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Risk of falls in community-dwelling older adults aged 65 or over with type 2 diabetes mellitus: a systematic review

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Objective: Older persons with diabetes mellitus (DM) are particularly more likely to have fallen in the previous year than those without DM. The purpose of this study was to investigate the relationship between the risk of falls and type 2 DM in older adults who are 65 years of age or above.
Design: A systematic review.
Methods: PubMed and other two databases were searched up to August 2, 2018. Observational and cohort studies evaluating fall risk in people who are 65 years of age or above with DM were included. This review extracted the following information from each study selected: first author's surname, year of publication, country, average follow-up period, sex, age at enrollment, study population, measurement variables, relative risk, 95% confidence intervals and controlled variables.
Results: This review involved nine cohort studies with 3,765 older adults with DM and 12,989 older adults without DM. Six studies compared with or without DM and two studies compared fallers with non-fallers with DM. Risk factors for falls included impaired cognitive function, diabetes-related complications (peripheral nerve dysfunction, visual impairment), and physical function (balance, gait velocity, muscle strength, and severity of physical activities).
Conclusions: People who are 65 years of age or above with DM have increased risk of falling caused by impaired cognitive function, peripheral nerve dysfunction, visual impairment, and physical function in community-dwellers. For adults who are 65 years of age or older with DM, research fields and clinical settings should consider therapeutic approaches to improve these risk factors for falls.

Key Words: Accidental falls, Community, Diabetes mellitus

Introduction

According to the World Health Organization, the number of people with diabetes mellitus (DM) has risen from 108 million in 1980 to 422 million in 2014 worldwide, and in 2015, an estimation of 1.6 million deaths were directly caused by DM [1]. Diabetes is a major cause of blindness, kidney failure, lower limb amputation as well as heart attacks and stroke [2]. These diseases are directly threatening to human life, therefore, management of DM is a very important consideration in public health. Appropriately 20% of older adults aged 65 to 75 years and about 40% of adults aged 80 years or over [3,4]. Although DM is a very common disease among elderly persons, most studies on DM investigating the clinical problems, complications and secondary impairments have been conducted regardless of age, and there is a relatively lack of focusing the problems in older adults 65 years or over with DM.

Falling is another problem that is common in the older population 65 years or over [5]. Approximately one in three community-dwelling older adults aged 65 or over suffer from one or more falls each year [5]. The incidence of falls appears more often in older persons with DM, and therefore several prospective studies reported DM to bes a risk factor

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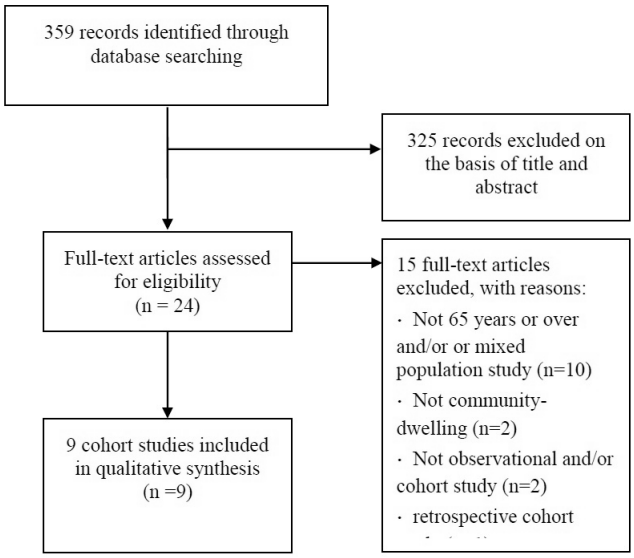

Figure 1. Flow diagram of this review.

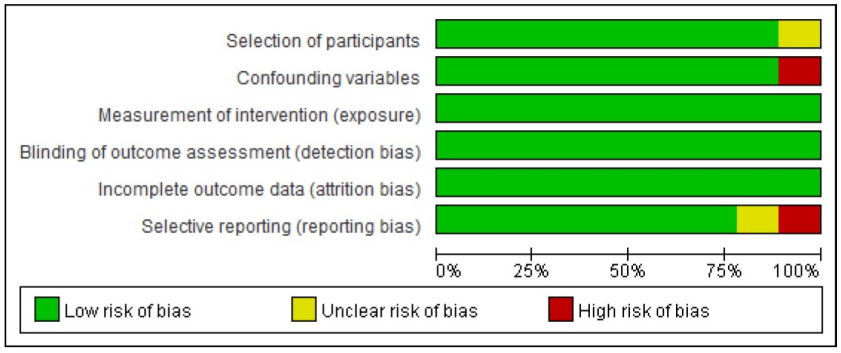

Figure 2. Risk of bias presented as percentages across all included studies.

of falls and fall-related injuries [6-10]. Falls in older persons with DM may lead to disabilities based on having decreased motivation and limitations in activities, resulting in ultimately lower quality of life even if it is not complicated with fractures. Previous studies reported that an increased risk of falling in diabetic patients is related with previous falls, poor lower extremity function, poor balance, a history of coronary heart disease, arthritis, being overweight, musculoskeletal pain, depression, poor vision, peripheral neuropathy, polypharmacy including hypnotics, peripheral neuropathy, and insulin therapy [7,10,11]. They may correlate to the presence of diabetic complications, long duration of disease, sex, or age difference or the study design. This study conducted a comprehensive systematic review of prospective observational studies to investigate whether DM was an independent risk factor for falls in community-dwelling individuals aged 65 or over.

Methods

This systematic review was performed on Patient/Participants/Population/Problem, Intervention, Comparison, Outcome with Timing, Setting Study Design. The search strategy of this review was performed by one researcher and one librarian.

Search strategy

This review was conducted in accordance with the checklist of the Meta-analysis of Observational Studies in Epidemiology (MOOSE). This study conducted literature review using three academic electronic databases (PubMed, EMbase, and CINAHL) for cohort studies published up to August 3, 2018. The following MeSH terms, words and combinations of words were used in constructing the systematic search: (diabetes mellitus OR diabetic OR DM) AND (falls OR falling OR accidental falls) AND (old OR older OR elder OR

elder*) AND (observational OR cohort). The search was restricted to studies in humans and those written English. The details of the search with five electronic databases are listed in Table 1 [7-11,12-15]. In addition, the reference lists of all identified relevant publications were reviewed.

Study selection

After completing the search in the databases, the researcher searched by hand to remove duplicate studies used on reference lists of obtained studies. The review questions and inclusion criteria were based on the MOOSE guidelines. Studies were included if (1) the participants were aged 65 and over; (2) the participants had a diagnosis of type 2 DM and were using anti-diabetic agents; (3) prospective cohort studies that investigated the association between diabetes and the risk of falls; (4) studies provided at least age-adjusted risk estimates of falls comparing diabetic to non-diabetic individuals. Studies were excluded if: the article was written in languages other than English; the article was not published as the full reports, such as case reports, commentaries, conference abstracts and letters to editors; the study had a retrospective design; the participants had a diagnosis of type 1 DM, gestational diabetes in addition to type 2 DM; the participants were 64 years of age or less. Studies were excluded if they did not provide data that allowed calculation of standard errors for effect estimates and if the estimates had not been adjusted for age. This review included observational and cohort studies for the assessment of the relationship between fall risk and DM. Two searchers discussed about the search process and selection of studies to include all available studies. This review included nine cohort studies included in a qualitative synthesis. The title and/or abstracts of the studies retrieved using the search strategy was screened independently by the review author to identify studies that potentially met the inclusion and exclusion criteria outlined above. The full text of these potentially eligible studies was retrieved and independently assessed for eligibility by the reviewer.

Data extraction

For each study selected, this review extracted data information of the first author's surname, year of publication, country, average follow-up period, sex, age at enrollment, study population, outcome, measurement, relative risk, 95% confidence interval, and controlled variables for by matching or multivariable analysis. This review also extracted information for assessment of the risk of bias including selection of participants, confounding variables, measurement of intervention (exposure), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), and selective reporting (reporting bias). This review used the RoBANS to assess internal validity of selected studies [16].

Results

Literature search and characteristics of the included studies

Based on the initial search strategies, this review retrieved a total of 359 studies from three mainstream electronic databases and the contents of 24 out of the 359 studies were relevant to the current review. Fifteen out of the 24 articles were further excluded with the following reasons: participants were not 65 years of age or over and/or it was a mixed population study, participants were not community-dwellers, the study was not an observational and/or cohort study and retrospective cohort; 9 articles were cohort studies (Table 1). This review involved nine cohort studies with 3,765 older adults with DM and 12,989 older adults without DM. Six studies compared with or without DM [8-10,12-15] and two studies compared fallers to non-fallers in those with DM [11,15]. One of nine cohort studies compared younger people (65 to 74 years old) to older people (75 years or over) with DM (Table 1).

Risk factors of falling in 65 years of age or over community-dwelling persons with DM

Risks of falls included impaired cognitive function, diabetes-related complications (peripheral nerve dysfunction, visual impairment), and impaired physical function (balance, gait velocity, muscle strength, and severity of physical activities). Seven studies reported visual impairment as a risk of falling in 65 years of age or over community-dwellers with DM [8-11,14,15]. They measured visual impairment, such as corrected visual acuity, contrast sensitivity, and depth perception (near and distant). Five studies reported impaired cognitive function as a risk of falling, and they measured cognitive function with the mini-mental state examination, modified mini-mental state examination, recall, orientation, executive function, trails B, and digit symbol score [7,8,10,13,14]. Peripheral nerve dysfunction was reported as another important risk factor of falling in five studies [8,9,11,13,15]. They measured peripheral nerve dysfunction using an ordinal scale, loss of light touch discrim-

Table 1. Characteristics of cohort studies of the association between diabetes mellitus and risk of falls

First author, year	Country	Follow-up period	Population (% female)	Age (y) at enrollment	Study population	Result			
						Subgroup	Relative risk	95% confidence interval	Controlled variables
Blackwood, 2018 [7]	United States		1,171 65-74 years, 662 75 or over years, 509	65 years	The 2010 wave of the Health and Retirement Study	65-74 years Executive function Delayed recall Older group Executive function Delayed recall	 1.06 1.07 1.28	 1.01-1.11 1.01-1.13 1.03-1.59	・Common characteristic ・Comorbidities ・Functional status ・Medications ・Psychosocial functioning
Schwartz *et al*., 2002 [8]	United States	7.2±1.9 years	9,249 (100) No-DM, 8,620 No insulin, 530 Insulin, 99		The Study of Osteoporotic Fractures, a prospective cohort study	Balance CHD Arthritis Peripheral neuropathy	1.34/2.98 1.43/3.70 1.45/3.92 1.49/3.83	1.00-1.81/1.67-5.32 1.06-1.92/2.08-6.57 1.08-1.95/2.21-6.95 1.11-1.99/2.16-6.79	・Common characteristic ・Comorbidities ・Functional status ・Medications
Patel *et al*., 2008 [11]	United Kingdom		150 Fallers, 61 Nonfallers, 89	65 years	The Merton and Sutton Community Diabetes register	Vibration threshold	19.0±7.7	6.7-50.2	・Common characteristic ・Medical examination
Pijpers *et al*., 2012 [10]	The Netherlands		1,145 No-DM, 1,060 DM, 85	65 years	LASA, a cohort study	Pain score Self-PH Physical activity Grip strength MMSE	1.54 1.55 1.59 1.58 1.59	1.01-2.34 1.05-2.31 1.05-2.41 1.05-2.40 1.05-2.42	・Common characteristic ・Comorbidities ・Functional status ・Medications ・Psychosocial functioning
Schwartz *et al*., 2008 [9]	United States	4.9 years	3,075 (44.6) No-DM, 2629 DM, 446	73.6±2.7 70-79	Health ABC study, a prospective cohort study	A1C 6% CMAP Vision Renal function DBP	4.36 1.50 1.41 1.38 1.54	1.32-14.46 1.07-1.12 0.97-2.04 1.11-1.71 1.21-1.95	・Common characteristic ・Comorbidities ・Functional status ・Medications
Tilling *et al*., 2006 [15]	United Kingdom		77 (58) Falls, 30 No falls, 47	65 years		Female Age>75 Frame to mobilize Stick to mobilize A1C>7% Stroke	2.336 1.62 2.679 1.839 7.83 1.929	1.144-4.766 1.014-2.586 1.998-3.593 1.048-3.227 2.948-20.799 1.143-3.257	・Common characteristic ・Comorbidities ・Functional status ・Medications
van Hateren *et al*., 2012 [12]	The Netherlands		563 (52.9) No-DM, 211 DM 352	70 years	Observational study	Symptomatic OH Age	2.87 1.07	1.09-7.55 1.01-1.14	・Common characteristic ・Comorbidities
Volpato *et al*., 2005 [13]	Norway	3 years	878 (100) No-DM, 742 No insulin, 97 Insulin, 39	65 years	WHAS, an epidemiological study	RF RRF	1.38 1.69	1.04-1.81 1.18-2.43	・Common characteristic ・Comorbidities ・Functional status ・Medications

Table 1. Continued

First author, year	Country	Follow-up period	Population (% female)	Age (y) at enrollment	Study population	Result			Controlled variables
						Subgroup	Relative risk	95% confidence interval	
Yau *et al.*, 2013 [14]	United States	10.1 years	3,075 (44.6)	73.6±2.7	Health ABC study,	Sex (female)	1.85	1.08-3.17	· Common characteristics
			No-DM, 2,356	70-79	a prospective	Race	2.10	1.24-3.56	· Functional status
			No insulin, 602		cohort study	Study site	2.34	1.35-4.06	· Medications
			Insulin, 117			Fell number	2.23	1.33-3.73	
						SBS	2.73	1.57-4.75	
						Insulin use (yes)	1.24	0.64-2.41	
						A1C level	1.76	1.02-3.05	

DM: diabetes mellitus, CHD: coronary heart disease, LASA: the longitudinal aging study Amsterdam, PH: physical health, MMSE: mini-mental state examination, Health ABC study: the health aging and body composition study, CMAP: compound muscle action potential, DBP: diastolic blood pressure, WHAS: the women's health and aging study, RF: risk of falls, RRF: recurrent risk of falls, SBS: standing balance score.

ination, peroneal nerve conduction velocity, peroneal nerve compound muscle action potential amplitude, vibration perception, and loss of pressure sensitivity.

Impaired physical function including balance, muscle strength, gait velocity, and previous fall experience was also reported to be a risk of falling. Four studies measured balance function with out measures, such as tandem walk score, tandem stance performance, standing balance time, balance test scale, and chair stand test [8,9,13,14]. Muscle strength was assessed for knee extension and grip strength in four studies [8-10,13], and gait velocity was assessed in four studies [7,8,13,14]. Previous experience of falls was reported in four studies [7,10,13,14], and the severity of impaired physical activity was reported in six studies that measured activities of daily living, physical activity time per day, physical activity at least once a week (percentage), independent mobility, and the amount of time spent on their feet every day (hours) [7,8,10,11,13,15]. Three of nine studies assessed hypertension as a risk of falls [9,13,14], and two of nine studies measured glycemic control (HBA1C [%]) [9,15].

Publication bias in all included studies

All included studies showed low risk in measurement of intervention (exposure), blinding of outcome measurement and incomplete outcome data. However, one of nine studies showed high risk in confounding variables, and another one of nine studies showed high risk in selective outcome reporting.

Discussion

This review aimed to identify risk factors of falling in community-dwelling older adults 65 years of age or over with DM. As results of all included studies, the most common risk factors of falling were impaired physical function, cognitive impairment and diabetes-related complications. Physical impairments that were identified included severity of impaired physical activities, muscle strength, balance and walking velocity, and diabetes-related complications including peripheral nerve dysfunction and visual impairment. Gravesande and Richardson reviewed the non-pharmacological risk factors for falling in older adults who were 50 years of age or over, with type 2 DM [17]. They reported that the most common risk factors were impaired balance, reduced walking velocity, peripheral neuropathy, and comorbid conditions, such as osteoarthritis and heart disease

[17]. Chiba *et al*. [18] investigated risk factors of falls in persons 60 years of age or over with type 2 DM and they reported that the risk factors were hypoglycemia, cognitive impairment, a high fall risk index score, and a high Timed Up-and-Go test score. They also reported that cognitive impairment, hypoglycemia, and fall risk indices show statistically significant differences between those with and without multiple falls. Maurer *et al*. [19] determined whether diabetes is an independent risk factor for falls in elderly residents of a long-term care facility with type 2 DM, and they reported peripheral neuropathy, hypoglycemia, visual impairments, and hypertension as the most important risk factors of falling in type 2 DM. This review investigated the population with DM who were 65 years of age or over, but showed similar risk factors of falling with those who were younger with DM.

This review showed several DM-related risk factors, such as peripheral dysfunction, poor visual acuity, poor depth perception, cognitive impairment, poor postural balance and walking velocity, reduced physical activities, and muscle strength, were associated with falling in adults with DM who were 65 years of age or over. The results of this review showed that the risk factors of falling were similar to those of the younger age group than this review. This review did not consider demographic information, such as race and family support, and did not consider the time after the onset of disease and diabetes severity, such as HbA1C. This review investigated cohort and observational studies, but not randomized controlled trials. Future studies should consider the review of randomized controlled trials, and examine the effect of therapeutic approaches on risk factors of falling in community-dwelling older adults who are 65 years of age or over with DM.

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Conflict of Interest

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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