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Clinical Decision Path for Identifying Recurrent Falls in Late Middle-Aged and Older Patients With Chronic Schizophrenia

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ABSTRACT

Background: Falls are a major hazard for elderly patients with schizophrenia. As patients with schizophrenia may experience a more-accelerated rate of physical aging than the overall elderly population, the risk of falls may emerge during the late middle-age period in this population. Furthermore, the risk of falls is affected by multiple, interrelated risk factors.

Purpose: This study was undertaken to capture the complexity of the risk of falls in patients with schizophrenia. A cross-sectional approach was used to apply classification and regression tree (CART) analysis to generate a clinical decision path to identify the risk factors of recurrent falls in late middle-aged and older patients with schizophrenia.

Methods: Two hundred ninety-one patients aged 55 years or older were recruited from psychiatric halfway houses for assessment. Frailty, physical functional performance, depressive severity, cognitive function, and level of fatigue were measured, respectively, using the Study of Osteoporotic Fractures Frailty Index, Short Physical Performance Battery (SPPB), Center for Epidemiological Studies Depression Scale, Short Portable Mental Status Questionnaire (SPMSQ), and Chinese version of the Fatigue Severity Scale. The variables revealed by descriptive statistics to be statistically significant were further analyzed using CART analysis.

Results: The overall proportion of recurrent fallers in this study was 19.2%. CART analysis revealed eight end groups and identified four predictors: frailty, physical functional performance, cognitive function, and sex. The most prominent condition for recurrent fallers was frailty, present in 57.1% of the frail participants. In the nonfrail group (both prefrail and robust), participants with an SPPB score of less than 10 had a 29.7% chance of being a recurrent faller versus 13.6% for those with an SPPB score of 10 or more. Furthermore, an SPMSQ score of 7 was the next-best split among participants without frailty, with an SPPB score of 10 or more. Finally, among participants without frailty and with an SPPB score of 10 or more and an SPMSQ score of more than 7, the proportion of recurrent fallers was higher in women than men.

Conclusions: The results of this study indicate that assessing frailty status may be an effective, first-step approach to identifying schizophrenic patients at an increased risk of recurrent falls. Among patients with prefrailty or robust status, an SPPB score cutoff of 10, an SPMSQ score cutoff of 7, and being female may be used sequentially to identify individuals at a heightened risk of recurrent falls.

KEY WORDS:
fall, frailty, older, schizophrenia.

Introduction

Falls in older adults are a major concern in clinical care. Fall-related injuries are leading causes of functional decline, hospitalization, and mortality in older adults (Sri-On et al., 2017). Furthermore, in older adults with mental disorders, falls are a common cause of serious injuries and are associated with increased emergency room visits and hospitalization (Hendrie et al., 2013; Stubbs et al., 2018). Moreover, a recent meta-analysis reported a pooled annual fall rate of 8.74% and a pooled lifetime prevalence of falls of 17.25% in patients aged 60 years or older with mental disorders (Rao et al., 2019), indicating that falls represent a serious and compelling healthcare problem in elderly patients with mental disorders.

Several factors, including frailty, may increase the risk of falls in patients with schizophrenia. Frailty develops as a consequence of the cumulative decline of multiple physiological systems and is well recognized as a high-risk factor for falls (Cheng & Chang, 2017). Characteristics of schizophrenia such as chronic systemic inflammation, malnutrition, obesity, and physical comorbidities (i.e., cardiovascular disease and diabetes) may place patients with schizophrenia at a higher risk of frailty or frailty-related deterioration (Cesari et al., 2016; Dent et al., 2016; Stubbs et al., 2015). Decreased bone mineral density and increased insulin resistance attributed to the use of antipsychotic medications may also underlie the problem of frailty in patients with schizophrenia (De Hert et al., 2016; Stubbs et al., 2015). Furthermore, frailty may aggravate the process of physical deterioration and subsequently increase the risk of falls in patients with schizophrenia. Frailty status

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has been reported to be associated with an increased risk of falls in patients with chronic schizophrenia over an 18-month follow-up period (Tsai et al., 2018).

Decreased gait speed and dynamic balance control are associated with falls in older individuals (Lauretani et al., 2019; Veronese et al., 2014). Compared with healthy individuals, patients with schizophrenia have shown slower gait speed, impaired motor imagery of gait, and impaired walking efficiency (Lallart et al., 2012; Nygård et al., 2019). Moreover, fatigue is a common complaint in patients with schizophrenia (Waters et al., 2013). Fatigue may affect the ability of older adults to respond to dynamic balance challenges such as climbing stairs and walking outside (Helbostad et al., 2007; Nagano et al., 2014). Subjective fatigue, examined using the Short Form 36 Health Survey vitality subscale, has been reported to be associated with falls in elderly people (Kamitani et al., 2019). Furthermore, decreased cognitive function, depressed mood, and side effects of medications, which are all well-recognized risk factors of falls in elderly people, have been associated with the incidence of falls in people with schizophrenia spectrum disorder (Stubbs et al., 2018).

Although there are numerous studies exploring the risk of falls among inpatients with schizophrenia (Aso & Okamura, 2019; Tsai et al., 2018; Tsuji et al., 2017), little information exists on fall risk among community-dwelling patients with schizophrenia. Patients with schizophrenia who shelter in community-based psychiatric rehabilitation institutions (i.e., halfway houses), although anchored to achieve recovery goals, may not be assessed or considered for fall risk. Furthermore, recurrent falls are a particularly significant risk factor for future injurious falls (Pohl et al., 2014). Patients who have experienced recurrent falls may be more likely to be readmitted to long-term care facilities. Notably, patients with schizophrenia have been reported to have an accelerated rate of physical aging compared with the overall population (Kirkpatrick & Kennedy, 2018). Given the increased risk of falls with age and the assumption of accelerated aging in patients with schizophrenia, the risk of falls may become significant starting from the late middle-age period in this population.

Although frailty, physical performance, depression, cognitive level, and fatigue have all been reported as associated with fall risk in elderly people, this risk may be attributable to the combined effect of multiple risk factors. To capture the complexity of this risk in patients with schizophrenia, the classification and regression tree (CART) methodology was used in this study to identify a specific combination of predictors, which was then used to estimate the probability of falls in this particularly vulnerable patient population. The CART method accounts for complex interactions between independent and dependent variables and provides an empirical description of the conditional distribution (Venkatasubramaniam et al., 2017). The main objective of this study was to use the CART approach to identify distinct subtypes of recurrent fallers in a group of late middle-aged and older patients with schizophrenia.

Methods

Participants

All of the participants were recruited from psychiatric halfway houses that offer tertiary services to patients with chronic mental illness in the Taipei Metropolitan Area in Taiwan. Data were collected between September 2017 and October 2018. The inclusion criteria were as follows: aged 55 years or older, diagnosed as having schizophrenia spectrum disorders for at least 2 years, and able to read and complete the study questionnaires. Patients with a primary diagnosis of another mental disorder (i.e., bipolar or related disorder, major depressive disorder, anxiety disorder, dementia, mild neurocognitive disorder, substance-related or addictive disorder, and sleep disorder) were excluded. Patients were also excluded if they had been admitted to an acute psychiatric inpatient setting during the previous year, if their medication profiles had been changed within 4 weeks immediately preceding the enrollment date, and if they had conditions that may hamper their ability to perform physical functional tests. These latter conditions included being physically disabled (e.g., poliomyelitis), being unable to walk 4 m with or without an assistive device, having vertigo, and having had an acute onset of a disease or injury of the musculoskeletal system.

Measurement

Background variables

Variables associated with fall risk, including age, sex, physical comorbidities, current use of prescribed medications, and nutrition status, were collected (Neyens et al., 2013; Stubbs et al., 2018; Tsai et al., 2018). The total number of physical comorbidities (i.e., hypertension, diabetes, cardiovascular disease, cancer, cataract, gout, arthritis, and osteoporosis) and prescribed medications (i.e., antipsychotics, antidepressants, benzodiazepines, hypnotics, anticholinergic agents, oral hypoglycemic agents, and antihypertensive or other cardiac medications) were collected from medical records. Nutrition status was measured using the Mini Nutritional Assessment-Short Form, which has been used for assessing nutritional status in the elderly population (Chang & Lin, 2016).

Fall history

A fall event was defined, for the purposes of this study, as a person losing balance unexpectedly in a manner that results in that person coming to rest unintentionally on the ground. Fall events that resulted from an overwhelming external hazard (e.g., a car accident) or sudden onset of paralysis resulting from a major adverse health event (e.g., stroke, epileptic seizure, or myocardial infarction) were excluded. The participants were asked to report any fall event they had experienced during the previous year. Following the practice in earlier studies (Gomez et al., 2017; Veronese et al., 2014), recurrent fallers were categorized as individuals who had fallen more than twice, and nonrecurrent fallers were categorized

as those who had experienced one or no falls. Data on the total number of previous hospital admissions attributed to falls or fall-related physical injuries (e.g., fracture) were collected from medical records.

Frailty status

The frailty status of each participant was assessed using the Study of Osteoporotic Fractures (SOF) frailty index (Ensrud et al., 2008). The value of using the SOF frailty index to identify individuals who had experienced two or more falls was supported in a survey of community-dwelling women aged 65 years and older (Lam et al., 2019). The SOF frailty index has three components: low mobility, decreased energy level, and weight loss. In this study, the participants who reported two or more, one, or zero indicators were classified as frail, prefrail, and robust, respectively. Mobility was assessed using the chair stand test, in which participants were required to fold their arms across their chest and stand up 5 consecutive times from a chair without the use of their arms. The participants who showed difficulty in completing this task were identified as having "low mobility." The participants who answered "no" to the question "Do you feel full of energy?" were identified as having a "decreased energy level." The participants who had experienced unintentional weight loss of more than 5% over the past year were identified with "weight loss."

Physical functional performance

Physical functional performance was assessed using the Short Physical Performance Battery (SPPB). The SPPB is a composite outcome measure of lower limb function and is performed in a sequence consisting of the standing balance test, gait speed test, and chair stand test (Haider et al., 2016). Standing balance was measured by asking the participants to perform side-by-side stand, semitandem stand, and tandem stand for 10 seconds each. For the first two positions, 1 point was given to participants who could hold for 10 seconds for each of the positions. For the tandem stand, 2 points, 1 point, or 0 points were given, respectively, if a tandem stand position was held for 10 seconds, 3–9 seconds, or less than 3 seconds. Gait speed was measured by asking participants to walk for 4 m at their usual pace. Scores were given according to the time taken (i.e., 4 points: < 4.82 seconds; 3 points: 4.82–6.20 seconds; 2 points: 6.21–8.70 seconds; 1 point: > 8.70 seconds; and 0 points: not completed). The chair stand test was measured by asking participants to perform five rises from a chair to an upright position without using their arms. Participants were required to perform the task without stopping in between and as quickly as possible. Scores were given according to the time taken (i.e., 4 points: < 11.19 seconds; 3 points: 11.20–13.69 seconds; 2 points: 13.70–16.69 seconds; 1 point: ≥ 16.7 seconds; and 0 points: not completed). The maximum total score for the three tests was 12 points, with higher scores representing superior functioning. Participants were categorized into three groups according to their SPPB scores, as follows: poor performers (0–6 points), moderate performers (7–9 points), and good performers (10–12 points; Veronese et al., 2014). A study that examined the test–retest reliability of SPPB in 124 community-dwelling older adults found intraclass correlation coefficients ranging from .83 to .89 over a 4- to 7-day interval in two research sites (Freire et al., 2012).

Depressive severity

The level of depression in the participants was assessed using the Center for Epidemiological Studies Depression (CES-D) scale. The CES-D scale is a self-reported questionnaire comprising 20 items, each of which is scored from 0 (less than 1 day of the last week) to 3 (5–7 days of the last week). The scale has shown an adequate internal consistency (Cronbach's α = .86), and a cutoff score of 16 yielded a sensitivity of 100%, a specificity of 76%, a positive predictive value of 7%, and a negative predictive value of 100% for screening out depressed participants in 166 community-dwelling women (Li & Hicks, 2010). A score of 16 or more has been used to identify older adults with moderate-to-severe depressive symptoms (Ylli et al., 2016). Participants were categorized into two groups in this study based, respectively, on CES-D scores of 0–15 and of 16 or more.

Cognitive function

Level of cognitive function was assessed in this study using the Short Portable Mental Status Questionnaire (SPMSQ). This 10-item cognitive screening instrument was designed to measure the orientation to time and place, memory, knowledge of current events, and calculation abilities of the respondent. One point was given for each correct answer, with a total possible score of 10. Higher scores indicated better cognitive function. Three or more errors was previously used as the cutoff point for screening dementia in 282 hospitalized elderly people with a sensitivity of 86.2% and a specificity of 99.0% (Erkinjuntti et al., 1987). In this study, the participants were divided into two groups based on SPMSQ score (0–7 and 8–10, respectively).

Fatigue level

Level of fatigue was assessed using the Chinese version of the Fatigue Severity Scale (CFSS; Wang et al., 2016). The CFSS is a self-reported fatigue questionnaire with nine items that measure subjective fatigue during the preceding 2-week period. Participants were asked to rate their degree of fatigue on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The average score was recorded as the CFSS score with a range of 1.0–9.0; higher scores indicated greater fatigue intensity. The psychometric properties of the CFSS were previously validated in 101 patients with major depressive disorder. The CFSS showed satisfactory internal consistency (Cronbach's α = .95) as well as acceptable concurrent, divergent, and contrasted-group validities (Wang et al., 2016). A score of 5.4 has been used to identify individuals with clinically significant fatigue (Ferentinos et al.,

2011). In this study, the participants were categorized into two groups based on CFSS score (1.0–5.4 and 5.5–9.0, respectively).

In addition to self-reported questionnaires, a research assistant administered the structured instruments, including the SPMSQ and Mini Nutritional Assessment-Short Form, and performed the SOF and SPPB tests.

Statistical Analyses

Descriptive statistics were used to describe the demographic data and summarize the measurement data. The differences between recurrent and nonrecurrent fallers were analyzed using independent t tests for continuous variables and the chi-square test for categorical variables, with a p value of < .05 considered statistically significant. Variables that were statistically significantly associated with recurrent falls, as determined using descriptive statistics, were treated as predictor variables and further analyzed using the CART method. The CART method uses subsets of a data set with all predictor variables to partition data recursively into sequential binary splits, with the proposed split decided by the degree of homogeneity of a node (i.e., impurity). The degree of decrease in impurity is measured using the degree of improvement, with greater improvement indicating superior classification (Ott & Hapfelmeier, 2017; Venkatasubramaniam et al., 2017). Data were analyzed using IBM SPSS Statistics Version 24.0 (IBM Inc., Armonk, NY, USA).

Ethical and Organizational Review

This study was approved by the Research Ethics Committee of Taipei City Hospital (TCHIRB-10603126). All of the participants were informed that their participation was voluntary and that they could withdraw from the study at any time. All of the participants provided informed consent before enrollment.

Results

Demographic Characteristics and Group Comparison

Two hundred ninety-one patients were assessed. The age of the participants ranged from 55 to 74 years, with a mean age of 61.49 years, and 57.7% of the participants were female. The proportions of recurrent and nonrecurrent fallers were 19.2% and 80.8%, respectively. None of the participants in either group had been hospitalized because of falls or fall-related physical injuries.

As is seen in Table 1, 23.5% of the female participants were classified as recurrent fallers, which was significantly higher than the proportion of male recurrent fallers (13.2%). The proportion of recurrent fallers among the participants with frailty status (57.1%) was significantly higher than that among those defined as robust or prefrail (15.2% and 20.2%, respectively). With regard to SPPB scores, the proportion of recurrent

fallers among participants with scores of 0–6 (50.0%) was higher than that of those with scores of 7–9 (29.8%) or 10–12 (14.9%). Moreover, the proportion of recurrent fallers among participants with CES-D scores of 16 or more (26.4%) was higher than that among participants with CES-D scores of 15 or less (14.1%). Furthermore, the proportion of recurrent fallers among participants with SPMSQ scores of 0–7 (30.8%) was significantly higher than that among those with SPMSQ scores of 8–10 (16.7%; Table 1).

Classification and Regression Tree Analysis of Risk Factors of Recurrent Falls

Variables that were found to be significantly associated with recurrent falls (i.e., sex, frailty status, SPPB scores, CES-D scores, and SPMSQ scores) were subsequently analyzed using CART analysis. Eight end groups were found along with four predictors, namely, frailty status, SPPB scores, SPMSQ scores, and sex, which were included in the final decision tree. The gains for the eight end groups that differed in terms of risk of recurrent falls based on specific combinations of predictors are presented in Table 2. A minimum of one and a maximum of four predictors were found to identify the end groups.

As is evident in Figure 1, frailty status was the first split used to segment participants into a frail group and a nonfrail group (i.e., prefrail or robust). Among those participants classified as frail, the proportion of recurrent fallers increased from 19.2% to 57.1% (i.e., Node 2). The branch of the tree for nonfrail participants was further split into two groups using a cutoff SPPB score of 10. In this branch, the proportion of recurrent fallers increased from 17.3% to 29.7% in participants with SPPB scores of 0–6 or 7–9. Furthermore, the proportion of recurrent fallers decreased from 29.7% to 18.2% among prefrail participants (i.e., Node 7) but increased from 29.7% to 41.9% among robust participants (i.e., Node 8).

Among nonfrail participants with SPPB scores of 10–12, this group was segmented into two groups as follows: SPMSQ scores of 0–7 and 8–10. The proportion of recurrent fallers in the group with SPMSQ scores of 0–7 increased from 13.6% to 29.0% (i.e., Node 5). In the end, sex was identified as the final split path in nonfrail participants whose SPPB scores were 10–12 and SPMSQ scores were 8–10. Among the participants in this subgroup with prefrailty status, the proportion of recurrent fallers was 22.0% for female (i.e., Node 11) and 9.7% for male (i.e., Node 12). Among the participants in this subgroup with robust status, the proportion of recurrent fallers was 9.8% for female (i.e., Node 13) and 4.1% for male (i.e., Node 14).

Discussion

In this study, 19.2% of the participants had experienced recurrent falls. The results indicate that frailty status may be used as a valid, initial cutoff for predicting recurrent falls in late middle-aged and older patients with schizophrenia. The proportion of recurrent fallers increased to 57.1% for participants

classified as frail. Moreover, the classification tree shows specific combinations of risk factors that identify the different end groups. In particular, an SPPB score of less than 10, an SPMSQ score of 7 or less, and being female may be used sequentially to identify an increased risk of recurrent falls in nonfrail patients.

A previous meta-analysis reported frailty as a risk factor for recurrent falls among individuals aged 65 years or more (Cheng & Chang, 2017). The results of this study provide further evidence that frailty status may be used to identify the risk of recurrent falls in patients with schizophrenia aged 55 years or more. Of concern, a 17.3% risk of being a recurrent faller was observed in patients in the prefrailty or robust status categories. A high rate of recurrent falls was reported previously in nonfrail patients with schizophrenia in an age group similar to this study (Tsai et al., 2018). Therefore,

Table 1

Participants' Characteristics

Variable	Nonrecurrent Faller (*n* = 235)		Recurrent Faller (*n* = 56)		*p*
	n	%	*n*	%	
Age (years)					.102
55–64	191	82.7	40	17.3	
≥ 65	44	73.3	16	26.7	
Sex					.028
Female	130	76.5	40	23.5	
Male	105	86.8	16	13.2	
Physical comorbidities					.227
0	102	84.3	19	15.7	
1	78	81.3	18	18.8	
≥ 2	55	74.3	19	25.7	
Medications (multiple choice)					
Typical antipsychotics	69	84.1	13	15.9	.228
Atypical antipsychotics	195	82.3	42	17.7	.119
Antidepressants	59	86.8	9	13.2	.101
Benzodiazepines	68	77.3	20	22.7	.202
Hypnotics	129	80.1	32	19.9	.440
Anticholinergic agents	136	82.4	29	17.6	.249
Oral hypoglycemic agents	34	77.3	10	22.7	.325
Antihypertensive or other cardiac medications	66	75.9	21	24.1	.112
MNA-SF (0–14)					.907
8–11	57	80.3	14	19.7	
12–14	178	80.9	42	19.1	
Frailty indicators (0–3)					.001
0	134	84.8	24	15.2	
1	95	79.8	24	20.2	
≥ 2	6	42.9	8	57.1	
SPPB (0–12)					.001
0–6	6	50.0	6	50.0	
7–9	40	70.2	17	29.8	
10–12	189	85.1	33	14.9	
CES-D (0–16)					.009
0–15	146	85.9	24	14.1	
≥ 16	89	73.6	32	26.4	
SPMSQ (0–10)					.020
0–7	36	69.2	16	30.8	
8–10	199	83.3	40	16.7	
CFSS (1.0–9.0)					.880
1.0–5.4	139	81.3	32	18.7	
5.5–9.0	96	80.0	24	20.0	

Note. MNA-SF = Mini Nutritional Assessment–Short Form; SPPB = Short Physical Performance Battery; CES-D = Center for Epidemiological Studies Depression Scale; SPMSQ = Short Portable Mental Status Questionnaire; CFSS = Chinese version of the Fatigue Severity Scale.

Table 2

Gains for End Nodes of CART Decision Tree

Node	Condition	Node		Gain		Response (%)
		n	%	*n*	%	
2	Frail	14	4.8	8	14.3	57.1
8	SPPB scores < 10, robust	31	10.7	13	23.2	41.9
5	SPPB scores of 10–12, SPMSQ scores of 0–7	31	10.7	9	16.1	29.0
11	SPPB scores of 10–12, SPMSQ scores of 8–10, prefrail, female	41	14.1	9	16.1	22.0
7	SPPB scores < 10, prefrail	33	11.3	6	10.7	18.2
13	SPPB scores of 10–12, SPMSQ scores of 8–10, robust, female	61	21.0	6	10.7	9.8
12	SPPB scores of 10–12, SPMSQ scores of 8–10, prefrail, male	31	10.7	3	5.4	9.7
14	SPPB scores of 10–12, SPMSQ scores of 8–10, robust, male	49	16.8	2	3.6	4.1

Note. CART = classification and regression tree; SPPB = Short Physical Performance Battery; SPMSQ = Short Portable Mental Status Questionnaire.

the results of this study not only raise concerns that recurrent falls may occur at an earlier age in patients with schizophrenia but also highlight the importance of paying close attention to the risk of recurrent falls in nonfrail patients with schizophrenia.

In this study, having an SPPB score of less than 10 was found to identify a significantly increased risk of recurrent falls in prefrail- and robust-status participants, with over 40% of robust-status participants in the group with an SPPB score of less than 10 having experienced recurrent falls. In addition to the chair stand test, the SPPB measured balance and gait speed, whereas the SOF frailty index measured energy level and weight loss. Two relevant studies have reported an association among falls, balance, and walking speed in inpatients with schizophrenia aged more than 60 years (Aso & Okamura, 2019; Tsuji et al., 2017). Thus, balance and gait speed may be more potent for identifying recurrent fallers than overall energy level and weight change, particularly among robust patients with schizophrenia. Thus, evaluating balance and gait speed may facilitate the identification of patients who are robust but may be at a higher risk of recurrent falls. Another possible explanation is that patients who are residents of halfway houses are typically up and freely ambulating during the day. Given that patients with robust status may have fewer mobility limitations than their prefrail-status peers, robust-status patients may be more exposed to situations in which falls may occur. Further investigations of information regarding the type, time, and location of falls may help clarify the contexts in which factors may increase the rate of recurrent falls in robust patients with schizophrenia.

Consistent with relevant studies (Fischer et al., 2014; Stubbs et al., 2018), poor cognitive function was found in this study to be associated with a higher risk of recurrent falls. Moreover, an SPMSQ score of 7 or less may be used to identify an increased risk of recurrent falls in nonfrail patients with an SPPB score of 10 or more. Because an SPMSQ score of 8 or more denotes relatively intact cognitive function in elderly psychiatric patients (Erkinjuntti et al., 1987), the findings of this study imply that, even for patients with nonfrail status and

good physical functional performance, health professionals should be highly attentive to those with declining cognition.

Furthermore, the results identified being female as a risk factor for recurrent falls in patients with a combination of an SPPB score of 10 or more and an SPMSQ score of 8 or more. Among patients with chronic schizophrenia, being male has been significantly associated with a higher risk of falls (Tsai et al., 2018), whereas other studies have reported no difference in fall risk between the sexes in patients with schizophrenia (Aso & Okamura, 2019; Tsuji et al., 2017). In fact, findings regarding the effects of an individual's sex on fall risk have been inconsistent in the general population. A longitudinal cohort study found male and female older adults to have different profiles for short- and long-term risk of injurious falls (Ek et al., 2019), However, another epidemiological study reported no sex-related differences in fall risk among older adults (Franse et al., 2017). The reasons for a higher fall incidence in women remain unclear despite a hypothesis having been postulated of a sex difference in the ability to generate sufficient power in step recovery from the forward loss of balance (Carty et al., 2012). Because women are more prone than men to experiencing osteoporotic fractures (Si et al., 2015), the findings of this study highlight that sex should be incorporated as a criterion in fall screening for patients with schizophrenia.

Notably, although patients with a diagnosis of major depressive disorder were excluded from this study, more than 40% of participants had moderate depressive symptoms. Nevertheless, depression severity was not included in the final CART analysis decision tree. The use of CART analysis was mainly proposed to categorize patients into several subgroups using the "if–then" condition of the given variables. Thus, the results of this study should be interpreted as follows: The discriminative capabilities of depression severity to distinguish participants as either recurrent or nonrecurrent fallers were found to be limited despite the association of this variable with recurrent fall risk as determined using descriptive statistics. Moreover, these divergent findings may be

Figure 1

Classification and Regression Tree Analysis Decision Tree for Predicting Recurrent Falls
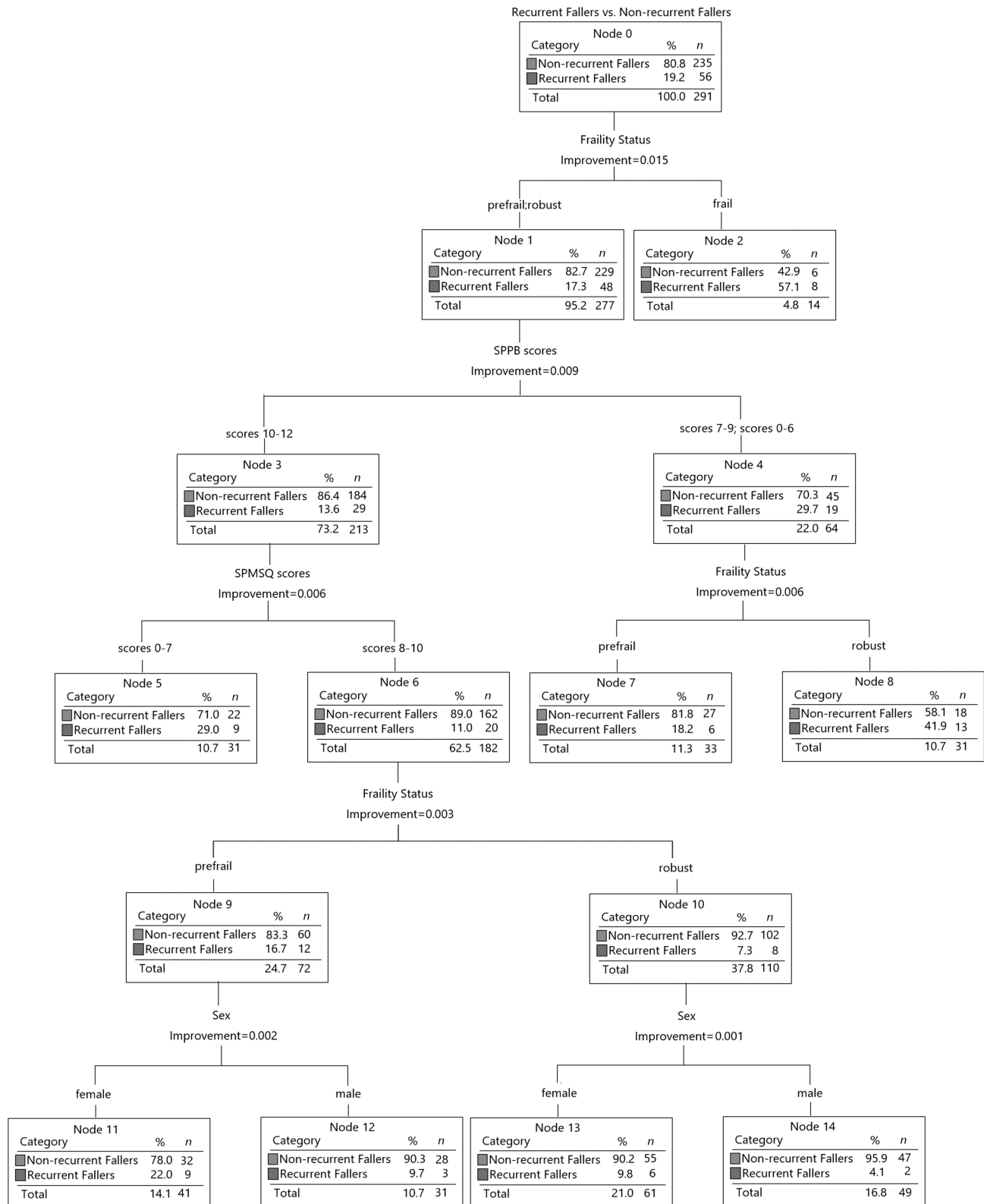
Note: SPPB = Short Physical Performance Battery; SPMSQ = Short Portable Mental Status Questionnaire.

attributable to potential discrepancies in the target population, as previous studies have focused on the general population rather than elderly patients with schizophrenia (Gomez et al., 2017; Prizer et al., 2016).

Limitations

This study was affected by multiple limitations. First, the fall history data were self-reported and thus vulnerable to recall bias. Nevertheless, recurrent fallers were defined in this study as having experienced falls at least twice during the previous year. A more-conservative definition may improve the accuracy of identifying recurrent fallers. Second, the patient assessment was limited to a single time, precluding analysis of how the predictor variables may change over time. The causal relationship thus remained undetermined. Nevertheless, the relevant interactions between covariates, such as combinations of frailty status and SPPB scores, may be identified using CART analysis. Third, other variables that impact the incidence of falls may have been overlooked in data collection. For example, information regarding the circumstances of fall events, which may reflect context-specific factors that affect the rate of falls in halfway houses, was not collected. Furthermore, the severity of psychotic symptoms may affect the incidence of falls. Psychopathology was not assessed using standard measurement instruments in this study. Thus, the results should be interpreted with caution. Nonetheless, the participants were initially screened and excluded if they had been admitted to an inpatient setting during the previous 1-year period or if their medical profiles had changed 4 weeks before the study. Therefore, the participants in this study were relatively stable in terms of psychotic symptoms and more likely to have a stable mental status. Finally, the generalizability of the results of this study is limited because all of the participants were recruited from psychiatric halfway houses. Thus, the results may not be generalizable to other populations such as institutionalized patients with schizophrenia.

Conclusions

In this study, the CART approach was applied to generate a clinical decision path for identifying the distinct subtypes of recurrent fallers in late middle-aged and older patients with schizophrenia. Frailty status was shown to be the strongest indicator of recurrent falls and thus may be appropriate for use as a first-line screening tool. For patients shown to have prefrailty or robust status, an SPPB summary score cutoff of 10, an SPMSQ summary score cutoff of 7, and being female may be used sequentially to identify those at an increased risk of recurrent falls more effectively.

Relevance to Clinical Practice

Falls may impose a substantial burden on aging patients with schizophrenia. In patients who receive community-based rehabilitation care, the impact of falls may deteriorate their ability to achieve rehabilitation goals and increase their risk of hospitalization. The SOF, SPPB, and SPMSQ assessments, each of which has been used widely to identify populations prone to accidental falls, were used in this study. Using these three assessment measures together may better stratify risk for recurrent falls than using these measures individually. The results obtained using CART analysis may be used to guide clinicians to apply these assessments in order of significance and provide cutoff points for high-risk-group identification. For instance, the risk of recurrent falls may be more accurately determined by also measuring cognitive function in nonfrail, physically well-performing patients. The purposeful assignment of preventive strategies may also be identified. Clinicians may consider including lower extremity strengthening exercises and balance function in fall prevention strategies for nonfrail patients in particular.

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Author Contributions

Study conception and design: All authors
Data collection: MYW
Data analysis and interpretation: All authors
Drafting of the article: All authors
Critical revision of the article: MYW

References

Aso, K., & Okamura, H. (2019). Association between falls and balance among inpatients with schizophrenia: A preliminary prospective cohort study. *Psychiatric Quarterly, 90*(1), 111–116. https://doi.org/10.1007/s11126-018-9609-0

Carty, C. P., Cronin, N. J., Lichtwark, G. A., Mills, P. M., & Barrett, R. S. (2012). Lower limb muscle moments and power during recovery from forward loss of balance in male and female single and multiple steppers. *Clinical biomechanics, 27*, 1031–1037. https://doi.org/10.1016/j.clinbiomech.2012.07.009

Cesari, M., Nobili, A., & Vitale, G. (2016). Frailty and sarcopenia: From theory to clinical implementation and public health relevance. *European Journal of Internal Medicine, 35*, 1–9. https://doi.org/10.1016/j.ejim.2016.07.021

Chang, S.-F., & Lin, P.-L. (2016). Prefrailty in community-dwelling older adults is associated with nutrition status. *Journal of Clinical Nursing, 25*(3–4), 424–433. https://doi.org/10.1111/jocn.13063

Cheng, M.-H., & Chang, S.-F. (2017). Frailty as a risk factor for falls among community dwelling people: Evidence from a meta-analysis. *Journal of Nursing Scholarship*, *49*(5), 529–536. https://doi.org/10.1111/jnu.12322

De Hert, M., Detraux, J., & Stubbs, B. (2016). Relationship between antipsychotic medication, serum prolactin levels and osteoporosis/osteoporotic fractures in patients with schizophrenia: A critical literature review. *Expert Opinion on Drug Safety*, *15*(6), 809–823. https://doi.org/10.1517/14740338.2016.1167873

Dent, E., Kowal, P., & Hoogendijk, E. O. (2016). Frailty measurement in research and clinical practice: A review. *European Journal of Internal Medicine*, *31*, 3–10. https://doi.org/10.1016/j.ejim.2016.03.007

Ek, S., Rizzuto, D., Fratiglioni, L., Calderón-Larrañaga, A., Johnell, K., Sjöberg, L., Xu, W., & Welmer, A. K. (2019). Risk factors for injurious falls in older adults: The role of sex and length of follow-up. *Journal of the American Geriatrics Society*, *67*(2), 246–253. https://doi.org/10.1111/jgs.15657

Ensrud, K. E., Ewing, S. K., Taylor, B. C., Fink, H. A., Cawthon, P. M., Stone, K. L., Hillier, T. A., Cauley, J. A., Hochberg, M. C., Rodondi, N., Tracy, J. K., & Cummings, S. R., Study of Osteoporotic Fractures Research Group (2008). Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. *Arch Intern Med*, *168*(4), 382–389. https://doi.org/10.1001/archinternmed.2007.113

Erkinjuntti, T., Sulkava, R., Wikström, J., & Autio, L. (1987). Short Portable Mental Status Questionnaire as a screening test for dementia and delirium among the elderly. *Journal of the American Geriatrics Society*, *35*(5), 412–416. https://doi.org/10.1111/j.1532-5415.1987.tb04662.x

Ferentinos, P., Kontaxakis, V., Havaki-Kontaxaki, B., Dikeos, D., & Lykouras, L. (2011). Psychometric evaluation of the Fatigue Severity Scale in patients with major depression. *Quality of Life Research*, *20*(3), 457–465. https://doi.org/10.1007/s11136-010-9769-3

Fischer, B. L., Gleason, C. E., Gangnon, R. E., Janczewski, J., Shea, T., & Mahoney, J. E. (2014). Declining cognition and falls: Role of risky performance of everyday mobility activities. *Physical Therapy*, *94*, 355–362. https://doi.org/10.2522/ptj.20130195

Franse, C. B., Rietjens, J. A. C., Burdorf, A., van Grieken, A., Korfage, I. J., van der Heide, A., Mattace Raso, F., van Beeck, E., & Raat, H. (2017). A prospective study on the variation in falling and fall risk among community-dwelling older citizens in 12 European countries. *BMJ Open*, *7*(6), e015827. https://doi.org/10.1136/bmjopen-2017-015827

Freire, A. N., Guerra, R. O., Alvarado, B., Guralnik, J. M., & Zunzunegui, M. V. (2012). Validity and reliability of the Short Physical Performance Battery in two diverse older adult populations in Quebec and Brazil. *Journal of Aging and Health*, *24*(5), 863–878. https://doi.org/10.1177/0898264312438551

Gomez, F., Wu, Y. Y., Auais, M., Vafaei, A., & Zunzunegui, M.-V. (2017). A simple algorithm to predict falls in primary care patients aged 65 to 74 years: The international mobility in aging study. *Journal of the American Medical Directors Association*, *18*(9), 774–779. https://doi.org/10.1016/j.jamda.2017.03.021

Haider, S., Luger, E., Kapan, A., Titze, S., Lackinger, C., Schindler, K. E., & Dorner, T. E. (2016). Associations between daily physical activity, handgrip strength, muscle mass, physical performance and quality of life in prefrail and frail community-dwelling older adults. *Quality of Life Research*, *25*(12), 3129–3138. https://doi.org/10.1007/s11136-016-1349-8

Helbostad, J. L., Leirfall, S., Moe-Nilssen, R., & Sletvold, O. (2007). Physical fatigue affects gait characteristics in older persons. *Journal of Gerontology, Series A: Biological Sciences and Medical Sciences*, *62*(9), 1010–1015. https://doi.org/10.1093/gerona/62.9.1010

Hendrie, H. C., Lindgren, D., Hay, D. P., Lane, K. A., Gao, S., Purnell, C., Munger, S., Smith, F., Dickens, J., Boustani, M. A., & Callahan, C. M. (2013). Comorbidity profile and healthcare utilization in elderly patients with serious mental illnesses. *The American Journal of Geriatric Psychiatry*, *21*, 1267–1276. https://doi.org/10.1016/j.jagp.2013.01.056

Kamitani, K., Yamamoto, Y., Kurita, N., Yamazaki, S., Fukuma, S., Otani, K., Sekiguchi, M., Onishi, Y., Takegami, M., Ono, R., Konno, S., Kikuchi, S., & Fukuhara, S. (2019). Longitudinal association between subjective fatigue and future falls in community-dwelling older adults: The Locomotive Syndrome and Health Outcomes in the Aizu Cohort Study (LOHAS). *Journal of Aging and Health*, *31*(1), 67–84. https://doi.org/10.1177/0898264317721825

Kirkpatrick, B., & Kennedy, B. K. (2018). Accelerated aging in schizophrenia and related disorders: Future research. *Schizophrenia Research*, *196*, 4–8. https://doi.org/10.1016/j.schres.2017.06.034

Lallart, E., Jouvent, R., Herrmann, F. R., Beauchet, O., & Allali, G. (2012). Gait and motor imagery of gait in early schizophrenia. *Psychiatry Research*, *198*(3), 366–370. https://doi.org/10.1016/j.psychres.2011.12.013

Lam, F. M. H., Leung, J. C. S., & Kwok, T. C. Y. (2019). The clinical potential of frailty indicators on identifying recurrent fallers in the community: The Mr. Os and Ms. OS cohort study in Hong Kong. *Journal of the American Medical Directors Association*, *20*(12), 1605–1610. https://doi.org/10.1016/j.jamda.2019.06.019

Lauretani, F., Ticinesi, A., Gionti, L., Prati, B., Nouvenne, A., Tana, C., Meschi, T., & Maggio, M. (2019). Short-Physical Performance Battery (SPPB) score is associated with falls in older outpatients. *Aging Clinical and Experimental Research*, *31*(10), 1435–1442. https://doi.org/10.1007/s40520-018-1082-y

Li, Z., & Hicks, M. H. R. (2010). The CES-D in Chinese American women: Construct validity, diagnostic validity for major depression, and cultural response bias. *Psychiatry Research*, *175*(3), 227–232. https://doi.org/10.1016/j.psychres.2009.03.007

Nagano, H., James, L., Sparrow, W. A., & Begg, R. K. (2014). Effects of walking-induced fatigue on gait function and tripping risks in older adults. *Journal of Neuroengineering and Rehabilitation*, *11*, Article No. 155. https://doi.org/10.1186/1743-0003-11-155

Neyens, J., Halfens, R., Spreeuwenberg, M., Meijers, J., Luiking, Y., Verlaan, G., & Schols, J. (2013). Malnutrition is associated with an increased risk of falls and impaired activity in elderly patients in Dutch residential long-term care (LTC): A cross-sectional study. *Archives of Gerontology and Geriatrics*, *56*(1), 265–269. https://doi.org/10.1016/j.archger.2012.08.005

Nygård, M., Brobakken, M. F., Roel, R. B., Taylor, J. L., Reitan, S. K., Güzey, I. C., Morken, G., Vedul-Kjelsås, E., Wang, E., & Heggelund, J. (2019). Patients with schizophrenia have impaired muscle force-generating capacity and functional performance. *Scandinavian Journal of Medicine & Science in Sports*, *29*(12), 1968–1979. https://doi.org/10.1111/sms.13526

Ott, A., & Hapfelmeier, A. (2017). Nonparametric subgroup identification by PRIM and CART: A simulation and application study. *Computational and Mathematical Methods in Medicine*, *2017*, Article ID 5271091. https://doi.org/10.1155/2017/5271091

Pohl, P., Nordin, E., Lundquist, A., Bergström, U., & Lundin-Olsson, L. (2014). Community-dwelling older people with an injurious fall are likely to sustain new injurious falls within

5 years—A prospective long-term follow-up study. *BMC Geriatrics*, *14*, Article No. 120. https://doi.org/10.1186/1471-2318-14-120

Prizer, L. P., Smith, M. L., Housman, J., & Ory, M. G. (2016). Depressive symptomology management and falls among middle aged and older adults. *Aging & Mental Health*, *20*(1), 13–21. https://doi.org/10.1080/13607863.2015.1021748

Rao, W.-W., Zeng, L.-N., Zhang, J.-W., Zong, Q.-Q., An, F.-R., Ng, C. H., Ungvari, G. S., Yang, F.-Y., Zhang, J., Peng, K. Z., & Xiang, Y.-T. (2019). Worldwide prevalence of falls in older adults with psychiatric disorders: A meta-analysis of observational studies. *Psychiatry Research*, *273*, 114–120. https://doi.org/10.1016/j.psychres.2018.12.165

Si, L., Winzenberg, T. M., Chen, M., Jiang, Q., & Palmer, A. J. (2015). Residual lifetime and 10 year absolute risks of osteoporotic fractures in Chinese men and women. *Current Medical Research and Opinion*, *31*(6), 1149–1156. https://doi.org/10.1185/03007995.2015.1037729

Sri-On, J., Tirrell, G. P., Bean, J. F., Lipsitz, L. A., & Liu, S. W. (2017). Revisit, subsequent hospitalization, recurrent fall, and death within 6 months after a fall among elderly emergency department patients. *Annals of Emergency Medicine*, *70*, 516–521.e2. https://doi.org/10.1016/j.annemergmed.2017.05.023

Stubbs, B., Gaughran, F., Mitchell, A. J., De Hert, M., Farmer, R., Soundy, A., Rosenbaum, S., & Vancampfort, D. (2015). Schizophrenia and the risk of fractures: A systematic review and comparative meta-analysis. *General Hospital Psychiatry*, *37*(2), 126–133. https://doi.org/10.1016/j.genhosppsych.2015.01.004

Stubbs, B., Mueller, C., Gaughran, F., Lally, J., Vancampfort, D., Lamb, S. E., Koyanagi, A., Sharma, S., Stewart, R., & Perera, G. (2018). Predictors of falls and fractures leading to hospitalization in people with schizophrenia spectrum disorder: A large representative cohort study. *Schizophrenia Research*, *201*, 70–78. https://doi.org/10.1016/j.schres.2018.05.010

Tsai, M.-T., Lee, S.-M., Chen, H.-K., & Wu, B.-J. (2018). Association between frailty and its individual components with the risk of falls in patients with schizophrenia spectrum disorders. *Schizophrenia Research*, *197*, 138–143. https://doi.org/10.1016/j.schres.2018.01.023

Tsuji, Y., Akezaki, Y., Mori, K., Yuri, Y., Katsumura, H., Hara, T., Usui, Y., Fujino, Y., Nomura, T., & Hirao, F. (2017). Factors inducing falling in schizophrenia patients. *Journal of Physical Therapy Science*, *29*(3), 448–451. https://doi.org/10.1589/jpts.29.448

Venkatasubramaniam, A., Wolfson, J., Mitchell, N., Barnes, T., JaKa, M., & French, S. (2017). Decision trees in epidemiological research. *Emerging Themes in Epidemiology*, *14*, Article 11. https://doi.org/10.1186/s12982-017-0064-4

Veronese, N., Bolzetta, F., Toffanello, E. D., Zambon, S., De Rui, M., Perissinotto, E., Coin, A., Corti, M.-C., Baggio, G., Crepaldi, G., Sergi, G., & Manzato, E. (2014). Association between short physical performance battery and falls in older people: The Progetto Veneto Anziani Study. *Rejuvenation Research*, *17*(3), 276–284. https://doi.org/10.1089/rej.2013.1491

Wang, M. Y., Liu, I. C., Chiu, C. H., & Tsai, P. S. (2016). Cultural adaptation and validation of the Chinese version of the Fatigue Severity Scale in patients with major depressive disorder and nondepressive people. *Quality of Life Research*, *25*(1), 89–99. https://doi.org/10.1007/s11136-015-1056-x

Waters, F., Naik, N., & Rock, D. (2013). Sleep, fatigue, and functional health in psychotic patients. *Schizophrenia Research and Treatment*, *2013*, Article ID 425826. https://doi.org/10.1155/2013/425826

Ylli, A., Miszkurka, M., Phillips, S. P., Guralnik, J., Deshpande, N., & Zunzunegui, M. V. (2016). Clinically relevant depression in old age: An international study with populations from Canada, Latin America and Eastern Europe. *Psychiatry Research*, *241*, 236–241. https://doi.org/10.1016/j.psychres.2016.04.096