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Falls and Balance Impairments in Older Adults with Type 2 Diabetes: Thinking Beyond Diabetic Peripheral Neuropathy

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ABSTRACT

Older adults with type 2 diabetes have significantly higher incidence of falls than those without type 2 diabetes. The devastating consequences of falls include declines in mobility, activity avoidance, institutionalization and mortality. One of the most commonly identified risk factors associated with falls is impaired balance. Balance impairments and subsequent increased fall risk in older adults with type 2 diabetes are most commonly associated with diabetic peripheral neuropathy (DPN). Consequently, DPN has been the central focus of falls prevention research and interventions for older adults with type 2 diabetes. However, isolated studies have identified adults with type 2 diabetes without overt complications of DPN to also be at increased fall risk. It is known that the ability to maintain balance is a complex skill that requires the integration of multiple sensorimotor and cognitive processes. Emerging evidence suggests that diabetes-related subtle declines in sensory functions (somatosensory, visual and vestibular), metabolic muscle function and executive functions may also contribute to increased fall risk in older adults with type 2 diabetes. Knowledge of these type 2 diabetes-related sensorimotor and cognitive deficits may help to broaden approaches to falls prevention in older adults with type 2 diabetes. Therefore, the purpose of this mini review is to describe the impact of type 2 diabetes on sensorimotor and cognitive systems that may contribute to increased fall risk in older adults with type 2 diabetes.

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RÉSUMÉ

Les personnes âgées souffrant du diabète de type 2 ont un nombre considérablement plus élevé de chutes que ceux qui ne souffrent pas du diabète de type 2. Les conséquences dévastatrices des chutes sont les suivantes : le déclin de la mobilité, l'évitement de l'activité, l'institutionnalisation et la mortalité. L'un des facteurs de risque de chutes le plus fréquemment observé concerne les troubles de l'équilibre. Les troubles de l'équilibre et l'augmentation subséquente du risque de chutes chez les personnes âgées souffrant du diabète de type 2 sont plus fréquemment associés à la neuropathie diabétique périphérique (NDP). Conséquemment, la NDP a constitué le point central de la recherche sur la prévention des chutes chez les personnes âgées souffrant du diabète de type 2. Cependant, des études isolées ont également établi que les adultes souffrant du diabète de type 2 sans complications avérées de NDP étaient également exposés au risque de chutes. Il est connu que la capacité à maintenir l'équilibre est une habileté complexe qui nécessite l'intégration de multiples processus cognitifs et sensorimoteurs. Des données scientifiques émergentes montrent que le déclin subtil du fonctionnement des systèmes sensoriels lié au diabète (somatosensoriel, visuel et vestibulaire), du fonctionnement du métabolisme musculaire et du fonctionnement exécutif peut également contribuer à l'augmentation du risque de chutes chez les personnes âgées souffrant du diabète de type 2. Le fait de connaître ces déficits sensorimoteurs et cognitifs liés au diabète de type 2 peut contribuer à élargir les approches sur la prévention des chutes chez les personnes âgées souffrant du diabète de type 2. Par conséquent, l'objectif de cette mini-revue est de décrire les conséquences du diabète de type 2 sur les systèmes sensorimoteurs et cognitifs qui peuvent contribuer à l'augmentation du risque de chutes chez les personnes âgées souffrant du diabète de type 2.

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Introduction

Falls are detrimental to quality of life because they can result in declines in mobility, activity avoidance, institutionalization and mortality. Falls are highly prevalent in older adults with type 2 diabetes; annual incidence rates of 39% occur in individuals over 65 years of age and occur more frequently in those with poor glycemic control (1). Although several risk factors are associated with falls, one of the most commonly identified risk factors is impaired balance (2).

To date, impaired balance and subsequent increased risk for falling in older adults with type 2 diabetes are most commonly attributed to diabetic peripheral neuropathy (DPN). However, balance is a complex skill that requires the integration of multiple sensorimotor and cognitive processes (3), and age-related deterioration in sensorimotor as well as cognitive systems can disrupt the ability to maintain balance (3). Isolated studies have reported increased risk for falls in older adults with type 2 diabetes without overt DPN (4,5). Consequently, falls may not be attributed solely to DPN, and knowledge of type 2 diabetes-related sensorimotor and cognitive deficits may help to broaden approaches to falls prevention in older adults with type 2 diabetes. Therefore, the purpose of this mini review is to describe the impact of type 2 diabetes on sensorimotor and cognitive systems that may contribute to increased fall risk in older adults with type 2 diabetes.

Sensory Systems

Three sensory systems (somatosensory, visual and vestibular) contribute sensory information required for balance control. The somatosensory system provides information about the position and motion of body's segments in relation to each other and the support surface by using proprioceptive (joint position/kinesthesia) and cutaneous (touch and vibration sensitivity) inputs. The visual system provides information about the environment and body orientation. The vestibular system provides information about head position and spatial orientation. Deterioration of 1 or more sensory systems reduces the sensory redundancy available to the central nervous system, and that may adversely affect balance and increase fall risk (3). Therefore, it is critical to assess not only somatosensory functions related to DPN but also visual and vestibular functions, which can contribute to impaired balance and falls.

Somatosensory system

Long-term hyperglycemia can lead to a progressive deterioration of sensory nerve fibres in the somatosensory system and to DPN. The largest and most rapidly conducting sensory fibres that are affected in DPN include 1a afferents from muscle spindles, 1b afferents from the Golgi tendon organs and cutaneous mechanoreceptors (6). Muscle spindles provide rapid information about changes in muscle length, and Golgi tendons sense changes in muscle tension (7). Cutaneous mechanoreceptors provide information about vibration and pressure sensations (7). DPN has long been considered the most dominant mediator between diabetes and falls because reduction in lower-limb somatosensation reduces the ability to detect changes in balance and make appropriate adjustments to avoid a fall (8). However, it is not surprising that emerging studies have reported that even subtle declines in somatosensory functions can result in balance impairments (9) and increased fall risk in older adults with type 2 diabetes without DPN (4,5) due to significant involvement of the lower limbs in balance control.

Visual system

Long-term hyperglycemia affects the circulatory system of the retina and can lead to diabetic retinopathy. Specifically, macular edema can distort an individual's central vision and the ability to see detail, form and colour within direct gaze (10). Damage to small blood vessels (nonproliferative diabetic retinopathy) and accumulation of scar tissue (proliferative diabetic retinopathy) can result in reduced contrast sensitivity. Additionally, the prevalence of cataracts, which reduces contrast sensitivity, is significantly higher in individuals with diabetes duration of more than 10 years (11). Older adults with type 2 diabetes and reduced contrast sensitivity have been reported to be 1.41 times more likely to fall as compared to older adults without type 2 diabetes (12). This meshes with that the fact that declines in contrast sensitivity have been shown to be one of the strongest risk-factors for falls in older adults due to the inability to recognize balance threats and successfully negotiate obstacles in the environment (13). Overall, these changes in vision may contribute to balance impairments and increased fall risk in older adults with type 2 diabetes, particularly under low light conditions (e.g. urgency to use the washroom at night) and in the presence of low contrast tripping hazards (e.g. scatter rugs).

Vestibular system

It is proposed that long-term hyperglycemia causes inflammation and reduced sensitivity of the highly active metabolic vasculature in the inner ear (14). Robust evidence from diabetic animal studies has shown that long-term hyperglycemia results in significant structural damage in the otolith organs of the vestibular system, which help to detect the linear acceleration of the head (15). Human studies, although limited, have shown prolonged phase lag of the vestibulo-ocular reflex and subsequent deficits in gaze-holding in the dark in older adults with type 2 diabetes as compared to older adults without type 2 diabetes (16). These functional and structural changes can reduce the quality and availability of vestibular information to the vestibulospinal tract to relay motor commands to maintain an upright posture and head stabilization.

Vestibular dysfunction has been reported to be 2.3 times more likely in those with diabetes than in those without diabetes (17). Considering the widespread effects of diabetes on the peripheral nerves of various structures, it is not surprising that diabetes may also adversely impact the vestibular neural structures. Robust evidence indicates individuals with vestibular dysfunction are 2.6 times more likely to have fallen in the past year (17). Therefore, given the strong physiological evidence of diabetes-related vestibular dysfunction, it is reasonable that inaccurate information about the head movement from the vestibular system can lead to symptoms of dizziness and disorientation and subsequently may increase the likelihood of falls in older adults with type 2 diabetes.

Subclinical deficits

Emerging evidence revealed that even older adults with type 2 diabetes but without DPN have subtle but clear degradation of sensory functions in all 3 sensory systems (somatosensory, worse lower-limb vibrotactile sensitivity; visual, marginal degradation in visual contrast sensitivity; vestibular, and weaker bilateral vestibulo-ocular response) (18). These subtle sensory declines resulted in significant balance impairments while standing during challenging conditions (eyes closed, foam surface) and reduced mobility (18). Therefore, in addition to diagnosed diabetes complications, subclinical sensory deficits in 1 or more sensory systems can also reduce the sensory redundancy available to the central nervous system and can adversely affect balance and mobility. Accordingly, it is important for healthcare professionals to consider