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Statistics and Factors Leading to Hip Fracture

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Abstract: There is also a strong need to investigate whether it is possible to improve upon current rehabilitation strategies for restoring functional recovery post-hip fracture surgery and particularly for preventing further joint injuries, including second and third hip fractures and certain types of articular degeneration.

In the following discourse, some of the primary risk factors for hip fractures, plus aspects of the remediation process and the determinants of this are discussed.Of the 300,000 hip fractures that occur each year (Apple and Hayes, 1994), over 90% of them are associated with falls (Grisso et al., 1994, Hedlund and Lindgren, 1987, Melton, 1993, Varney et al., 1992). Although fractures at the hip may be caused by a sudden muscle contraction prior to impact (Gardner et al., 1998, Smith, 1953), falls and bone impact seem to precede the hip fracture, rather than vice versa (Grisso et al., 1991a). Frequently, a fall that impacts the lateral aspect of the hip may strike the greater trochanter and fracture the neck of the femur (Cummings et al., 1995, Greenspan et al., 1994, Lauritzen, 1997, Parkkari et al., 1999). Research by Hayes et al. (1993), who have begun to examine precisely what constitutes a fall with a high risk for hip fracture, has shown that an impact on the hip or side of the leg raises the risk of a hip fracture over 20-fold in nursing home fallers, and 6-fold in community-dwelling men and women. It has also been shown that a decrease of one standard deviation in femoral neck bone mineral density, a similar decrease in body mass index, and an increase of one standard deviation in the potential energy associated with a fall, are all significant and independent risk factors for hip fractures of both genders (Greenspan et al., 1994), as are impairments in balance, neuromuscular functioning and musculoskeletal impairments (Myers et al., 1996a) (see Fig. 2). These findings, plus findings that falls to the side coupled with high impact velocity are more likely to result in hip fracture than other falls (Cummings et al., 1995, Greenspan et al., 1994, Greenspan et al., 1998) suggest factors related to both the mechanics of loading and bone fragility, as well as fall speed play important roles in hip fracture etiology (Hayes et al., 1996). The decreased effectiveness of protective responses, due to increases in reaction time, along with decreases in strength with age may also explain why hip fractures occur to a greater extent in elderly people who fall than in younger people (Sabick et al., 1999).Interestingly, Hayes et al. (1996) found that during a relaxed fall, impact occurred earlier, and was usually located at the knee or at the side of the leg, before any impact fell on the hip. This suggested a larger portion of the energy available at impact dissipated in the surrounding soft tissue. In further findings they noted that the state of muscle activation predicted average peak forces, at least in men. While neuromuscular control in the descent phase of the fall may reduce the velocity of impact and allow the ‘faller’ to adjust the body into a safe landing configuration, striking the ground in a stiff state was actually found to increase the impact forces. This was an intriguing finding and somewhat counter-intuitive, as the generation of submaximal or maximal muscular contractile forces would seem to afford a joint exposed to impact more protection than a muscle in its relaxed state, as indicated by findings of

Sabick et al. (1999) and Sandler and Robinovitch (2001). The findings also fail to explain why older persons with decreased leg and arm strength fall and sustain injuries to a significantly greater extent, than those with stronger arm and leg muscles (Tinetti et al., 1995a).However, the following explanation by Luukinen et al. (1997) seems plausible and in line with the hypothesis generated by Hayes et al. That is, fear of falling, a serious disorder in older people, resulting in their limited physical activity and reduced functional ability, may have the effect of inducing a co-contraction, or tenseness rather than a graded contraction of muscle agonists and antagonists during a postural perturbation. By increasing the lever arm, the resultant stiffening reaction of the musculature might contribute to, rather than absorb, the impact experienced during a fall, and accordingly, the risk of fracturing a bone such as the hip.Cummings (1985), Birge (1993) and Greenspan et al. (1994) report that while several studies have found low bone mass to be associated with an increased risk of fracturing a hip prior to age 70 years, virtually all have found a considerable overlap in bone densities between hip fracture patients and age- and gender-matched controls after the age of 70 years. Low calcium intake, thought to impact detrimentally upon peak bone mass, is also not a risk factor for hip fracture (Cooper et al., 1988, Cummings et al., 1995, Farmer et al., 1989, Nieves et al., 1992, Wickham et al., 1989a). As well, the propensity to fall and fall mechanisms is more important in the pathogenesis of hip fracture than bone mineral density (Runge and Schact, 1999). Wei et al. (2001) found the effect of risk factors for hip fracture among community-dwelling ambulatory elderly to remain the same, regardless of femoral neck bone mineral density. It has also been observed that bone mineral density is a weaker predictor of intertrochanteric hip fractures than femoral neck fractures (Fox et al., 2000) and osteoporotic indices were found to be comparable between cases and controls in a recent study (Fitzpatrick et al., 2001). In addition, several studies have concluded that hip fracture patients are not more osteopenic than age and gender-matched controls (Cummings et al., 1985), and Asians, who have similar, or lower bone mineral densities than whites, and partake in diets low in calcium, have a low incidence rate of hip fracture, especially in women (Yan et al., 1999). Mathematical models too, cannot account for the exponential rise in hip fractures with age solely on the basis of bone density levels (Cummings and Nevitt, 1989, Melton et al., 1988). Further, individuals with osteoarthritis and higher bone density levels than the norm are not protected against hip fractures (Arden et al., 1996, Jones et al., 1995).Such findings strongly suggest factors other than having a low bone mineral density and peak bone mass may contribute to the risk of fracturing a hip, and that an examination of factors unrelated to bone mass must merit consideration in establishing the causes of hip fractures. These factors include: environmental hazards, lifestyle habits, factors that are related to or increase the risk for falling, the location of the fall impact, the mode of falling, the property of the fall surface, the geometry of the hip, the distance to impact, the height and weight of the moving body parts, body size, the degree of soft tissue coverage over the hip bone, reduced agility and motor function, and muscle weakness (Cumming and Klineberg, 1994a, Cummings and Nevitt, 1989, Cummings and Nevitt, 1994, Dargent-Molina et al., 1999, Farmer et al., 1989, Fitzpatrick et al., 2001, Fujita, 1994, Jones et al., 1995, Nevitt et al., 1989, Lauritzen, 1997, Luukinen et al., 1997, Parker et al., 1996, Runge and Schact, 1999, Slemenda, 1997, Wolinsky and Fitzgerald, 1994)

In terms of body size characteristics, it has been argued that body height greater than 65 in. may be a predictor variable for hip fracture (Birge, 1993, Greenspan et al., 1998), because the impact energy from the increased fall height of taller subjects is equal to the square root of the falling height of a body (Gardner et al., 1998). Indeed, Joakimsen et al. (1997) report that high body height is a risk factor for fractures, and estimate one in four low-energy fractures among women today might be ascribed to the increase in average stature since the turn of the century. Owusa et al. (1998) similarly report that having a high body height is positively associated with significant elevations in the incidence of hip fractures among men, as do Lau et al. (2001) for Asian men and women, and Farahmand et al. (2000) for postmenopausal Swedish women.

Another body size feature, namely a low body mass, has been found associated with a higher risk of fractures, especially in white men (Mussolino et al., 1998), after the age of 50 years (Langlois et al., 1998) (see Table 2). Weight losses of 10% or more from maximum weight are also associated with an increased risk of hip fracture (Farahmand et al., 2000, Langlois et al., 2001. Older women with smaller body size are potentially at increased risk for a hip fracture because of their lower bone mineral density levels (Ensrud et al., 1997). It is equally likely that women with a low body mass have less soft tissue covering the hip than women of normal body weight (Lauritzen, 1997). According to Gardner et al. (1998), having a low body mass that reduces the extent of soft tissue padding and energy absorption over the greater trochanter, might explain the observed tendency of underweight individuals towards incurring a hip fracture if they fall on their side. The interaction between low body mass, low muscle mass and muscular weakness leading to failure of protective responses, could also be expected to heighten the risk of incurring a hip fracture, regardless of femoral bone density status (Meunier, 1997).

However, although many people who fracture their hips could be classified as being thin, and high body weight has been deemed protective (Farahmand et al., 2000), in accord with Cumming and Klineberg (1994b) and Maffulli et al. (1999) that one risk factor for hip fracture could be excessive body weight, or an elevated waist-to-hip ratio (Owusa et al., 1998) we recently noted that among 35 elderly community-dwelling elders hospitalized with acute hip fractures and a mean age of 76.2±7.6 years, 51.4% were overweight or obese, and only 2.9% were underweight, as indicated by their body mass index. Dretakis and Christadoulou (1983) too, noted similar rates of overweight and underweight hip fracture cases among their 373 patients. This may suggest, that even though overweight individuals would be expected to have a relatively higher proportion of body fat than average to dissipate a fall, it is possible that if they fall on their hips, their restricted mobility, plus the direct impact sustained by their high body and leg weights, along with their potentially inferior muscle mass, which may constituted by a large fat mass, could cause the safety threshold of the hip to be exceeded, even if their bone mass is within normal limits. Similarly, when patients with severe dementia were excluded, Bean et al. (1995) found thinness was not necessarily associated with hip fracture. However, their observations of differences in handgrip strength among hip fracture patients and controls of comparable body mass indices, supported the view that some hip fracture cases might have muscles constituted by a high proportion of fat.

In this context, it is especially noteworthy that although body weight is considered to affect bones of children and adults positively, recent studies suggest overweight and obesity in childhood and adolescence reduces bone mineral content below that predicted based on weight and this is associated with an increased incidence of childhood fractures (Whiting, 2002) and hip fractures as adolescents (Maffeis and Tato, 2001). Heavier individuals may also be expected to have low levels of sex hormone-binding globulin, a finding among women with recent hip fractures (Skalba et al., 2001), and a high rate of comorbid conditions that are known risk factors for falling, such as hypertension, arthritis, diabetes and medical conditions associated with osteoporosis, such as cancer (Folsom et al., 2000, Marks and Allegrante, 2002, Nicodemus and Folsom, 2001).

Hayes et al. argue that in the presence of muscle weakness, both the characteristics of the fall, and to a lesser degree, body habitues, which can both influence the risk of incurring a hip fracture, may be detrimentally altered, with a consequent increase in trauma intensity, regardless of bone strength. Having weak muscles may also decrease the force required to fracture a hip (Bean et al., 1995). Muscle weakness, which is usually associated with a decreased muscle mass could also impact adversely upon total body mass, which is found to have independent relationship to the risk of hip fracture (Farmer et al., 1989). Farmer et al. who found the risk of hip fracture was negatively associated with a low arm muscle area, suggested having a low arm muscle mass might slow normal reflexive protection mechanisms, such as extension of the forearm, thereby reducing the effectiveness of inherent protective strategies against bone fractures when falling. Similarly, Cummings and Nevitt (1989) have argued that the effectiveness of protective responses which depends on arm strength, and declines with age, along with hip strength, might heighten the risk of fracturing a hip when falling.

Muscle weakness also hastens bone demineralization (Birge, 1993), and this, along with poor protective responses heightens the risk of incurring a hip fracture during a fall (Luukinen et al., 1997). Also, in the presence of any reduced muscle mass at the hip joint, there may be insufficient soft tissue protection of the hip bone and, thus, a reduced ability to prevent the occurrence of a hip fracture in response to a fall injury.

An increased risk of falling, which can lead to a hip fracture, has also been noted in association with hip weakness (Robbins et al., 1989), poor grip strength (Cooper et al., 1988), neuromuscular impairment (Slemenda, 1997), poor ankle strength (Lord et al., 1994, Whipple et al., 1987), low body and knee extensor strength (Lord et al., 1994, Roy, 1993, Sherrington and Lord, 1998), and the inability to rise from a chair without using one's arms (Cummings et al., 1995). There may also be a greater proclivity to incur a hip fracture if the knee extensors are weak because this could greatly increase the velocity of falling (Luukinen et al., 1997) and/or reduce gait speed, which potentiates sideways or backward falls, and impact on or near the hip (Smeesters et al., 2001). The status of the neuromuscular system at the ipsilateral hip and knee just prior to fracture, may also play a dominant role in gait speed and hip fracture risk (Dargent-Molina et al., 1999), the distribution and absorption of stresses on the femur, and the localization of a fracture (Christodoulou and Dretakis, 1984, Dretakis and Christadoulou, 1983).

In addition to cognitive factors and those related to falls, disturbances of the mechanisms of balance can also predispose the elderly to hip fracture (Boonen et al., 1993, Falsh et al., 1993, Sherrington and Lord, 1998). Disturbances of balance, may in turn, be related to age-associated declines in perception with respect to vision, vestibular function, proprioception and/or transient circulatory insufficiencies (Baker, 1985, Grisso et al., 1991a, Meunier, 1997, Nevitt et al., 1989) and impaired sensory integration or motor functioning (King and Tinetti, 1995, Slemenda, 1997). Loss of vibration sense, reduced pain perception at the knee, and having absent Achilles and quadriceps reflexes may influence hip fracture risk during falls as well (Luukinen et al., 1997).

Impaired vision may be an independent risk factor for hip fracture (Boonen et al., 1999, Grisso et al., 1991a, Luukinen et al., 1997). Evidence for this has been provided by Ivers et al. (2000) in a case–control study of 911 cases and 910 controls aged 60 years or older. The population attributable risk of hip fracture due to poor visual acuity or stereopsis, vision wherein two separate images from two eyes are successfully combined into one image in the brain, was 40%. Pfister et al. (1999) also noted impaired vision as significantly prevalent among women ages 50 and older with fractures of the proximal femur. Impaired vision has also been associated with hip fractures occurring in the hospital (Lichtenstein et al., 1994) and among the Framingham Study Cohort, the fracture rates in those with moderately impaired vision to poor vision were higher than in those whose vision was good (Felson et al., 1989). Further, those with moderately impaired vision in one eye and good vision in the other had higher risk of fracture than those with a similar degree of binocular impairment.

Norton et al. (1997) investigated the circumstances of falls resulting in hip fractures among older adults in New Zealand and explored whether the circumstances differed by gender, age, or residential status. Information collected for 911 patients aged 60–104 years (mean age 82 years) who had been hospitalized with a hip fracture between 8 July 1991 and 7 February 1994 showed 96% of the fractures were associated with a fall, and 16% were associated with an acute medical or physical condition. Although 85% of the fractures involving a fall occurred at home, only about 25% of these were associated with an environmental hazard, leaving the authors to conclude that intrinsic factors such as balance play a greater role than extrinsic factors, regardless of age or residential status in causing falls that cause hip fractures. Further, while environmental factors may be one of several factors that contribute to falls (King and Tinetti, 1996), a recent study by Allander et al. (1998), which found the correlation between the number of risk factors of the faller and the environment to be 0.07, suggested environmental hazards are of minimal importance in mediating hip fractures.

Although Rashic and Logan (1986), who examined the role of drugs in hip fractures found that with the exception of antibiotics, fracture risk was lower in those taking drugs, drugs reported to be related to falls include: cimetidine, psychotropic anxiolytic/hypnotic drugs, barbiturates (which may decrease bone quality), opioid analgesics, and antihypertensives (Baker, 1985, Boonen et al., 1993; Grisso et al., 1991b, Grisso et al., 1997; Guo et al., 1998), long-acting benzodiazepines, anticonvulsants (which can accelerate bone demineralization and cause osteoporosis) and caffeine (Cummings et al., 1995, Schwab et al., 2000). Tranquilizers, sedatives and exposure to any of the three classes of antidepressants is associated with a significant increase in the risk of falling and sustaining a hip fracture (Liu et al., 1998, Meunier, 1997, Ray et al., 1987). In particular, along with impaired perception, long-acting sedatives and alcohol that can slow reaction time might partly explain the increased risk of hip fractures associated with the use of sedatives and regular intake of alcohol (Boonen et al., 1999, Cummings and Nevitt, 1989, Grisso et al., 1994, Jacqmin-Gadda et al., 1998, Lau et al., 2001). Alternately, alcohol abuse may increase corticosteroid secretion and negative bone balance (Rees et al., 1977), and decreased balance, impaired gait, and risk-taking behaviors (Hemenway et al., 1988). Tricyclic antidepressants may increase the risk for hip fracture due to their detrimental cardiovascular side effects, and/or their side effects of sedation and confusion (Pacher and Ungvari, 2001). Use of corticosteroids is also a documented risk factor for hip fracture (Lauritzen, 1997), and may reflect the detrimental effect of corticosteroids on bone mineral density, as may levothyroxine when used by males (Sheppard et al., 2002). Smoking cigarettes or a pipe, and the consumption of tea, and fluorine concentrations over 0.11 mg/l (Jacqmin-Gadda et al., 1998) also increases the risk of hip fracture (Grisso et al., 1997, Kanis et al., 1999).Certain chronic illnesses, in particular, arthritis and Parkinson's disease, substantially increase the risk of falling, and hence, of incurring a hip fracture (Boonen et al., 1993, Grisso et al., 1991a, Johnell et al., 1992b). This may be due to pain, impaired joint motion, sensory changes or reduced muscle strength around the affected lower-extremity joints. Problems in postural control are associated with Parkinson's disease (Nevitt et al., 1989). In addition, arrhythmias, postural hypertension, and peripheral neuropathies may increase the risk of falls and hip fractures (Meunier, 1997), as may the presence of lower limb dysfunction, Alzheimer's type dementia (Buchner and Larson, 1987) and other neurological conditions, such as stroke with hemiplegia that cause poor gait patterns and reduced bone density on the affected side (Christodoulou and Dretakis, 1984, Grisso et al., 1991a). Diabetes mellitus (Schwartz et al., 2001), hyperthyroidism (Boonen et al., 1999, Cummings et al., 1995), medical conditions associated with osteoporosis (Poor et al., 1995b), other forms of disability associated with an increased risk of falling (Poor et al., 1995b), use of walking aids (Grisso et al., 1994), as well as prolonged immobilization (Lauritzen, 1997), may also lead to an increased risk of hip fracture.

In summary, as indicated in a variety of experimental and epidemiological studies, a variety of age-related and other factors may affect the two ultimate determinants of hip fracture, femoral bone strength and propensity to trauma. In particular, the decline in muscle function that occurs with aging will affect both determinants of hip fractures and, hence, the incidence and impact of falls (Boonen et al., 1996). Muscle strength and size and its influence on reaction time, balance, proprioception, fracture site and bone mass may also underlie sub-group differences in hip fracture incidence and functional outcomes. The relationship between these factors and the cycle of disability associated with hip fractures is shown in Fig. 2, Fig. 3.

In terms of the nature of hip fracture injuries, five categories have commonly been described: (1) nondisplaced or minimally displaced femoral neck fractures; (2) displaced femoral neck fractures; (3) stable intertrochanteric fractures; (4) unstable intertrochanteric fractures; and (5) subtrochanteric fractures. Femoral neck fractures are considered intracapsular fractures, and intertrochanteric and subtrochanteric fractures are extracapsular fractures.

In terms of management, for most hip fracture patients, surgical management is considered the optimal and most cost-effective approach for treating nondisplaced, minimally displaced, and displaced intracapsular fractures and all extracapsular fractures (Lyons, 1997). However, nondisplaced intracapsular fractures can be treated with bedrest and a 6–8 weeks' delay of weight bearing in the "younger" elderly (<70 years). In addition, if the patient is <50 years of age, and the fracture is nondisplaced, attempts should be made to treat the fracture by means of open reduction, internal fixation and stabilization.

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