



Type 2 Diabetes and Falls Incidents among the Elderly: An Umbrella Review of their Associations with Vitamin D Levels and Other Salient Peer Reviewed Research Observations

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Abstract

Diabetes prevalence, increasing rapidly among older populations, has many health implications including disabling orthopedic consequences. This brief specifically examines whether **adults with type 2 diabetes are at increased risk for injurious falls** and if so, what preventive approaches other than medication are recommended. It also examines if a fall can engender a diabetic state in its own right and a possible associated link to vitamin D deficiency. To this end, relevant literature located in key databases and published predominantly in the time periods 2020-2026 using the search terms: falls, type 2 diabetes, vitamin D, among others, were sought and carefully examined in narrative form. These data revealed: 1) There is a possible increased risk of falling in older diabetic adults with a type 2 diagnosis. 2) Most falls determinants identified are preventable. 3) **Falls may pose a possible unrecognized risk factor for type 2 diabetes** or its exacerbation. 4) Controlling type 2 diabetes, as well as vitamin D plus consistent exercise training, will likely reduce health costs and suffering attributable to injurious falls as well as recurrent falls among the older type 2 diabetic populations. Indeed, falls injuries, diabetes and overall deficits in vitamin D and mobility linkages, although hard to unravel, clearly pose an enormous public health concern especially if overlooked and is one public health issue that not only warrants, but demands more current universal preventive actions, as well as future research and well founded clinical attention:

Keywords: Falls; Falls Injuries; Fractures; Neuropathy; Older Adults; Prevention; Type 2 Diabetes; Vitamin D

Introduction

It appears beyond dispute that falls defined as a loss of balance from a stable state due to extrinsic or intrinsic factors or as a result of tripping or a slip incident occurs readily in the elderly population. Inducing highly adverse late life consequences this often unanticipated unwanted potentially highly injurious event is one clearly engendering serious multiple costly health consequences, including one or more physical, social, multisensory, psychological and functional challenges that rarely diminish without due consideration and effort [1-3]. At the same time, the number of older adults, especially high age adults who may have to increasingly rely on multiple medications are more likely to increasingly fall as the years unfold, no matter where the older adult resides. At the same time, this scenario is juxtaposed by the lack of effective falls prevention efforts, alongside increasingly vocal demands by aging adults for more autonomy as well as efficacious efforts to extend their years of healthy life as well as efforts to improve or maximize their life quality. A related public health aim therefore is to assure more is done in this regard so that the goal of successful aging for all can indeed be realized and in doing so, limit at least some if not all, preventable costly health degrading situations such as polypharmacology linked injurious accidental or predictable falls.

Unfortunately, the ability to effectively reduce the persistently high prevalence of falls among the elderly as a vulnerable population remains limited, despite many years of dedicated efforts aimed at uncovering their underpinnings and some robust guidance as to how to direct and implement related falls prevention goals towards achieving more desired outcomes and affirming this need.

However, even though a steady inventory of identified remediable or changeable risk factors for falls in the older adult population as well as in the case of a type 2 diabetes diagnosis has emerged and that can likely be harnessed effectively to develop possible solutions for mitigating this growing health challenge, what has unfolded in this regard remains suboptimal at best. In particular, the idea that certain behaviors and beliefs, as well as biomechanical factors rather than blood glucose levels alone that appear to heighten diabetes falls risk is poorly studied and hence rarely addressed or translated effectively clinically speaking. For example, in addition to possible misuse of single and especially multiple medications, including their under or over usage, the deterministic proven role of physical inactivity, knee extensor muscle quality, poor diet, postural control, cognitive and sleep problems and low self-efficacy beliefs are rarely embraced in mainstream medicine or realms of standard geriatric care [2,4-12].

Diabetes type 2, a common largely chronic metabolic health condition occurring frequently among the older adult population and one increasing in prevalence is a topic affecting and likely to continue affecting millions of this growing cohort globally and is especially disabling if the sufferer goes on to eventually experience serious nerve, blood vessel and organs damage including those that affect the eyes, kidneys, heart and other parts of the body such as bone, as well as associated multiple adverse cognitive alterations [13]. In addition to its immense impact on overall wellbeing if unabated or controlled successfully, type 2 diabetes, often linked to an exaggerated risk of frailty, falls and falls mediated injuries, bone mass density losses and fractures, deficient proprioception, vision impairments and signs of peripheral and central neuropathy alongside its growing prevalence, remains a major public health concern [3,10,14,15].

In particular, older obese and/or frail type 2 diabetes adult cases may be more likely to experience worse outcomes if they fall than those observed at present among disease free similar age adults [1,3,16-19]. As well, research reveals older people with type 2 diabetes especially those with measureable muscle strength declines, postural dyscontrol and functional impairments are likely to have a 2.5 fold increased risk of incurring an injury as a result of a fall, as well as having a higher fracture and additionally impaired mobility risk [5,7,15,18,20-22].

Added to this may be a host of progressive health problems, including possible excess sarcopenia and/or sarcopenic obesity muscle mass declines as well as deficient vitamin D levels and diverse foot-related factors [12,19,22].

At the same time, those subjected to recurrent falls or injuries may experience a variety of psychological and social impairments that ultimately heighten the chances of a severe disabling outcome, especially if preventive approaches to counter these likely events are not forthcoming considered or consistently enacted. Moreover, data show, it is not uncommon to observe those older adults with type 2 diabetes who have fallen once or repeatedly, may go on to exhibit the development of a reactive fear of moving and other pervasive immobilizing falls concerns termed kinesiophobia, and known to be especially harmful to the cardiovascular and musculoskeletal systems of the aging adult.

In the event of an injurious fall, Type 2 diabetic cases may also encounter slower healing and surgical recovery rates if this is indicated, as well as possible functional loss increases, especially in the case of those who adopt sedentary fear evoked behaviors and/or exhibit poor proprioception, impaired dynamic postural control, gait and stability responses [1,7,14,15,23].

This cycle of cascading events is extremely hard to reverse or mitigate, however, thus many support the importance not only of periodic assessments, but early assessments and the implementation of cross cutting related interventions that can advance rather than impede the subject's perceived overall wellbeing and day to day self-care abilities, plus their ability to function independently, safely, confidently and socially [24].

In this regard, while most researchers favor exercise as an adjunct to glycolic control to limit dysmobility impacts of failing to do this, most work in the past has placed little importance on what is emerging as having a possible parallel and powerful mediating role in the outcome realm. These possible oversights include an increasing role for diverse neuromotor forms of dysfunction, as

well as vitamin D micro nutrient or exposure deficiencies that may affect many life affirming functions and body systems as well as multiple functional attributes. These include, but are not limited to, muscle mass, strength and bone health attrition impacts, as well as the potential ability to impact balance and falls injuries due to cognitive factors such as depression and others [21,25,26].

Problem Statement

Although falls injuries clearly pose a major threat to an older person's life quality, most articles on type 2 diabetes and its outcomes do not focus on this topic even though emerging evidence has suggested this may be of high relevance to many individuals as well as society. In particular, exposing aging adults with type 2 diabetes or the risk of an adult onset of diabetes to a comprehensive falls prevention plan, as well as periodic screenings for any physiological changes that can heighten falls risk, such as gait challenges is not a standard practice or a mainstream public health or medical strategy or one that has universal consensus. In this regard a potentially key mediating or explanatory link to vitamin D is largely ignored even though Zhang, et al., found that 50.4% of their studied elderly type 2 diabetes patients developed type 2 diabetes and 25% reported at least one episode of falling especially if their serum vitamin D, calcium and albumin levels were low or where the adult was deemed to manifest a vitamin D deficiency [21,26].

Rationale

Falls represent one of the most common preventable geriatric syndromes encountered in primary care and one or more impose a growing incalculable burden on many aging individuals, their families and healthcare systems [2]. They are particularly likely to occur in the presence of type 2 diabetes, even though this may not be inevitable, but rather preventable, but are often ignored, undertreated or unrecognized. Indeed, from the multi factorial nature of falls in the elderly, it appears most of their specific causes can be traced to one or more chronic diseases such as type 2 diabetes, plus its neuromuscular associations, as well as the impact of polypharmacy status that can reduce bone quality and heighten fracture risk, alongside various nutrition factors that can possibly be mitigated or managed more effectively, for example eating low glycemic content foods [29]. While preventing type 2 diabetes in the first place is the most obvious solution here and critically ill patients may need intravenous insulin infusion therapy and pharmacotherapy, these approaches do not truly change the underlying causes of the condition at all effectively and may exacerbate rather than attenuate any disease associated falls risks.

Moreover, even if concerted prevention efforts to counter falls in this population is likely to markedly influence late life wellbeing and severity regardless of diabetic status, their utility is to /date has been marginal at best, despite their promise. Those older adults who already have type 2 diabetes must also contend with multiple health related issues related to this at a time when they are aging and may be in pain or in general poor health and are possibly experiencing declines in social support and cohesion, overall strength, balance and walking ability [25], as well as sarcopenia [an age and chronic disease associated decline in muscle mass and strength] [28]. We elected to specifically focus on type 2 diabetes rather than diabetes type I or falls in general, as their consequences are often less well documented than those of diabetes type 1, but are costly in multiple ways nevertheless and potentially magnified by an unrecognized or untreated falls linkage and proclivity.

Review Aim

While the most common risk factors for falls among healthy older adults also affect those with diabetes type 2, we sought to update what appears to have emerged as regards the specific risk factors occurring in the older type 2 diabetic case over time and if this warrants further attention or not, especially in the realm of a possible interactive impact of modifiable factors such as a vitamin D deficit on the risk of falling. In particular, based on an understanding of the risk factors for falling, in general, plus those that are specific to those with diabetes type 2, we sought to identify documented strategies proposed to avert or reduce falls and falls risks among this population.

Methodology and Approach

To gain some perspective on the state of knowledge in this regard and if more can be done to reduce the burden of falls injuries among older adults diagnosed as having type 2 diabetes, if anything, we conducted a comprehensive albeit selective review of related articles housed in the PUBMED CENTRAL, GOOGLE SCHOLAR and PUBMED computerized databases over an extended time frame of 40-45 years using the key words: falls, older adults, type 2 diabetes. In terms of the data collected, only those sources related to community-dwelling elders with diabetes type 2 were considered. Excluded were studies that took place in nursing homes or that discussed type 1 diabetes or pharmacologic management approaches or genetic and biochemical

mechanisms of pathology. The data including factors leading up to both type 2 diabetes as well as falls, falls outcomes and preventive strategies against both health conditions were summarized in a narrative format designed to highlight the persistence and severity of this set of linkages despite years of study and largely widely reported preventable underpinnings. The term used here to describe what was previously termed diabetes mellitus was type 2 diabetes and vitamin D was the term used rather than any formulaic definition, we did not explore how type 2 diabetes might be prevented but chose to focus on whether falls that are linked to this condition are preventable.

Overview of Findings

The aforementioned extensive search, while not necessarily inclusive of all related data sources and perspectives, revealed a considerable number of related papers over the years that not only describe type 2 diabetes manifestations, but speak to a clinically significant type 2 diabetes falls injury linkage among older adults and when compared to the falls rates in the older non diabetic population [27]. Many articles also stress or focus on both the negative outcomes of this linkage, a strong need for solutions to minimize falls risk, as well as a type 2 diabetes risk among the frail elderly [28]. Several continue to provide both innovative and feasible potentially impactful insights into the link between falls and associated orthostatic hypotension and strategies including multi pronged assessments, more physical activity and behavioral interventions [30]. Others focus on identifying risk factors for falls among the older adult population who suffer from type 2 diabetes and which turn out to be numerous, but largely and essentially modifiable or preventable.

Among these multidimensional falls risk factors as observed in various diabetes type 2 sufferers are: a) The use of multiple medication, including diabetic drugs, b) Excess muscle weakness, especially at the ankle and c) A host of environmental factors, such as unattended icy sidewalks, in the winter or pollution that impacts vitamin D uptake.

Others include the presence of various motor and/or sensory neuropathies, subnormal blood glucose levels [1, 17], low levels of physical activity, poor postural control impairments in mobility or balance [7,14,21,24,29]. As well, neuromuscular control deficits, diabetic foot ulcers and high rates of body and foot pain, are consistently implicated as is sarcopenic obesity and indirectly vitamin D insufficiency in cases with polyneuropathy, a known falls determinant [12,24]. Notably, when vitamin D levels drop below 26.1 ng/mL, the severity of the neuropathic condition is accelerate markedly [24].

What is especially interesting is that a vitamin D deficiency, a health state that affects over one billion persons globally and is associated with type 2 diabetes and cardiometabolic diseases, can be fostered by the the presence of a type 2 diabetes diagnosis, as well as changes in body composition that may lead to cardiovascular complications and related secondary problems such as injurious falls and sleep related deficits [8,21,30,36].

Additional factors often cited as to heighten falls risk in this regard that may be magnified if untreated are a role for:

1. High rates of impaired/blurred vision [10,14]
2. Lower limb amputations/foot located skin/structural problems [19]
3. Depression, anxiety and impaired sleep [8,31]
4. Vestibular dysfunction [8,32]
5. Medication overuse/misuse/underuse [33,39]
6. Lack of awareness of diabetes falls/falls injury linkages [24,35]
7. Poor appreciation of the role of nutrient/micronutrient intake
8. Loss of muscle mass, possible muscle myopathy, sensory decrements [14,18]
9. Mild cognitive impairments and reduced cognitive functioning.
10. Poorer than anticipated walking performance/endurance [14,27,36]

In addition, the muscle disease termed sarcopenia, as well as various degrees of neuropathy accompanied by a decreasing degree of bone mineral density, muscle force capacity, possible muscle afferent alterations and low walking speed may have the additional effect of disturbing as well as delaying inherent protective motor functions that may otherwise reduce the risk of incurring an injurious fall [1, 24, 36-38]. Other data imply a related role for widespread health impacts on other body systems along with chronic pain and disability and progression of this disease.

Additionally, there is some concern that offloading devices used to reduce the risk of foot ulceration that may ensue inadvertently will actually increase postural instability and thereby heighten rather than reduce a falls risk if not monitored and applied carefully [24]. Oliviera, et al., who studied a convenience sample of men and women between the ages of 50 and 65 with and without type 2 diabetes found an association between hyperglycemic status and poorer mobility, with an increased fall risk even in younger patients and in those with a short disease duration, as well as postural control deficits in those with neuropathy suggesting more should be done to identify at risk individuals sooner rather than later [40-43].

Other injurious falls mediators that are possibly remediable or preventable include frailty, retinopathy, altered body composition, cardiovascular disease, poor neuromuscular responses [44] and bone quality [11,20,24,27,43]. As well, high pain levels, all forms of diabetes medication, lower strength levels, depression and cognitive impairment are unique or interactive injurious falls determinants [24,27,45]. Another is the onset of kinesiophobia or the fear of moving that may be evoked by an actual falls event or even a perceived event [46]. Low exercise participation rates, poor exercise tolerance, deficient exercise self-efficacy beliefs, diabetes distress and the failure to correctly perceive vulnerability to incurring a fall are likely to prove especially harmful as well [34].

According to Kashmoola, et al., type 2 diabetes cases classified as being polypharmacologically dependent are likely to not only encounter adverse drug-drug interactions, but possibly an increased falls risk and attenuation of bone maintenance antiresorptive therapies. To avert both a possible falls as well as fracture risk in this subgroup, clinical interventions to counter skeletal deterioration alongside periodic medications reviews and deprescribing of high-risk agents is indicated. In addition, a role for calcium and vitamin D supplementation and life-style modifications cannot be ignored. Personalized and multidisciplinary strategies to enhance balance as well as metabolic status are indicated as well [33,45,49].

In particular type 2 diabetes cases with sub optimally efficient ankle muscle coordination when trying to balance, diabetic foot ulcers or deformities, possible muscle spindle afferent alterations, poor vision, frailty, vision impairments and peripheral neuropathy who are likely to walk more slowly and with uncertainty need to be carefully monitored as well [10,39,44,47,48].

Additional Falls-Linked Mitigation Strategies

In addition to the ideas noted above, promoting balance, strength, proprioception and gait, plus attention to the use of customized footwear and skin care may help to provide for sufficient postural control that can help limit unwanted related falls events [24,25,33,36,50,51].

As well, careful cognitive assessments including the client's self perceived falls risk is likely to prove beneficial in allaying the possible adverse impact of failing to apprehend any 'danger' when walking especially when coupled with subnormal timed and well modulated neuromotor processing responses [34]. Added to this may be harmful eating practices such as a diet high in sugary contents and low on micronutrients that can impact cognitions and cognitive declines, muscle fat mass encroachment, incautious movement behaviors and others [15,48,52].

At the same time very carefully devised medication regimens plus regular medication reviews appear imperative, alongside regular vision exams, gait and muscle strength analyses as indicated. Others encourage the inclusion of vitamin D serum assays, glucose monitoring and selected balance assessments as indicated [14,30,36,50]. Specific efforts towards minimizing pain and distress, as well as safely raising aerobic capacity and dynamic balance levels and encouraging indicated lifestyle changes are clearly of high import as well [19,53-55,57-62].

To this end, Whelen and colleagues propose the use of wearable digital health technologies designed to provide vital personalized real time behavioral and physiological feedback messages and directives for change and to enable more tailored intervention plans that help avert the excess use of impairing medications and their falls linkages to unfold especially in cases with signs of neuropathy [20,30,35,47,63].

In the interim, biomechanically oriented therapies to improve gait appear as important or even more important than medications or nutrition oriented approaches alone and where relevant a supplementary focus on cognitive training, vitamin D optimization efforts and a comprehensive frailty informed assessment protocol may prove valuable [20,47,65,66].

However, even if helpful in prioritizing treatments, the fact nerve damage centrally and in the periphery, including vital muscle sensory pathways, may be present should be borne in mind, as may a role for damaged or degraded vitamin D receptors on muscle rather than available vitamin D and that uniquely or collectively prevent many singular therapies from attaining their intended effects and implies early intervention and recognition as well as long term follow up of the client is not only warranted, but is essential [26,44,49,68,69,93].

Vitamin D assessments are further indicated in cases with type 2 diabetes who have possible muscle related dysfunction, especially among neuropathic cases and those with elevated rates of diabetic foot ulcers, poorly controlled diabetes and balance as well as those with leg muscle coordination deficits or dysmobility [41,48,49]. The use of wearable technologies that can effectively detect and monitor subtle gait changes associated with the progression of type 2 diabetes also appears worthy of consideration for averting falls and dynamic stability problems [42]. Also discussed are balance-enhancing interventions involving intentional weight shifting, manipulation of the base of support and displacement of the center of mass such as Tai-Chi, yoga and mind-body methods [53-55,70].

Simultaneously, daily low-dose vitamin D regimens in those with a perpetual vitamin D insufficiency may favorably impact body composition and with this motor control as well as effective glycemic control and thereby the proclivity towards one or more falls [36]. The co-supplementation of flaxseed oil and high-dose vitamin D is also of potential usage and a method shown to have systemic inflammatory reducing benefits among the elderly with type 2 diabetes. Other promising benefits include potential reductions in oxidative stress, subnormal glycemic control, unwanted lipid profiles and physical quality of life while possibly reducing the rate of disease progression [67,73].

The wellbeing of adults with type 2 diabetes mellitus worldwide may also be influenced by vitamin D deficits and their brain health effects that are often linked to depression and thereby to falls in fair numbers of elderly type 2 diabetes cases [93,96].

Other data imply maintaining plasma vitamin D levels at 75 nmol/L or above [which is higher than recommended levels] may confer benefits as far as muscle function and long-term prevention of injurious falls requiring hospitalization is concerned, even if negated by some with the exception of obese cases and where life quality benefits are observed [95,96].

More robust data to uncover if indeed vitamin D can play an overall beneficial role on type 2 diabetes health status, bone density, muscle mass and sensory systems, along with the extent of depression, if any and in what dosage or what medium this may prove revealing and clinically relevant. In the meantime, polypharmacology and psychoactive drug use that can all heighten the chances of incurring a falls event, fracture risks and recurrent injury cycles, especially in those with neuropathy and poor positional sense or those deemed frail may be reduced accordingly and significantly [18,68,69].

Needed however, are more efforts to educate older type 2 diabetics, who may not be as conversant with the disease as those with genetic type 1 diabetes histories, as well as their families and healthcare providers about the increased dangers of falling in this group and especially for the importance of ensuring safe medication regimens and falls counter interventions if indicated. Including possible vitamin D supplements to optimize bone health and improve muscle function and healing in the face of a fracture that will likely prove helpful as indicated should be considered salient as well [73,74].

Those high age adults who use insulin as well as those who do not, those who have fallen in the past year and exhibit balance, dizziness, gait impairments and mobility limitations especially when encountering obstacles when walking and who may fail to react accordingly in the face of increased mechanical demands on the ankle plantar flexors should be specifically targeted here in our view [17,36,47,74,78,88]. Additionally, cases showing subnormal muscle and nerve response latency thresholds, low visual acuity, as well as unpredictable bouts of hyper or hypoglycemia, should be helped without delay to prevent a high chance of further strength declines, gait unsteadiness and muscle mass losses [20,44].

Indeed, it appears that in all cases those diagnosed promptly and followed up accordingly will likely be more successful in accomplishing their goals than those who are not. Moreover, even if exercise participation can impact multiple dimensions of type 2 diabetes pathologies, we believe much more effort placed on obviating misconceptions and erroneous personal beliefs as well as unsafe behaviors that often mitigate directly or indirectly against falls prevention are essential. This applies equally in

our estimation to those cases experiencing a modest as well as a benign diabetic state of being rather than one fraught with severe repercussions and possible permanent states of muscle weakness, poor balance, falls denial, fears of falling and poorly or uncontrolled blood pressure and glucose levels.

Summary of Key Points

Despite many years of study, falls among type 2 diabetes cases remain a major public health concern among all aging adult populations. Especially noticeable is the reliance on pharmacologic methods of diabetes management, in contrast to possible non pharmacologic approaches and that fail to address many of the key determinants of falls in this population, such as possible diminished proprioception, muscle activation and movement accuracy [14].

Indeed, whereas falls and their disabling consequences in older populations have been discussed for many many years, the reasons for trying to do more to avert falls in this population is that its associated far reaching costly public health and personally linked impacts remains.

This situation may be due to the lack of any well articulated research in this realm as a whole to date, reliance on cross-sectional studies that cannot establish causation or the acceptance that nothing can be done even if untreated falls mediators such as visual acuity are apparent [14].

Other falls indicators that appear intuitive in type 2 diabetes, namely possible deficits in joint position sense and kinesthesia, plus emergent states of kinesiophobia, neuropathy, dizziness, hyperglycemia or hypoglycemia are not common research nor clinical targets and health correlates only inconsistently integrated into public health guidelines designed to obviate falls. In addition, although bone health may well be compromised in a sizeable number of older type 2 diabetes cases, few may be treated according and prophylactically. Recently too, it is shown obese type 2 diabetes cases who lose weight via drugs may also lose muscle mass, thus remaining at risk for falls even if diabetes is minimized. Indeed, a lack of attention in this regard and especially in the frail type 2 diabetes case may remain major disablers, especially if factors such as the role of optimal vitamin D levels in this regard is ignored [76]. At the same time, even if one accepts more should be done, it is hard to dispute a need here for more emphasis on patient education, stress control, exercise adherence as indicated, sleep and nutrient health, plus tangible social and emotional forms of support. These opportunities should however be based not only on sound assessments and what is known specifically and tailored accordingly, but on robust data extracted from large samples over an extended period in well controlled research that can possibly validate a sound clinical role for:

Cognitive behavioral therapy [104, 105]
Falls prevention interventions
Foot care interventions [15]
Health education/literacy promotion [103]
Lifestyle modifications [20]
Light exposure/sleep pattern assessments [8]
Medication monitoring*
Nutrition education
Micronutrient supplementation [20, 98]
Physical activity participation [105]
Strength/balance training [15, 48, 64]**
Vitamin D monitoring/optimization [26, 49, 67, 95, 98]***
Vision/proprioception deficit screenings/remediation [10, 14]
Weight management

Notes: *In terms of glucose control an effort to prevent hypoglycemia-induced falls, possibly due to insulin use should be sought alongside careful selection of glucose-lowering medications that may otherwise contribute indirectly to fractures and the risk of a fall [24, 66]. Also includes efforts to recognize polypharmacology effects and risks [80]; ** Most essential; ***Vitamin D should be viewed as a context-dependent, threshold-driven nutrient rather than a universal preventive therapy. Clinically, priority should be given to preventing and correcting severe deficiency (< 12 ng/mL [< 30 nmol/L]), a threshold below which adverse skeletal outcomes are well documented. Supplementation should target evidence-based indications, and laboratory testing should be reserved for situations in which results inform management [26].

Additional Implications

Since many falls experienced by older adults with type 2 diabetes appear largely determined by modifiable factors, addressing these systematically in the early disease phases in particular, appears imperative, as well as highly promising.

Indeed, it is safe to say that investments into more concerted efforts to spend more time on comprehensive assessments in this regard can possibly prove sufficiently insightful in influencing a life of greater quality and autonomy outcome for many, while effectively helping to counter rising type 2 diabetic disability and dysmobility increases.

In particular, the role of environmental safety and food access factors may be imperative to examine as well to better address the relative role of physical, biological, social, biomechanical, neurosensory, environmental and mental health attributes that can all heighten the risk of a serious falls event in a specific type 2 diabetes older adult case who is not well cared for. In addition, the disease state may be adversely impacted in the case where distal motor system deficits and limited exercise tolerance, are overlooked or treated non specifically and without due caution [75,84].

At the same time, working to maximize public health approaches as well as targeted clinical approaches can be expected to help in altering the trajectory of adverse type 2 diabetes health outcomes that plague many and may prevail because so little is invested in educating the general public as well as health providers in this regard. Non tailored approaches may also prove unsafe or undesirable [eg., if delivered technologically] and poorly aligned with the clients' personally desired life outcomes falls self-efficacy and outcome expectation beliefs and degree of multimorbidity.

Those who may benefit from intervention most may be those at highest risk and include females older than 75 years of age, those with neuropathy and/or retinopathy dizziness or subnormal vestibular motion perception manifestations, proprioception deficits, muscle strength losses and poor stability [79,74,84]. In addition, those employing psychotropic drugs and diabetes medications routinely, especially those categorized as having a polypharmacologic history appear to be at high risk for falls as well as high levels of diabetes associated distress and should not be neglected [76,77,80,104]. In particular, those with longstanding type 2 diabetes [20] and osteoporosis or frailty histories who may incur fractures readily should be sought out and duly targeted [43]. Conversely, those less likely to fall are those with a higher appreciation of their falls risk higher balance, gait scores and leg muscle strength [74,78,79]. In addition, those who are active and who receive and carry out relevant instructions including those that address muscle attributes and sarcopenia presence or extent followed by personalized prophylactic treatments, such as well designed targeted food based muscle building diets and periodic follow-ups are likely to be of considerable benefit as well [43,62].

The cumulative potential of Tai Chi in this regard is exceptionally promising in our view even in the presence of mild cognitive impairments. Observed benefits that warrant future study and validation include possible improvements in memory, executive function, metabolic profiles, postural and weight control, muscle coordination and balance [107-110].

However, if a client is not improving, a vitamin D insufficiency [which may hasten or encourage fat mass deposition] and that may be due to poor glucose control as well as a possible an altered vitamin D receptor status responsible for musculoskeletal biology regulation should be suspected and investigated as indicated [99,102]. Additionally, polyneuropathy may be implicated and weighing these possibilities carefully may prove highly valuable to the sufferer [36,84].

Unfortunately, until more well-funded long term well-controlled randomized research on this topic prevails, falls among older adult type 2 diabetes populations that pose a myriad of adverse high cost health outcomes even if potentially remediable to a high degree will undoubtedly continue to rise in prevalence and possibly severity. In particular, more intense and visible community wide efforts towards preventing the well described costly type 2 diabetes falls incident sooner rather than later are essential, as are comprehensive holistic geriatric care approaches for all. Policies and resources to help assess problems as well as mitigate an otherwise highly probable downward health spiral for many no matter where they reside are indeed achievable and especially imperative to implement in our view [87].

In addition, more consistent conclusive surveillance studies, well-powered and technology supported follow up studies of the trajectory of type 2 diabetes as this pertains to a high falls risk and adverse costly outcomes if these occur repeatedly using

optimal diagnostic instruments and carefully stratified samples and outcome targets that can allow for both sound statistical procedures as well as clinically significant implications to unfold are essential [109,110].

Topics of possible clinical utility in the future include efforts to uncover:

- a. Skeletal muscle vitamin D profiles in normal older adults versus type 2 diabetes
- b. Joint position sense manifestations at the ankle/knee/cervical spine in type 2 diabetics
- c. Movement speed and accuracy in type 2 older neuropathic type 2 diabetes cases
- d. Cognitive disease beliefs and motivation to actively pursue behavior changes
- e. Role of obesity drugs, disease duration and education on type 2 diabetes falling risk

Added to this are efforts to optimize science based local as well as public health imperatives to avert diabetes type 2 and if present, their excess falls events risk and to examine how the media potentially contribute to many diabetes related misconceptions, that may evoke fear rather than any hope, encouragement, active or salient solutions.

Clinicians too can help by stressing the importance of falls prevention in instructing their type 2 diabetes cases and not neglecting to consider the related specific import of:

- i. Periodic falls risk assessments/referrals to experts as indicated [71,81]
- ii. Falls prevention education/interventions [35,74]
- iii. Frailty/obesity prevention [71,90]
- iv. Foot care as indicated [39]
- v. Health literacy [103]
- vi. Multidimensional/sensory integrated exercise programs [82,84,88,100]
- vii. Nutritional education and resource support [26]
- viii. Optimization of glucose control in light of possible complications [83,85,102]
- ix. Vision/sensorimotor deficit screenings/neuropathic pain [10,14,76]
- x. Frequent medication reviews [33,35]
- xi. Efforts to reduce distress, falls fears, sleep challenges, low vitamin D levels
- xii. Efforts to mitigate anxiety and depression [31,87,80,90]

More efforts by clinicians to identify the neuropathic type 2 diabetic case in this realm, as well as any specific influences of vitamin D deficiency and their likely singular or dual increased impact on muscle mass and functional losses, bone attrition and recurrent falls risk, as well as bone healing in the event of a fracture is especially warranted [37,84,86,89-92,101].

In general however, while much remains to be resolved, it appears the role of physical therapies known to improve proprioception, muscle strength, balance, bone health and walking ability, as well as pain appear among the most promising for averting type 2 diabetes falls risk, alongside cognitive therapies that focus on moderating or eliminating mindless harmful repetitive behaviors and beliefs, immobilizing fears of falling, often not associated with diabetes distress, plus safety and non adherence issues. Since a vitamin D deficiency is frequently found in adults with type 2 diabetes, it appears more efforts to arrive at a consensus as to what this implies clinically is also strongly indicated [8,78].

Moreover, in cases suffering from long-standing diabetes type 2 histories, those who are obese, those with cognitive or sensory problems other than neuropathy, those who exhibit bouts of hypoglycemia or depression and anxiety, plus those who are older than 75 and frail and use multiple medications should be assessed regularly and targeted accordingly, to avoid the affected adult from experiencing a remaining life of possible functional dependence, unwanted health complications and costs and even premature death [47,74,80,85].

In particular, since even when well-tested complimentary medicine approaches are employed, these alone may not prove as effective as anticipated in mitigating either diabetes or falls risk in the face of suboptimal long term non holistically oriented clinical support, as well as unexamined psychosocial factors and psychosocial screenings, in general. Applications carried out in group settings or delivered solely online may also fail to counter social or behavioral sources of glucose dyscontrol such as poor

health literacy, low self-efficacy and erroneous disease and aging beliefs, as well as a lack of desirable social support mechanisms. These extrinsic as well as intrinsic factors even if largely modifiable are indeed features that may collectively heighten various degrees of diabetes distress, a widespread under-recognized state of being leading to more adverse health behavioral contributors to the disease trajectory than not. As well, poor adherence to recommendations in the face of a poor attention span, a lack of motivation, memory deficits, fears of falling, depression and sleep impairments may ensue readily.

Clearly, a failure to address these often neglected cognitive falls and disease progression attributes and others that appear to adversely influence effective disease management as well as its overall burden, may well provoke one or more accidental falls injuries and their unwanted repercussions [104]. In particular, cognitive performances scores as assessed in type 2 diabetes cases and that register more than 1 standard deviation below the norm and are accompanied by low aerobic fitness/physical activity levels are shown to exhibit significantly lower cognitive performance skills, especially in the attention-concentration realm and where executive functioning, episodic memory and visuospatial or vestibular processing domains may interact so as to have a strong bearing on falls management participation as well as the ability to carry out instructions, for example, if these are delivered remotely, rather than in person [105]. High falls predictive attributes of wearable digital gait biomarkers that may capture these as well as early functional changes relevant to type 2 diabetes risk, such as vestibular motion threshold perceptions and food intake quality may however warrant consideration in those who are not technologically averse [76,106,108-110]. At the same time, even if data point to a key role for gait challenges and others, a failure to appreciate the importance of ensuring vitamin D adequacy, where a deficiency is associated with type 2 diabetes, even in locations with adequate sunlight and exposure opportunities, screening in this regard followed by supplementation may prove imperative [98].

Conclusion

On the basis of the literature presently explored we confidently conclude:

- Older adults with type 2 diabetes will continue to fall at high rates if no major advancements or robust translatable conclusions about their many modifiable antecedents can be reached in a timely manner
- Early well conceived screenings and ongoing monitoring of falls risks, as well as glucose and vitamin D serum levels and extent of polypharmacology usage followed by patient specific preventive strategies and action plans are likely to reduce much harm and undue older adulthood distress and overall suffering costs
- Those type 2 diabetes cases in the higher age ranges, those who are frail, have multiple health distress provoking challenges and exhibit mobility limitations as well as sleep challenges and low vitamin D levels should be specifically targeted without delay
- Type 2 diabetes may however be magnified in its own right in the face of an injurious fall and a failure to address this possibility
- To optimize clinical efforts, research samples studied should aim to include high age adults and their 'actual' voices, rather than surveys alone. Sound data collection procedures and extent, plus clearly defined inclusion and exclusion criteria of representative samples here will be especially helpful in all likelihood

Conflict of Interest

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethical Statement

The project did not meet the definition of human subject research under the preview of the IRB according to federal regulations and therefore was exempt.

Informed Consent Statement

Not applicable.

Authors' Contributions

All authors contributed equally to this paper.

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