Running Title: Recovery from a Trip in Fear of Falling

Title: Fear of Falling Does Not Alter the Kinematics of Recovery from an Induced Trip: A Preliminary Study

Jane R. Marone, MD, Noah J. Rosenblatt, PhD*, Karen L. Troy, PhD*, Mark D. Grabiner, PhD*

Biomechanics Research Laboratories, Department of Kinesiology and Nutrition,

University of Illinois at Chicago

For re-submission as a Brief Report to: Archives of Physical Medicine and Rehabilitation,

MS Ref # ARCHIVES-PMR-D-11-00610; June 22, 2011

Corresponding author: Jane R. Marone, M.D., Department of Kinesiology and Nutrition (M/C 194); University of Illinois-Chicago; 901 W. Roosevelt Rd.;

Chicago, Illinois 60608; Tel: 312.355.0653; FAX: 312.413.3699;

Email: janem@uic.edu

*From the Biomechanics Research Laboratories, Department of Kinesiology and Nutrition, University of Illinois-Chicago, Chicago, Illinois

Supported by Center for Disease Control and Prevention R49CE000620, R01 CE001430

We certify that no party having a direct interest in the results of the research supporting this article has or will confer a benefit on us or on any organization with which we are associated AND, if applicable, we certify that all financial and material support for this research (eg, NIH or NHS grants) and work are clearly identified in the title page of the manuscript.

Abstract:

Objective: To provide preliminary information about the relationships between self-reported fear of falling (FOF) in healthy community-dwelling women, the number of falls, and recovery kinematics in response to a laboratory-induced trip.

Design: Cohort study

Setting: Clinical research laboratory

Participants: A subset of community dwelling older women (N=33) recruited from studies of laboratory induced trips and fall-prevention.

Intervention: A laboratory-induced trip.

Main Outcome Measures: The number of fallers in the FOF vs. the control group. Recovery kinematics of FOF falls vs. control group falls, and FOF recoveries vs. control group recoveries were compared. The degree of FOF was assessed by Activities Balance Confidence Scale (ABC).

Results: Falls occurred in 6/14 (43%) of the FOF and 4/16 (25%) of control subjects (p=0.26). Kinematics of FOF falls were similar to those of control falls. At the completion of the initial recovery step, FOF showed significantly greater trunk extension velocity than controls (-82.1±-66.1 vs. -25.0±-53.0 degrees/sec respectively; p=0.05). All other variables were not significantly different. ABC scores of FOF subjects did not differ significantly between fallers and those who recovered (mean=75.2±5.6, 71.1±11.8, respectively; p=0.84).

Conclusion: Healthy community-dwelling older adults would benefit from fall prevention, regardless of the presence of self-reported FOF.

Key words: biomechanics, women, posture

Introduction:

Fear of falling (FOF) affects approximately half of community-dwelling older adults. Prospective studies report an association between FOF and increased number of falls in this population.[1,2] However, it is unclear how FOF contributes to falls. Gait adaptations to FOF do not appear to increase fall risk. Adults with FOF typically alter gait by decreasing velocity and step length,[3] which has been shown decrease the likelihood of a fall following a laboratory-induced trip.[4] Trips may account for over 30% of community-occurring falls.[5]

Important predictors of falls following laboratory-induced trips are the step and trunk kinematics during the initial recovery step. Our work with healthy community-dwelling adults demonstrated that the ability to arrest/reverse trunk flexion is crucial to recovery from a laboratory induced trip.[6] This is accomplished, in part, by a rapid response following the trip and by spatially and temporally appropriate stepping kinematics and kinetics.[6,7] It is possible that FOF could contribute to falls by deleteriously affecting recovery task variables, but this does not appear to have been previously studied.

The purpose of this study was to provide preliminary information about the relationships between self-reported fear of falling (FOF) in healthy community-dwelling women, the number of falls, and recovery kinematics following a laboratory-induced trip.

Methods:

Thirty three female subjects (aged: 60.3 ± 5.8 years, height: 163.34 ± 7.4 cm, mass: 74.38 ± 15.69 kg) participated in this study. Subjects were part of two larger fall prevention studies targeting women concurrently conducted in our laboratory. The study was approved by our Institutional Review Board. Subjects provided written informed consent prior to participation. Each subject was screened and excluded for neurological, cardiovascular, pulmonary and/or musculoskeletal impairments including femoral neck bone mineral density of <0.61 g/cm^2 (Hologic QDR 4500, Waltham, MA).

Subjects were classified as either FOF or control (non-fearful) based on their response to the question, "Do you have any fear of falling that concerns you when you go about your daily activities?" Although multiple measurement techniques for FOF are reported in the literature, this direct question allowed us to estimate the prevalence of self-perceived FOF[8] among a group of subjects willing to participate in a protocol which induces falls. To determine if differences in the degree of fear and balance confidence existed among those who answered "yes", the Activities-specific Balance Confidence Scale; a 16-item questionnaire which rates confidence from 0% (no confidence) to 100% (very confident) was implemented.[9]

Subjects, wearing a safety harness, walked several times at a self-selected speed across an 8m walkway. Trips were induced using a hidden, pneumatically driven obstacle that rose 5.1cm from the floor in 175ms when manually triggered.[6] Subjects were tripped only once during an unspecified pass across the walkway. Trips were classified as a fall (weight supported by harness), recovery, or a miss (resulting from either poor timing of the triggering of the tripping mechanism). Misses were excluded from further analysis. Based on FOF and trip outcome,

subjects were assigned to one of four analysis categories: FOF falls, FOF recoveries, control falls, or control recoveries.

The motions of 23 passively reflective markers over bony landmarks[10] were tracked using an eight camera motion capture system operating at 120 Hz (Motion Analysis, Santa Rosa, CA). From these markers, custom software (Matlab, Mathworks, Natick, MA) was used to create 12-segment rigid body model from which the whole body center of mass (COM) and kinematic variables were computed at the instant of initial recovery step completion. Recovery step length was the distance in the sagittal plane between the centroids of the support (trailing) and recovery (leading) feet, respectively. Anterior-posterior COM (APCOM) represented the sagittal plane perpendicular distance between the centroid of the recovery foot and the vertical projection of the whole body COM; a positive APCOM indicated the recovery foot contacted the ground anterior to the whole body COM. Trunk angle and angular velocity were calculated relative to vertical. Walking velocity, normalized to body height (BH) was calculated as the rate of displacement of the sacral reflective marker for all recorded steps prior to trip initiation.

A Fisher's exact test was used to compare the number of FOF falls and control group falls. Independent t-tests were used to compare the ABC scores of FOF fallers vs. non-fallers. Pre-planned comparisons using independent t-tests were used to compare kinematic variables for FOF falls vs. control group falls and FOF recoveries vs. control recoveries. All analysis was done using SPSS 17.0 (Chicago, IL), with significance level set to $p \leq 0.05$.

Results:

Falls occurred in 6/14 (43%) of the FOF and 4/16 (25%) of control subjects (p=0.26). ABC scores (range: 43.8 – 95.6) of FOF subjects did not differ significantly between those who fell (mean ± SD: 75.2 ±5.6) and those who did not fall (mean ± SD: 71.1±11.8; p=0.84). Normalized walking velocity was not significantly different between FOF (mean ± SD: 0.71 ±0.11 BH/sec) and control group subjects (mean ± SD: 0.78±0.10 BH/sec; p = 0.08).

The differences between the kinematics of FOF falls and control group fall were not significant (Table 1). With the exception of trunk angular (extension) velocity, which was significantly larger for FOF recoveries than for control group recoveries (p=0.05), between-group differences did not achieve significance for any of the variables.

Discussion:

Our purpose was to provide preliminary information about the relationships between self-reported fear of falling in healthy community-dwelling women, the number of falls, and recovery kinematics following a laboratory-induced trip. We found that the number of FOF falls vs. control group falls was not significantly different, and generally, no between-group differences in the selected kinematics prior to and following the induced trip. One possibility for the failure of the between-group differences to achieve significance may be the small sample size. However, many of the between-group differences are relatively small and difficult, at present, to attribute biomechanical importance. Although a preliminary study, to our knowledge, this is the first biomechanical study of falls and recoveries by women with self-reported FOF.

ABC scores did not distinguish those women who fell from those who did not fall. Previous work utilizing retrospective fall data of a large sample (including residents of senior communities and nursing homes) associated ABC scores of less than 67% with increased fall-risk.[11] However, our subjects were healthy and self-sufficient women, willing to participate in a laboratory-based fall-prevention study. Although each FOF subject answered a definitive "yes" to the initial screening question, the subsequent large range in ABC scores included one score (95.6) that would generally not be classified as FOF. It is possible that these women represent "early-stage" fearful adults who contextually view themselves as fearful but have not, as yet, restricted their activities. Those with FOF sufficient to restrict activity may be unwilling to participate in experiments which induce falls; indeed one subject refused participation upon learning of the protocol details. Furthermore, the ABC scale addresses self-reported confidence associated with performance of multiple activities, including those frequently performed by self-sufficient adults. It is possible that self-perception of FOF may develop simultaneously with initial diminution in confidence in one or more activities addressed by the scale, and may develop independently of kinematics associated with falls.

Study Limitations:

Limitations to this study include a small sample size of community dwelling women who were willing and able to travel to a laboratory. Generalizations to other populations may not be appropriate. Furthermore the controlled environment of the laboratory, although necessary for the examination of kinematics, does not allow for observation of behavior in the community.

However, we believe this is an important first step in directly examining fall kinematics in adults reporting FOF.

Conclusion:

Healthy, community-dwelling older adults would benefit from fall prevention, regardless of the presence of self-reported FOF.

References:

1. Friedman SM, Munoz B, West SK, Rubin GS, Fried LP. Falls and fear of falling: which comes first? A longitudinal prediction model suggests strategies for primary and secondary prevention. J Am Geriatr Soc 2002;50:1329-35.

2. Maki BE. Gait changes in older adults: predictors of falls or indicators of fear? J Am Geriatr Soc 1997;45:313-20.

3. Rochat S, Bula CJ, Martin E, Seematter-Bagnoud L, Karmaniola A, Aminian K, Piot-Ziegler C, Santos-Eggimann B. What is the relationship between fear of falling and gait in well-functioning older persons aged 65-70 years? Arch Phys Med Rehabil 2010;91:879-884.

4. Pavol MJ, Owings TM, Foley KT, Grabiner MD. Gait characteristics as risk factors for falling from trips induced in older adults. J Gerontol Med Sci 1999;11:M583-M590.

5. Berg WP, Alessio HM, Mills EM, Tong C. Circumstances and consequences of falls in independent community dwelling older adults. Age Ageing 1997;26:261-268.

6. Pavol MJ, Owings TM, Foley KT, Grabiner MD. Mechanisms leading to a fall from an induced trip in healthy older adults. J Gerontol Med Sci 2001;56A:M428-M437.

7. van den Bogert AJ, Pavol MJ, Grabiner MD. Response time is more important than walking speed for the ability of older adults to avoid a fall after a trip. J Biomech 2002;35:199-205.

8. Legters K. Fear of falling. Phys Ther 2002; 82:264-272.

9. Powell LE, Myers AM. The activities-specific balance confidence scale. J Gerontol Med Sci 1995;50:199-205.

10. Kadaba MP, Ramakrishnan HK, Wootten ME. Measurement of lower extremity kinematics during level walking. J Orthop Res 1990;8:383–392.

11. Lajoie Y, Gallager SP. Predicting falls within the elderly community: comparison of postural sway, reaction time, the Berg balance scale and the activities-specific balance confidence (ABC) scale for comparing fallers and non-fallers. Arch Gerontol Geriatr 2004;38:11-26.

208

	FOF falls (n=6)	Control falls (n = 4)	*P*	FOF recovery (n = 8)	Control recovery (n = 12)	*P*
AP COM (mm)	-330.8 ± 146.0	-261.0 ± 257.3	0.60	104.9 ± 95.4	69.3 ± 96.8	0.44
Recovery step length/BH (%)	22.8 ± 17.5	39.1 ± 4.3	0.07	48.7 ± 9.7	53.7 ± 6.0	0.19
Trunk angle at recovery (deg)	32.0 ± 9.5	36.9± 7.6	0.41	19.4 ± 14.1	24.4 ± 10.0	0.38
Trunk angular velocity at recovery(deg/sec))	43.4 ± 58.1	21.7 ± 25.1	0.44	-82.1 ± 66.1	-25.0 ± 53.0	0.05

209

210 Table 1. Mean and standard deviations of kinematic variables for FOF and control subjects, at
211 the instant of recovery. Numbers of subjects are indicated in parentheses. Negative values of
212 APCOM reflect that recovery foot is posterior to whole body COM. Negative trunk angular
213 velocity indicates trunk is extending.

214