team of qualified exercise professionals who had received training on the PPA. The PPA was completed immediately before (pre) and immediately following (post) the participant’s 8-week strength and balance exercise intervention.

**Intervention**

The intervention consisted of exercises for both resistance and balance. The participants were supervised individually at all times by exercise physiologists. The strength exercises consisted of hip abduction, ankle plantar flexion and dorsi flexion, straight-leg raise, hip flexion, knee extension and knee flexion. All strength exercises were done in a seated position and performed intradialytically (i.e., carried out during hemodialysis). The participants began with a resistance that allowed them to perform one set of 10 repetitions for each exercise. The intensity level for each exercise was moderate, eliciting a rating of perceived exertion (RPE) of 15 to 17. When they were able to perform a set of 20 repetitions for each exercise, the exercises were progressed using a combination of Theraband® elastic bands and tubings of different tensile strength.
the participant’s preference and ability, the strength exercises were performed before, during and/or after dialysis and took ~15 min to perform.

For static balance, participants were asked to stand and maintain a static position for 30 to 90 sec. The participants were initially assessed by an exercise physiologist to establish their ability. Then, they commenced with a challenging exercise. Participants were progressed by narrowing the base of their support with different stances, decreasing hand support, challenging support surface, and/or closing their eyes to remove visual input that further challenged the postural system (Table 1). For dynamic balance, participants walked along a 2.5 m line by off-set tandem/tandem walking (heel/toe walking), backward walking, and lateral walking. Progression was made by changing the amount of hand support, stepping over or on/off different surface objects. Balance exercises were performed either before or after dialysis due to space restrictions while on dialysis. If they arrived early for dialysis, they could do the balance exercises pre-dialysis. Otherwise, they performed them following the dialysis treatment. The balance exercises took 10 min to complete.

Table 1. Progression of Static and Dynamic Balance Exercises.

<table>
<thead>
<tr>
<th>Base of support (static)</th>
<th>Hand support</th>
<th>Surface</th>
<th>Eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal stance</td>
<td>2 hands</td>
<td>Normal hard surface</td>
<td>Eyes open</td>
</tr>
<tr>
<td>Rhomberg’s stance^</td>
<td>1 hand</td>
<td>Foam block</td>
<td>Changing point of focus (vision, head position)</td>
</tr>
<tr>
<td>Off-set tandem*</td>
<td>1 finger</td>
<td>Therapy disc (1 for each leg)</td>
<td>Eyes closed (not for dynamic exercises)</td>
</tr>
<tr>
<td>Tandem stance*^</td>
<td>No hand &amp; arms wide</td>
<td>Foam roller (half)</td>
<td></td>
</tr>
<tr>
<td>Single leg stance</td>
<td>No hand &amp; arms near body</td>
<td>Rocker board</td>
<td></td>
</tr>
</tbody>
</table>

^Feet together side by side; *1 foot in front of the other but not touching; **1 foot in front of the other and touching heel to toe.

**Statistical Analyses**

All data were analyzed using IBM SPSS Statistics version 18. Exercise compliance was calculated as the mean percentage of balance and strength sessions completed out of the total 16 sessions. Participants with compliance scores less than 50% were excluded from analysis. The outcomes included the overall falls risk z-score and the five individual components of the PPA. Wilcoxon Signed Rank Tests were used to compare the pre- and post-intervention results, with a Bonferroni adjustment (37) made to the P value (<0.008) to account for multiple comparisons. An effect size (r) was calculated for each pre-post comparison with .3 considered a medium effect and .5 a large effect (37).
RESULTS

The following figure (Figure 1) outlines the recruitment of participants. A total of 84 participants participated in the initial falls risk assessment testing. They moved into the second stage of recruitment. Of these, 72 participants (83%) met the criteria to indicate higher falls risk and were invited to participate in the exercise intervention of which 32 participants (44%) consented to be involved.

Eligible patients (i.e., met inclusion/exclusion criteria)  
N = 87

Provided consent for falls risk testing

Yes  n = 84
No  n = 3

Eligible for intervention
1. Higher overall fall risk, based on Physiological profile Assessment (PPA), compared to the individual’s normative age group risk, and/or
2. PPA component z-score among normative population that was lower than -1 compared to age 60 years and over.

Yes  n = 72
No  n = 12

Provided consent for exercise program

Yes  n = 32
No  n = 40

Completed at least 50% of intervention sessions

Yes  n = 24
No  n = 8
Consent to undertake the strength and balance exercise program was voluntary. If for any reason, a potential participant was unable to undertake the program, the participant was not included. The reasons provided by 40 participants for not agreeing to participate were typically related to co-morbidities and social/personal reasons (e.g., not enough time). Given that the balance exercises were required to be done either before or after dialysis, lack of time was a common reason for not commencing the exercise intervention. Eight participants failed to meet the target of 50% compliance. They were excluded from further analysis. Four participants transferred to other dialysis centers. Two participants received kidney transplants, and two withdrew for unrelated medical reasons. Thus, the final sample that completed the pre- and post-intervention falls risk assessment and the strength and balance intervention consisted of 24 participants. These participants had an exercise compliance rate of 76%. Of these 24 participants, 18 (75%) were 60 yrs of age or over, which reflected a more elderly population. Other demographic characteristics of the participants are outlined in Table 2.

Table 2. Demographic Characteristics of Participants (n=24).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>40-49 years</td>
<td>3</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>50-59 years</td>
<td>3</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>60-69 years</td>
<td>6</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>70-79 years</td>
<td>8</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>80 years or more</td>
<td>4</td>
<td>16.7</td>
</tr>
<tr>
<td>Gender</td>
<td>Female</td>
<td>10</td>
<td>41.7</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>14</td>
<td>58.3</td>
</tr>
<tr>
<td>Language</td>
<td>No difficulty with English</td>
<td>21</td>
<td>87.5</td>
</tr>
<tr>
<td></td>
<td>Some difficulty with English</td>
<td>3</td>
<td>12.5</td>
</tr>
<tr>
<td>Aboriginal or Torres Strait Islander</td>
<td>Yes</td>
<td>5</td>
<td>20.8</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>19</td>
<td>79.2</td>
</tr>
<tr>
<td>Falls History</td>
<td>No falls in previous year</td>
<td>16</td>
<td>66.7</td>
</tr>
<tr>
<td></td>
<td>1 fall in previous year</td>
<td>3</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>Multiple falls in previous year</td>
<td>5</td>
<td>20.8</td>
</tr>
</tbody>
</table>

Table 3 outlines the pre- and post-falls z-scores and the five PPA components. Based on the adjusted P values, there were two items where the differences between pre- and post-test scores were statistically significant (i.e., falls z-score and reaction time). There was a significant decrease in falls z-score (i.e., overall falls risk) from the pre-test (Mdn = 1.67) to the post-test (Mdn = .52), z
The falls z-score for 18 participants decreased (i.e., improved), and there was a medium effect size ($r = .45$). For reaction time, the median score decreased (i.e., improved) from the pre-test ($Mdn = .29$) to the post-test ($Mdn = 0.26$), $z = -2.86$, $P<.008$. Specifically, there was an improvement in reaction time for 18 participants and there was a medium effect size ($r = .41$). For knee extension force, 17 participants showed improvement from the pre-test to the post-test and, although a medium effect size was recorded, this comparison failed to reach statistical significance using the adjusted $P$ value of .008.

Table 3. Pre- and Post-Intervention PPA Scores ($n = 24$).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Phase</th>
<th>Median</th>
<th>Interquartile range</th>
<th>$r$</th>
<th>$z$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls z-score</td>
<td>Pre</td>
<td>1.67</td>
<td>.53 - 2.26</td>
<td>.45</td>
<td>-3.11</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>.52</td>
<td>-.08 - 1.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction time</td>
<td>Pre</td>
<td>.30</td>
<td>.22 - .42</td>
<td>.41</td>
<td>-2.86</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>.26</td>
<td>.21 - .32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower limb force</td>
<td>Pre</td>
<td>15.59</td>
<td>10.58 - 22.66</td>
<td>.32</td>
<td>-2.23</td>
<td>.026</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>17.27</td>
<td>14.52 - 23.60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity</td>
<td>Pre</td>
<td>18.00</td>
<td>17.00 - 20.00</td>
<td>.22</td>
<td>-1.48</td>
<td>.138</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>19.00</td>
<td>18.00 - 21.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proprioception</td>
<td>Pre</td>
<td>1.70</td>
<td>.85 - 3.35</td>
<td>.21</td>
<td>-1.48</td>
<td>.139</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>1.40</td>
<td>.85 - 2.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postural sway</td>
<td>Pre</td>
<td>951.00</td>
<td>452.00 - 1514.25</td>
<td>.02</td>
<td>-.11</td>
<td>.909</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>782.00</td>
<td>419.50 - 1160.50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant based on Bonferroni adjusted $p$ value of $p < .008$

Figure 2 illustrates the pre- and post-falls z-scores for the 24 participants. Scores >1 indicate moderate risk, >2 indicate marked risk, and >3 indicate very marked risk. On the pre-intervention PPA, 16 participants had a score that placed them into one of these three highest risk categories, but only 10 participants scored in this range after the intervention. Importantly, 14 participants (58%) were classified into a lower falls risk category (i.e., improved) on the post-intervention PPA compared with the pre-intervention. Falls risk for an additional eight participants (33%) remained unchanged and two patients (8%) were classified into a higher risk category (i.e., performed worse).

Based on the change in mean falls risk z-score between the pre- and post-intervention PPA observed in this study (-.99), and assuming no such change in a control group with power set at .80, alpha set at a $P=.05$, and allowing for 25% attrition (as per this study), it is estimated that 107 participants would need to be recruited for a larger, randomized controlled trial with an intervention and control group.
DISCUSSION

Our study confirmed the high risk of falls in this group as measured by the pre-intervention PPA, which is a validated risk assessment tool specifically designed to assess falls risk (32). The PPA has been used to assess falls risk in the elderly (10-11,44-45,50), older women (3,28-29), younger adults (49), and in people with knee disorders (14,25), Parkinson disease (18), age-related macular degeneration (47), and cognitive impairment (26,31). Given that 75% of our participants were over 60 yrs old and that the majority of all hemodialysis patients are over 60 yrs old, the use of the PPA is appropriate for this group. Sixty-eight percent of the participants were moderate to very marked falls risk on the pre-intervention PPA, with 14% classified as very marked. These findings compare with actual reported falls of 47% of patients in the dialysis population (9).
Although the primary purpose of our pilot study was to explore the feasibility of a combined strength and balance exercise intervention, we did show a significant decrease in overall falls risk, as measured by PPA, following a supervised 8-week program. In addition, there was a statistically significant reduction in reaction time, and small to medium effect sizes for knee extension force, edge contrast sensitivity, and proprioception. This is consistent with the findings of Morrison et al. (36) who reported improvements in reaction time, leg strength, decreased sway, and an overall age-matched falls risk improvement in an older diabetic ‘non-dialysis’ population following a strength and balance intervention. Similar strength and balance programs have decreased falls risk in recently discharged patients (52) and people who undertake home-based exercise and balance programs (27). Although these studies show reduced falls risk and not reduced falls per se (34), the positive benefit of a combined strength and balance intervention program appears to improve the falls risk and physical functioning of older people with chronic kidney disease (21).

Dialysis programs can play a major role in the improvement of the strength and balance of dialysis patients by interventional exercise programs. Poor physical function can be exacerbated by poor vision, poor balance, reduced strength, and intradialytic hypotensive episodes that may increase the risk of falls within the dialysis center (41). Additionally, the dialysis procedure itself may contribute to the falls risk. There is a high degree of syncope among the patients (40) with dialysis treatment-related postural hypotension. Also, the anti-hypertensive medications contribute to this increased falls risk (41). Strength and balance exercise programs designed to reduce falls risk may best be managed by exercise professionals who can focus on the exercise program rather than the dialysis process itself (2). The terrible irony of most dialysis programs is that, on one hand, they keep patients alive while, on the other hand, do very little about the declining physical function and increasing falls risk (5). This irony should not be lost on dialysis managers, hospital administrators, educators, researchers, and clinicians.

Falls not only limit the physical function of patients on dialysis, but they also contribute to the increasing healthcare costs. With an ageing population, falls related costs in Australia are expected to triple by 2051 to $1375 million per year. It is estimated that 886,000 additional hospital bed days and 3320 extra nursing home placements will be required (46). The cost of falls related injury in the state of South Australia (where this study was undertaken) with a population of 2 million people has been estimated at $54.3 million per year with 5.4% of all hospital beds consumed by falls related injuries of people over 65 (46). A combined strength and balance exercise program is likely to contribute to some reduction in costly hospital admissions.

This study has demonstrated that it is possible to introduce a “strength and balance” intervention for patients in a dialysis unit, and provides some valuable insights to inform the development of future research in this area. The inability to obtain consent of 40 participants (or over 50% of all original cohort) was unexpected and reinforces the value of feasibility studies. Understanding the reasons that patients chose not to participate may assist researchers to anticipate and develop strategies to overcome this challenge in future studies. The major reason for this refusal was the time commitment to interdialytic balance exercises. Otherwise, it is important to acknowledge that there was minimal attrition over the course of the 8 weeks and that the majority of patients were able to successfully complete the program. This suggests the intervention was well-accepted and suitable for those patients who chose to participate.
Strengths and Limitations
The strength of this study is that the findings help to promote the feasibility of a larger study. Although it was only an 8-week strength and balance intervention, it is clear that the potential for improvement in falls risk for dialysis patients merit significant consideration. The limitations of this study include the targeted recruitment of patients with higher falls risk into the exercise program that may have enhanced the potential for improvements. Additionally, this study enlisted a small number of participants without an allocated control group for comparison. The measurement tool used in the assessment of fall risk, the PPA, requires specific equipment, brief training, and software. Other simpler measures such as minimal chair height standing ability, voluntary sway measures, and timed up and go may be easier to undertake but may not exhibit the validity of the PPA (49). Although the sensitivity and specificity of the PPA are high, it may not be suitable for smaller, regional dialysis units with limited resources and space.

CONCLUSIONS

Although falls risk in the hemodialysis population is multi-factorial, exercise and balance programs may reduce falls risk and increase physical function in this group. Identifying at risk patients and undertaking a combined strength and balance exercise program may benefit this group and reduce falls related injuries. Strength and balance exercises to reduce the risk of fall in the dialysis population is an under-researched area and improvements in screening and predicting people at high risk may contribute to improved patient physical function, decreased falls, and improved quality of life. Further research with a sample size of 107 with a randomized control design is recommended to measure the efficacy of combined strength and balance exercise programs for the hemodialysis population. Also, a study that measures the strength and balance exercise intervention in hemodialysis patients compared to non-dialysis patients should prove useful in decreasing falls risk and injuries.

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