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Hip fracture mortality and morbidity in Switzerland and Japan: A cross-cultural comparison

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Hip fracture incidences differ substantially from country to country. It is interesting to note that most studies found that the frequency of hip fractures is higher in Western Europe than in Asia and Africa [1–12] or higher in Whites than in Hispanics, Blacks, and Asians in the US [13]. Nevertheless, hip fractures are considered as an increasing public health problem even in Asian populations [14].
In studying cross-cultural differences in diseases, one can compare countries in which both medical and social conditions are as similar, or as dissimilar, as possible. If one wishes to compare the frequency of hip fractures in elderly people in Switzerland to those in a medically similar country of Asia, Japan would probably be the most appropriate country because of the similarities in the level of health care and in affluence in general. For example, the infant mortality rate (known to reflect the quality of both perinatal care and the health system of a country) was 6.9 per 1000 live-births for 1985 in Switzerland, while it is 5.5 per 1000 live-births in Japan. The life expectancy for the Japanese was 75.5 years in 1988 in males and 81.3 years in females, which is similar to Swiss figures.
Given the importance of hip fractures at old age, this paper compares hip fracture mortality and morbidity of elderly people in both Switzerland and Japan, discusses possible reasons for the differences observed, and finally suggests a new hypothesis to explain the apparently high hip fracture incidence in the Swiss population.

Methods

In order to describe mortality from hip fractures, we used the vital statistics from 1986 to 1988 in both Switzerland [15] and those in Japan [16]. According to 1987 data, the population over 60 years old was 1.3 million in Switzerland and 19.4 millions in Japan. To estimate the death rates, we used the death numbers averaged over three years (1986 to 1988). We calculated both the age-specific death rates per 100000 population by sex and the age-adjusted death rates over 60 years old using the world standard population.
The disease classification codes used here were the ICD-8 (International Classification of Diseases, revision 8) in Switzerland and the ICD-9 (International Classification of Diseases, revision 9) in Japan. The diseases considered for the mortality comparison were all accidents (Switzerland: ICD-8, 800–949, Japan: ICD-9, E800–E949), hip fractures (Switzerland: Special code 887, Japan: ICD-9, 820) und falls (Switzerland: ICD-8, 880–887, Japan: ICD-9, E880–E888).
There exist no representative data on the Swiss nationwide incidence rates of hip fracture. Therefore, we used the estimations published by Gonin et al. [17] and by Gass and Gutzwiller [18] as Swiss data of incidence of hip fracture. These authors estimated the age-specific annual incidence rates of hip fractures only for patients who were hospitalized. Gonin et al. [17] used data of 1986 from the canton of Vaud in Switzerland, including six different sources: (1) medical statistics of central hospital in Lausanne (CHUV), (2) statistical system of main diagnosis on admission in the Swiss Hospital Association (Vereinigung Schweizerischer Krankenhäuser: VESKA), (3) reports from orthopedic surgery, (4) registry of emergency patients of clinic and radiology, (5) registry of operations and (6) reports of protocols of operations. Gass and Gutzwiller [18] used data for 1988 from all Swiss hospitals participating in the VESKA statistics to estimate the incidence of hip fractures.
For Japan, we used incidence data of hip fractures obtained by Hosoda et al. [19,20], who estimated the age-specific annual incidence rates of hip fractures using the number of cases for 1987 reported by hospitals with 200 beds or more throughout Japan. To compare the annual incidence rates for the Swiss with those for the Japanese, we calculated the age-adjusted annual incidence rates.

Results

The age-adjusted death rate (1986/88) for hip fractures for Swiss males over 60 years old is 19.98 (number of deaths: n = 133), and it is 28.93 in females (n = 408), while for the Japanese the rates are only 1.61 in males (n = 136) and 2.73 in females (n = 414) (Table 1). In both sexes, the Swiss death rates thus exceed largely those of Japan. Table 1 shows age-specific death rates due to hip fractures per 100000 per year. These data are also displayed in Figure 1 where the ordinate indicates the loga-

Tab. 1. Age-specific annual death rates[a] due to hip fracture in Switzerland and Japan, 1986/88.

Age	Male		Female	
	Swiss	Japanese	Swiss	Japanese
60–64	1.33 (2)[b]	0.04 (1)	0.57 (1)	0.05 (2)
65–69	3.76 (5)	0.09 (2)	2.20 (3)	0.28 (7)
70–74	9.20 (9)	0.54 (8)	11.30 (15)	0.66 (14)
75–79	24.81 (20)	2.17 (24)	37.19 (47)	2.05 (34)
80–84	84.84 (39)	5.95 (35)	107.26 (95)	10.01 (96)
85–	235.13 (58)	22.04 (66)	391.74 (247)	41.30 (261)
age adjusted[c] rate over 60 years old				
	19.98	1.61	28.93	2.73

[a] Death rates averaged over three years (1986 to 1988), per 100000 population.
[b] Values in parentheses indicate the averaged death numbers of hip fractures.
[c] Standard: world population.

rithm of the death rate. The age-specific death rates in both countries are straight lines with almost the same slope, which means that the gender-independent death rate ratio of at least ten is nearly stable throughout the whole age range. At older age, i.e. above around 70 in Switzerland and above around 80 in Japan, the death rates due to hip fractures in females clearly exceed those in males. Table 2 shows a comparison of annual incidence rates of hip fracture per 100000 population between the Swiss and the Japanese. The annual incidence rates of hip fractures in both countries increase exponentially with age. The annual incidence rate of hip fractures for the Swiss over 85 years old was roughly around 1000 in males per 100000 population and even between 2500 and 3200 in females per 100000, while in Japan, clearly lower values were observed. The age-adjusted annual incidence rates of hip fractures in males aged 60 or more was around 140 and 220 for the Swiss according to the two sources, and about 130 for the Japanese, while in females they were 420 and 490 for the Swiss and about 280 for the Japanese. These results show that the incidence rates of hip fractures are at best two times higher for the Swiss than for the Japanese. In the methodologically more rigorous of the two Swiss studies [17], the incidence rate of hip fracture in men even approached the Japanese male one. Thus, the age-specific ratios of incidence between the two countries did not exceed two, which is smaller than the differential in death rates from hip fracture mentioned above.

Hip fractures in elderly people will obviously most often be caused by falls [21]. The population-wide incidence of falls may therefore be one determinant of the rate of hip fractures and of subsequent deaths, even if only a very small proportion of all falls actually lead to death. In the absence of incidence data on falls among elderly people both in Switzerland and Japan, we also examined mortality data on accidents and falls. Table 3 and Table 4 show the age- and sex-specific death rates from accidents and from falls. Accidental death rates are higher in men than in women, and Swiss rates are higher than Japanese ones, to the extent that accidental mortality is slightly higher in Swiss women than in Japanese men. Remarkably, this excess mortality from accidents in Switzerland seems to be almost entirely due to higher death rates from falls in Switzerland, as Table 4 shows. The proportion of deaths due to falls among all the deaths caused by accidents increases with age in

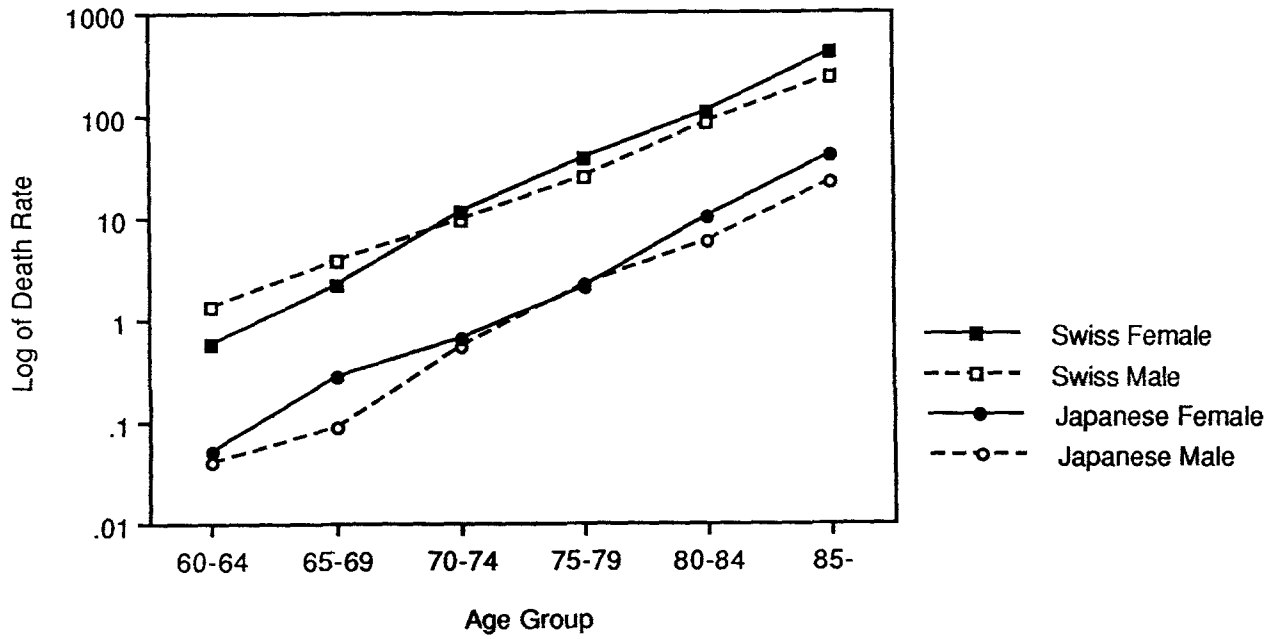

Abb. 1. Annual death rate per 100000 population due to hip fracture in Switzerland and Japan.

Tab. 2. Age-specific annual incidence rates due to hip fracture per 100000 population in Switzerland and Japan.

Age	Male			Female		
	Swiss		Japanese	Swiss		Japanese
	Gonin et al. [17]	Gass & Gutzwiller [18]	Hosoda et al. [20]	Gonin et al. [17]	Gass & Gutzwiller [18]	Hosoda et al. [20]
60–64	41[a] (6)[b]	97	37(180)	143[a] (21)[b]	126	59 (361)
65–69	120[a](11)[b]	120	64(229)	180[a] (22)[b]	206	138 (674)
70–74	103[a] (9)[b]	192	134(408)	410[a] (51)[b]	463	284(1182)
75–79	246[a](17)[b]	345	277(570)	720[a] (77)[b]	924	601(1793)
80–84	410[a](17)[b]	685	425(466)	1475[a](114)[b]	1707	985(1778)
85–	793[a](20)[b]	1179[c]	702(365)	2533[a](152)[b]	3150[c]	1638(1753)
age-adjusted[d] rate over 60 years old						
	143.4	219.3	131.7	423.3	491.2	284.6

[a] Calculated from Fig. 2 of Gonin et al. [17].
[b] Values in parentheses indicate the number of cases upon which the rates were calculated.
[c] Calculated from the annual incidence rates in 85–89 years old age-group and in 90 years older age-groups.
[d] Standard: world population.

Tab. 3. Age-specific annual death rates[a] due to accidents (ICD-8: 800–949 and ICD-9: E800–E949) in Switzerland and Japan 1986/88.

Age	Male		Female	
	Swiss	Japanese	Swiss	Japanese
60–64	60.00 (90)[b]	51.44(1436)	19.89 (35)	15.38 (499)
65–69	75.42 (94)	64.24(1183)	31.28 (47)	23.68 (612)
70–74	128.53(130)	91.83(1412)	58.70 (80)	37.43 (798)
75–79	200.55(159)	135.24(1493)	133.45(169)	63.79(1049)
80–84	379.64(176)	188.05(1096)	310.08(267)	105.89(1019)
85–	763.85(187)	278.07 (837)	878.77(553)	196.73(1243)
age-adjusted[c] rate over 60 years old				
	135.96	86.41	92.20	38.41

[a] Death rates averaged over three years (1986 to 1988), per 100000 population.
[b] Values in parentheses indicate the averaged death numbers of accidents.
[c] Standard: world population.

Tab. 4. Age-specific annual death rates[a] due to falls (ICD-8: 880–887 and ICD-9: E880–E888) in Switzerland and Japan, 1986/88.

Age	Male		Female	
	Swiss	Japanese	Swiss	Japanese
60–64	19.78 (30)[b]	8.21(229)	6.69 (12)	1.55 (50)
65–69	32.21 (40)	10.12(186)	12.55 (19)	2.62 (68)
70–74	62.13 (63)	14.80(228)	36.84 (50)	5.11(109)
75–79	104.69 (83)	20.83(230)	96.26(122)	10.35(170)
80–84	251.65(117)	35.22(205)	246.13(218)	27.86(268)
85–	604.83(148)	77.08(232)	790.89(498)	88.82(561)
age adjusted[c] rate over 60 years old				
	75.72	15.44	68.45	8.45

[a] Death rates averaged over three years (1986 to 1988), per 100000 population.
[b] Values in parentheses indicate the averaged death numbers due to falls.
[c] Standard: world population.

both countries. However, in Swiss men, this proportion (i.e. deaths from falls among all deaths from accidents) rises from 33.3% in the 60 to 64 year olds to 79.1% in the over 85 year olds [15], while in Japanese men the corresponding figures are 16.0% and 27.7% [16]. In females, the corresponding proportions rise from 34.3% to 90.0% for the Swiss [15], and from 10.0% to 45.1% for the Japanese [16]. As a consequence, the majority of accidental deaths in Swiss persons over 75 years are due to falls.

Discussion

This cross-cultural comparison of the frequency of hip fractures between Switzerland and Japan found a striking gradient in hip fracture mortality – approximately ten times more frequent in Switzerland -, while the differential was more modest regarding hip fracture morbidity. Before discussing reasons for these differences, the validity of the data analyzed should be examined.

The codes for causes of death in the vital statistics are principally based on the primary cause of death as described in death certificates, according to recommendations by the World Health Organization. Like in many other countries, these codings are done by specialists in both Switzerland and Japan. In Switzerland, the coding is centralized for the whole country (Federal Office of Statistics). One could thus argue that since such probably reliable national vital statistics were used to compare the death rates of hip fractures, accidents and falls for the Swiss and the Japanese, the results obtained should be valid.

However, it is also known that coding practice for reasons for death may not be completely consistent between countries. For example, in Switzerland, as a rule, violent death is given the highest priority in the

„hierarchy" of causes of death[22], and this „upwards shifting" of all accidental deaths, including those from hip fracture, accidents and falls in death certificates, may inflate the Swiss mortality rate, hereby exaggerating the true difference in deaths from hip fracture between Switzerland and Japan. This possibility is further confirmed by the lesser differential between the two countries when hip fracture morbidity is considered. British authors[23] have, indeed, demonstrated that undercertification of fractured neck of the femur in death certificates can be substantial, and this may be one reason for falseley-low mortality rates from hip fracture in some countries. As a consequence, the present mortality data should only be interpreted with caution.

Unfortunately, the reliability of the hip fracture incidence data is even more problematic than for the mortality data since, at least for Switzerland, the representativity of the hospital data for hip fracture is less than optimal (Gass and Gutzwiller[18]). As a recent validation study in a distinct part of Switzerland showed (Gonin et al.[24]) the Swiss VESKA hospital statistics provides a useful approximation of the actual number of cases treated, while for calculating representative incidence rates a greater proportion of all hospitals nationwide should participate in these statistics.

Our observation of an apparently higher lethality of hip fractures in Switzerland (i.e. the proportion of those dying from hip fracture among all those sustaining hip fracture) must therefore be viewed with caution. Nevertheless, the size of the differential is impressive, since in Switzerland one in 7 to 11 hip fractures in men, and one in 15 in women, is lethal, while the corresponding figures for Japan are one in 82 for men and one in 104 for women (all based on age-adjusted rates).

Even though the extent to which Swiss-Japanese differences in hip fracture mortality and morbidity are influenced by limitations of data quality remains unknown, such methodological drawbacks are, in our opinion, unlikely to explain the *whole* cross-cultural differential observed. We thus believe that biological explanations should also be looked for.

Interestingly, in Figure 1 if one shifts the lines in both sexes for the Swiss 10 years upwards, they almost overlap with the lines for the Japanese, indicating that the death rates for the Swiss equal those for the Japanese approximately 10 years older. This means that the age-associated increase in slope is much the same both for the Swiss and for the Japanese. The "force of aging" on hip fracture occurrence seems thus to have a comparable size in both countries, but in Japan its effect becomes evident later in life.

Which may now be, leaving aside potential assessment errors, the factors influencing the cross-cultural differential in hip fracture morbidity and mortality observed between Switzerland and Japan? As suggested in many papers, main risk factors, of hip fractures are age, female sex, white race, low calcium intake, low body weight, estrogen deficit, low physical activity, hereditary factors, smoking, heavy alcohol drinking and several others[25–36]. However, there is no overwhelmingly important single factor related to hip fractures according to present knowledge.

Several studies indicate that dietary calcium intake during adolescence and young adult age affects peak bone mineral content[37]. Average calcium intake per day per capita in 1985 was about 900 mg for the Swiss and 550 mg for the Japanese, estimated from national food consumption data[38]. The average calcium intake for the Japanese is thus only about one half of that of the Swiss. The Japanese 60 years old in 1987 even had a much lower average calcium intake of about 270 mg per day in 1950 when they were young[38]. Therefore, a difference in calcium intake cannot explain the burden of hip fractures in the Swiss, even though there may exist differences in calcium absorption[39,40] between the Swiss and the Japanese.

Estrogen deficit is one of the more important risk factors of osteoporosis, which in turn may cause hip fractures[27,28]. The effect of estrogen is, however, unlikely to account for any of the difference in the frequency of hip fracture between Switzerland and Japan, since estrogen replacement therapy is apparently not widely used by Japanese perimenopausal women[41]. Neither are differences in the prevalence of obesity – which is a protective factor against hip fracture[25] – a likely explanation for the difference in hip fracture incidence, since average body weight for height tends, if anything, to be lower in Asian than in Western European populations[42–44].

Regular physical activity and weight-bearing exercise could prevent bone loss or even increase bone mass[29,30]. Approximately one third of the Swiss elderly people do physical exercises such as walking, hiking, swimming and skiing[45], while few Japanese elderly people have such habits. This increased physical activity of Swiss elders could enhance bone mass and thus reduce fracture risk. On the other hand, frequent exercise could also elevate the risk of falls and thus the risk of hip fracture. Preliminary evidence shows that the "net effect" of regular activity rather protects from than provokes hip fractures[46].

As shown in Tables 3 and 4, a higher absolute and relative incidence of falls in Switzerland might be one relevant reason for the greater burden of hip fractures in Switzerland compared with Japan. The proportion of deaths due to falls among all accidental deaths is much greater in both sexes for the Swiss than for the Japanese. This might at least in part be responsible for the age-specific differences between the death rates of hip fractures for the

Swiss and the Japanese. Main causes of falls may be diseases use of drugs, sensory impairments, handicaps, alcohol drinking and so on[47–49]. Unfortunately, we have no appropriate data to discuss the importance of these causes in explaining differences between the Swiss and the Japanese.

We have the impression that all the factors discussed so far can still not explain the substantial difference in hip fracture morbidity and mortality between Switzerland and Japan. On one hand this could be due to the fact that all these factors are only based on ecological comparisons, with all the possibilities of confounding they involve. On the other hand, we would like propose another aetiological hypothesis that may explain at least some of the difference observed in the burden of hip fracture between Switzerland and Japan: we speculate that body build could be one significant cause of falls and, hereby, also of hip fractures. The weight distribution for Japanese apparently differs from that for the Swiss, even though they have comparable height and weight. As the average Japanese has a rather longer body and shorter legs[50] than the average European, the body center of gravity of a Japanese adult may be lower than that of a Swiss adult. On one hand, this might explain in part that frequencies of falls for the Japanese are so much lower than for the Swiss. In European countries like Switzerland, the westernized life style such as putting on shoes inside rooms, having rugs in rooms and sleeping in beds may further increase the risks of falls[51]. On the other hand, the Japanese body build may attenuate the impact of a fall in those who do fall, leading to a diminished proportion of fall-related hip fractures.

In summary, death rates of hip fractures of elderly people appear to be clearly higher for the Swiss than for the Japanese. This is also true for death rates from all accidents and from falls. However, given the doubts on the reliability and, consequently, the comparability of the international mortality and morbidity data, this conclusion should be regarded as preliminary. The reasons for these apparent cross-cultural differences remain largely unclear. Future investigations should be done to define more precisely the relevant risk factors of hip fracture. This goal might, for example, be approached by conducting an epidemiological study involving measurement of femoral neck bone density as well as rate of falls in both Swiss and Japanese people living in Switzerland.

Summary

Based on national mortality data, the frequency of hip fractures in elderly people was compared between Switzerland and Japan. Age-adjusted annual incidence rates per 100 000 population estimated for Swiss persons over 60 years were around 150 and 200 in males and around 450 in females, while for the Japanese they were only 132 in males and 285 in females. Age-adjusted death rates from hip fracture for the Swiss over 60 were 20.0 in males and 28.9 in females, while for the Japanese they were only 1.6 in males and 2.7 in females. The inclination of the age-dependent slope in hip fracture mortality rates was substantially the same in both countries, but there was a "lag time" of approximately 10 years in Japan. Remarkably, the proportion of deaths due to falls among all accidental deaths was several times greater in both sexes for the Swiss than for the Japanese. This differential might be an important underlying reason for the observed difference between death rates of hip fracture in Switzerland and Japan. Other known behavioral risk factors for hip fracture such as diet, exercise, estrogen use etc. are unlikely to explain the observed difference in hip fracture mortality and morbidity between Switzerland and Japan. However, given the doubts on the reliability and thus comparability of the available data on mortality and morbidity, the present findings should be regarded as preliminary. In conclusion, we believe that the unexplained and large difference in the burden of hip fracture between Switzerland and Japan merits further studies, including new aetiological hypotheses.

Résumé

Mortalité et morbidité des fractures de la hanche en Suisse et au Japon: Une analyse transculturelle

Basée sur les données de mortalité nationales, la fréquence des fractures de hanche des personnes âgées est comparée entre la Suisse et le Japon. Les taux d'incidence annuels corrigés pour l'effet de l'âge chez les personnes suisses âgées de plus de 60 ans sont d'environ 150–200 chez les hommes (par rapport à 100 000 habitants), ainsi qu'environ 450 chez les femmes, tandis qu'au Japon les incidences correspondantes s'élèvent à 132 chez les hommes et 285 chez les femmes. La mortalité des fractures de hanche, corrigée pour l'effet de l'âge s'élève chez les Suisses âgés de plus de 60 ans à 20,0 (par 100 000) chez les hommes et à 28,9 chez les femmes, alors que chez les Japonais les taux correspondants sont 1,6 chez les hommes et 2,7 chez les femmes. La proportion de décès faisant suite à des chutes parmi l'ensemble des accidents mortels est remarquablement plus élevée en Suisse qu'au Japon, pour les femmes comme pour les hommes. Cette différence pourrait expliquer le taux élevé de décès suite à une fracture de hanche observé en Suisse. D'autres facteurs de risque pour la fracture de hanche liés au style de vie ne sont apparemment pas en mesure d'expliquer les différences de mortalité et de morbidité par fracture de hanche observées entre la Suisse et le Japon. Face aux doutes qui concernent la fiabilité et la comparabilité des données à disposition, ces résultats doivent être interprétés avec

prudence. Toutefois, nous pensons que la différence substantielle des taux de fractures de hanche entre Suisse et Japon, qui reste inexpliquée, devrait être examinée plus en détail, également en ce qui concerne de nouvelles hypothèses étiologiques.

Zusammenfassung

Mortalität und Morbidität von Hüftfrakturen in der Schweiz und Japan: Eine transkulturelle ökologische Analyse

Gestützt auf nationale Sterbedaten wird die Häufigkeit von Hüftfrakturen bei Betagten in der Schweiz und Japan verglichen. Alterskorrigierte jährliche Inzidenzraten (bezogen auf 100000 Einwohner) bezifferten sich bei den Schweizer Personen über 60 Jahren auf ca. 150–200 bei den Männern sowie ca. 450 bei den Frauen, während bei den Japanern die entsprechenden Inzidenzen lediglich 132 bei den Männern und 285 bei den Frauen betrugen. Die alterskorrigierte durch Hüftfrakturen bedingte Mortalität (pro 100000) betrug bei den Schweizern über 60 Jahren 20,0 bei den Männern und 28,9 bei den Frauen, während bei den Japanern die entsprechenden Werte bei 1,6 für Männer und 2,7 für Frauen lagen. Die Gerade, die das Verhältnis zwischen Alter und Hüftfraktur-Mortalität charakterisiert, zeigte in beiden Ländern ungefähr die gleiche Steigung, war in Japan jedoch um ca. 10 Jahre „rechtsverschoben". Bemerkenswerterweise war der Anteil sturzbedingter Todesfälle unter allen unfallbedingten Todesfällen bei beiden Geschlechtern in der Schweiz wesentlich höher als in Japan. Dieser Unterschied könnte eine wichtige, zugrundeliegende Ursache für die Differenz in der Hüftfrakturmortalität zwischen der Schweiz und Japan darstellen. Andere verhaltensabhängige Risikofaktoren für Hüftfraktur wie Ernährung, körperliche Bewegung, Oestrogenzufuhr usw. vermögen die beobachteten Unterschiede in der Mortalität und Morbidität an Hüftfraktur zwischen der Schweiz und Japan kaum zu erklären. Angesichts der ungewissen Reliabilität und Vergleichbarkeit der zur Verfügung stehenden Daten müssen die vorliegenden Ergebnisse allerdings mit Vorsicht interpretiert werden. Zusammenfassend glauben wir, dass der grosse und weitgehend unerklärte schweizerisch-japanische Unterschied im Auftreten von Hüftfrakturen weiter abgeklärt werden sollte, unter Einschluss neuer ätiologischer Hypothesen.

References

1 *Gallagher JC, Melton LJ, Riggs BL, Bergstrath E.* Epidemiology of fractures of the proximal femur in Rochester, Minnesota. Clin Orthop 1980; *150*:163–171.
2 *Lewinnek GE, Kelsey J, White III AA, Kreiger NJ.* The significance and a comparative analysis of the epidemiology of hip fractures. Clin Orthop 1980; 152:35–43.
3 *Pogrund H, Makin M, Robin G, Menczel J, Steinberg R.* The epidemiology of femoral neck fractures in Jerusalem: A prospective study (1967–1971). Clin Orthop 1977; *122*: 141–146.
4 *Chalmers J, Ho KC.* Geographical variations in senile osteoporosis: The association with physical activity. J Bone Joint Surg 1970; *52B*:667–675.
5 *Solomon L.* Osteoporosis and fracture of the femoral neck in the South African Bantu. J Bone Joint Surg 1968; *50B*: 2–13.
6 *Smith RW, Rizek J.* Epidemiologic studies of osteoporosis in women of Puerto Rico and Southeastern Michigan with special reference to age, race, national origin and to other related or associated findings. Clin Orthop 1966; *45*:31–48.
7 *Obrant KJ, Bengnér U, Johnell O, Nilsson BE, Sernbo I.* Increasing age-adjusted risk of fragility fractures: a sign of increasing osteoporosis in successive generations? Calcif Tissue Int 1989; *44*:157–167.
8 *Hedlund R, Ahlbom A, Lindgren U.* Hip fracture incidence in Stockholm 1972–1981. Acta Orthop Scand 1985; *57*:30–34.
9 *Falch JA, Ilebekk A, Slungaard U.* Epidemiology of hip fractures in Norway. Acta Orthop Scand 1985; *56*:12–16.
10 *Evans JG.* Incidence of proximal femoral fracture. Lancet 1985; *1*:925–926.
11 *Johnell O, Nilsson B, Obrant K, Sernbo I.* Age and sex patterns of hip fracture-changes in 30 years. Acta Orthop Scand 1984; *55*:290–292.
12 *Elabdien BSZ, Olerud S, Karlstrom G, Smedby B.* Rising incidence of hip fracture in Uppsala, 1965–1980. Acta Orthop Scand 1984; *55*:284–289.
13 *Silverman SL, Madison RE.* Decreased incidence of hip fracture in Hispanics, Asians, and Blacks: California hospital discharge data. Am J Publ Health 1988; *78*:1482–1483.
14 *Lau E, Donnan S, Barker DJP, Cooper C.* Physical activity and calcium intake in fracture of the proximal femur in Hong Kong. Br Med J 1988; 297:1441–1443.
15 *Bundesamt für Statistik*, Sektion Bevölkerungsbewegung, Todesursachenstatistik ESPOP-File. Bern, 1991.
16 Statistics and information department, minister's secretariat, ministry of health and welfare ed. Vital statistics of Japan in 1986–1988. Vol. 2; Tokyo: Zaidan houzin kousei-toukei kyoukai (Foundation society of public welfare and statistics), 1988–1990.
17 *Gonin M, Vader JP, Paccaud F.* Incidence des fractures du fémur proximal dans le canton de Vaud. Schweiz. med. Wschr. 1991; *121*:259–263.
18 *Gass R, Gutzwiller F.* Nutritional risk factors for osteoporosis; A population based study of perimenopausal women in Switzerland. In: Proceedings of international symposium on nutrition aspects of osteoporosis. Lausanne: Raven Press 1991:1–10.
19 *Ross PD, Norimatsu H, Davis JW, et al.* A comparison of hip fracture incidence among native Japanese, Japanese Americans, and American Caucasians. Am J Epidemiol 1991; *133*:801–809.
20 *Hosoda Y, Sasaki R, Yamamoto K, et al.* Incidence of hip fracture. In: Report of Ministry of Health and Welfare Silver Science Research Group. (Intramural report). Ohbu, Aichi Prefecture, Japan: Silver Science Research Group 1988: 96–97.
21 *Melton III LJ, Cummings SR.* Heterogeneity of age-related fractures: implications for epidemiology. Bone Miner 1987; *2*:321–331.
22 Bundesamt für Statistik Schweiz. Die Studie der Todesursachen-Schlüsselung des ISPM aus der Sicht des BFS. Die Sterblichkeitsstatistik in der Schweiz. Bern: 1989:48–51.
23 *Donaldson LJ, Parsons L, Cook AJ.* Death certification in fractured neck of femur. Public Health 1989; *103*:237–243.
24 *Gonin M, Vader JP, Paccaud F.* Qualité des donnees fournies par la statistique médicale VESKA: le cas de la fracture du fémur proximal. Soz Präventivmed 1992; *37*:3–5.
25 *Riggs BL, Melton III LJ.* Medical progress: Involutional osteoporosis. N Engl J Med 1986; *314*:1676–1686.

26 *Nordin BEC, Heaney RP.* Calcium supplementation of the diet: justified by present evidence. Br Med J 1990; *300*:1056–1060.
27 *Kiel DP, Felson DT, Anderson JJ, Wilson PWF, Moskowitz MA.* Hip fracture and the use of estrogens in postmenopausal women: The Framingham Study. N Engl J Med 1987; *317*:1169–1174.
28 *Weiss NS, Ure CL, Ballard JH, Williams AR, Daling JR.* Decreased risk of fractures of the hip and lower forearm with postmenopausal use of estrogen. N Engl J Med 1980; *303*:1195–1198.
29 *Wickham CAC, Walsh K, Cooper C, Barker DJP, Margetts BM, Morris J, Bruce SA.* Dietary calcium, physical activity, and risk of hip fracture: a prospective study. Br Med J 1989; *299*:889–892.
30 *Cooper C, Barker DJP, Wickham C.* Physical activity, muscle strength, and calcium intake in fracture of the proximal femur in Britain. Br Med J 1988; *297*:1443–1447.
31 *Pocock NA, Eisman JA, Hopper JL, Yeates MG, Sambrook PN, Ebert S.* Genetic determinants of bone mass in adults: a twin study. J Clin Invest 1987; *80*:706–710.
32 *Khaw KT, Tazuke S, Barrett-Connor E.* Cigarette smoking and levels of adrenal androgens in postmenopausal women. N Engl J Med 1988; *318*:1705–1709.
33 *Felson DT, Kiel DP, Anderson JJ, Kannel WB.* Alcohol consumption and hip fractures: the Framingham study. Am J Epidemiol 1988; *128*:1102–1110.
34 *Melton III LJ.* Epidemiology of osteoporosis: Predicting who is at risk. Ann N Y Acad Sci 1990; *592*:295–306.
35 *Cummings SR, Kelsey JL, Nevitt MC, O'Dowd KJ.* Epidemiology of osteoporosis and osteoporotic fractures. Epidemiol Rev 1985; *7*:178–208.
36 *Stevenson JC, Lees B, Devenport M, Cust MP, Ganger KF.* Determinants of bone density in normal women: risk factors for future osteoporosis? Br Med J 1989; *298*:924–928.
37 *Matkovic V, Fontana D, Tominac C, Goel P, Chesnut III CH.* Factors that influence peak bone mass formation: a study of calcium balance and the inheritance of bone mass in adolescent females. Am J Clin Nutr 1990; *52*:878–888.
38 *Kagawa A, ed.* Standard table of food composition in Japan. Tokyo: Woman Nutritional College, 1990:512 pp.
39 *Hasling C, Charles P, Jensen T, Mosekilde L.* Calcium metabolism in postmenopausal osteoporosis: The influence of dietary calcium and net absorbed calcium. J Bone Miner Res 1990; *5*:939–946.
40 *Rivlin RS.* Osteoporosis: Nutrition. Public Health Rep 1987; Suppl:131–135.
41 *Orimo H.* Osteoporosis in postmenopausal women. Acta Obst Gynaec Jpn 1990; *42*:785–790.
42 *Keys A.* In: Seven countries. A multivariate analysis of death and coronary heart disease. Harvard University Press, Cambridge, Massachusetts 1980.
43 WHO MONICA Project (prepared by Pajak A, Kuulasmaa K, Tuomilehto J, Ruokokoski E). Geographical variation in the major risk factors of coronary heart disease in men and women aged 35–64 years. World Health Stat Q 1988; *41*:115–140.
44 Health and welfare statistics association, eds. Trend of vital statistics of Japan. Tokyo: Health and welfare statistics association, 1991:512 pp.
45 *Marti B.* Körperliche Bewegung. In: Weiss W, ed. Gesundheit in der Schweiz 1991. Bundesamt für Gesundheitswesen. Bern/Lausanne: Schweizerisches Institut für Gesundheits- und Krankenhauswesen. (in press).
46 *Cooper C, Barker DJ, Wickham C.* Physical activity, muscle strength and calcium intake in fracture of the proximal femur in Britain. Br Med J 1988; *297*:1443–1446.
47 *Gryfe CI, Amies A, Ashley MJ.* A longitudinal study of falls in an elderly population. I. Incidence and morbidity. Age Ageing 1977; *6*:201–210.
48 *Wild D, Nayak USL, Isaacs B.* How dangerous are falls in old people at home? Br Med J 1981; *282*:266–268.
49 *Tinetti ME, Speechley M.* Prevention of falls among the elderly. N Engl J Med 1989; *320*:1055–1059.
50 *Tanner JM, Hayashi T, Precce MA, et al.* Increase in length of leg relative to trunk in Japanese children and adults from 1957 to 1977: comparison with British and with Japanese Americans. Ann Hum Biol 1982; *9*:411–423.
51 *Norimatsu H, Mori S, Uesato T, Yoshikawa T, Katsuyama N.* Bone mineral density of the spine and proximal femur in normal and osteoporotic subjects in Japan. Bone Miner 1989; *5*:213–222.

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