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Review Article

Diabetes and Hip Fractures: an Important Underrepresented Topic in the Related Literature

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Abstract

Diabetes prevalence is increasing rapidly among older populations, who are also at high risk for hip fractures. This article examines whether hip fracture risk is increased in the presence of a diabetes diagnosis, and if so what are the ramifications of this association. It also examines the risk factors for incurring a hip fracture in the presence of diabetes, and the increased risk of adverse outcomes experienced by hip fracture patients with diabetes. Possible implications of this body of literature include efforts to reduce the risk and burden of hip fractures among the elderly as well as the severity of diabetes, in general. This article which provides a synthesis of this topic may hence be of value to clinicians interested in preventing adverse diabetes outcomes, as well as those who strive to promote healthy aging and positive life quality among the elderly with either type 1 or type 2 diabetes.

Keywords: Bone diabetes; Falls; Fracture; Hip fracture; Type 1 and Type 2 diabetes

Introduction

Hip fractures are a well-established prominent cause of premature and excessive morbidity, as well as mortality among aging adults [1]. As well, type 2 diabetes, is an increasingly prevalent health problem among the older population, along with type 1 diabetes, and both forms affect multiple organs and body systems. This brief examines the role of diabetes in general, in increasing the risk of sustaining a hip fracture among the elderly. It also examines evidence for poor post surgical outcomes after hip fracture. As well, it examines what can be done to minimize this risk, given the finding diabetes clearly increases the risk for hip fractures [2], as well as the outcomes of hip fractures among the elderly quite negatively [3-6]. Based on the most recent data in the literature, the topics discussed in this review are hip fractures and their relationship to diabetes, diabetes and bone health, diabetes and falls injuries, and potential prevention strategies to offset hip fracture prevalence and severity among older adults. This effort was undertaken given the apparent lack of attention to the impact of diabetes on musculoskeletal health status, when compared to physical status and glycemic control issues alone. It was hypothesized that adults with both type 1 and type 2 diabetes are at higher risk for falls that lead to hip fractures, as well as poorer health outcomes. It was also believed there would be few publications drawing attention to the need for vigilance against this debilitating health condition in the current literature compared to the number of nutrition and physical activity related recommendations even though this information is quite compelling. Limited post hip fracture rehabilitation strategies that are modified in light of the impact of diabetes on this process were expected even though reasons for the increased hip fracture risk and poor outcomes in this group are largely modifiable factors.

The specific questions were:

1. Is there a consistent relationship between the presence of a diabetes diagnosis and the risk of incurring a hip fracture?

2. Is the literature on diabetes self-management focused to the same degree on preventing disabling falls and subsequent hip fractures compared to articles on glycemic control alone?

3. What are the risk factors for hip fractures among diabetics and are adults with diabetes who sustain hip fractures likely to experience worse outcomes than those with no diabetes?

4. Is there a concerted effort to translate what we know about the link between diabetes and hip fractures into clinical research and practice?

Methods

Data sources sought were those that might provide topical information and interrelated data on diabetes and hip fractures, the possible causes of hip fractures among diabetics, and the implications of diabetes for preventing hip fractures in the peer reviewed literature. Data sources used were those published in the English language and covering the years 1993-2014, located in Academic Search Complete, which yielded 237 articles, many of which were housed in Pubmed or Cihahl or both using the key works Diabetes and Hip fracture; Diabetes and Falls; Diabetes and Balance; Hip Fracture Epidemiology; Hip Fracture Outcomes. Due to the diversity of the literature a meta-analysis was not conducted, rather a narrative synthesis of the data from clinical studies, and systematic reviews was conducted.

Findings

Diabetes and hip fracture risk: The examination of whether diabetes type 1 or 2 or both increases the risk for hip fractures has proceeded for more than 15 years. As outlined in (Table 1), many of these studies have been prospective in nature with large samples and have tended to conclude people with diabetes are more likely to be at increased risk for hip fracture than not. Although these studies reported in (Table 1) do not clearly differentiate type 1 from type 2 diabetes in all cases, according to Hothersall et al. [7]. who recently

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Table 1: Studies conducted over the last 15 years linking either type 1 or type 2 diabetes and hip fracture.

Authors	Study design	Sample	Finding
Ahmed et al. [36]	Prospective	27,159 subjects were followed for 7 years	Hip fractures were associated with diabetes especially type 1 diabetes
Chen et al. [37]	Prospective	500, 868 diabetes patients	Diabetes generally increased hip fracture risk
Forsen et al. [38]	Prospective	35,444 adults	Diabetes type 1 and 2 increase hip fracture
Holmberg et al. [17]	Prospective	33,000 adults	Diabetes is a strong hip fracture risk factor
Janghorbani et al. [2]	Prospective	109,983 women	Type 1 + 2 diabetes increase hip fracture
Koh et al. [11]	Prospective	63,257 patients	Diabetes almost doubled risk for hip fracture
Lipscombe et al. [8]	Retrospective	197, 412 diabetes cases	Adults with diabetes have higher hip fracture risk
Miao et al. [39]	Prospective	24,605 diabetes patients	Type 1 diabetes increases hip fracture risk
Nicomedus and Folsom [34]	Prospective	32,089 older women	Diabetes increases risk for hip fracture
Ottenbacher et al. [40]	Prospective	3050 older adults	Diabetes is related to increased hip fracture
Scwartz et al. [41]	3 Prospective studies	1969 adults	Type 2 diabetes may present hip fracture risk
Segal et al. [42]	Case-control	142 hip fracture cases	Diabetic patients have increased hip fracture
Strotmeyer et al. [13]	Cross-sectional	5888 older adults	Type 2 diabetes was related to hip fractures
Tal et al. [43]	Prospective	1161 older adults	Diabetes increases trochanteric fracture risk
Vestergaard et al. [70]	Case-control	373,962 controls	Type 1 + type 2 diabetes increase hip fracture risk

examined the risk of incurring a hip fracture among patients ages 20-84 years with either type I or type 2 diabetes in a national sample from Scotland, a substantial increase of risk of hip fracture is present among patients with type 1 diabetes, especially at higher ages, but not among patients with type 2 diabetes, except for a small risk among women. However, these data were extracted from a pre-collected data base and may not have exemplified confounding factors or how type 2 diabetes affects hip fractures, as this is often undetected, even if present. The results presented by Hothersall et al. [7]. were also inconsistent with those of Lipscombe et al. [8]. who showed older individuals with diabetes are at increased risk for hip fractures. Janhorbani et al. [2], similarly found type 1 as well as type 2 diabetes are associated with an increased risk of hip fracture among women, when comparing rates to women without diabetes.

Likewise, in an earlier report, Schwartz et al. [9], noted higher fracture rates among older women with type 2 diabetes, and suggested this group might experience more rapid bone loss at the hip with aging than those without the condition, even though their bone mineral density may be increased rather than decreased [10]. In the Asian population where both diabetes and hip fracture rates are rising, Koh et al. [11], found the risk of hip fracture was almost double among people with diabetes compared to those without the disease. This relationship remained even when controlled for by stratifying the data according to body mass index. The relationship was deemed to be strong and dose-dependent based on baseline interviews, and the incidence of hip fractures post-enrollment over a 12 year study period of 63, 257 Chinese adults.

Using a large-population based health care data base, Reyes et al. [12], recently reported that diabetes is independently associated with an increased risk of hip fracture in elderly men. These data were supported by earlier work of Strotmeyer et al. [13]. who found diabetes among older men and women was associated with higher hip fracture rates after adjusting for body mass.

Thus, even though Puar et al. [14]. who produced counter intuitive data stating type 2 diabetes patients with tighter glycemic control are at greater risk of hip fracture, suggesting poor glycemic control is not associated with hip fracture, it seems safe to conclude, adults with either type 1 or type 2 diabetes, may experience a heightened risk for incurring a hip fracture over and above that due to age as concluded by Vestergaard et al. [15]. They may also sustain worse outcomes after hip fracture. However, it appears equally safe to say that this important fact is not always stressed in the context of diabetes management programs or hip fracture prevention programs.

Diabetes and increased risk for poor outcomes after hip fracture: The impact of diabetes among hip fracture cases is quite apparent even if there is sparse literature in the area. Among other detrimental outcomes exacerbated by diabetes, Gulceleik et al. [16], found that patients followed for more than 10 years after sustaining a hip fracture were more likely to die, if they had diabetes type 2 diagnoses. The main factors that were found to influence this were age, and HbA1c levels, suggesting more emphasis on controlling blood sugar among those of higher ages, post hip fracture might be helpful.

Wang et al. [6]. followed a sample of 707 hip fracture patients for one year and found that those hip fracture patients with diabetes had a higher risk of incurring postoperative cardiac complications, urinary tract infections, and gastrointestinal symptoms than healthy controls. They found that before the hip fracture, those with diabetes had more limited functional ability. These diabetes cases, stayed in hospital for longer periods, and underwent longer surgeries than those with no health condition (Table 2). Other data reveal that diabetes raises the risk for shorter life expectancy among hip fracture cases [17], as well as the risk for medical complications after hip fracture surgery [18], as well as second hip fractures [19].

Factors predisposing to increased hip fracture risk in diabetes cohorts: According to Garg et al. [20], it is the changes in hip geometry that are found among diabetics which predispose to fracture risk in diabetic women. After conducting an observational

Table 2: Summary of studies depicting selected negative health outcomes of diabetic patients post hip fracture.

Author	Sample	Results	Conclusion
Gulcelik et al. [16]	356 hip fractures cases	1 year survival was almost 20% higher in controls	Diabetic patients have increased mortality rates post hip fracture
Huang et al. [58]	Secondary analysis of 242, hip fracture cases 25.2%	Those with diabetes had higher mortality, and readmission rates, Those without diabetes had better rates of recovery at 1 year	Diabetes negatively impacts hip fracture outcomes
Janmohammadi et al. [66]	195 hip fracture cases	Diabetics had high intertrochanteric fracture rates. Diabetics required higher blood transfusion volumes	Awareness and care could reduce poor outcomes
Norris et al. [4]	477 hip fracture cases, 5489 non diabetics	Complications increased in those with diabetes after surgery, Diabetics had longer hospital stays Diabetes cases had worse baseline functional ability	Pre and postoperative recovery rates are influenced by diabetes
Wang et al. [6]	707 hip fracture cases	Cases with diabetes had more cardiac and other complications, post-surgery Initial walking ability of the diabetics was worse than controls	Diabetics are at increased risk for post surgical complications

study of 128 insulin treated type 2 diabetic women, 299 type 2 diabetic women on diet or medication regimens, and 5497 controls, and after adjusting for lean body weight, they found the bone mineral density and bending strength in the femoral neck were significantly reduced when compared to control women.

Yamaguchi and Sugimoto [21] reported that meta-analyses of multiple clinical studies depict increased hip fracture risk and type 2 diabetes cases in the range of 1.4-1.7 compared to controls. They suggested bone quality rather than quantity may be compromised in this group. Another theory is that despite having higher bone density than controls, diabetic women have lower indices of femoral neck strength relative to load, which raises their fracture risk. Guicelik et al. [16], found mortality rates were increased among type 2 diabetes patients after hip fracture, which was partially explained by the presence of elevated HBA1c levels, an indicator of glycemic control. Ishii et al, [22] found that diabetic women have lower femoral neck strength values relative to load, and that insulin resistance appears to play an important role in reducing bone strength in people with diabetes. In addition, research reveals older people with type 2 diabetes, the most common form of diabetes, have a 2.5 fold increased risk of fractures due to their high rate of falling [23,24]. Pipes et al. [25], too found patients with diabetes had an increased risk of recurrent falls. Obesity is also linked to increased falls risk, and is a common feature of diabetes [26]. Napoli et al. [27] found men with diabetes using insulin – which can require the use thiazolidinediones related to increasing the risk of becoming obese and having poor bone density [28] to have an increased risk of non vertebral fractures such as hip fractures, for a given age and bone mineral density. It is possible that those who are overweight incur fractures quite readily due to their altered bone quality [28] as well as the added mechanical impact they sustain in any fall related situation if they are overweight. Their fat mass might also impede their muscular system from serving a shock absorber during perturbations such as falling. Lee et al. [29] found total body muscle mass to be the most significant factor predicting femoral neck bone mineral density and the risk of falls that often lead to hip fractures among elderly cases with type 2 diabetes. Other factors that predict fracture risk in this patient group are alterations in bone material properties leading to increased bone fragility, longer disease duration, inadequate glycemic control, and insulin use [30]. Others are diabetes medications and very tight glycemic control [14]. Poor glycemic control is also a predictor of worse post-surgical outcomes among diabetic hip fracture cases [16]. Other factors are shown in (Box 1).

Reducing hip fracture risk and their poor outcomes among diabetics: Intervening to prevent hip fractures among diabetes patients is clearly of high importance given the rising prevalence of both diabetes among all populations [30], along with the aging of all populations, especially among adults with type 2 diabetes, who have been shown to have an 80 or 90% greater risk of hip fracture than non-diabetics [31]. Moreover, adults who sustain hip fractures have worse outcomes in general than controls if they have diabetes [32]. Early intervention is especially indicated to prevent this increased risk of excess disability because according to Leslie et al. [33], diabetes has a much more profound effect on the risk of fracturing a hip among younger, rather than older individuals. As well as worse outcomes [32], diabetic hip fracture patients have a higher risk of complications [11], and longer hospital stays [4] with consequent significant morbidity and mortality. Bone healing is also poor in this group [4], as is mobility when compared to age-matched non diabetics [4]. To improve the outlook for diabetes patients who are at risk for fracturing a hip, interventions to prevent osteoporosis and falling in post-menopausal women are recommended [34]. In addition, optimizing glycemic control, limiting substance and hormonal use, and encouraging physical activity may improve bone health in this population [35], especially among those using insulin who are very

- Altered gait patterns and reduced toe obstacle clearance [44]
- Balance disturbances [45i]
- Cardiovascular problems [13]
- Changes in hip geometry [20]
- Diabetes medications
- Decreased bone toughness or bone quality [21, 46, 69]
- Greater propensity for falling [25, 46]
- High alcohol use [56]
- Hip strength and ankle proprioception [47]
- Hypoglycemia [69]
- Impaired cognition
- Impaired postural control [48]
- Ischaemic cerebral events [69]
- Low physical activity levels
- Lower indices of femoral neck strength [22]
- Medications that increase falls risk [8, 65]
- Muscle fat ratio is altered
- Muscle mass loss [50, 51]
- Obesity leading to increased falls risk [26]
- Oral diabetes type 2 medication [64]
- Osteoporosis [52]
- Peripheral neuropathy [8, 53, 65, 69]
- Reduced vibration perception [54]
- Renal disease [56]
- Slow walking time [55]
- Stroke [65]
- Use of insulin [64]
- Vision problems leading to increased falls risk [8, 56, 65, 69]
- Vitamin D deficiency [57]

Box 1: Constellation of factors believed to influence hip fracture risk among diabetics directly or indirectly through increasing falls risk.

- Drugs to control diabetes [70]
- Early assessment for osteoporosis and increased fracture risk [11]
- Falls prevention interventions [34]
- Foot care
- Managing hyper or hypotension optimally
- Maintaining a healthy weight
- Medication monitoring
- Minimize duration of initial hospitalization [70]
- Nutritional education
- Optimizing chronic disease states [70]
- Optimal glycemic control [72]
- Physical activity participation
- Screening for falls risk
- Strength and balance training
- Tighter metabolic control [40]
- Vision deficit screenings

Box 2: Some possible strategies for minimizing falls and hip fracture risk and poor outcomes among diabetics.

vulnerable to hip fracture, including those with type I and 2 diabetic [36-43]. Gait training, balance interventions, along with efforts to optimize bone density, muscle mass, and proprioception may impact both falling and its increased risk in this group, as well as sustaining a primary or secondary hip fracture according to the known risk factors for falls and fracture in diabetic adults [44-55]. Other factors increasing the risk of excess disability due to a hip fracture that may be amenable to intervention have been described by Lai and Waldron [56], Kanpurwala and Afzal [57], Huang et al. [58] and Khan et al. [59]. See (Box 2) for possible strategies to reduce injuries, hip fracture risk, and readmissions after hip fracture care among diabetics.

Comparative publication numbers on hip fractures and diabetes prevention: Using the Academic Search Complete Data base from 1977-2014, selecting only peer reviewed articles, (Table 3) shows the limited number of published works on this diabetes and hip fractures topic compared to other related topics. This is despite the high importance of examining this association in more detail and developing a more profound knowledge base that can be applied clinically in this realm.

Conclusion

Although an early study by Nuso and Harrar [31] clearly showed

Table 3: Comparison of number of citations on hip fractures and diabetes and other topics in academic search complete 1977- December, 2014.

Keywords	Total Number Publications	Number of Journal Articles
Diabetes	210, 897	181,330
Diabetes and Nutrition	20,253	17,500
Diabetes and Glycemic Control	9358	8958
Diabetes and Exercise	8640	7024
Diabetes and Falls	31	28
Hip Fractures	5836	5338
Fracture Prevention	4881	4423
Hip Fracture Prevention	924	839
Hip Fractures and Diabetes	237	212

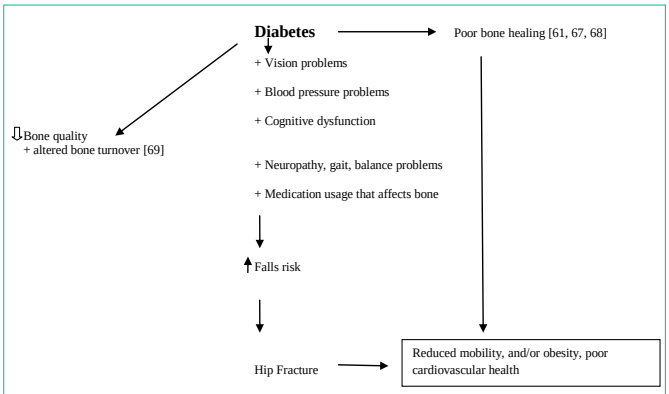

Figure 1: Hypothetical pathway implicating diabetes in hip fracture risk and poor health outcomes.

individuals with type 2 diabetes had an 80 or 90% greater risk of hip fracture than non-diabetics, and patients with diabetes who sustain hip fractures have worse outcomes in general than those without diabetes [32], including re-admission rates after surgery [59], plus a 20% excess risk in the first years following disease onset [60], and impaired bone healing [61], this topic is not a commonly explored one in the related literature. That is, even though diabetes clearly affects the outcomes of the diabetic patient who sustains a hip fracture, very negatively and significantly, and may be amenable to secondary intervention, very little emphasis appears to have been placed by researchers, and clinicians on preventing possible hip fractures among older diabetic patients in light of the existing evidence. As well, even if screening newly diagnosed diabetic patients for their hip fracture risk would be helpful in the long run, very few tools and guidelines on how to do this or who to target specifically exist. Causes for the increased fracture risk among type 2 diabetes patients, especially among older women [62], preventive strategies against hip fractures in general, and among those with diabetes in particular are also sparsely documented. The focus on exercise and nutrition in diabetes care practices at the expense of other potentially useful preventive strategies against falls injuries that lead to fractures is however, not consistent with the research clearly supporting a wider view of diabetes self-management strategies and what we do know about preventable comorbidities of this condition. In addition, because a fracture injury can seriously compromise mobility, an important activity for glycemic control, regardless of type of diabetes, more clearly needs to be done in this realm both among younger adults, as well as among those with recent diabetes type 1 or 2 diagnoses, as well as among older adults with more advanced type 2 diabetes, at the outset according to research by Janghorbani et al[63] and Cortes-Sanchez et al [64]. Those who are older should be especially targeted [65, 66] to avoid complications [67-69], and the impact of insulin and oral antidiabetic medication on relative fracture risk [70], and readmissions after hip fracture care [71], along with the importance of optimizing glycemic control [72] should be borne in mind in any effort to reduce excess morbidity. In the interim, universalizing fracture prevention strategies in both type 1 and type 2 diabetes as a standard element of diabetes care has been recommended [2], as has raising awareness among health providers of the link between type 1 and 2 diabetes and hip fractures, including their increased risk for falls [73], and post-operative complications [74].

Future Directions

Assuming imaging resources are available, examining the geometry of the bones in the hip region, as well as assessing bone density in high risk diabetes cases as a standard practice among those clearly at risk for falls may be extremely helpful. In addition, it appears the medication regimens of older type 2 diabetes cases should be reviewed periodically given the association between diabetes medications and hip fractures [34]. Glycemic control should be monitored as well. As outlined by Norris [4] and others [16], heightened physical activity levels should be encouraged [35] to avoid the highly limited degree of function observed in fallers who have fractured a hip. More effort too is clearly needed to discriminate the needs of the type 1 versus type 2 diabetic in this realm. In addition, role of physical therapy to improve proprioception and walking ability should be examined. Those who have long-term diabetes histories, those who are obese, those with cognitive or sensory problems, and those who are older should be especially targeted [65,66] to avoid complications [66] and pathways outlined in (Figure 1).

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