Exercise vs Calcium Intake – The Best Strategy to Reduce Hip Fracture Risk

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ABSTRACT

Background: Hip fractures are a growing problem in Canada and account for approximately 35% of all fall-related hospitalizations among seniors aged 65 and older. Exercise and calcium supplements have been shown to decrease the risk associated with hip fractures. However, most studies do not exclusively compare the associations between exercise and calcium intake as preventative strategies to reduce hip fracture risk.

Objective: To summarize relevant literature and critically assess the evidence to determine the best preventative strategy to reduce hip fracture risk by assessing its relationship with exercise and calcium intake.

Methods: A literature review of studies published between 1988 to 2015 was conducted using Medline and Cochrane Reviews. Keywords included "Risk of Hip Fractures" AND "Exercise" or "Physical Activity", "Risk of Hip Fractures" AND "Calcium", "Prevention" AND "Intervention" AND "Risk of Hip Fractures". Exempted studies were those that focused on populations with osteoporosis and fall risk, or lacked relative risk measurements; the remaining nine articles were examined.

Results: The majority of studies indicated negative associations between exercise and hip fractures, and mixed associations between calcium intake and hip fracture risk.

Conclusion: Although the majority of studies concluded a negative association between exercise and hip fracture risk, there were mixed results for calcium intake that could be explained by an addition of vitamin D intake. Only a few studies included multiple preventative strategies to assess hip fracture risk, however, there are no studies that specifically examine the relationship between exercise and calcium intake and hip fracture risk. Further studies are required to make definitive conclusions.

Research Question

Which is the best strategy to reduce the risk of hip fractures among older adults 50 years and older, calcium intake or exercise?

BACKGROUND

The rising rate of hip fractures among older adults is a growing health concern for Canadian populations. Hip fractures impact the healthcare system, contribute to avoidable medical care costs, require more post-surgical care, and impacts the individual's physical and psychological health, leading to poor quality of life. In Canada, approximately 20% of older adults 65 and older die within 12 months as a result of hip fractures due to a fall (PHAC, 2011). Also, older adults with hip fractures use more hospital beds than patients with myocardial infarctions, stroke, or diabetes (Jaglal, 1998). Not only hospital beds, but the average length of stay in a hospital is significantly longer for older adults who fall compared to other reasons for hospitalizations from 22 days compared to 12 days respectively (PHAC, 2014). In 2012, hip fractures alone cost $1.1 billion in medical costs and these expenses are only expected to rise (Nikitovic et al., 2013). Hip fractures and fall related injuries in older adults are also the cause of approximately 40% of long-term care admissions (PHAC, 2011). Apart from the economic and healthcare burdens associated with hip fractures, there are many psychological and physical consequences including sadness, grief, immobility, isolation, depression, and fear of falling (Proctor et al. 2008). Therefore, preventive efforts to reduce one's risk of hip fracture, and in turn, prevent additional comorbidities and psychological impacts, are important in Canada.

Multiple studies have indicated that both calcium supplementation and exercise help to decrease the risks associated with hip fractures. Additionally, both are usually recommended as strategies to reduce one's risk of hip fractures related to falls in older adults. Sufficient calcium levels help maintain the regulation of bone structure and strength for muscle movement (Kessel, 2004). Physical activity helps maintain bone mineral density and improves posture, coordination and balance, all of which decrease the likelihood of falls, and therefore fractures (Kessel, 2004). Furthermore, there are many studies that independently test their effects on reducing the risk of hip fracture that show mixed results. However, most studies do not identify an exclusive link between calcium intake and exercise with the prevention of hip fractures.

Previous findings of the association between calcium supplementation and risk of hip fracture have typically been inconclusive. Calcium supplementations were mainly found to be beneficial only when added to vitamin D supplements (Kessel, 2004). However, in clinical trials it was noted that calcium and vitamin D supplements were not sufficient to prevent hip fracture risks in high-risk women (Kessel, 2004). Studies that test the association between physical activity and risk of hip fractures concluded mixed results. In a study of 1419 participants that included a follow up after 15 years, revealed that decreased physical activity increased the likelihood of the risk of hip fractures (Paganini et al., 1991). A more current study pooled the results of eight studies with 1844 participants, which showed no decrease in the rate of fractures within the population with physical activity (Cooper, 2008). Further research is necessary to understand the inconsistences in research and to determine the association between calcium intake and exercise on the risk of hip fractures. This will aid in providing evidence-based prevention and intervention strategies to reduce the rising rates of hip fractures in Canada.

METHODOLOGY

A literature search using Medline and Cochrane Reviews was conducted to identify studies that indicated the best strategy to prevent hip fractures either through exercise or calcium intake. Systematic reviews, cohort studies, meta-analysis, experimental, and case-control studies from 1991 to 2015 were included. Our search involved articles containing keywords that included 'Risk of Hip Fractures' AND 'Exercise' AND 'Physical Activity', 'Risk of Hip Fractures' AND 'Calcium', 'Prevention' AND 'Intervention' AND 'Risk of Hip Fractures'. This search generated 24 articles for exercise/physical activity and hip fracture risk, 37 articles for calcium and hip fracture risk, and 22 articles for prevention and interventions related to hip fracture risk. The majority of articles focused on drug studies, hip protectors, or post hip fracture interventions. Only 9 studies were relevant to our study by comparing both calcium intake and exercise among other factors. We excluded articles that focused on osteoporosis and fall risk, lacked risk measurements, hip fractures in children, studies that did not test for calcium or exercise, or studied only calcium or physical activity and the risk of hip fracture. We did not combine 'Exercise' AND 'Calcium' AND 'Risk of Hip Fracture' because this search strategy only generated 2 articles and excluded many relevant ones. Other combinations of keywords did not generate enough articles to come to a conclusion.

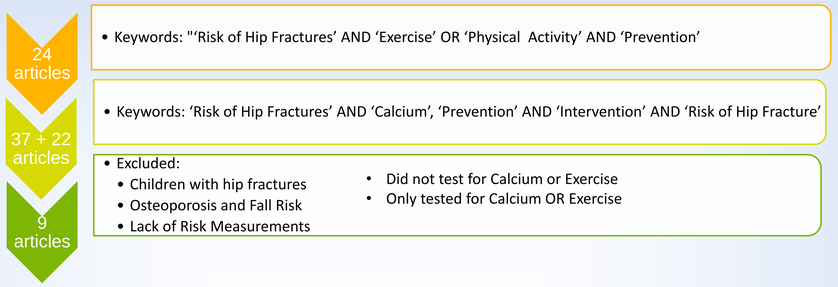

Figure 1: Strategy to obtain relevant articles for our literature review.

RESULTS

Title and Type of Study	Main Findings	Relative Risks/Odds Ratio of Calcium & Exercise
1. Interventions for preventing falls in older people in care facilities and hospitals (Review): Systematic Review	Calcium was used as a control in most studies but also with Vitamin D as a treatment, no significant difference found. One study compared exercise vs usual care in care facilities and results were significant.	Calcium with Vitamin D vs Calcium alone (95% CI) RR: 0.71, 0.56-1.90 Exercise RR: 0.16, 0.01-2.81
2. Risk factors for hip fractures in men from southern Europe: The MEDOS study: Case-Control Study	No significant dose-response relationship present between the dietary calcium and the reduction of hip fractures. Milk consumption was J-shaped indicating a protective effect with more milk. However, cheese intake was more effective compared to milk. Recreational physical activity is associated with a decrease in risk of hip fractures in men.	Calcium Intake (through Cheese) RR: 0.75, 95% CI 0.49-1.14; p=0.128 Calcium Intake (though Milk) RR: 0.82, 95% CI 0.61- 1.11; p=0.199 Recreational physical activity RR: 0.68, 95% CI 0.53-0.86; p=0.002
3. Calcium intake and hip fracture risk in men and women: A meta-analysis of prospective cohort studies and randomized control trials: Meta-Analysis	In 7 prospective cohort studies, calcium intake was not significantly associated with hip fracture in both men and women. Calcium supplementation may actually increase hip fracture risk by up to 64%.	Pooled RR of 300mg of calcium per day: 1.01, 95% CI 0.97–1.05
4. Exercise and other factors in the prevention of hip fracture: The leisure world study: Prospective Cohort Study	Calcium was not indicated as a protective factor against fracture risk. Physical exercise had the strongest association with hip fracture risk. Men and women who exercised for at least an hour a day had a significant reduction in the risk of hip fracture compared to those who exercised for less than ½ hour a day.	Calcium supplements: 1-500 mg/day RR: 1.45, 95% CI 0.92–2.30 =/>500mg/day RR: 1.27, 95% CI 0.79–2.05 Active Exercise: >1hr/day RR: 0.62, 95% CI 0.47–0.80; p<0.001
5. Fracture prevention in postmenopausal women: Systematic Review	High doses of calcium supplementations significantly increased hip fracture risk and myocardial infarction compared to the placebo. At home exercise programs did not lead to significant differences.	Calcium Intake: 800-1200mg/day RR: 1.64, 95% CI 1.02–2.64 Exercise: RR: 0.28, 95% CI 0.06–1.33
6. Several strategies prevent falls and subsequent injury in older persons: Meta-analysis	In 7 trials of the Frailty and Injuries: Cooperative Studies of Intervention Techniques program, exercise reduced risk of falling significantly.	Exercise: RR: 0.9, 95% CI 0.81-0.99; P=0.04
7. Physical activity, muscle strength, and calcium intake in fracture of the proximal femur in Britain: Case-Control Study	No association between risk of fracture and calcium intake in women. Men had slightly lower risk of hip fracture for the highest level of calcium intake (>1041mg/day). As association between increased calcium intake and risk of hip fracture was inconclusive. Calcium supplementation showed some beneficial effect on the rate of bone loss. Increased risk of hip fracture with inactivity in both sexes. Physical activity and calcium intake are both associated to an increased risk of hip fracture when independent of other factors.	Calcium intake: 95% CI; Women: <433mg/day (RR: 1.2, 0.7-2.2); 433-567mg/day (RR: 1.4, 0.8-2.5); 567-684mg/day (RR: 1.1, 0.6-2.0); 684-838mg/day (RR: 1.2, 0.7-2.1) Calcium intake: 95% CI; Men: <500mg/day (RR: 6.2, 1.3-29.7); 500-668mg/day (RR: 5.8, 1.1-29.0); 668-841mg/day (RR: 3.3, 0.8-14.1); 841->1041mg/day (RR: 62, 1.2-3.7) Exercise: (by walking speed); Women: Very slow (RR: 2.6, 1.3-5.2); Brisk/Fast (RR: 1.5, 0.7-3.1); Men: Very Slow (RR: 1.6, 0.5-5.7); Brisk/Fast (RR: 0.9, 0.2-3.4)
8. Physical activity and calcium intake in fracture of the proximal femur in Hong Kong: Case-Control Study	Calcium intake was related to a lower risk of hip fracture in women and in men. Physical activity and weight bearing exercises were associated with reduced hip fracture risk in women but was not significant for men.	Dietary calcium intake: (95% CI); Women: <75mg/day (RR: 1.9, 1.2-2.9) 129->244mg/day (RR: 1.2, 0.8-2.0) Dietary calcium intake: (95% CI); Men: <75mg/day (RR: 2.1, 1.1-4.2) 129->244mg/day (RR: 1.5, 07-3.2) Exercise: (walking uphill) Women: RR: 1.6, 1.1-2.3 Men: RR: 1.5, 0.8-2.9
9. Dietary calcium, physical activity, and the risk of hip fracture: A prospective study: Prospective cohort study	Dietary calcium is unrelated to the risk of hip fracture. Only among men taking more than 1041mg/day of calcium had lowered risk. Hip fracture risk decreased with increasing mobility and outdoor activity.	Calcium intake: (95% CI) Women: <588mg/day (OR: 0.7, 0.1-3.9); 588->802mg/day (OR: 0.9, 0.2-4.3) Men: <694mg/day (OR: 0.7, 0.1-3.9); 694->999mg/day (OR: 0.9, 0.2-4.3) Exercise: (through mobility) Housebound to Limited outdoor: RR: 2.2, 0.3-16.1 Limited outdoor to Full outdoor: RR: 1.6, 0.2-10.5

DISCUSSION

Overall, the studies reviewed indicate a greater association between exercise and hip fracture risk compared to calcium intake as a preventative measure. In general, studies related to hip fractures are done with postmenopausal women, but our search strategy has included men as well.

In general, prospective cohort studies and meta-analysis indicated no significant relationship between calcium intake and hip fracture risk in men and women. One meta-analysis also showed increased risk of hip fractures with calcium supplementations alone. There are several explanations for this. First, calcium supplements, such as calcium carbonate and calcium citrate, reduce phosphate absorption necessary for bone mineralization, which can increase hip fracture risk but also the risk for myocardial infarction. Second, studies that involved food for dietary calcium may have other nutrients like phosphate, which could also explain the lack of the association in cohort studies (Bischoff-Ferrari et al., 2007). Third, observational studies may cause non-differential error in measuring calcium intake which can lead to an underestimation of calcium's true effect (Bischoff-Ferrari et al., 2007). Therefore, controversies between studies may be explained by the differences between dietary calcium intake, calcium supplements, combinations with vitamin D or phosphate, and dose of calcium per day.

However, the three case-control studies in this review portrayed a significant association between calcium intake and hip fracture. One study found that calcium intake in the form of cheese was associated with decreased hip fracture risk. Dietary calcium is more important in later age as calcium intake typically diminishes, which may increase hip fracture risk (Kanis et al., 1999). Another study indicated that men consuming the highest calcium (>1041mg/day) had slightly lowered risk of hip fracture occurrence but was not significant and unknown as to why. The last study to this exception proposed that in individuals with low calcium diets, calcium supplementation significantly reduced one's hip fracture risk (Lau et. al., 1988). Advancing age may lead to homeostatic imbalances in one's ability to maintain appropriate blood calcium levels, therefore calcium supplements provide balance (Wickham et al., 1988). However, the association was described through greater physical activity and exercises in the past compared to the present which may be the reason for increased incidence of hip fractures among older adults. It was not attributed to a change in dietary calcium. Additionally, this study had biases in both hospital and community controls in that they overestimated an inactive population and a healthier population respectively, not reflecting the general population (Lau et. al., 1988). Recall bias was a significant problem with food questionnaires in case-control studies due to difficulties in accurately recalling retrospective information. Case-control studies tend to show an association between calcium intake and hip fracture risk, however, recall bias and the quality of study needs to be considered.

Physical activity and different exercises were considered as a protective factor against both falls and hip fractures. A dose-response relationship exists between recent immobility and increased hip fracture risk, especially in advancing age; however, this relationship has been associated with recall bias (Kanis et al., 1999). Regular exercise can maintain or increase bone mass, especially in postmenopausal women, which can explain the strong relationship between exercise and reduced hip fracture risk (Paganini-Hill et al., 1991). Also, exercise and physical activity can reduce one's risk of falling and the severity of falls by improving balance and coordination (Cooper et al., 1988). Again, physical exercise is indicated by self-report questionnaires, susceptible to recall bias can be the result of a difference in remembering physical activity levels better if you had a hip fracture compared to those who did not (Joakimsen et al., 1997). Additionally, in two of the studies, weight bearing exercises, outdoor activity, walking uphill, and walking with a load were included as exercises that aided in the reduction of hip fracture risk (Lau et. al., 1988), (Cooper et al., 1988). In general, individuals that are physically active also differ from those who are not and may be a healthier subset of the population. Other inconsistencies in studies can be the result of inaccuracies in classifying the type, intensity, frequency, duration, and complexity of physical activities leading to misclassification bias (Joakimsen et al., 1997).

The limitations for the articles presented in this study related mostly to the quality or design of the study. Independent studies indicated problems with smaller sample sizes (poor statistical power), low sensitivity of risk factors to identify susceptible individuals, or low quality evidence (Lau et. al., 1988), (Bischoff-Ferrari et al., 2007). Although this review studied the effects on both men and women, there are a limited number of studies that include men. Prospective cohort studies also experienced loss to follow-up, residual confounding, and a lacked vitamin D and phosphate doses. Confounding may have been a result of studies not adjusting for significant risk factors (Bischoff-Ferrari et al., 2007). The main limitation of our study was the inability to access relevant studies or obtaining high quality studies that compare calcium intake and exercise exclusively or in multicomponent intervention studies.

CONCLUSIONS

Overall, our findings indicated a strong relationship between exercise and reduced hip fracture risk, whereas calcium did not produce significant effects in adults older 50 years in prospective cohort studies and meta-analysis studies. From our analysis, we recommend that hip fracture prevention should focus on physical activity and exercise as it is inexpensive, can be easily modified for the different populations, and is effective for other health benefits. However, further quality studies should be done to exclusively test the differences between calcium intake and exercise to reduce hip fracture risk.

FUTURE DIRECTIONS?

Analyzing the association between both calcium and exercise and the risk of hip fracture is an important area of research. Fractures are of the most common injuries affecting elderly populations which lead to serious health and social implications. Further research regarding the biological mechanisms and benefits of both calcium supplements and dietary calcium is crucial in order to better understand and protect high-risk individuals. Studies should focus on the optimal combination between calcium, vitamin D, and phosphate supplements to improve bone health and subsequent fractures. Also, the creation fracture or injury registries or an extensive patient history are important to create consistency between studies. Also, public health strategies need to be made and implemented to reduce the rising incidence of hip fractures. Studies need to focus on strategies to limit recall bias, especially in older adults where it is fairly common to obtain inaccurate histories on past falls and injuries. The studies under investigation also recommended studies that focus on male hip fracture risk, prospective studies to identify risk factors that can be used for the basis of interventions, and more studies that provide epidemiological data to compare exercise and calcium and how it influences one's hip fracture risk.