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Falls and Fall-Related Injuries in an Evidence-Based Tai Ji Quan Intervention in Rural West Virginia Churches

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Abstract

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Background: This paper identifies the independent predictors of falls in an implementation study of Tai Ji Quan: Moving for Better Balance® (TJQMBB) in older adults in rural West Virginia churches.

Methods: Falls and injuries were identified via calendars, questionnaire, and verbal reports.

Results: Fall predictors were gait speed (OR 0.27; 95% CI 0.08, 0.90); low back pain (OR 8.04; 95% CI 1.71, 37.79); and pain, stiffness, or swelling limiting activity (OR 2.44; 95% CI 1.09, 5.45).

Conclusions: Determining differences between fallers and non-fallers may identify people with different fall risk profiles and ultimately better tailor fall-prevention programming to individual needs.

Keywords

balance; exercise; fall prevention; injuries; physical activity; Tai Chi; Tai Ji Quan

Introduction

Falls were the leading cause of fatal and nonfatal injuries in older US adults in 2018. [1,2] West Virginia (WV) is the third most rural state in the nation[3] with medically underserved areas in most of its counties.[4] In 2018, fall-related deaths in WV exceeded the US average.[5] Rural populations have higher rates of falls, fall-related injuries, and mortality as compared with urban ones.[6] Rural residents also tend to be older, poorer, and less educated with more chronic conditions and less access to healthcare than their urban counterparts,[7] all of which are risk factors for falls.[8,9] Thus, fall-prevention interventions are needed in these medically-underserved, hard-to-reach older adults. Fall-prevention studies have included rural populations; however, rural populations are not all alike.[10] Little is known about the factors that contribute to fall risk in rural WV.

Physical activity, such as Tai Ji Quan (TJQ), is safe and effective in reducing older adult falls.[11–13] Participants who fall during an exercise intervention may have certain baseline characteristics that differentiate them from non-fallers. It is thus important to know the fall risk profile of participants to specifically tailor fall-prevention interventions to their needs.

This study reports on falls and injuries during a 16-week implementation study of an evidence-based fall-prevention program, Tai Ji Quan: Moving for Better Balance® (TJQMBB), in older adults in rural WV churches. Churches were widespread throughout WV and provided a way to access hard-to-reach older adults. The specific aims of this study were to examine the: 1) baseline characteristics of fallers and non-fallers during the intervention, 2) details of the falls and fall-related injuries, and the 3) baseline socio-demographics and fall risk factors that independently predicted falls during the intervention. We previously reported on the impact of the intervention on functional outcomes[14].

Materials and Methods

Recruitment

We used Urban Influence Codes to identify 7, rural WV counties[15] that were medically underserved.[16] The methods for recruiting churches and exercise instructors, between May 2013 and May 2014, have been described.[17] The study was approved by the Institutional Review Board at West Virginia University (Protocol # #1302019019) and all participants provided written informed consent. All community-dwelling adults, aged 55 years or older, were eligible for the study. Participants were recruited between February and July 2014 by the researchers, churches, and instructors using press releases, church announcements, flyers, and word-of-mouth. Participants were first screened for eligibility via telephone by members of the research team. Eligible participants were then scheduled for a baseline assessment at the church.

Data Collection

Data on socio-demographics and fall risk factors were collected via questionnaire and performance-based tests. The questionnaire was created for this study and included: 1) a list of fall risk factors (participants answered yes or no), 2) 2 standardized questions about any falls/injuries in the past 12 months,[18] 3) the Falls Efficacy Scale,[19] and 4) the Geriatric Depression Scale-Short.[20] Risk factors included: chronic conditions[21]; pain, stiffness, or swelling limiting activity [22]; lower extremity surgery in past year[23]; medication usage[24]; incontinence[25]; assistive device use during ambulation[26]; activities restricted due to fear of falling[27]; fear of falling (falls efficacy)[27]; depression[28]; cognitive impairment[24]; obesity[9]; falls/injuries in past 12 months[29]; and impairments in gait,[24] mobility,[30] balance,[24] and lower extremity[30] and grip[31] strength.

Standardized questions determined the number of falls/injuries in the past 12 months.[18] Participants reporting more than 1 fall were classified as frequent fallers.[29] The Falls Efficacy Scale assessed fear of falling.[19] Participants rated their confidence in performing 10 activities without falling.[19] Scores over 70 indicated fear of falling.[19]

The 15-item Geriatric Depression Scale-Short measured past-week depression.[20] Scores were categorized as normal (0–5), suggestive of depression (6–9), or almost always indicates depression (10–15).[20,32] A 6-item cognitive screener assessed the likelihood of a cognitive impairment.[33] Scores ranged from 0 to 6 with scores between 0 and 3 indicative of dementia.[33] Height and weight were measured to calculate body mass index.

The Four-Square Step Test (FSST) measured balance.[34] Participants were timed while stepping in 4 directions over 2 polyvinyl chloride pipes that were arranged as a cross.[34] Lower scores indicated better balance.[34] A timed Five-Meter Walk Test, at a usual pace, determined gait speed in meters per second.[35] Higher scores indicated a faster gait speed.[35] The Timed Up-and-Go (TUG) test measured mobility.[36] Participants were timed as they rose from a chair, walked 3 meters at a usual pace, turned around, walked back, and sat down.[36] Lower scores indicated better mobility.[36] The Five-Times Sit-to-Stand Test (FTSST) measured lower extremity strength by timing how long it took to stand and sit from a chair 5 times.[37] Grip strength of the dominant hand was measured using a Jamar® Hydraulic Hand Dynamometer (Sammons Preston Rolyan, Bolingbrook, IL).

Intervention

The TJQMBB program is an “integrative movement therapy” that uses TJQ principles and Yang-style movements[38] to increase balance, gait, postural control, and mobility in older adults.[38] The instructors were all new to TJQ and underwent a 2-day training with the developer. Participants were offered free, 1-hour classes, twice weekly for 16 weeks (32 sessions). The sessions consisted of 5 to 10 minutes of preparatory exercises, 40 to 45 minutes of core movements (i.e., therapeutic balance and mobility exercises), and 5 minutes of closing exercises.[39–41] Participants could perform the exercises in sitting or standing.

Falls and Fall-Related Injuries

A fall occurred when a participant came to rest on the ground or a lower level unintentionally, and not because of [42]: 1) an intrinsic event (e.g., stroke, epileptic seizure); 2) an overwhelming force (e.g., hit by a car); 3) a near fall such as stumbling against an object; or 4) coming to rest against furniture, a wall, or other structure.[43] Injuries were fractures, joint dislocations, head injuries requiring hospitalization, sprains, lacerations, or other serious joint injuries[43]; however, we also documented minor injuries.

Participants were given monthly calendars to prospectively record falls/injuries each day. At the end of the intervention, a questionnaire asked about any falls/injuries that occurred during the past 16 weeks.[18] We also documented verbal reports of falls from participants or instructors. Participants who fell completed a standardized telephone interview to ascertain the details of each fall/injury including mechanism, location, injured body part(s), type of injury, and treatment received. Falls were graded using the four-point Hopkins Falls Grading Scale.[44]

Data Analyses

Participants were grouped by fall status (yes/no). Baseline comparisons between groups were conducted using Chi-square or Fisher Exact tests for categorical data, and Independent T-Tests or Mann-Whitney U tests for continuous data. The mean number of sessions attended were compared between groups using the Mann-Whitney U test. Participants who attended at least 24 (75%) of the 32 sessions were considered completers.[45] A Chi-Square test compared completion rates between fallers and non-fallers.

The frequency and proportion of falls/injuries were tallied. The Chi-Square test determined if fallers in the past 12 months were more likely to fall during the intervention. The data source(s) that identified each faller (i.e., calendar, 16-week questionnaire, and/or verbal report) was recorded. Agreement between the fall calendars and questionnaire in identifying fallers was assessed with Cohen’s Kappa.

Statistically significant variables were entered into a backward, logistic regression model to determine which variables independently predicted falls. Entry and removal criteria were 0.05. All tests were 2-tailed and conducted with an alpha of 0.05. Data were analyzed using

JMP® Pro Statistical Discovery Software version 11.0[46] and IBM® SPSS® Statistics for Windows version 26.0.[47]

Results

Baseline Characteristics of Fallers and Non-Fallers

Of 263 people screened for eligibility, all were eligible, and 237 (90%) enrolled (26 declined). Two-hundred twenty-three (94.1%) of the 237 participants started classes (14 did not start). Analyses were limited to the 193 participants with falls data. Forty-two (21.8%) of 193 participants fell during the intervention. There were no significant differences in socio-demographics between fallers and non-fallers (Table 1).

Eighteen churches sponsored 16 TJQMBB classes at 13 churches and 2 senior centers that were led by 19 instructors, between March and November 2014. The mean number of participants per class was 14 ± 4.0 (range, 6 to 23). Average attendance at the 32 sessions was 65%. The most common reasons for missing class were medical appointments (39% of missed classes), travel (36%), family obligations (35%), and health (33%). The mean number of sessions attended did not differ between fallers (20.6 ± 7.7, range 1–30) and non-fallers (20.9 ± 8.3, range 1–32) ($p = 0.69$). Completion rates were similar between fallers (44.7%) and non-fallers (42.5%) ($p = 0.81$).

Fallers were more likely than non-fallers to report a breathing problem ($p = 0.048$); low back pain ($p = 0.001$); peripheral neuropathy ($p = 0.03$); pain, stiffness, or swelling limiting activity ($p = 0.02$); using an assistive device to ambulate ($p = 0.02$); and frequent falls during the past 12 months ($p = 0.04$) (Table 2). Fallers also had a slower gait speed than non-fallers ($p = 0.01$) (Table 3).

Fall Events and Fall-Related Injuries

The 42 fallers reported 56 falls. Nine (21.4%) of the 42 fallers were frequent fallers. Fallers (54%) were more likely than non-fallers (46%) to have fallen during the past 12 months ($p = 0.05$). Sixteen (38.1%) fallers reported 19 injurious falls. We interviewed 35 (83.3%) of the 42 fallers to obtain fall details.

Eighty-five percent of falls were Grade Two in severity (no medical attention received) (Table 4). The most common mechanism was slipping, tripping, or stumbling. The most frequent injury site was in the lower extremities. Bruising was the most common injury. Of the 2 serious injuries, both occurred on steps/ladder, 1 participant fractured a hip and underwent replacement surgery while another fractured both wrists that were casted.

Twenty-five (59.5%) of the 42 fallers were identified by more than 1 method. Fall calendars detected 28 (66.7%) fallers, the 16-week questionnaire captured 34 (81.0%) fallers, and verbal reports identified 8 (19.0%) fallers. Agreement between the prospective calendars and retrospective questionnaire was 0.87 (Kappa) (95% CI 0.75, 0.98, $p < 0.001$).

Independent Predictors of Falls

Baseline gait speed; low back pain; and pain, stiffness, or swelling limiting activity were significant independent predictors of falls in the logistic regression model (Table 5). The model explained 18% (Nagelkerke R^2) of the variance in falls. For every meter/second increase in baseline gait speed, participants were 73% less likely to fall. Participants with low back pain were 8 times more likely to fall than those without low back pain. Participants reporting pain, stiffness, or swelling limiting activity were 2.4 times more likely to fall than those without these symptoms.

Discussion

This study reported on falls/injuries in a 16-week implementation of TJQMBB in older rural adults. A greater proportion of participants fell than in a prior TJQMBB study (5.2%).[45] Falls may have been higher because our population was rural[6] and had a high prevalence of fall risk factors. Although one-third of falls resulted in injury, which was higher than previously reported (18.4%),[39] the severity of injuries appeared similar.

Falls should be recorded prospectively with a calendar and telephone follow-up.[48–50] We used 2 additional methods to track falls. There was substantial agreement[51] between the prospective calendars and retrospective questionnaire, and the agreement was similar to other studies.[49,52] The 2 additional methods allowed us to capture falls that may have otherwise been missed.

Gait speed was the only performance-based test that predicted falls, which was surprising given that the TUG and FTSST are among the most evidence-supported tests for determining fall risk.[53] Perhaps, 4 months of tracking falls was not enough to detect between group differences with these tests. One meta-analysis of tests for assessing fall risk only included studies with 6 or more months of monitoring.[53]

Participants with low back pain were 8 times more likely to fall. Back pain is the most commonly reported musculoskeletal complaint in older adults[54] and is an independent risk factor for falls in men and women.[55,56] Given the high prevalence of back pain in older adults, screening participants in community-based fall-prevention programs for back pain may help identify those at high risk for falls.

We asked about pain, stiffness, and swelling to identify chronic musculoskeletal conditions such as arthritis,[57] which is a risk factor for falls.[21,58,59] These symptoms were associated with a 2.4 times greater risk of falling which was most likely due to the high prevalence of arthritis in our participants. West Virginia has the highest prevalence of arthritis in the US.[60]

Retaining participants in fall-prevention programs is challenging.[61] Our attendance and completion rates were lower than expected, but similar to a 12-week dissemination study in 3 states.[61] Participation in fall-prevention programs is lower in those who are older, female, and/or obese.[62,63] Our study contained predominantly older females and over 75% of participants were overweight or obese.

Rural areas have fewer community-delivered health promotion and prevention services, fewer healthcare facilities and personnel, longer distances to travel to access healthcare resources, and a lack of infrastructure (e.g., public transportation).[64,65] Subsequently, evidence-based disease and fall-prevention programs are less available in rural as compared to urban areas.[66,67] This study was conducted in medically-underserved rural communities where we were able to reach older adults at high risk for falls. Our participants were similar demographically to both urban and rural participants in a national dissemination of evidence-based fall-prevention programs except that a higher proportion were white.[67] Our sample also had a higher prevalence of arthritis, diabetes, and depression than urban and rural participants in that study[67] which indicates that not all rural areas are alike.

Rural areas are heterogeneous and interventions should be specifically tailored to each population's needs.[10] It is thus important to know the fall risk profile of participants when planning fall-prevention interventions. To our knowledge, this may be the first study to describe fall risk factors and fall/injury events in older adults in rural WV. Determining the differences between fallers and non-fallers in this study contributed to creating a fall risk profile of rural adults in WV and ultimately, may allow us to better tailor fall-prevention programming based on their needs. For instance, participants from our population may have needed: 1) an intervention before starting the fall-prevention program (e.g., physical therapy for low back pain or arthritis), 2) an extended form of the intervention, or 3) even a different intervention(s) altogether.

This study's strength was that we intervened in hard-to-reach, medically-underserved, rural older adults. There were 3 limitations to this study. The study did not include a control group and was not powered to detect a significant reduction in falls because the focus was on implementation and not efficacy. Lastly, participants in our study were rural older adults who were predominantly female and white and thus, our results may not be generalizable to other populations.

Conclusion

This study examined the characteristics of fallers and non-fallers in an implementation study of TJQMBB and identified gait speed; low back pain; and pain, stiffness, and swelling as independent predictors of falls during the 16-week intervention. Future studies should continue to examine TJQMBB implementation in other settings, as well as identify other factors that can help tailor fall-prevention programming to hard-to-reach, rural, older adult populations.

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Data Availability:

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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Table 1:

Baseline Socio-Demographics of Fallers and Non-Fallers

n (%) or mean ± SD (range)	Fallers (n=42)	Non-Fallers (n=151)	P-Value
Age (mean ± SD, range) (n=193)	72.3 ± 10.4 (56–94)	71.5 ± 8.8 (57–98)	0.61
Sex n (% female) (n=193)	33 (78.6)	126 (83.4)	0.46
Ethnicity n (% Hispanic) (n=179)	1 (2.6)	2 (1.4)	0.63
Race n (% white) (n=193)	41 (97.6)	142 (94.0)	0.69
Education n (%) (n=190):			
High school or less	17 (41.5)	72 (48.3)	0.45
More than high school	24 (58.5)	77 (51.7)	
Income n (%) (n=172):			
< $25,000	11 (31.4)	36 (26.3)	0.66
$25,000–$49,999	14 (40.0)	65 (47.5)	
≥ $50,000	10 (28.6)	36 (26.3)	
Marital status n (%) (n=191):			
Single	3 (7.3)	8 (5.3)	0.67
Married	21 (51.2)	92 (61.3)	
Separated or divorced	3 (7.3)	11 (7.3)	
Widowed	14 (34.2)	39 (26.0)	
Employment status n (%) (n=190):			
Homemaker	2 (5.0)	28 (18.7)	NA *
Worked full-time	1 (2.5)	7 (4.7)	
Worked part-time	3 (7.5)	8 (5.3)	
Unemployed (not due to health)	0 (0.0)	2 (1.3)	
Retired (not due to health)	26 (65.0)	88 (58.7)	
Disabled, unemployed, or retired due to ill health	7 (17.5)	10 (6.7)	
Other	1 (2.5)	7 (4.7)	

* Not applicable - cells with low counts

Table 2:

Baseline Risk Factors in Fallers and Non-Fallers

n (%) or mean ± SD (range)	Fallers (n=42)	Non-Fallers (n=151)	P-Value
Chronic conditions n (% yes): *			
Arthritis (n=186)	29 (72.5)	91 (62.3)	0.23
Breathing problem (n=189)	**13 (31.7)**	**26 (17.6)**	**0.048**
Cancer (n=190)	10 (24.4)	33 (22.1)	0.76
Cataracts (n=186)	24 (58.5)	65 (44.8)	0.12
Diabetes (n=185)	5 (11.9)	36 (25.2)	0.07
Foot problems (n=190)	15 (35.7)	40 (27.0)	0.27
Heart attack (n=186)	4 (9.8)	7 (4.8)	0.26
Insomnia (n=185)	14 (34.1)	31 (21.5)	0.10
Irregular or rapid heartbeats (n=191)	16 (38.1)	35 (23.5)	0.06
Low back pain (n=189)	**9 (21.4)**	**5 (3.4)**	**0.001**
Parkinson’s disease (n=185)	1 (2.4)	1 (0.7)	0.40
Peripheral neuropathy (n=183)	**7 (18.4)**	**10 (6.9)**	**0.03**
Stroke (n=186)	6 (14.6)	8 (5.5)	0.09
Pain, stiffness, or swelling limiting activity	**25 (59.5)**	**59 (39.1)**	**0.02**
Hip, knee, ankle, and/or foot surgery in past year n (% yes) (n=190)	2 (4.8)	8 (5.4)	0.99
Took ≥ four medications n (% yes) (n=190)	31 (73.8)	90 (60.8)	0.12
Took prescription sedatives n (% yes) (n=188)	12 (29.3)	27 (18.4)	0.13
Took sedating over-the-counter medications n (% yes) (n=190)	11 (26.2)	29 (19.6)	0.36
Difficulty holding urine n (% yes) (n=190)	31 (73.8)	100 (67.6)	0.44
Assistive device used during ambulation n (% yes) (n=189)	**14 (33.3)**	**24 (16.3)**	**0.02**
Restricted activities due to fear of falling n (% yes) (n=188)	13 (31.7)	41 (27.9)	0.63
Falls efficacy score > 70 n (%) (n=183)‡	1 (2.6)	11 (7.6)	0.26
Depression score (0–15) n (%) (n=193):			
Normal (0–5)	28 (66.7)	90 (59.6)	0.47
Suggestive of depression (6–9)	12 (28.6)	59 (39.1)	
Almost always indicates depression (10–15)	2 (4.8)	2 (1.3)	
Cognitive impairment n (% dementia) (n=191)	1 (2.4)	1 (0.7)	NA†
Body mass index (kg/m^2) n (%) (n=185)			
< 18.5 kg/m^2 (underweight)	0 (0.0)	1 (0.7)	0.2
18.5–24.9 kg/m^2 (normal)	7 (17.5)	29 (20.0)	
25.0–29.9 kg/m^2 (overweight)	21 (52.5)	50 (34.5)	

n (%) or mean ± SD (range)	Fallers (n=42)	Non-Fallers (n=151)	P-Value
≥ 30 kg/m^2 (obese)	12 (30.0)	65 (44.8)	
Fall history past 12 months:			
Number of fallers (at least 1 fall) n (%) (n=190)	22 (53.7)	55 (36.9)	0.053
Total number of falls (n=190)	87	105	NA[†]
Number of frequent fallers (> 1 fall) n (%) (n=190)	**12 (29.3)**	**23 (15.4)**	**0.04**
Number of fallers with injuries n (%) (n=189)	8 (19.5)	15 (10.1)	0.11
Total number of injurious falls (n=189)	10	21	NA[†]

Note: Bold-face type indicates p < 0.05

[*]Totals may not sum to 100%. Participants could report more than 1 response.

[†]Not applicable - cells with low counts

[‡]Scores can range from 10 to 100. Higher scores indicate a fear of falling

Table 3:

Baseline Physical Performance Tests in Fallers and Non-Fallers

(mean ± SD, range)	Fallers (n=42)	Non-Fallers (n=151)	P-Value
Four-square step test (seconds)	11.6 ± 3.1 (6.7–19.6)	11.3 ± 3.4 (5.6–30.2)	0.62
Gait speed (meters/second)	**1.0 ± 0.4 (0.3–2.6)**	**1.2 ± 0.5 (0.3–3.3)**	**0.01**
Timed up-and-go test (seconds)	13.4 ± 6.4 (6.1–35.5)	11.4 ± 5.2 (5.2–42.7)	0.09
Five-times sit-to-stand test (seconds)	16.4 ± 4.9 (8.4–29)	15.0 ± 4.0 (8–27.2)	0.15
Grip strength dominant hand (kilograms)	20.6 ± 6.8 (6.3–40.3)	22.8 ± 8.1 (3.3–48.7)	0.16

Note: Bold-face type indicates $p < 0.05$

Table 4:

Falls and Fall-Related Injuries During Intervention

n (%)	Falls (n=56 falls)
Fall grades (n=48):	
Grade 1 (did not qualify as a fall in study)	0 (0.0)
Grade 2	41 (85.4)
Grade 3	6 (12.5)
Grade 4	1 (2.1)
Timing of falls during intervention n (%) (n=51):	
Weeks 1–4	22 (43.1)
Weeks 5–8	14 (27.5)
Weeks 9–12	11 (21.6)
Weeks 13–16	4 (7.8)
Mechanism of falls (n=56):	
Slipped, tripped, stumbled	24 (42.9)
Other	11 (19.6)
Steps/ladder	8 (14.3)
Unknown	7 (12.5)
Pet-related	4 (7.1)
Picking up object	2 (3.6)
Fall location (n=52):	
Indoors	26 (50.0)
Outdoors	26 (50.0)
Injured body part(s) (n=29): *	
Lower extremity	14 (48.3)
Upper extremity	8 (27.6)
Head/face	6 (20.7)
Neck	1 (3.4)
Type of injury (n=18): *	
Bruising	9 (50.0)
Laceration	3 (16.7)
Fracture	2 (11.1)
Black eye	2 (11.1)
Meniscal tear	1 (5.6)
Sprain	1 (5.6)
Medical care received (n=11): *	
Saw primary care physician	4 (36.4)
Visit to Emergency Department	3 (27.3)
Saw specialist	3 (27.3)
Other	1 (9.1)
Treatment received (n=12): *	

n (%)	Falls (n=56 falls)
Cortisone shot	4 (33.3)
Physical therapy	4 (33.3)
Braced/casted	2 (16.7)
Stitches	1 (8.3)
Surgery	1 (8.3)

*Totals may not sum to 100%. Participants could report more than 1 response.

Table 5:

Logistic Regression of Factors Predicting Falls During Intervention

Variable (n=172)	Beta Estimate	Standard Error	Wald Statistic	Degrees of Freedom	P-Value	Odds Ratio	95% CI Odds Ratio	
							Lower	Upper
Baseline gait speed (meters/second)	−1.33	0.62	4.55	1	**0.03**	0.27	0.08	0.90
Low back pain (yes/no)	2.08	0.79	6.96	1	**0.01**	8.04	1.71	37.79
Pain, stiffness, or swelling limiting activity (yes/no)	0.89	0.41	4.69	1	**0.03**	2.44	1.09	5.45
Constant	−4.70	1.85	6.48	1	0.01	0.01	-	-

Note: Bold-face type indicates $p < 0.05$