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Original Article

Physical Activity and Risk Factors for Hip Fractures in Thai Women

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Abstract. Hip fractures are among the most important causes of ill health and death among elderly people. Several potentially modifiable risk factors have been reported. Most claimed physical activity as a promising, inexpensive preventive measure for hip fracture. However, knowledge about risk factors for hip fracture in Asian populations is very limited. We therefore conducted a case–control study to assess the relationships between physical activity and risk of hip fractures in Thai women. From 14 hospitals in Thailand, 229 cases with a radiologically confirmed first hip fracture were enrolled. Two hundred and twenty-four controls were randomly recruited from the same neighborhood and were matched to the cases by age within a 5 year range. Information on physical activity as well as other potential confounders was obtained through personal interviews. Multivariate logistic regression revealed that past physical activity was protective in both very active and active women (OR = 0.67, 95% CI = 0.40–1.12 for moderately active women and OR = 0.20, 95% CI = 0.10–0.38 for very active women; p value for trend <0.01). Recent physical activity reduced the risk to about two-thirds (OR = 0.33, 95% CI = 0.19–0.60 and OR = 0.35, 95% CI = 0.18–0.69 for moderately and very active women respectively). In addition, breastfeeding was identified to be a protective factor (OR = 0.87, 95% CI = 0.80–0.94). In contrast, the following risk factors were identified: current use of antihistamine (OR = 13.96, 95% CI = 1.38–141.13) or traditional medicine (OR = 7.66, 95% CI = 2.71–21.63), underlying cerebrovascular diseases (OR = 6.53, 95% CI = 2.10–20.34), history of fracture (OR = 4.04, 95% CI = 1.26–12.99), parental Chinese racial background (OR = 2.52, 95% CI = 1.49–4.23), alcohol consumption (OR = 2.30, 95% CI = 1.04–5.09).

Keywords: Hip fracture; Case–control study; Physical activity

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Introduction

Hip fracture, a significant cause of morbidity and mortality in the elderly, is expected to increase exponentially in frequency over the next 50 years as a result of increased life expectancy and population growth [1]. In Thailand, the age-adjusted incidence was 7/100 000 in 1993 [2]. Two-thirds of the patients in this study were women. Medical care cost for hip fracture in this country was about US $1000 per event, nearly one-third of the national per capita income [2]. Because of the economic and social burdens of hip fracture, risk factors should be explored in an attempt to find novel means of prevention. Many reports from the western world have revealed several potentially modifiable risk factors [3]. Most claimed physical activity as a promising, inexpensive preventive measure for hip fracture [4]. Review of studies in our country revealed no report regarding physical activity and hip fracture risks. We therefore conducted a case–control study to identify hip fracture risks in Thai elderly women. The study concentrated on physical activity and some possible confounding factors involving parental racial background, type of housing and activity before fracture, breastfeeding and reproductive history, smoking and

alcohol consumption, body mass index (BMI), history of medication and calcium intake, underlying diseases, history of fracture and past falls.

Subjects and Methods

Subjects

In this case–control study, women with a first hip fracture (case patients) were compared with women without hip fracture (controls) to determine whether past and present physical activity were associated, taking into account possible confounding factors. Fourteen hospitals in Bangkok and its vicinity participated in the study during August 1, 1997 to September 15, 1998.

Selection of Cases

Cases were women aged $\geqslant 51$ years old admitted to the emergency rooms or orthopedic wards of the participating hospitals during the study period with a first episode of hip fracture (ICD codes 820.0, 820.2). The diagnosis was confirmed by radiology reports. The following were excluded: patients with pathologic hip fracture, patients with traumatic fractures or patients who were severely ill, unable to cooperate and had no proxy respondents.

Selection of Controls

Since the census was not complete in the study area, controls were selected from women who lived in private homes within a 20 min walk clockwise from the houses of cases. Each control subject was matched by age (within a 5 year range, but not less than 51 years old) and had no history of hip fracture. Controls who were severely ill or unable to cooperate and had no proxy respondents were excluded.

Data Collection

A structured questionnaire constructed with the aid of experts was tested and validated. Trained interviewers used the questionnaire to ask the subjects within 2 weeks of the fracture episode about the study variables. Proxy respondents were interviewed when a subject was medically incapacitated or cognitively impaired.

Measurements

Three types of past physical activity at three different ages (18–24, 25–50, and 51 years up) were assessed: housework, physical labor during employment, and heavy sport exercise. Scores for each activity were calculated in the following manner: if the respondent did not participate in an activity, she received a score of 0. If she did participate, she received a score of 1, 2 or 3 according to the frequency (hardly ever = 1, sometimes = 2, very often = 3). These scores were then summed and categorized as inactive, active and very active on the basis of the tertiles of total scores in controls.

Eight types of physical activity performed during the year before hip fracture were assessed: shopping, walking upstairs, walking uphill, lifting heavy objects, doing housework and labor work. For each activity, a frequency of 1, 2 or 3 or more times per week were scored as 1, 2 or 3 respectively. The individual activity scores were summed to produce a total score that was categorized as inactive, active or very active based on the tertiles of total scores in controls.

Activity before fracture was classified into four groups: did not require a gait aid (human or equipment) for either indoor or outdoor activity, could walk outdoors with a gait aid, had to stay at home and walk with a gait aid, and wheelchair-bound or bedridden.

All subjects were asked whether their parents were of Chinese race or ethnicity. Questions on the type of building in which the subject lived (high-rise or low-rise), whether she lived alone or with relatives, residence on the first floor or higher, and use of lifts were also included in the questionnaire.

Alcohol consumption was assessed by the total amount, types of liquor and frequencies of drinking in 1 week. Subjects were classified as a drinker based on the tertile of the total amount of alcohol consumption in controls. Since the amount of the first and second tertiles equaled zero, reclassification was done using the median: if the alcohol consumption exceeded zero, the subject was labeled as a drinker.

Number of packs (20 cigarettes/pack) and duration of smoking were recorded. A subject was classified as a smoker based on the tertiles of the total amount smoked in controls. Since the amount of the first and the second tertiles equaled zero, reclassification was done using median: if the cigarette consumption exceeded zero, the subject was labeled as a smoker.

Daily calcium intake was measured using a food frequency questionnaire with portion size estimation within a 1 week period prior to the interview. Average daily calcium intakes of 1 week of regular diet were calculated by multiplying the frequency of consumption of each food item by its calcium content and summing over all foods.

Questions on the current use of the following drugs were included in the questionnaire: diuretics, steroids, sedatives, antihypertensives, anticonvulsants, antihistamines, thyroid hormones and traditional medicine.

The underlying diseases included in the questionnaire were hypertension, diabetes mellitus, cerebrovascular diseases, Parkinsonism, cancer, and thyroid, renal and cardiac diseases.

All subjects were asked whether they had experienced a fall in the year before the interview and whether they had had a physician-diagnosed fracture since the age of 40 years.

Age at menarche and menopause, number of pregnancies, livebirths and children breastfed for at least 3 months, history of oophorectomy and hormone replacement therapy were recorded.

Height and weight were measured using standard techniques and BMI calculated (BMI; kg/m^2).

Statistical Analysis

Data analysis was conducted using STATA (Stata Statistical Software; release 5.0; Stata Corporation, College Station, TX). The univariate analysis was done using chi-squared tests, or Fisher's Exact test where appropriate, to determine the association. Multiple logistic regression analysis was used to estimate the odds of hip fracture, which was affected by physical activity after controlling for confounding variables. Variables whose *p*-values were less than or equal to 0.10 in the univariate analysis were included in the logistic model. Likelihood ratio tests were used to determine what confounding factors should be excluded from the model, which already contained physical activity.

Results

There were 453 women in this study: 229 cases and 224 controls aged (mean $\pm$ SD) 75.3 $\pm$ 9.1 and 73.9 $\pm$ 8.5, respectively. Proxy interviews were required in 26 cases and 32 controls. Among these 229 cases, 114 (49.8%) suffered from intertrochanteric fracture, 103 (44.9%) from cervical fracture and 12 (5.3%) from subcapital fracture.

Comparison of Cases and Community Controls

Table 1 presents the associations between each study variable and hip fracture from univariate analysis which reached a statistically significant level ($p<0.10$). The factors associated with an increased risk included parental Chinese race (both father and mother), activity before fracture, alcohol consumption, underlying diseases such as hypertension, diabetes, cerebrovascular diseases and thyroid diseases, a history of taking diuretics, sedative, antihistamines and traditional medicine, a history of fracture and past falls, number of pregnancies, livebirths and children breastfed. No association was detected for smoking, BMI and calcium intake, or ages at menarche and menopause. Adjusted odds ratio estimates from multiple logistic regression finally revealed three protective factors and seven risk factors as depicted in Table 2. Protective factors were recent physical activity, past physical activity and breastfeeding. Recent physical activity reduced the risk to about two-thirds (OR = 0.33, 95% CI = 0.19–0.60, and OR = 0.35, 95% CI = 0.18–0.69 for moderately and very active women respectively). There was a dose–gradient relationship of past physical activity and risk of hip fracture (OR = 0.67, 95% CI = 0.40–1.12 for moderately active and OR = 0.20, 95% CI = 0.10–0.38 for very active women; *p* value for trend <0.01). Breastfeeding was also protective (OR = 0.87, 95% CI = 0.80-0.94). This indicated that for each additional child breastfed, the risk decreased by 13%. History of antihistamine use increased the risk about 14-fold (OR = 13.96, 95% CI = 1.38–141.13). Other risk factors were, in order: traditional medicine (OR = 7.66, 95% CI = 2.71–21.63), underlying cerebrovascular diseases (OR = 6.53,

Table 1. Distribution of general characteristics and physical activity among cases and community controls

Factors	Cases (n = 229)	Control (n = 224)	p value
Physical activity			
Recent physical activity			
Very active	12.66	31.25	<0.001
Active	21.40	34.38	
Inactive	65.94	34.38	
Past physical activity			
Very active	8.73	32.59	<0.001
Active	28.82	29.46	
Inactive	62.45	37.95	
Race			
Chinese father and mother	38.86	19.64	<0.001
Chinese father or mother	56.33	74.11	
Thai father and mother	4.80	6.25	
Lives with			
Relatives	95.20	93.75	0.031
Other people	3.49	1.34	
Alone	1.31	4.91	
Activity before fracture			
Goes out with gait aid	14.85	12.05	<0.001
Home with gait aid	41.48	16.96	
Sits or bedridden	2.62	2.68	
Normal	41.05	68.30	
Risk behavior			
Alcohol consumption, mg/week, median (range)	(0–663)	0 (0–464)	0.090[b]
>0	12.23	7.59	0.099
0	87.77	92.41	
Underlying diseases			
Hypertension, Yes	43.67	29.46	0.002
Diabetes mellitus, Yes	25.76	16.96	0.022
Cerebrovascular diseases, Yes	13.54	2.23	<0.001
Thyroid, Yes	5.68	1.79	0.029
Medication			
Diuretics, Yes	7.21	2.74	0.031
Sedative, Yes	7.14	2.73	0.032
Antihistamine, Yes	6.64	0.45	<0.001
Traditional medicine, Yes	8.77	3.57	0.022
History of falls, Yes	43.67	29.91	0.002
No. of falls, median (range)	2 (1–17)	1 (1–6)	<0.001[b]
History of fracture, Yes	7.42	2.68	0.021
No. of pregnancies			
⩽4	37.12	28.12	0.041
>4	62.88	71.88	
Breastfeeding, median (range)	4 (0–13)	5 (0–16)	0.010[b]
⩽4	58.52	48.20	0.028
>4	41.48	51.79	
No. of liveborn, median (range)	4 (0–13)	5 (0–16)	0.032[b]
⩽4	52.84	44.20	0.066
>4	47.16	55.8	

Figures are frequencies (% of column for each characteristic)
[b]Mann–Whitney test.

Table 2. Multiple logistic regression analysis on the relationship between hip fracture and predictor variables

Physical activity	OR (95% CI of OR)
Recent physical activity	
Very active	0.35 (0.18–0.69)
Active	0.33 (0.19–0.60)
Inactive	1
Past physical activity	
Very active	0.20 (0.10–0.38)
Active	0.67 (0.40–1.12)
Inactive	1
Breastfeeding	0.87 (0.80–0.94)
Race	
Chinese father and mother	2.52 (1.49–4.23)
Chinese father or mother	1.02 (0.35–2.92)
Thai father and mother	1
Activity before fracture	
Goes out with gait aid	1.12 (0.59–2.39)
Home with gait aid	2.06 (1.13–3.77)
Sits or is bedridden	0.42 (0.11–1.67)
Normal	1
History of fracture	
Yes	4.04 (1.26–12.99)
No	1
Alcohol consumption (mg/week)	
>0	2.30 (1.04–5.09)
0	1
Cerebrovascular diseases	
Yes	6.53 (2.10—20.34)
No	1
Antihistamine	
Yes	13.96 (1.38–141.13)
No	1
Traditional medicine	
Yes	7.66 (2.71—21.63)
No	1

95% CI = 2.10–20.34), history of fracture (OR = 4.04, 95% CI = 1.26–12.99), parental Chinese racial background (OR = 2.52, 95% CI = 1.49–4.23), any alcohol consumption (OR = 2.30, 95% CI = 1.04–5.09) and staying at home with a gait aid (OR = 2.06, 95% CI = 1.13–3.77). Calcium intake, smoking, BMI, menstrual history, number of livebirths and other underlying diseases except cerebrovascular diseases were not significantly associated with hip fracture after adjustment by multivariate analysis. Possible interactions among independent variables were explored by adding interaction terms into the multiple-variable model, and none of the interactions achieved statistical significance ($p>0.05$)

Discussion

The result of this study confirmed the previously reported associations between physical activity and risk of hip fractures. We found that past physical activity significantly reduced the risk with a dose–response relationship. Recent physical activity also decreased the risk to about two-thirds for both levels of activity. Joakimsen et al. [4] reviewed 18 case–control studies on physical activity and predisposition for hip fracture. They found that people who were physically active had a reduced risk of later hip fracture by up to 50%. Subsequent reports were consistent with their conclusion. In premenopausal women job-related physical activity is an important factor in maintaining adequate bone mass [5]. Another study by Madsen et al. [6] revealed that weight-bearing exercise enhanced bone mineral density (BMD) in young adult women. Lifetime occupational physical activity also had a positive effect on BMD of the femoral neck of postmenopausal farmers [7]. Coupland et al. [8] showed that habitual physical activity increased BMD at the hip and whole body in postmenopausal women. The latest prospective cohort study including four medical centers confirmed a reduced risk for hip fracture among older community-dwelling women. The important issue is to focus on types of physical activity that substantially reduce risk. Housewives who do more than 9 h of heavy chores per week would reduce the risk to one-third [9]. For those who worked in an office, trends in reducing risk were evident for customary activity such as standing for more than 4 h, walking for more than 1 h daily, brisk fast walking and stair climbing. Moderate-to-vigorous intensity of sport or recreational activity also halved the risk of hip fracture. Another important finding from the national health survey in Thailand was the high incidence of falls in the old age group [10]. Fall-related hip fracture has been known for several years. In 95% of our patients hip fracture resulted from a fall. To prevent falls, physical activity plays an important role in increasing BMD as well as improving gait, balance, coordination and proprioception [11]. These balancing mechanisms decrease the propensity to fall. Weight-bearing exercise also reduced the chance of falling [12]. We therefore recommend future research, preferably a randomized trial, on the types and duration of physical activity and fall preventive measures in reducing the risk of hip fracture in Thai women.

Taking another approach to measuring physical activity, i.e., the activity before fracture, we found that women who could go out with a gait aid did not have an increased risk of hip fracture but those who had to stay at home and used gait aid had a 2-fold increased risk. We postulated that those who could go outside had greater muscle strength, better neuromuscular function, stability and visual acuity, thus reducing the propensity to fall.

Breastfeeding is the other possible protective factor for hip fracture. We found a 13% risk reduction for hip fracture for each child breastfed. Theoretically, infants need calcium from breast milk resulting in a reduction in maternal bone density. However, no report has found this expected negative association. Some studies have shown the protective effect of breastfeeding. Cumming and Klineberg [13] found that the odds ratio for ever versus never breastfeeding was 0.47, with a dose–response relationship between average duration of breastfeeding per child and risk of hip fracture. However, a recent study in Mexican women could not duplicate this finding [14]. A prospective cohort study is needed to provide better evidence of the relationship.

Several independent risk factors for hip fracture emerged from this study. Use of antihistamine increased the risk about 14-fold. However, the estimate seems to be less reliable due to a very wide 95% confidence interval. The other drug found to be a risk factor was traditional medicine. This could be due to the fact that traditional medicine was mixed with corticosteroid, the osteoporotic effect of which has been well documented for decades [15] . Even in a country with well-regulated pharmaceutical products, traditional medicine containing corticosteroid has been identified [16].

Apart from medications, some other factors were found to increase the risk of hip fracture i.e., alcohol intake, cerebrovascular diseases , history of fracture after the age of 50, and Chinese parental race. Except for the latter, the association of these factors to hip fractures have been well documented [17–19].

The association of Chinese parental race with hip fractures is a new finding. It is evident that 80% of the variance in BMD can be attributed to genetic factors [20]. Potential candidate genes for the regulation of bone mass include the vitamin D receptor (VDR), the estrogen receptor, interleukin-6, and the collagen type 1 genes [21]. Recent study showed that VDR genotype distributions in Thai postmenopausal women were different from those reported in Caucasians [22]. This could partly explained the genetic risk of hip fracture among different races or ethnicity. Future research on genetics epidemiology may clarify the hip fracture risk difference between the population of Chinese and non-Chinese parental racial background found in our study.

In summary, our evidence shows that lifestyle modification, particularly lifetime physical activity, breastfeeding and alcohol abstinence may help prevent hip fractures in Thai women.

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