Originals

Prevalence of diabetes mellitus in elderly men aged 65 to 84 years in eastern and western Finland

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Summary. We studied the prevalence of diabetes mellitus in men aged 65 to 84 years in Finland. The study sample consisted of 763 men, the survivors of the Finnish cohort of the "Seven Countries Study" first examined in 1959. The participation rate in the present survey was 94%. Blood glucose, fasting and 2 h after a 75-g oral glucose load, was determined from capillary blood. Current WHO criteria for diabetes mellitus were used. The mean fasting blood glucose level, adjusted for age and body mass index, was higher in east than west Finland. It rose with age in both areas. The prevalence of diabetes was 38% in the east and 36% in west Finland. About one-third of the men had impaired glucose tolerance. In the age group 75

to 79 years, the prevalence of diabetes was 65% in the east and 50% in the west. No systematic variation in the prevalence of impaired glucose tolerance with age was found. The mean levels of body mass index decreased with age in the same way in men with diabetes, impaired glucose tolerance and normal glucose tolerance. Body mass index was not higher in men with diabetes or impaired glucose tolerance than in men with normal glucose tolerance.

Key words: Type 2 diabetes, diabetes prevalence, blood glucose, glucose tolerance, epidemiology.

The prevalence and incidence of diabetes mellitus vary considerably between population and between different age groups within populations [1, 2]. Recent revisions in classification and diagnostic criteria for diabetes mellitus by the World Health Organization in 1980 [3] and 1985 [4] have reduced the methodological problems of diagnosis often found in earlier studies which have made direct comparisons between studies impossible [1, 2]. Diabetes is known to be prevalent in elderly, but until now only few epidemiological studies on diabetes in the elderly have reported their data according to WHO criteria.

It has been suggested that the prevalence of diabetes is about 17% in people older than 65 years in the United States [5, 6]. The second National Health and Nutrition Examination Survey (Hanes II) in the USA found a prevalence of diabetes of 17% in Caucasoid persons and 25% in Black persons aged 65–74 in 1976–80 [7]. In Finland the prevalence of Type 1 (insulin-dependent) diabetes in children and adolescents is known to be the highest in the world [8, 9], and there is good evidence to suggest that Type 2 (non-insulin-dependent) diabetes is also at least as prevalent as in other developed countries [10, 11].

A cohort of men born in eastern and western Finland between 1900 and 1919 were examined first in 1959 in connection with the Seven Countries Study [12, 13]. A 25-year follow-up was accomplished in 1984. The present paper examines the prevalence of diabetes in the survivors of this well-defined cohort of elderly men.

Subjects and methods

Subjects

The survey was carried out from October to November 1984. The study sample consisted of 763 men, 334 from eastern and 414 from western Finland, of whom 716 participated in the present survey. The participation rates were 95% and 93% in eastern and western Finland respectively. The 763 men were the survivors of the 1711 men of the Finnish cohort of the Seven Countries Study [11, 12] first examined in 1959 and followed up for 25 years. The original cohort consisted of all men born 1900–19 from two geographically defined areas, one in eastern and one in western Finland. The procedures of the 1984 survey have been described elsewhere in more detail [14]. The population of the present study in 5-year age groups is shown in Table 1.

Procedures

All men were asked to fast at least 4 h before their appointment at the clinic. The examinations took place between 08.00 and 16.30 hours. Everyone received a letter of invitation which included instructions for fasting and stated the exact time reserved for the clinical examination. At the clinic, capillary blood samples were obtained before and 2 h after a 75-g oral glucose load. All blood glucose measurements were determined from capillary blood using a refractometric method, i.e. by reading Dextrostix sticks in a Glucometer refractometer (Miles Laboratories, Ames Division, Elkhart, Ind, USA) [15]. Excellent correlation and satisfactory replication has been obtained with this method when used in a careful way in comparison to Auto Analyzer or the Hexokinase method [15, 16]. The correct use in our study was assured by adequate training of one laboratory technician who carried out practically all the measurements. During the training period, three control sera with low, intermediate and high glucose concentrations were used in mixed order with other sera. The training was considered adequate when all determinations within one day with the control sera had a precision of at least 95%. During the field survey, the equipment was calibrated daily using the control sera with low

Table 1. Values (mean $\pm$ SD) of fasting capillary blood glucose and blood glucose measured 2 h after a glucose load of 75 g by age group in men aged 65 to 84 years in eastern and western Finland

Age group (years)	Fasting blood glucose (mmol/l)		Two-hour blood glucose (mmol/l) ^a		Total	
	East Mean $\pm$ SD (n)	West Mean $\pm$ SD (n)	East Mean $\pm$ SD (n)	West Mean $\pm$ SD (n)	Fasting blood glucose Mean $\pm$ SD (n)	Two-hour blood glucose Mean $\pm$ SD (n)
65–69	5.7 $\pm$ 2.0 (117)	5.6 $\pm$ 2.0 (116)	8.3 $\pm$ 3.8 (104)	8.9 $\pm$ 3.2 (108)	5.7 $\pm$ 2.2 (234)	8.6 $\pm$ 3.2 (212)
70–74	6.0 $\pm$ 2.4 (97)	5.2 $\pm$ 1.4 (111)	8.8 $\pm$ 2.9 (82)	8.3 $\pm$ 2.8 (101)	5.5 $\pm$ 2.0 (208)	8.5 $\pm$ 2.9 (183)
75–79	6.5 $\pm$ 2.7 (60)	6.1 $\pm$ 2.0 (88)	9.9 $\pm$ 3.2 (44)	10.0 $\pm$ 3.3 (71)	6.3 $\pm$ 2.3 (148)	9.9 $\pm$ 3.2 (115)
80–84	7.0 $\pm$ 3.5 (22)	5.7 $\pm$ 1.7 (52)	8.2 $\pm$ 2.6 (18)	9.8 $\pm$ 3.6 (45)	6.1 $\pm$ 2.4 (74)	9.3 $\pm$ 3.4 (63)
Total	6.1 $\pm$ 2.5 (296)	5.6 $\pm$ 1.9 (367)	8.7 $\pm$ 3.1 (252)	9.1 $\pm$ 3.2 (331)	5.8 $\pm$ 2.2 (663)	8.9 $\pm$ 3.2 (583)
Analysis of variance between age groups:	$p = 0.009$	$p = 0.040$	$p = 0.061$	$p = 0.016$	$p = 0.001$	$p = 0.001$

^a People known to have diabetes or fasting blood glucose 10.0 mmol/l or more were not included in the oral glucose tolerance test

and high concentrations. Every second day the precision of the measurement technique was validated against the intermediate control sera. In the case of measurement error more than 5%, specific procedures were included in the study protocol. However, these procedures were never needed, since the error in the quality assurance test never exceeded the 5% level.

Men (62 in eastern Finland and 56 western Finland) who were treated with insulin or oral hypoglycaemic agents, or whose fasting blood glucose was over 10 mmol/l, were excluded from the glucose tolerance test. All men were classified hierarchically according to the current WHO criteria for diabetes mellitus [4]: (1) Diabetes mellitus – 2-h postchallenge capillary blood glucose level > 11.0 mmol/l or hypoglycaemic drug treatment; (2) Impaired glucose tolerance (IGT) – 2-h blood glucose 8.0–11.1 mmol/l; (3) Normal – 2-h blood glucose > 8.0 mmol/l.

Fifty-three men could not be classified according to these criteria because 22 participated only in the assessment of blood glucose, and 31 had no glucose determinations done at all. Three of these 53 men reported that they had been told that they had diabetes but none of them had ever been treated with hypoglycaemic drugs.

Statistical analysis

The statistical evaluation of differences in the mean values between the strata by age group and diabetes status was carried out by the analysis of variance using the SAS general linear models procedure.

Results

The mean fasting capillary blood glucose level was significantly higher in eastern than in western Finland ($p < 0.001$) (Table 1). In the east the mean fasting blood glucose level rose with age ($p = 0.009$). In the west, such an increasing trend with age was not seen, and the highest mean level was found in the age group 75–79 years. In each 5-year age group the mean fasting blood glucose was higher in the east than the west.

The mean 2-h blood glucose level was highest in men aged 75–79 years. The fall in the oldest age group of 80–84 years was especially marked in the east. The mean 2-h blood glucose level was slightly higher in the west than in the east, except in men aged 70–74 years, but the differences between areas were nonsignificant.

Table 2 gives the prevalences of diabetes and IGT for men in the east and west of Finland by 5-year age

Table 2. Prevalence of diabetes mellitus and impaired glucose tolerance (IGT) by area and age group

Age group (years)	Normal		IGT		Diabetes previously unknown		Diabetes previously known		Total	
	n	%	n	%	n	%	n	%	n	%
East ^a 65–69	56	46.7	37	30.8	17	14.7	10	8.3	120	100.0
70–74	34	34.0	37	37.0	16	16.0	13	13.0	100	100.0
75–79	20	30.3	16	24.2	16	24.2	14	21.2	66	100.0
80–84	10	41.6	8	33.3	2	8.3	4	16.7	24	100.0
total	120	38.7	98	31.6	51	16.5	41	13.2	310	100.0
West ^b 65–69	45	38.8	38	32.8	28	24.1	5	4.3	116	100.0
70–74	60	51.3	33	28.2	17	14.5	7	6.0	117	100.0
75–79	24	26.1	29	31.5	24	26.1	15	16.3	92	100.0
80–84	15	28.3	21	39.6	12	22.6	5	9.4	53	100.0
Total	144	38.1	121	32.0	81	21.4	32	8.5	378	100.0

^a Data missing in 25 men; ^b data missing in 28 men

groups. Both in the east and in the west, 30% of men had diabetes and 32% had IGT. The prevalence of diabetes was particularly high in men aged 75–79 years (45% and 42%). The lowest prevalence of diabetes was found in the youngest age group of 65–69 years (23% in the east and 28% in the west).

The prevalence of IGT varied with age ranging from 24% to 40%, but in the prevalence of IGT no systematic trend was found either with age or between areas.

Of the diabetic patients, 45% in the east but only 28% in the west were aware of their condition before the survey. The proportion of those unaware was especially high in the youngest age group of 65–69 years (62% in the east and 85% in the west). Although the overall prevalence of diabetes was the same (30%) for both areas, the prevalence of known diabetes was 13% in the east and 9% in the west, giving a false impression about a regional difference. This problem was especially pronounced in the age group 65–74 years, where the prevalence of known diabetes was 11% in the east and 5% in the west, but the actual prevalence was 24% for both areas.

The higher overall mean fasting blood glucose level in the east was mainly due to the difference in the blood glucose level in diabetic subjects. Men with IGT did not

Table 3. Values (mean $\pm$ SD) of fasting blood glucose by area, age group and diabetes status

Age group (years)	East			West			Total		
	Normal	IGT	Diabetes	Normal	IGT	Diabetes	Normal	IGT	Diabetes
65–69	5.1 $\pm$ 0.7	5.2 $\pm$ 0.9	7.8 $\pm$ 4.1	5.0 $\pm$ 0.6	5.2 $\pm$ 0.8	6.6 $\pm$ 3.5	5.1 $\pm$ 0.7	5.2 $\pm$ 1.1	7.2 $\pm$ 3.8
70–74	5.3 $\pm$ 1.1	5.1 $\pm$ 0.8	7.7 $\pm$ 3.6	4.8 $\pm$ 0.9	5.1 $\pm$ 0.9	6.0 $\pm$ 2.4	5.0 $\pm$ 1.0	5.1 $\pm$ 1.2	6.9 $\pm$ 3.2
75–79	5.6 $\pm$ 1.0	5.8 $\pm$ 1.0	7.3 $\pm$ 3.5	5.1 $\pm$ 1.1	5.2 $\pm$ 1.3	7.1 $\pm$ 2.4	5.3 $\pm$ 1.0	5.4 $\pm$ 0.8	7.2 $\pm$ 2.9
80–84	5.7 $\pm$ 0.9	5.7 $\pm$ 0.7	11.3 $\pm$ 5.6	5.4 $\pm$ 0.8	5.3 $\pm$ 1.2	6.5 $\pm$ 2.4	5.5 $\pm$ 0.8	5.4 $\pm$ 0.8	7.6 $\pm$ 3.8
Total	5.3 $\pm$ 0.9	5.3 $\pm$ 0.9	7.8 $\pm$ 3.9	5.0 $\pm$ 0.9	5.2 $\pm$ 1.0	6.6 $\pm$ 2.8	5.1 $\pm$ 0.9	5.2 $\pm$ 1.0	7.2 $\pm$ 3.3

Analysis of variance: diabetes status, $p < 0.001$; age group NS. Interaction: diabetes status, age group NS

Table 4. Values (mean $\pm$ SD) of 2-h capillary blood glucose by area, age and diabetes status

Age group (years)	East			West			Total		
	Normal (n)	IGT (n)	Diabetes (n)	Normal (n)	IGT (n)	Diabetes (n)	Normal (n)	IGT (n)	Diabetes (n)
65–69	5.9 $\pm$ 1.2 (52)	9.3 $\pm$ 0.9 (37)	13.9 $\pm$ 2.9 (16)	5.9 $\pm$ 1.3 (44)	9.3 $\pm$ 1.0 (38)	13.1 $\pm$ 1.9 (28)	5.8 $\pm$ 1.2 (96)	9.3 $\pm$ 0.9 (75)	13.4 $\pm$ 2.3 (44)
70–74	5.8 $\pm$ 1.3 (30)	9.2 $\pm$ 0.9 (37)	13.1 $\pm$ 1.6 (17)	6.2 $\pm$ 1.2 (52)	9.2 $\pm$ 0.8 (33)	12.9 $\pm$ 1.9 (18)	6.0 $\pm$ 1.2 (82)	9.2 $\pm$ 0.9 (70)	13.0 $\pm$ 1.8 (35)
75–79	6.5 $\pm$ 1.3 (14)	9.5 $\pm$ 0.9 (16)	13.1 $\pm$ 2.6 (15)	6.2 $\pm$ 1.1 (18)	9.3 $\pm$ 0.9 (29)	13.6 $\pm$ 2.0 (26)	6.0 $\pm$ 1.1 (32)	9.4 $\pm$ 0.9 (45)	13.4 $\pm$ 2.2 (41)
80–84	6.1 $\pm$ 1.4 (9)	9.6 $\pm$ 1.1 (8)	14.5 $\pm$ 0.0 (1)	5.9 $\pm$ 1.2 (12)	9.6 $\pm$ 0.9 (21)	14.0 $\pm$ 2.9 (12)	5.9 $\pm$ 1.2 (21)	9.6 $\pm$ 1.0 (29)	14.1 $\pm$ 2.8 (13)
Total n	6.0 $\pm$ 1.3 (105)	9.1 $\pm$ 0.9 (98)	13.4 $\pm$ 2.3 (49)	6.0 $\pm$ 1.2 (126)	9.3 $\pm$ 0.9 (121)	13.3 $\pm$ 2.1 (84)	5.9 $\pm$ 1.2 (231)	9.3 $\pm$ 0.9 (219)	13.4 $\pm$ 3.2 (138)

Analysis of variance: age group, $p = 0.040$

Table 5. Values (mean $\pm$ SD) of body mass index (kg/m²) by area, age group and diabetes status

Age group (years)	East			West		
	Normal	IGT	Diabetes	Normal	IGT	Diabetes
65–69	25.3 $\pm$ 4.0	25.9 $\pm$ 3.7	25.5 $\pm$ 4.3	26.3 $\pm$ 4.3	26.3 $\pm$ 3.9	27.5 $\pm$ 3.6
70–74	26.4 $\pm$ 3.6	26.0 $\pm$ 4.7	26.6 $\pm$ 4.8	25.8 $\pm$ 4.5	27.0 $\pm$ 4.3	26.5 $\pm$ 3.0
75–79	25.0 $\pm$ 4.8	25.3 $\pm$ 3.6	24.1 $\pm$ 3.1	25.2 $\pm$ 2.7	25.1 $\pm$ 3.5	26.2 $\pm$ 4.6
80–84	24.0 $\pm$ 3.1	22.8 $\pm$ 3.7	22.4 $\pm$ 4.0	23.6 $\pm$ 3.8	25.1 $\pm$ 4.6	24.9 $\pm$ 4.1
Total	25.3 $\pm$ 4.0	25.6 $\pm$ 3.9	25.2 $\pm$ 4.2	25.6 $\pm$ 4.2	26.0 $\pm$ 4.1	26.4 $\pm$ 4.0

Analysis of variance: diabetes status NS; age group $p < 0.001$. Interaction: diabetes status, age group NS

have higher mean fasting blood glucose levels than men with normal glucose tolerance. The difference in fasting blood glucose level between the diabetic and non-diabetic men was larger. Diabetic patients in the age group 80–84 years in the east had particularly high values.

The mean 2-h blood glucose values for men who were not previously known to have diabetes are shown in Table 4. Overall, the 2-h glucose level varied only little, although significantly ($p = 0.040$), with age. The age-specific levels for the two areas were not different. In men with diabetes and IGT, it was the oldest age group which had the highest 2-h blood glucose level, whereas in men with normal glucose tolerance the highest mean level was found in the middle age groups.

The mean levels of body mass index (BMI) indicated that obesity was not prevalent in the study population (Table 5). The mean BMI in western Finland was slightly higher than that in eastern Finland in each category of diabetes status. Neither diabetic men nor men

with IGT had a significantly higher BMI than those with normal glucose tolerance. In the east in each strata and in the west in men with IGT the highest mean BMI value was seen in the age group 70–74 years and, thereafter, it decreased with increasing age, as it did in the west in normal and diabetic men over the entire age range.

Discussion

The prevalence of diabetes mellitus in men aged 65 to 84 years was found to be extremely high. Using the new 1985 WHO criteria [4], about one-third of the elderly men studied had diabetes. The prevalence was approximately the same both in eastern and western Finland, and in our study was higher than in most other studies of elderly populations. Comparisons of diabetes prevalence between different populations have earlier been hampered by several methodological problems, but the recent criteria recommended by the WHO Expert Committee in 1980 [3] and revised in 1985 [4] will reduce this problem in the future.

The Pima Indians are known to have the highest prevalence of diabetes in the world [17, 18]. In male Pima Indians aged 65 to 74 years, this prevalence is about 40%; in the age group 75 to 84 years, it is about 35%, although the number of elderly Pima Indians is very small [18]. Thus, the prevalence of diabetes in elderly Finnish men was of the same order as that found in the Pima Indians. The diagnostic criteria for diabetes in the Pima

Indian survey - clinical diagnosis of diabetes or a 2-h post load plasma glucose of 200 mg/dl or known clinical diabetes - differed only slightly from that of our present study. The most striking difference between the Pima Indians and our study population is that the Pima Indians are extremely obese, whereas obesity was not common in the Finnish men studied.

The second National Health and Nutrition Examination Survey (Hanes II) in the USA carried out between 1976-1980 [7] used the criteria suggested by the National Diabetes Data Group in 1979 [19], which are essentially the same as the WHO criteria. Hanes II reported a prevalence of diabetes of 18% for Caucasoid and 27% for Black men aged 65 to 74 years. The prevalence in Finnish men in the same age group was similar to that in US Black men. In the recent diabetes survey in Malta, where Type 2 diabetes is known to be very common, the prevalence was 19% in men aged 65 to 74 years [20]. All other earlier prevalence studies in elderly Caucasoid populations, unfortunately using varying methods and criteria, reported less than 15% diabetes for men aged 65 years or more [21-30]. Some of the surveys in the male populations of the Pacific Islands showed a very high prevalence in middle-aged men [31], but usually a lower prevalence of diabetes in the elderly than that in Finnish men. Only the Republic of Nauru, which has the highest prevalence of diabetes in the Pacific Basin - about 35% in the population over 15 years of age [32] - may have a still higher frequency of diabetes, although the number of Nauruan people over 65 years of age is small.

The peak prevalence in our present study was in the age group 75 to 79 years, in which half of the men had diabetes. The prevalence started to decline thereafter. For the age group 75 to 84 years the prevalence in our study material was higher than reported in any other population of this age. In a recent Swedish study in the small community of Ystad, the peak prevalence of diabetes was found in the age group 80 to 84 years [36], but it was as low as 10%.

In a survey carried out in Finland among the citizens of Tampere aged 85 years or more, a diabetes prevalence of 16% for men was reported [45]. This prevalence estimate fits rather well with our findings, although in our present study men over 85 years of age were not included. There are two other recent attempts to estimate prevalence of diabetes where elderly populations were included [10, 11]. Unfortunately, neither of these studies have used the WHO criteria for diabetes but are based on known or reported diabetes. In 1979-80, according to Reunanen [10], the prevalence was 7% in men aged 60 to 74 years and about 10% for the men over 70 years. The study provided some suggestive evidence that the prevalence of diabetes in the elderly has increased (almost doubled) during the 1970s. Much of this might be because of better diagnostic procedures and due to the introduction of free-of-charge drug treatment for diabetes in Finland in 1970.

Another study reviewed all medical records of an area in eastern Finland [11]; the prevalence of previously known diabetes in men was found to increase up till the age of 65 years, but the peak prevalence reported was only about 5%. In our study the prevalence of known diabetes was 23% and the prevalence of treated diabetes 11%. These differences stress the importance of standardized methodology and criteria for comparisons attempted between studies. Our results showed very clearly the possibility of a bias if only self-reported cases or treated patients are considered diabetic. The east-west difference (13% vs. 9%) completely disappeared when the results of the oral glucose tolerance test were taken into account.

Our study population was initially part of the well-known epidemiological study of cardiovascular diseases, the Seven Countries Study. The incidence of and mortality from coronary heart disease in men originally belonging to this particular cohort was found to be the highest in the world [12, 13]. Unfortunately, standardized assessment of diabetes mellitus was not done in earlier examinations of this cohort. More than half of the men who originally belonged to this cohort had died by 1984, 41% from coronary heart disease.

Jarrett [34] recently reviewed the literature, finding evidence against a correlation between the duration of Type 2 diabetes mellitus and the risk of coronary heart disease. He proposed that Type 2 diabetes is associated with but not causally related to coronary heart disease. Our present study indirectly supports Jarrett's hypothesis, as such a high frequency of diabetes among the long-term survivors of this cohort of men would be otherwise unlikely.

The association of diabetes and aging may be secondary to decreased glucose tolerance [1, 2, 35], but our knowledge of factors associated with diabetes in elderly is rather limited. The decline in glucose tolerance starts in the third to fourth decade, and it is believed that it is progressive throughout the entire life span [36-38]. Several factors, including increase of fat in proportion to muscle tissue, i.e. decreased lean body mass [26, 36, 37], and decreased physical activity [37-39] appear to contribute to this decrease in glucose tolerance. It seems likely that the aging process has an independent effect of tissue sensitivity to insulin [36, 37, 40, 41]. In our cross-sectional study we did not find any correlation between body mass index and glucose intolerance.

Although our study confirmed the increased occurrence of overt diabetes with advancing age, we did not find a linear trend of increasing fasting or 2-h blood glucose with age in men with IGT or normal glucose tolerance. Furthermore, the inter-individual variation in both fasting and 2-h blood glucose did not increase with age at all. Thus, the major contribution to the age-related rise in blood glucose concentration in our population was the increasing number of diabetic men with age. Our results are, in this respect, in full agreement with those of Zimmet et al. [42], who found in Polyne-

sian men and women only little change in both fasting and postload glucose concentrations with age except for the 90th percentile.

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