MULTIDIMENSIONAL CORRELATES OF FALLS IN OLDER WOMEN*

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ABSTRACT

Older women who had fallen within the last year (n = 63) were compared with those who had not fallen (n = 67) on several psychological and motor measures. Both fallers and nonfallers demonstrated high levels of functioning. Discriminant analysis results indicated that a combination of variables, including physical activity and both psychological (general well-being, self-efficacy) and motor (functional reach, mobility) measures differentiated fallers and nonfallers. Results suggest that falling is a multidimensional phenomenon, that small declines on multiple factors may increase risk of falls, and that multifaceted interventions may help maintain high levels of functioning and prevent declines often associated with increased age.

Falls are common in older adults, often resulting in catastrophic consequences. Sattin (1992) reported that for persons over age sixty-five, falls are the leading cause of death from injuries. Falls lead to 230,000 hip fractures per year, and place a tremendous burden on both individuals and the health care system. Even healthy, well-functioning seniors are concerned about falls, and Sattin (1992)
noted that a better understanding of the extent and etiology of falls among older persons can help public health professionals develop a systematic approach to fall prevention.

Investigations of falls among the elderly have focused on many different causes, including balance ability (Speechley & Tinetti, 1991), self-efficacy (Tinetti, Richman, & Powell, 1990), and general physical performance and perceptions of performance (Cress, Schechtman, Mulrow, Fiatarone, Gerety, & Buchner, 1995). Early studies examined these variables separately. Recently investigators have begun to study the relationship between psychological and motor factors and how they might jointly contribute to increased risk for falling (Arfken, Lach, Birge, & Miller, 1994; Studenski, Duncan, Chandler, Samsa, Prescott, Hogue, & Bearon, 1994; Tinetti, Mendes de Leon, Doucette, & Baker, 1994). This study is the first part of a larger investigation of psychological, balance, and motor coordination factors associated with falls and fall prevention in older adults, and specifically focuses on self-efficacy and balance and motor coordination variables.

Motor variables related to balance and gait were targeted because these correlates have been identified as risk factors in previous studies. For example, Tobis, Friis, and Reinsch (1989) found impaired postural stability and leg strength predicted subsequent falls in the healthy elderly, and DiPasquale et al. (1989) found unilateral standing time was 45 percent shorter and dorsiflexion strength was 18 percent less in a subset of healthy subjects who had subsequent falls. Studenski, Duncan, and Chandler (1991) reported fallers were more unstable in response to clinical balance tests than non-fallers, and Studenski et al. (1994) found men with impaired mobility were at greater risk for falling than those who were not impaired.

Although some decline seems inevitable, evidence suggests individuals with active lifestyles maintain high levels of function longer than sedentary individuals. Activity is especially relevant for typical community-dwelling seniors, our target population, and activity may be especially beneficial for the motor variables under investigation. For example, individuals who participated in masters' athletics demonstrated better balance in clinical and functional (i.e., walking) situations than their sedentary peers (Brown & Mishica, 1989). Investigators consistently report that elders move more slowly than younger individuals (Gabell & Nayak, 1984; Williams & Bird, 1992). Despite those speed differences, Williams and Bird (1992) found only minor changes in coordination in a group of healthy, older women who were not athletes, but simply maintained life-long patterns of physical activity.

We focused on self-efficacy as the primary psychological variable because it predicts varied exercise and health behaviors, and because self-efficacy is especially relevant to falls and fall prevention. According to Bandura (1986) self-efficacy is the belief that one can perform a specific behavior, and self-efficacy is the critical mediator for behavioral change. Considerable research
FALLS IN OLDER WOMEN

demonstrates that self-efficacy or confidence in one’s capabilities relates to performance of varied physical tasks as well as to preventive health behaviors (e.g., Bandura, 1986). Sallis and associates (1986) note a relationship between efficacy and physical activity in a community sample; Ewart, Taylor, Reese, and Debusk (1983) report relationships between efficacy and physical activity for men in cardiac rehabilitation programs; and McAuley and Jacobsen (1991) report a relationship between efficacy and exercise participation for middle-aged women. Only recently has self-efficacy research been extended to older adults and applied specifically to falls and fall prevention.

Tinetti, Richman, and Powell (1990) developed a Falls Efficacy Scale (FES) and advocated its use to assess the contribution of falls efficacy or fear of falling to functional decline among the elderly. Tinetti, Mendes deLeon, Doucette, and Baker (1994) subsequently documented the relationship of fear of falling and fall-related efficacy to functioning among the elderly. This scale is used widely to assess fall-related efficacy, including at many FICSIT (Frailty and Injuries: Cooperative Studies of Intervention Techniques) sites (Ory, Schechtman, Miller et al., 1993). Following Tinetti’s suggestions, we focus on self-efficacy and examine relationships among physical activity, self-efficacy, falls, and psychological well-being in older adults.

In a preliminary study with typical community-dwelling older adults, Gill, Kelley, Williams, and Martin (1994) found these older adults were healthy, active, confident, and had no particular problems with stairs, physical activities, or falls. This positive profile and the movement profile described by Williams and Bird (1992) suggest that active, healthy seniors maintain many characteristics of motor coordination and psychological function observed in younger subjects. We now ask if older individuals with a history of falling differ from such active, healthy older individuals.

Earlier studies revealed clear relationships between poorer performances on balance, mobility or psychological measures and increased risk of falling. However, the relationship is less clear for relatively healthy individuals. Tinetti and colleagues (1994) found only a marginal relationship between fear of falling and performance on tests of activities of daily living; fear of falling was not related to higher levels of physical or social functioning. It may be that in higher functioning individuals the magnitude of change is small and not detected by tests currently in use, or it may be that the nature of changes is subtle and multifaceted, and not detected by single, simple measures. Rather, multidimensional measures may be necessary to detect risk for falling. In this study we ask if relatively healthy, active individuals with a history of falls are characterized by motor coordination and psychological patterns that differ from active, healthy older individuals who have not fallen. The motor measures emphasize balance and movement patterns, and the psychological measures focus on self-efficacy and perceived health and well-being. Although physical activity has not been linked directly to falls, a measure of physical activity was included because the
existing research supports the relationship of activity to both physical and psychological well-being in older adults. Based on our previous research (Gill et al., 1994; Williams & Bird, 1992) we did not expect large differences with our healthy, active sample, but we expected fallers to demonstrate lower motor capabilities, less self-efficacy, less positive health and well-being, and lower activity levels. Because we expected subtle differences in the overall multivariate profile, we examined the overall combination to determine the relative roles of specific motor, psychological, and activity measures in discriminating fallers and nonfallers. The measures most directly related to falling (i.e., fall efficacy; mobility on stairs) should be the strongest discriminators, but the existing literature does not provide any basis for hypothesizing the relative discriminating strength of psychological, motor, and activity measures.

METHOD

Participants

We focused on women in this investigation because they are overrepresented in the senior population and have greater risk of injury due to falls (Craven & Bruno, 1991). Women were recruited from senior residences, activity programs, and announcements in local newspapers and senior newsletters in the Triad region of North Carolina. Specifically, we recruited older women (over age 65) who had fallen within the last twelve months (n = 63) and who had not fallen (n = 67). The sample included women living independently and living in senior residential housing, as well as women who were largely sedentary and some who were very active.

Each prospective participant completed a questionnaire that was used to determine her fall status and demographic characteristics, as well as to assess psychological measures. We adopted the Hindmarsh and Estes (1989) definition of a fall as events which lead to the conscious subject coming to rest inadvertently on the ground. To identify fallers, participants were asked to document the number of falls they had within the past year, as well as provide pertinent information regarding the falls. Participants completed the questionnaires individually or in small groups at residences, activity centers, or on campus. Investigators were present to answer questions, and if necessary, to read and record responses.

Psychological Measures

The psychological survey included demographic characteristics and perceived health and well-being, as well as self-efficacy measures.
Demographic and Activity Information

Demographic information included age, gender, race/ethnicity, marital status, education, employment, living arrangements, and wearing glasses/contacts. Participants also completed items on stair climbing activity and checked factors that influenced them when climbing and descending stairs. Respondents who had fallen within the last twelve months completed items describing the circumstances of the fall.

Self-Efficacy

For all self-efficacy measures, participants indicated how confident they were that they could perform a task, using a percentage scale ranging from 0 percent (not at all confident) to 100 percent (absolutely certain). Our activity efficacy measure included three items each for stair climbing (climb 2 stairs, 1 flight, 4 flights), stair descent (go down 2 stairs, 1 flight, 4 flights), walking (walk 1 block, 1 mile, 2 miles), and participating in moderate or vigorous physical activity (1, 3, 5 days per week). Percentages were averaged over the three levels to measure strength of efficacy. To assess efficacy and fear of falling directly across daily activities, all participants completed the Falls Efficacy Scale (FES; Tinetti et al., 1990). Because the FES focuses on relatively nonhazardous daily activities, we added two items on stair climbing and descent, and four items on getting back up and avoiding injury after a fall going up or down stairs. Thus, in addition to the ten-item FES, respondents completed six items on stair fall efficacy.

Health and Well-Being Measures

To assess perceived health and well-being, we adopted a set of ratings King, Taylor, Haskell, and DeBusk (1989) used with middle aged adults in an exercise program. Specifically, respondents rated themselves in comparison to others of their gender and age on: health, physical fitness, sense of confidence and well-being, ability to concentrate, satisfaction with body shape and appearance, general mood, and energy level using a 5-point (1 = poor, 5 = excellent) scale. Participants also completed the General Well-Being Schedule (GWB), an eighteen-item self-report questionnaire developed by Duphy for the U.S. Health and Nutrition Examination Survey. McDowell and Newell (1987) report reliability and validity information and recommend the GWB as an indicator of subjective well-being. The GWB includes six subscales: anxiety, depression, positive well-being, self-control, vitality, and general health which can be totalled for an overall GWB score.

Motor Coordination and Balance Measures

After completing the psychological survey, participants were invited to campus for a physical exam and the motor tests. A physician specializing in
gerontology screened participants for medical problems that might preclude completing the motor tasks. After receiving medical clearance, participants completed the motor task battery and an activity survey. The testing session took about one hour. All participants completed four tests of motor coordination and balance: a modified functional reach (Duncan et al., 1990), a mobility test (Imms & Edholm, 1981) aimed at assessing gait abnormalities during walking and stair climbing, a measure of stability margin (Patla et al., 1989), and a reaction time test involving a stepping response (Patla et al., 1989). In addition, a subset of participants was videotaped as they walked up and down a set of five “typical” stairs. These videotapes were analyzed to determine the speed at which participants climbed and descended the stairs and to examine the coordinative pattern between the lower limbs. For each test, a safety harness was available for participants at great risk for falling, and research assistants were stationed close at hand to guard against potential falls.

Functional Reach

For this test, participants stood facing a meter stick affixed perpendicular to a wall and extending out toward the subject. Before beginning, the meter stick was adjusted for the participant’s height and positioned just below her horizontally outstretched arms. A trial consisted of the subject leaning as far forward (or to the side) as possible over the meter stick, while flexing only from the ankles, without taking a step, and without falling. An investigator recorded the difference (in cm) between the participant’s initial position with outstretched arms and the final position when she had reached as far as possible. As formulated by Duncan et al. (1990), this test emphasized forward reaching and was validated on frail groups of older adults. Because our participants were relatively healthy, we added sideward reaching (to the dominant side) to increase the challenge. Each completed five trials in a forward direction, followed by five trials to the dominant side.

Mobility Test

Participants began seated comfortably in a wooden chair without arms. On a “go” signal, they stood up, walked 2.13 m across a room, and ascended five standard steps to a 1.86 m long platform. They walked to the back of the platform, turned and retraced their steps, and completed a trial by returning to be seated in the chair. Participants completed two trials at a typical pace. Each trial was timed (in sec) and videotaped for later qualitative analysis, which consisted of evaluating each trial for twenty-six possible gait anomalies (Imms & Edholm, 1981). Each anomaly or error (e.g., leaning on the handrail, shuffling as they walked, using their hands to push out of the chair) was assessed one point; higher scores reflect poorer performance and a greater number of mobility anomalies. To assure reliability, the second author and an assistant reached 90 percent exact agreement in categorizing errors before final data reduction.
Stability Margin

For this test, participants stood in a neutral position on a force platform and then leaned as far as possible in each designated direction (front, back, left, right) before returning to the start position. As in the functional reach, they were instructed to flex only from the ankles as they leaned as far as possible. Participants completed two trials, with maximal leans in each of four directions (front, back, right, left). Deviations (in cm) of the center of pressure from the initial position were computed.

Reaction Time Stepping Response

For the reaction time test, individuals began by standing on the force platform. After a short delay (1-3s), a directional stimulus command (front, back, left, right) on a computer screen prompted participants to step off the platform as quickly as possible in the specified direction. A total of twenty trials were divided equally among the four stimulus directions in randomized order. Reaction time (in msec) and whether or not the response was in the correct direction were recorded for each trial.

Stair Climbing and Descent Velocity and Interlimb Coordination

A small number of fallers (n = 15) and nonfallers (n = 14) were videotaped as they climbed and descended a set of five stairs. Stair climbing was examined as a specially constrained form of walking and an example of an important and challenging activity of daily living. x- and y-coordinates of the hip for selected trials of stair climbing and descent were digitized using a Peak Performance Video Analysis System. Average resultant velocity was computed from these data. In addition, foot strikes and takeoffs were visually identified during climbing and descent to determine the relationship between the lower limbs (interlimb coordination). The temporal relationship of intermediate footfalls was determined as a proportion of separate walking cycles. In other research (c.f., Williams & Bird, 1992), one leg has been consistently demonstrated to be 50 percent out-of-phase with the other, resulting in a symmetric, alternating pattern.

Activity Measure

Although assessment of physical activity is problematic in general, and especially so for older populations, DiPietro, Caspersen, Ostfeld, and Nadel (1993) developed and provided reliability and validity evidence for the Yale Physical Activity Survey (YPAS) for older adults. The YPAS is an interviewer-administered questionnaire with two sections. In the first section respondents indicate the time (hours per week) spent in specific work, exercise, and recreational activities. In the second section respondents indicate the frequency and duration of their participation in five categories of activities (i.e., vigorous
activity, leisurely walking, moving, standing, and sitting). The first section yields a total time index and an energy expenditure index calculated by multiplying each activity time by an intensity code. The second section yields indices for each of the five activity categories, which can be totalled for an overall index.

RESULTS

The results are presented in several sections. First, a profile of participants including demographic characteristics and specific information on activities and fall history is presented. Then, separate results are presented comparing fallers and nonfallers on: 1) psychological survey measures (i.e., self-efficacy, well-being), 2) motor tasks (i.e., functional reach, balance, mobility), and 3) activity levels. For the primary analysis, fallers and nonfallers are compared on selected, combined psychological, motor, and activity measures with multivariate discriminant analyses. Additionally, fall-related differences are presented for the subsample with measures of stair climbing and descent velocity and interlimb coordination.

Participant Profile

Our sample \((n = 130)\) included sixty-seven nonfallers and sixty-three fallers, with twenty-five of the fallers reporting more than one fall in the last year. Participants ranged in age from sixty-five to ninety-five \((M = 75.0, SD = 7.1)\) with sixteen women over age eighty-five. More \((87)\) lived independently than in senior housing \((43)\), and many who were in senior housing were actually living independently in their own homes. Most participants were white/Caucasian \((91.5\%)\), retired \((83.3\%)\), married \((41.3\%)\) or widowed \((42.1\%)\), highly educated \((52.7\% \text{ had completed college})\), and of particular relevance to falling, nearly all \((96.1\%)\) wore glasses and most \((91.2\%)\) wore bifocals or trifocals.

Most had stairs in their home and climbed them regularly. About half \((52\%)\) had fallen on stairs at some time, but they did not report problems with stairs. Few indicated factors that affected them going up to down stairs, but a majority did indicate that a handrail was important \((66.4\% \text{ going up, 70.3\% going down})\).

Those who had fallen \((n = 63)\) described the circumstances of the fall. Most falls \((56.5\%)\) involved tripping over obstacles \((e.g., \text{ steps, boxes, sidewalks})\), often when they were hurrying or inattentive. Although many \((61.7\%)\) reported injuries, most were minor bruises and pains. Almost no one reported any medical symptoms prior to or after the fall \((4 \text{ people reported feeling light-headed before the fall, and two lost consciousness})\).

Psychological Measures

The psychological measures included several different self-efficacy measures \((\text{activity efficacy, FES, stair-fall efficacy})\), GWB subscores and total, and the
ratings of health and well-being (HWB). We examined subscores and internal reliabilities with the multi-item measures before combining measures.

Internal consistency for the FES (alpha = .96) was strong and all items contributed. With all twelve activity efficacy items internal consistency was good, all items contributed, and the overall alpha (alpha = .92) was stronger than the alpha for any subsets (e.g., walking). Similarly, the overall alpha for the six stair-fall efficacy items was good (.86) and all items contributed. Thus, we used three efficacy scores—FES, activity efficacy, and stair efficacy—for group comparisons.

Internal consistencies for the six subscales of the GWB ranged from .57 to .72, with all items contributing to each respective subscale. However, the alpha (.89) for the total was stronger and all items contributed. Thus, we used the total GWB score for group comparisons. Although the seven health and well-being (HWB) ratings were not designed as a scale, we examined the internal consistency to consider combining the ratings into a total score. All ratings were interrelated with an overall alpha of .86. As with the GWB, we examined separate ratings, but used a HWB ratings total score for group comparisons with multiple measures.

A one-way MANOVA compared fallers and nonfallers on the five psychology total scores: FES, activity efficacy, stair efficacy, GWB, and HWB ratings total. The multivariate group difference was nonsignificant, Wilks lambda = .95, $F(5,111) = 1.20$, n.s., and all scores were similar (see Table 1 for group means and univariate $F$ values). Nonfallers did score higher than fallers on the GWB measure, but even this difference was not particularly strong (eta-square = .05).

**Motor Measures**

Data from each motor test were analyzed in separate one-way MANOVAs comparing fallers and nonfallers, and no significant differences occurred in any analyses. Stair climbing and descent speed and interlimb coordination are not

<table>
<thead>
<tr>
<th>Measure</th>
<th>Nonfallers M (SD)</th>
<th>Fallers M (SD)</th>
<th>Univ. $F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FES</td>
<td>94.0 (12.6)</td>
<td>92.8 (12.0)</td>
<td>.28</td>
</tr>
<tr>
<td>Activity efficacy</td>
<td>80.3 (21.3)</td>
<td>80.5 (21.8)</td>
<td>.003</td>
</tr>
<tr>
<td>Stair efficacy</td>
<td>73.2 (19.5)</td>
<td>71.6 (20.4)</td>
<td>.19</td>
</tr>
<tr>
<td>GWB</td>
<td>82.1 (16.4)</td>
<td>75.2 (15.9)</td>
<td>5.25*</td>
</tr>
<tr>
<td>HWB ratings</td>
<td>25.3 (4.7)</td>
<td>24.0 (4.1)</td>
<td>2.58</td>
</tr>
</tbody>
</table>

*p < .05
included in the multivariate analyses because they involved only a subset of the participants. Those data are summarized separately.

**Functional Reach**

No group differences occurred for either functional reach task, Wilks lambda = .99, \( F(2,126) = .13 \), n.s. (Table 2). Participants in both groups tended to reach farther in the sideward direction, as opposed to forward reaching; apparently sideward reaching afforded greater stability to our participants.

**Mobility Test**

No group differences were observed for either the speed of movement or the number of gait anomalies detected, Wilks lambda = .99, \( F(2,122) = .39 \), n.s. (Table 2). Regardless of fall status, participants required approximately 20.6 s to traverse the pathway. They were characterized by an average of 2.2 (of 26 possible) gait anomalies. This latter characteristic demonstrates dramatically that participants in this investigation were at an extremely high level of function.

| Table 2. Motor Test Scores for Fallers and Nonfallers |
|-----------------|-----------------|-----------------|-----------------|
| Measure         | Nonfallers (M, SD) | Fallers (M, SD) | Univ. F          |
| Functional Reach (cm)          |                 |                 |                 |
| Forward reach   | 20.9 (6.2)       | 21.4 (5.4)       | .23             |
| Sideward reach  | 25.0 (7.9)       | 25.6 (7.1)       | .19             |
| Mobility Test   |                 |                 |                 |
| Time(s)         | 20.8 (7.5)       | 20.3 (8.0)       | .12             |
| Errors          | 2.1 (1.4)        | 2.3 (1.4)        | .64             |
| Stability Margin (cm) |         |                 |                 |
| Front           | 7.9 (1.9)        | 7.7 (2.4)        | .96             |
| Back            | 5.2 (2.1)        | 5.6 (2.4)        | .67             |
| Right           | 8.7 (3.2)        | 9.0 (2.9)        | .29             |
| Left            | 8.9 (2.6)        | 8.6 (3.1)        | .25             |
| Reaction Time (ms) |               |                 |                 |
| Front           | 411.9 (114.3)    | 406.4 (95.0)     | .07             |
| Back            | 400.3 (112.0)    | 387.4 (91.1)     | .41             |
| Left            | 429.5 (115.1)    | 415.7 (89.6)     | .46             |
| Right           | 426.5 (131.3)    | 417.4 (101.0)    | .15             |
Stability Margin

In this task, participants leaned as far as possible forward, backward, to their left, and right. No significant main effect for fall status occurred, Wilks lambda = .98, F(4,122) = .53, n.s. Again, fallers and nonfallers did not differ as they leaned in any of the four directions (Table 2). As expected, participants did not lean as far backward as they did in other directions.

Reaction Time

The two components to the reaction time task, time and directional errors, were considered separately. The reaction time task simulates participants' ability to avoid an obstacle, and, typically, individuals have more than a single option in performing avoidance maneuvers. Based on this logic, trials where participants stepped incorrectly were retained for additional analyses. Data from error trials were examined visually, however, to determine whether participants responded differently on those trials. No obvious differences occurred, and, therefore, reaction times from error trials were analyzed in the same MANOVAs as non-error trials.

The one-way ANOVA on error rates yielded no significant differences, F(1,128) = .017, n.s. Nonfallers demonstrated slightly lower error rates than fallers (5.65% vs. 5.82%). Regardless of fall status, these error rates represented slightly more than a single error per participant. A similar pattern emerged in the reaction time (RT) data, with no significant group effect, Wilks lambda = .99, F(4,100) = .18, n.s. The two groups did not differ in reaction times for stepping in any of the directions.

Activity Levels

The YPAS total activity time, total activity intensity, and total index score were used to compare the faller and nonfaller groups in a one-way MANOVA. The overall multivariate difference was nonsignificant, Wilks lambda = .98, F(3,126) = .75, n.s., and as Table 3 indicates, the two groups were similar on all activity scores.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Nonfallers</th>
<th></th>
<th>Fallers</th>
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<th>Univ. F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>(SD)</td>
<td>M</td>
<td>(SD)</td>
<td></td>
</tr>
<tr>
<td>Total time</td>
<td>30.3</td>
<td>(23.0)</td>
<td>27.0</td>
<td>(16.1)</td>
<td>.92</td>
</tr>
<tr>
<td>Total intensity</td>
<td>113.6</td>
<td>(104.9)</td>
<td>101.6</td>
<td>(59.7)</td>
<td>.66</td>
</tr>
<tr>
<td>Total index</td>
<td>44.4</td>
<td>(18.6)</td>
<td>47.0</td>
<td>(22.3)</td>
<td>.52</td>
</tr>
</tbody>
</table>
Discriminant Analyses

The primary goal of this project was to consider the combination of psychological and motor factors that determined fall status. Thus, we selected measures from the preceding analyses and considered them together with discriminant function analyses. From the psychological measures, we included the FES because it was the most relevant efficacy score, along with the GWB total and HWB ratings total. We included the mean scores for the motor tasks: functional reach, reaction time, stability margin, mobility time, and mobility errors. Finally, we included the total activity time and total index scores for the activity survey. DiPietro et al. (1993) reported that total time and intensity are highly correlated; we confirmed that in our data \( r = .97 \), and thus, did not include the intensity score.

First, we included all variables in an overall discriminant analysis comparing the faller and nonfaller groups. The overall discriminant analysis was significant, Wilks lambda = .80, chi-square (10) = 18.48, \( P < .05 \), with GWB and mobility errors contributing most to the canonical discriminant function. The means and standard discriminant coefficients for all measures are given in Table 4.

We conducted a stepwise discriminant analysis to determine which subset of variables best discriminated fallers and nonfallers. The stepwise analysis entered GWB, functional reach, mobility errors, mobility time, FES, and activity index, in that order, yielding a significant Wilks lambda = .81, chi-square (6) = 18.38, \( p < .01 \). Again the GWB and mobility errors had the largest coefficients and correlations with the discriminant function.

Table 4. Discriminant Analysis Results for Combined Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Nonfallers</th>
<th></th>
<th>Fallers</th>
<th></th>
<th>Stan. Disc.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td></td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FES</td>
<td>94.6 (11.8)</td>
<td></td>
<td>92.7 (13.4)</td>
<td></td>
<td>-.36</td>
</tr>
<tr>
<td>GWB</td>
<td>84.0 (18.1)</td>
<td></td>
<td>74.4 (15.1)</td>
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<td>-.75</td>
</tr>
<tr>
<td>HWB ratings</td>
<td>25.2 (4.6)</td>
<td></td>
<td>24.1 (4.1)</td>
<td></td>
<td>-.09</td>
</tr>
<tr>
<td>Activity time</td>
<td>27.3 (16.6)</td>
<td></td>
<td>29.5 (17.6)</td>
<td></td>
<td>-.09</td>
</tr>
<tr>
<td>Activity index</td>
<td>43.2 (18.0)</td>
<td></td>
<td>48.0 (23.0)</td>
<td></td>
<td>.35</td>
</tr>
<tr>
<td>Reaction time (ms)</td>
<td>419.7 (97.3)</td>
<td></td>
<td>411.1 (75.9)</td>
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<td>-.11</td>
</tr>
<tr>
<td>Stability margin (cm)</td>
<td>7.5 (1.8)</td>
<td></td>
<td>7.9 (1.8)</td>
<td></td>
<td>.12</td>
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<tr>
<td>Functional reach (cm)</td>
<td>22.3 (6.4)</td>
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<td>23.8 (5.5)</td>
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<td>.36</td>
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<tr>
<td>Mobility time(s)</td>
<td>21.3 (7.7)</td>
<td></td>
<td>19.8 (8.9)</td>
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<td>-.39</td>
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<tr>
<td>Mobility errors</td>
<td>1.9 (1.3)</td>
<td></td>
<td>2.5 (1.5)</td>
<td></td>
<td>.55</td>
</tr>
</tbody>
</table>

Note: Some scores differ from earlier results because of missing data with the combined analyses.
Stair Climbing/Descent Velocity and Interlimb Coordination

A small number of videotaped trials ($n = 41$) of performances of twenty-nine different individuals (15 fallers, 14 nonfallers) were analyzed to determine the movement speed used by participants to climb and descend stairs. Approximately 25 percent of the trials, representing multiple performances by the same individuals, were analyzed to determine the consistency of movement speed used by individual participants.

Fallers and nonfallers did not differ ($p > .05$) in the movement speed used to climb and descend stairs. Nonfallers' movement speed averaged 0.84 m/s, while fallers climbed and descended the stairs at 0.87 m/s. Also, participants were consistent in the velocity they used across trials, varying by only 0.03 m/s.

Participants also demonstrated consistency in the coordinative pattern of the legs during gait. During stair ascent, for both fallers and nonfallers, intermediate foot contact occurred at 49 percent of the stepping cycle ($p > .05$). For descent, there was a statistically significant difference between fallers and nonfallers, $F(1,36) = 6.10, p < .05$. Actual differences in phasing between fallers ($M = 50\%$) and nonfallers ($M = 49\%$) were small and not meaningful, and these differences were within the measurement error of the video system.

DISCUSSION

In contrast to earlier research, we did not find strong differences between fallers and nonfallers using single motor or psychological variables. Group differences were detected only when variables were examined jointly in discriminant function analyses, demonstrating the importance of considering a combination of psychological and motor tasks for determining who had and had not fallen in the last year. Specific variables that distinguished fallers and nonfallers included general well-being, functional reach, mobility errors and time, self-efficacy, and the physical activity index. Overall, fallers were actually more active than nonfallers, but slightly less positive on well-being and slightly poorer on the mobility task.

Differences between the current results and those of earlier studies may be largely due to differences in samples. Many previous studies of falls involved more infirm participants or clinical samples. Our participants were recruited from the general population of older adults, and were required to come to a university laboratory, resulting in some self-selection. Less active or less confident older adults, or those at greater risk for falls, may have declined to participate. Thus, our high functioning participants are similar to the low risk samples of earlier studies. Studenski et al. (1994) demonstrated that older men in a low-risk mobility category (who were similar to our participants) rarely fell, but those in a high-risk category had five times the risk of falling. Recently, with a similar sample of community-dwelling elders, Myers et al. (1996) also failed...
to find differences between fallers and nonfallers on balance and walking measures.

Several of our results and observations confirm that both our fallers and nonfallers were similarly healthy, active, well-functioning adults. Both groups had activity scores similar to those reported by DiPietro et al. (1993) for their slightly younger sample. Our fallers were slightly less positive on general well-being than nonfallers, but both groups scored quite high. According to the typical GWB classification (McDowell & Newell, 1987) scores below 60 reflect severe distress, those from 61 to 72 moderate distress, and those above 73 (which includes both our groups) reflect positive well-being. Self-efficacy scores were very high with many participants indicating they were 100 percent confident on most items. Scores on the FES, the most widely used and relevant measure, approached the 100 percent ceiling, and were higher than those reported by Tinetti et al. (1994). Similarly, our participants did well on the motor tasks, and the subsample analyses indicated both fallers and nonfallers demonstrated similar, consistent coordination patterns on stair climbing and descent. On the mobility task, which did show some faller-nonfaller differences, both groups had low error scores similar to those reported by Imms and Edholm (1981) for adults with unlimited mobility.

Many of the fallers in our study reported falls that occurred while they were engaged in active pursuits. Many falls resulted from tripping or confronting obstacles, and such falls would not be related to physical or medical conditions. Our results confirm earlier clinical results of Hale, Delaney, and McGaghie (1992). They reported that one-third of the relatively healthy adults who made office visits fell during a year, but that the Tinetti mobility test and physicians’ estimates did not predict who would fall. As part of the medical screening with our participants, the physician-consultant administered a battery of thirty-one clinical tests of balance and mobility based on Tinetti's (1986) recommendations. As with our motor and psychological measures, participants’ scores indicated high functioning on these clinical measures. Over half of the participants received perfect scores, passing all items in the clinical battery. Moreover, this clinical mobility measure was related to age and our mobility time measure, but not related to fall status (Hale, Delaney, Gill, & Williams, 1995). Our fallers were not at risk in any clinical sense. Generally, it seems that falls within the typical, healthy community of older adults are not predicted by single, specific psychological, motor, or clinical factors. Rather, healthy, active older adults may place themselves at risk because they are active and mobile.

Given the overall high functioning and lack of risk factors for falls among our participants, the emergence of any differences is notable, and the particular measures that discriminated between fallers and nonfallers suggest a multidimensional phenomenon. Our results generalize primarily to high functioning individuals, and are important for those individuals. Declines may be subtle and difficult to detect in these relatively healthy elders. The current results suggest
that small declines on multiple factors might result in increased risk of falls. Multifaceted interventions may help maintain these high levels of function and prevent declines often associated with increasing age.

Although few participants experienced problems with falls, many commented on their concerns about falling. Moreover, their comments reflected both psychological and physical concerns. Fallers often mentioned that the falls caused them to be cautious, sometimes to the point of anxiety, immediately after a fall. The few participants who had serious falls noted that recovering confidence and overcoming anxiety was a formidable task. Many commented specifically on balance and maintaining balance while moving and performing activities. These comments, as well as our results and observations, suggest research and interventions aimed at balance in typical, active settings is called for.

Powell and Myers (1995) recently developed the Activities-specific Balance Confidence (ABC) scale and demonstrated that the ABC was a better discriminator between fallers and nonfallers and between high and low mobility subjects than was the FES. In contrast to the FES, the ABC includes relatively challenging tasks typically encountered by active elders. Myers et al. (1996) subsequently reported that ABC scores, but not FES scores, were related to performance measures, and concluded that the ABC scale is a more useful measure for moderate to high functioning older persons. Given the extremely high FES scores of our participants and most healthy adults, the ABC scale may well be a more appropriate measure. Similarly, research measures (such as the mobility task) and interventions that focus on maintaining and regaining balance may be most appropriate for healthy older adults who are concerned about falls.

Our study was not prospective, and the observed differences may well reflect consequences of falls rather than predictors. A fall, even without serious injury, may lead to some doubts about confidence and well-being, and may also affect mobility. For example, someone who has fallen may take extra precautions or go more slowly on stairs. These slight changes may begin a cycle of declining confidence, restricted mobility, and ultimately increase the risk of falls. Minor falls and slight changes may start a declining cycle, and intervention at early stages may prevent or reverse declines. Interventions aimed at maintaining activity, mobility, and particularly efficacy for maintaining this activity may well be more effective than interventions aimed at specific, direct precursors of falls for typical, healthy older adults.

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REFERENCES


FALLS IN OLDER WOMEN


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