Table 1.—Characteristics of Participants by Income, Education, and Occupation Categories

Categories of specification	Income categories			Education categories (years)			Occupation categories		
	Low	Middle	High	<12	12	>12	Blue collar	White collar	Other
Sample size	968	953	850	2107	1457	911	1019	1490	1208
Diabetes cases	94	86	56	267	74	39	84	89	88
Prevalence (%)	9.71	9.02	6.59	12.67	5.08	4.28	8.24	5.97	7.28
Income (mean, $)	17940	42370	92700	39854	55603	59487	57415	57455	44150
Income (median, $)	18600	41700	83500	27800	46400	53800	51000	46400	37100
Education (mean, years)	10.1	11.4	11.9	8.4	12	14 7	11.9	11.4	10.7
Education (median, years)	9	12	12	9	12	14	12	12	12
Age (*SD*)	59 0 (17.6)	50.2 (16.0)	49.7 (17.6)	63.5 (13.7)	43.8 (13.5)	42.2 (13.9)	47.3 (14 9)	48.9 (15.4)	53.5 (16.5)
BMI (*SE*)	22.9 (0.17)	22.8 (0.17)	22.6 (0.18)	22.8 (0.13)	22.4 (0.15)	22.6 (0 17)	22.9 (0.25)	23.2 (0.24)	22.8 (0.24)
Female (%)	54.0	47.0	46.5	57.3	56.5	45.5	51.2	34.3	86.0
Smoking (%)									
Never	47.3	40	42.8	49.6	43.7	40.6	39.7	35.4	64 9
Past	19.1	17.1	16	16.4	13.1	16.8	15 7	15.7	10.8
Current	33.6	44.9	41.2	34.0	43.2	42.6	44.6	48.9	24.3
Hypertension (%)	39.1	29.3	25.9	45.7	20 1	17.7	25	27 5	32.4
Hypercholesterolemia (%)	30.8	30	27.4	33.4	22.7	25.2	30.3	23.7	30.1
Alcohol, g/day (*SE*)	56.0 (6.8)	71.4 (6.9)	76.8 (7.1)	49.8 (5.0)	63.7 (5.7)	78.4 (6.4)	82.5 (10.2)	77.2 (9.9)	20.6 (9.9)
Physical activity, MET-h/week (*SE*)	32.4 (3.0)	40.5 (3.1)	38.6 (3.2)	30.8 (2.2)	33.2 (2.5)	33.3 (2.8)	32.3 (4.5)	39.1 (4.3)	43.5 (4.4)
SF-36 mental health (*SE*)	67.7 (0.98)	70.2 (0.99)	70.4 (1.03)	67.3 (0.79)	70.8 (0.89)	69.8 (0.97)	70.8 (1.4)	71 1 (1.3)	69.6 (1.3)

low-, middle-, and high-income categories were $18,600, $41,700, and $83,500, respectively. Participants in the high-income category received education for longer duration (mean duration, 11.9 years), and they were less likely to be women (46.5%), more likely to be current smoker (41.2%), and physically active (mean MET-h/week, 38.6) than those in other income categories. Of the participants 4,457 reported years of education. The median duration of education in less than 12 years, 12 years, and more than 12 years of education categories were 9, 12, and 14 years, respectively. Participants in >12 years of education category had higher income, were more likely to be young (mean age, 42.2), less likely to be women (45.5%), more likely to be current smoker (42.6%), and physically active (mean MET-h/week, 33.3). Of the participants 2,509 were classified into white collar or blue collar workers. Compared with blue collar workers, white collar workers had higher income, had higher income (mean income, $51,000), had longer mean education duration (mean duration, 11.9 years), more likely to be female (51.2%), less likely to be current smoker (44.6%), and less physically active (mean MET-h/week, 32.3).

Next, we evaluated the association between household income and diabetes cases (Table 2). Compared with those in the lowest income category, the age-adjusted odds ratio for prevalent diabetes cases was 1.42 (95% confidence interval [CI], 1.02–1.97) for those with middle income, and 1.06 (95% CI, 0.73–1.53) for those with high income. For those with middle income, the association between household income and diabetes rather intensified after adjusting for possible confounders. The odds ratios for prevalent diabetes cases were 1.46 (95% CI, 1.04–2.05) adjusting for age, gender, and body mass index, and 1.57 (95% CI, 1.08–2.28) for the multivariable-adjusted model. The association of the highest income category remained insignificant even after adjusting for possible confounders. Sensitivity analysis by considering the family size did not alter the association between household income and prevalent diabetes cases. Compared with those in the lowest income tertile, the multivariable-adjusted odds ratios were 1.78 (95% CI, 1.21–2.62) and 1.39 (95% CI, 0.93–2.10, respectively, for middle- and highest-income categories.

The association between years of education and diabetes prevalence is shown in Table 3. Although nonsignificant, the trend is the same as in the previously done studies: the risk of diabetes decreases monotonically with increasing number of years of education.

The association between occupation and prevalent diabetes cases is shown in Table 4. Compared with white collar workers, the age-adjusted odds ratio for prevalent diabetes cases was 1.91 (95% CI, 1.37–2.64) in blue collar workers. This association was slightly attenuated, but remained significant in the multivariable model; the multivariable adjusted

Table 2.—Association Between Income and Prevalence of Diabetes

	Income categories (unadjusted for no. of family members)				
	1st tertile (0–27800) (*N* = 968)	2nd tertile (27801–55700) (*N* = 953)		3rd tertile (55701–) (*N* = 850)	
Household income ($)					
Mean	17940	42370		92700	
Median	18600	41700		83500	
	OR	OR	95% CI*	OR	95% CI*
Adjusted for					
Age	1.00	1.42	1.02–1.97	1.06	0 73–1 53
Age, gender, and BMI	1.00	1.46	1.04–2.05	1.04	0.71–1.53
Multivariate†	1.00	1.57	1.08–2.28	1 16	0.77–1.74
	Income categories (adjusted for no. of family members)				
	1st tertile (0–18600) (*N* = 935)	2nd tertile (18601–32500) (*N* = 929)		3rd tertile (32501–) (*N* = 907)	
Adjusted income‡ ($)					
Mean	11581	24907		51540	
Median	13000	24600		45900	
	OR	OR	95% CI*	OR	95% CI*
Adjusted for					
Age	1.00	1.52	1 09–2.11	1.20	0.85–1.71
Age, gender, and BMI	1.00	1.59	1.13–2.25	1 20	0.82–1.73
Multivariate†	1.00	1.78	1.21–2.62	1.39	0.93–2.10

*CI indicates confidence interval. The probability that both confidence intervals cover their respective odds ratio is 0 95^2 that is 0.9025.
†Adjusted for age, gender, body mass index (BMI), physical activity (MET-h/week), smoking status (current, past, never), history of hypertension, history of hypercholesterolemia, and SF-36 mental health score.
‡Adjusted income equals household income divided by square root of the number of family members

odds ratio was 1.82 (95% CI, 1.27–2.61). Although not statistically significant, there seemed to be an interaction between gender and occupation. Compared with blue collar workers, the multivariable-adjusted odds ratios for white collar workers were 2.20 for men (95% CI, 1.46–3.31) and 0.98 for women (95% CI, 0.47–2.06) (p for interaction = .0619).

COMMENT

Our results have shown that low socioeconomic status was not necessarily associated with a higher diabetes prevalence. The association varied depending on the sort of measure of SES. Among household income categories, those in the

Table 3.—Association Between Education and Prevalence of Diabetes

	Education categories (years)				
	<12 (*N* = 2107)		12 (*N* = 1457)		>12 (*N* = 911)
Education (years)					
Mean	8.4		12		14 7
Median	9		12		14
	OR	95% CI*	OR	95% CI*	OR
Adjusted for					
Age	1.29	0.87–1.89	1.13	0.76–1.66	1.00
Age, gender, and BMI	1.38	0.93–2.05	1.25	0.83–1.88	1.00
Multivariate†	1.28	0.85–1.91	1.18	0.77–1.74	1.00

*CI indicates confidence interval. The probability that both confidence intervals cover their respective odds ratio is 0 95^2 that is 0.9025.
†Adjusted for age, gender, body mass index (BMI), physical activity (MET-h/week), smoking status (current, past, never), history of hypertension, history of hypercholesterolemia, and SF-36 mental health score.

Table 4.—Association Between Occupation and Prevalence of Diabetes

	Blue collar occupation (versus white collar occupation)						
	All (men and women) (N = 2482)		Men (N = 1461)		Women (N = 1021)		
	OR	95% CI	OR	95% CI	OR	95% CI	Test for interaction
Adjusted for							
Age	1.91	1.37–2.64	2.17	1.49–3.15	1.25	0.65–2.42	$p < .001$
Age and BMI	1.94	1.39–2.72	2.22	1.51–3.26	1.33	0.68–2.60	$p = .1671$
Multivariate†	1.82	1.27–2.61	2.20	1.46–3.31	0.98	0.47–2.06	$p = .0619$

*CI indicates confidence interval. The probability that both confidence intervals cover their respective odds ratio is 0.95^2 that is 0.9025.
†Adjusted for age, body mass index (BMI), physical activity (MET-h/week), smoking status (current, past, never), history of hypertension, history of hypercholesterolemia, and SF-36 mental health score.

middle income tertile had highest prevalence of diabetes mellitus, whereas duration of education was not significantly associated with a higher diabetes prevalence; compared with white collar workers, blue collar workers were about 2 times more likely to be prevalent diabetes cases, and this was also the case when adjusting for a large number of possible confounders.

The association between household income and diabetes prevalence was quite inconsistent with previous reports. Sturm et al[10] investigated the cross-sectional association between household income and prevalence of diabetes or high blood sugar in a nationally representative household telephone survey, and reported that household income was negatively associated with diabetes prevalence; the prevalence of diabetes or high blood sugar was 10.3%, 8.2%, 6.2%, 3.2%, and 2.3%, respectively, for 1st to 5th household income quintiles, and a statistically significant negative linear trend was observed adjusted for age, sex, ethnicity, and family composition ($p = .026$).[10] Maty et al[11] investigated the association between education, income, occupation, and incidence of diabetes in the Alameda County Study, and reported that higher income was associated with lower risk of developing diabetes, although the result was not statistically significant.[11]

We do not have enough data to explain why the prevalence of diabetes is high in those with middle income, and why the prevalence of diabetes is not highest in those with lowest income categories; however, we may say at least that the association between low income and worse health outcome does not hold universally, and is dependent on the health service system. Japan's health system is universal and egalitarian and helps to keep its population healthy at an exceptionally low cost.[9,12] Japan finances medical care through a pluralistic social-insurance system, with mandatory enrollment based on employment or residence, and premiums proportional to income. Everyone in Japan is equally treated as far as medical care is concerned, and every Japanese can go to any physician or hospital with no difference in cost, and physicians are in principle free to treat or prescribe as they deem fit. It could be inferred that low income is not necessarily associated with worse health outcome in this universal and egalitarian health care system.

The association between education and diabetes was rather consistent with previous reports, but the association between income or occupation and diabetes were inconsistent. Lipton et al reported that education (≤12 years versus >12 years) was not significantly associated with subsequent diabetes cases over 16 years of the First National Health and Nutrition Examination Survey (NHANES I) Epidemiologic Follow-up study (odds ratio 1.18), although ethnicity was a strong predictor of the incidence of diabetes mellitus.[13] Maty et al reported that those who received a shorter duration of education tended to have higher risk of diabetes, although the result is not statistically significant. Compared with those with more than 12 years of education, the hazard ratios of developing diabetes were 1.27 (95% CI, 0.93–1.74) and 1.31 (95% CI, 0.99–1.74) for those with less than 12 years of education and those with 12 years of education, respectively, adjusting for demographics, behaviors, body composition, high blood pressure, heath insurance, and regular access to a medical doctor.[11] Our results corroborate these findings.

The association between occupation and diabetes is also consistent with previous reports. Morikawa et al investigated the work environment and risk of developing diabetes in a cohort of 1,218 workers of a zipper and aluminum sash factory, and reported that compared with clerical workers, workers in transport had about 4 times higher risk of developing diabetes (odds ratio 3.59).[14] Maty et al[11] reported that blue collar workers had about 30% higher risk of developing diabetes compared with white collar workers, although the result was only almost significant (hazard ratio 1.31, 95% CI 0.91–1.89). In this study, male blue collar workers were more likely to develop diabetes than female blue collar workers, and this is consistent with our results.

There may be several limitations to this study. Firstly, the socioeconomic status measurements were self-reported. Although some misclassification of these measurements is likely, the bias effect on the risk of diabetes should be quite small, and thus our results for the association between socioeconomic status and the risk of diabetes cannot be dismissed. Secondly, because this is an observational study, confounding factors could be a plausible explanation for the findings, but this is limited by the adjustments made for the many covariates that could be confounders in the association between socioeconomic status and diabetes prevalence. Thirdly, because our study population consisted of a relatively lean Asian population, caution should be used when comparing our results to those valid for more obese, non-Asian populations.

In conclusion, as far as results to which significance may be attached are concerned, blue collar occupation and middle household income, rather than low income and years of education, were associated with high prevalence of diabetes mellitus. On the wider world scale, the association between household income and diabetes varies depending on the health care system.

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Effect of feedback in promoting adherence to an exercise programme: a randomized controlled trial

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Abstract

Objective We investigated whether providing participants in an exercise programme with regular feedback on their exercise progress affected their adherence to the programme regimen.

Method We conducted a randomized controlled trial. Adult men and women with borderline hypertension and a body mass index ≥ 25.0 were randomized to two intervention groups (groups A and B) and one control group (group C) and were prescribed regular aerobic exercise. During the 12-week study period, group A was provided with both feedback information on their exercise progress and a health letter, while group B was provided with the health letter only. The main outcome measure was exercise performance, per cent achievement of target exercise level (%) defined as the number of weeks during which the exercise target was reached divided by the number of weeks in the programme. Results were compared using the Kruskal–Wallis test.

Results A total of 105 study subjects were randomized into three groups (A, $n = 37$; B, $n = 37$ and C, $n = 31$). Per cent achievement of target exercise level during the 12-week period was highest in group A (26.5%), followed by groups B (22.9%) and C (17.4%) ($P = 0.36$). Subjects who received regular feedback during the exercise programme tended to have higher exercise performance.

Conclusions In improving adherence to exercise intervention, the provision of regular feedback to participants in an exercise programme may be an effective intervention.

Introduction

Reduced physical activity is a major public health concern in many developed countries. The importance of physical activity and exercise in the primary prevention of disease [1,2] is increasingly recognized, and regular exercise and the maintenance of cardiovascular and respiratory function are now considered important components of an integrated approach to the prevention of chronic diseases [3].

Although programmes promoting aerobic exercise are prevalent throughout Japan, concern has been raised that participants may not adhere to the programmes that are of extended duration and may tend to stop exercising particularly soon after the programme is finished. A prior study, for example, showed that more than half of the programme participants stopped exercise 2–4 months after cessation [4]. Effective interventions in improving adherence to exercising remain unknown. Given that the determinants of long-term adherence include the maintenance of motivation, personal experience of the benefits of exercise and willingness to continue the exercise programme [5], we hypothesized that the provision of regular feedback to participants on their progress may encourage them to continue doing exercise. Studies in other countries have shown that subjects provided with regular feedback on their progress during an exercise programme achieve higher physical activity levels and are less likely to drop out of the programme than those without such feedback; however, a method of specific intervention has yet to be established [6,7]. The establishment of exercise programmes for health promotion thus requires the creation of effective feedback methods and confirmation of their efficacy.

Here, we conducted a randomized controlled trial to assess whether the regular provision of information on the physical effects of exercise and the maintenance of log books recording the details of the exercise affect the adherence to exercise.

Methods

Subjects

Subjects were adult men and women with borderline hypertension and a body mass index (BMI) ≥ 25.0 at five companies in Komatsu City, a coastal city on the Japan Sea, Ishikawa Prefecture, who underwent a routine physical examination from April to May 2005. Borderline hypertension was defined as a systolic blood pressure (SBP) of 130–159 mmHg or diastolic blood pressure (DBP) of 85–99 mmHg, both of which are categorized as high normal to mild hypertension by the Japanese Society of Hypertension.

Study participants were recruited by representatives of each company and the overview of the exercise programme was posted on a company bulletin board. Employees willing to participate in the study were briefed on the contents of the first session and the necessary cautions to be observed. We also explained favourable effects of aerobic exercise on a variety of chronic conditions. A total of 111 participants aged 25–68 years volunteered to participate and all of them agreed to sign the letter of study consent. After the informed consent was obtained from all participants, we measured height, weight and blood pressure, and we conducted submaximal step test to predict maximal oxygen consumption (Vo2max). Six participants were excluded owing to normal blood pressure or BMI, leaving 105 subjects as participants in the trial.

Study design and intervention

The study was conducted as a randomized controlled trial. The subjects were stratified by company, disease (obesity, hypertension, both) and age (age 20–40, 41–69 years), then randomized into three groups, A ($n = 37$), B ($n = 37$) and C ($n = 31$).

All subjects undertook a home-based aerobic exercise programme during the study period, which included any or all of walking, jogging and swimming at the discretion of the individual. Target exercise dose for each participant was set to meet the exercise recommendations proposed by the American College of Sports Medicine in 1990, namely aerobic exercise of more than 20 minutes per session and three sessions per week [8]. The minimum duration of any particular exercise within a session was set at 10 minutes and above. We set exercise intensity at moderate intensity or higher according to the definition by the American College of Sports Medicine. An exercise of moderate intensity is equivalent to 3–6 metabolic equivalents [9].

Subjects in group A were provided with feedback based on their exercise and a 'health letter', which is a newsletter on health issues every 2 weeks, while Group B was given the health letter alone every 2 weeks. Group C was a control group that was instructed to submit exercise records without any intervention. Comparison of groups A and B allowed us to evaluate whether the provision of regular feedback to participants in an exercise programme affected their adherence, while comparison of groups B and C indicated the effect of regular contact with participants via periodic health letter. The newsletter contained general health-related topics without specific reference to the effects of exercise.

Content of feedback intervention

We quantitatively analysed exercise records submitted by group A subjects and returned the resulting data sheets to them as feedback via regular mail or fax. Feedback contents included the following items:

1 a graph of body weight and blood pressure (daily changes over the preceding 2 weeks; changes during the study period; elapsed exercise time; overall increase or decrease since the start of the programme; and variation from normal weight and blood pressure);

2 exercise history (daily exercise achievement represented by coloured boxes on calendar boxes),

3 pedometer record (cumulative walking distance illustrated on a map from Komatsu City through famous sightseeing spots in Japan; cumulative steps, average steps and walking distance per day; maximum/minimum steps; and maximum/minimum walking distance), and

4 caloric expenditure (cumulative caloric expenditure over the preceding 2 weeks, calculated from the pedometer recordings).

Data collection

We collected the following information at the first study session: sex, age, height, BMI, SBP and DBP, Vo2max, medical history, history of present illness, current medication, smoking history, drinking habit and stage of change in exercise behaviour [10].

All participants were instructed to record pedometer, weight and blood pressure data by disease and daily exercise achievement on a specific sheet everyday. Daily target exercise level was met if the subjects performed more than 20 minutes' aerobic exercise per day. The subjects submitted the exercise records to the data centre by mail or fax once every 2 weeks, with the due date written on each record sheet in advance to facilitate compliance. When records were more than 3 days overdue, we sent a reminder by mail or fax.

We held the programme-end assessment after the 12-week study period, at which time we evaluated BMI, blood pressure and Vo2max by conducting submaximal step test for all participants to determine the effects of exercise.

To assess adherence to exercise after the programme ended, participants were sent a questionnaire 1 month after completion of the survey, which investigated how many days a week and for how many hours a day the participants were still performing aerobic exercise.

Table 1 Characteristics of subjects at baseline

	Group A (*n* = 37)	Group B (*n* = 37)	Group C (*n* = 31)
Age	39.3 ± 9.1	41.8 ± 10.9	40.4 ± 10.3
Male	30 (81)	28 (76)	27 (87)
Body mass index (kg m⁻²)	27.5 ± 3.4	27.0 ± 3.0	26.5 ± 2.8
Systolic blood pressure (mmHg)	140 ± 18	141 ± 17	140 ± 14
Diastolic blood pressure (mmHg)	88 ± 11	86 ± 10	86 ± 11
Vo2max (mL kg⁻¹ minute⁻¹)	33.6 ± 8.2	32.6 ± 5.7	34.4 ± 4.3
Present illness	8 (22)	5 (14)	9 (29)
Smoking	15 (32)	11 (49)	11 (36)
Excessive drinking	8 (22)	5 (14)	4 (13)
Habitual exercise	18 (49)	15 (40)	11 (35)

Data expressed as mean ± standard deviation or number of subjects (%).

The main outcome measure throughout the study was the % achievement of target exercise level (%), defined as the number of weeks during which the exercise target was reached divided by the number of weeks in the programme. When records of daily exercise achievement were missing, the subject was defined as not having exercised. Secondary outcomes included BMI, SBP/DPB, Vo2max, and adherence to exercise and total exercise time (in minutes) per week at 1 month after the end of the programme. Adherence was defined as the maintenance of aerobic exercise for 3 or more days per week and for 20 minutes per day.

We submitted the protocol of this study to the Institutional Review Board of the Faculty of Medicine, Graduate School of Medicine, Kyoto University in March, 2005. This study was approved by the Institutional Review Board of the Faculty of Medicine, Graduate School of Medicine, Kyoto University.

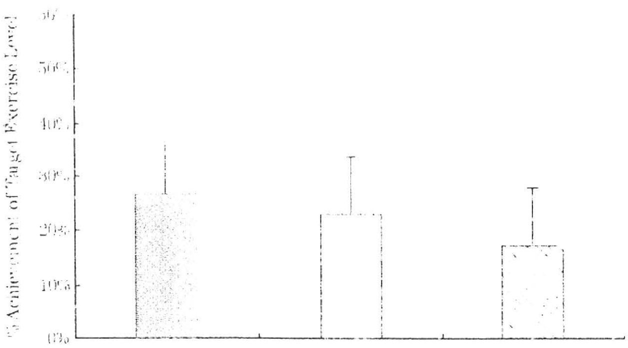

Figure 1 The % achievement of target exercise level. The provision of regular feedback tends to be effective in improving adherence to the programme.

Statistical analysis

We compared the % achievement of target exercise level in the three groups by the Kruskal–Wallis test. We also analysed the data after stratification by age (≤40 or >40 years) at the beginning of the exercise programme.

We compared BMI, SBP/DPB and Vo2max at the first and second sessions by the paired *t*-test. Statistically significant differences were analysed for variance using the groups (A, B, C) as explanatory variables. Data from subjects taking antihypertensive medications were excluded from analysis of SBP and DPB.

We also compared differences among the groups in the proportion of adherent subjects and in exercise time per week in minutes at 1 month after the exercise programme by the Kruskal–Wallis test.

All analyses were performed using SPSS version 11.5 for Windows.

Results

Subjects

Average age of the 105 subjects was 40.5 ± 10.1 years. The number of subjects in groups A, B and C after randomization was 37, 37 and 31, respectively. Baseline characteristics of the subjects by group showed no statistically significant differences (Table 1).

A total of 99 subjects (34 in group A, 35 in group B, 30 in group C) attended the programme-end session.

Main outcome measure

The % achievement of target exercise level during the 12-week period was highest in group A (26.5%), followed by groups B (22.9%) and C (17.4%) ($P = 0.36$) (Fig. 1). Figure 2 compares the % achievement of target exercise level by age group.

Secondary outcome measures

Changes in physiological indicators

Changes in BMI before and after the exercise programme were 0.21 kg m⁻² in group A ($n = 34$), 0.21 kg m⁻² in group B ($n = 34$) and 0.05 kg m⁻² in group C ($n = 30$). BMI after the programme appeared to be lower in each group.

Changes in SBP before and after the programme trended downward by 0.9 mmHg in group A ($n = 30$) and 2.9 mmHg in group B ($n = 32$), whereas that in group C ($n = 29$) trended upward by 1.6 mmHg. Likewise, DBP in groups A and B decreased by 0.4 and 2.3 mmHg, respectively, whereas that in Group C increased by 0.4 mmHg.

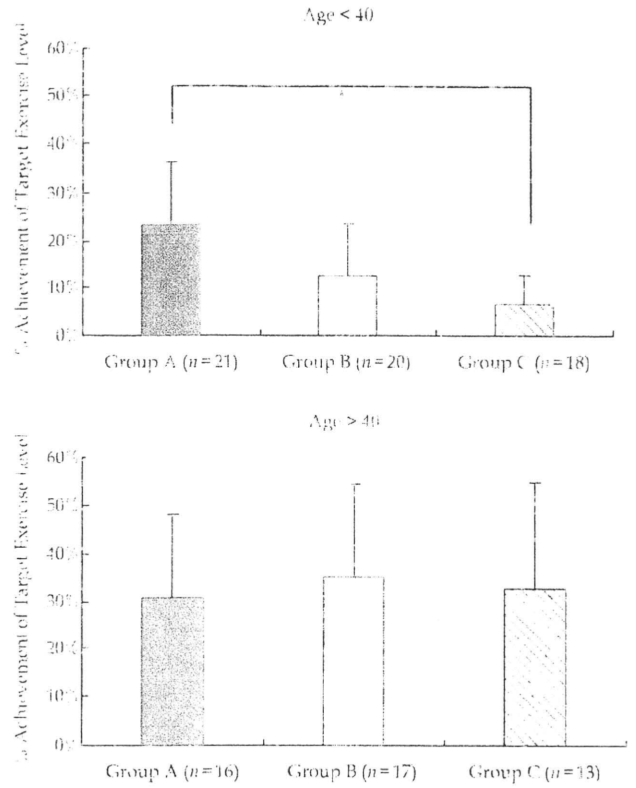

Figure 2 Comparison of the % achievement of target exercise level by age group. There was significantly different (*P = 0.040) between groups A (23.4%) and C (6.4%).

Among other variables, Vo2max increased by 1.0 mL kg^{-1} $minute^{-1}$ in group A (n = 34), 1.2 mL kg^{-1} $minute^{-1}$ in group B (n = 30) and 0.8 mL kg^{-1} $minute^{-1}$ in group C (n = 29).

Maintenance of exercise and total exercise time per week at 1 month

The number of respondents to the follow-up questionnaire evaluating exercise adherence at 1 month after cessation was 46, representing 43.8% of the original study subjects (48.6% in group A, 35.1% in group B and 48.4% in group C). The percentage of subjects maintaining exercise at 1 month was highest in group A (22%), followed by groups B (15%) and C (13%) (P = 0.76). Total exercise time per week was 108.1 hours in group A, 64.2 hours in group B and 90.7 hours in group C.

Discussion

In our study, subjects who received regular feedback during an exercise programme tended to have better adherence to the target exercise level than those receiving a periodic health letter only. This finding suggests that the provision of regular feedback may be effective in improving exercise adherence. Furthermore, the results also suggested that the provision of a newsletter to contact subjects alone may also promote exercise adherence.

In this study, stratified analysis by age indicated that subjects aged over 40 years performed exercise more often than those below 40 throughout the study. Subjects aged over 40 years may have been more concerned about their health, with greater motivation to stay fit, with or without the intervention. In subjects aged below 40, the finding that group A attained a higher target level than group C suggests that the provision of regular feedback in an exercise programme is more effective for younger participants. For younger people who are relatively less concerned about their health, active intervention to keep them motivated may enhance adherence to exercise.

Body mass index in groups A and B tended to decrease in a similar manner after the exercise programme, suggesting that the regular provision of a newsletter alone may be as effective for weight control as feedback. BMI is determined by other factors, such as diet and basal metabolism. Given that the effect of exercise on weight loss is approximately 30% of that of diet, and that an increase in physical activity alone does not easily contribute to weight loss [11], the present intervention may have been insufficient to bring about a visible effect on BMI.

Blood pressure tended to decrease after the exercise programme in both groups A and B, suggesting that blood pressure was unaffected by the provision of feedback. In contrast, Fagard reported that aerobic exercise under direct observation decreased SBP by 7.4 mmHg and DBP by 5.8 mmHg [12]. This difference in findings may have been due to the fact that our subjects performed exercise without direct observation. Given that exercise may be an effective intensity level to exert a hypotensive effect, the lack of direct observation in the present programme may have meant that intensity was insufficient, notwithstanding some increase in physical activity brought about by the feedback intervention itself. Consistent with a previous report [13], we further observed that blood pressure showed weekly fluctuations despite an overall downward trend, suggesting that short-term changes in blood pressure may not be a suitable monitor of the effects of exercise.

The feedback method used in this study was created to overcome various barriers to exercise adherence, such as time constraints on visits to gyms and poor accessibility [14]. The idea of this feedback contents can be meaningful in future study. Further investigation is required on the optimal frequency, period and content of the feedback intervention as a means of encouraging more voluntary exercise. It has been reported that a computer-based feedback system reduced the drop-out rate from an exercise programme [15], suggesting that contacting participants more quickly through text messages or email may be a more effective way of providing feedback. A previous study also suggested that the lack of enjoyment or amusement, as well as the lack of motivation, may reduce exercise adherence, especially when the programme is prolonged [16]. This finding highlights the importance of promoting adherence by making the programme more rewarding and less boring, such as by changing the content and providing feedback during the course of the programme, particularly for participants with no established exercise habit.

Several limitations deserve mention. First, the exercise records were filled out by the subjects themselves, so misclassification cannot be ruled out and we also cannot measure the subjects' exercise intensity accurately in the case of prescribing home-based exercise; this issue can be the problem to be solved. Second, it is not clear if the study period was long enough to allow the effect of the intervention to be assessed. Third, although we found the provision of regular feedback tends to be effective intervention in improving adherence to the participants, the sample size was not sufficient to allow the detection of statistically significant differences among the groups. On the basis of the two-sided test ($\alpha = 0.05$, power of 80%), the enrolment of at least 172 subjects is required to detect the observed difference in exercise performance between groups A and C.

This study showed that the provision of regular feedback to participants in an exercise programme may be effective in improving adherence. Conventional exercise programmes can be valuable to bring in a feedback mechanism, such as that used in this study. Future studies with more subjects should confirm these findings with greater statistical power and explore an optimal intervention method of feedback.

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Conflict of interest

Masaaki Shakudo, Takahiro Higashi, Michio Katsuki and Shunichi Fukuhara have indicated no financial conflicts of interest.

Contributors

Masaaki Shakudo worked out research plan of this study and analysed the data, and also carried out the management of the study.

Misa Takegami advised the idea and design of this study, and also analysed and interpreted the data.

Takahiro Higashi and Yasuaki Hayashino advised the idea of this study, and also analysed and interpreted the data.

Yoshimi Suzukamo advised research plan and interpreted the data.

Satoshi Morita designed analysis plan of this study.

Ai Shibata, Miki Kuzumaki and Michio Katsuki carried out the management of the study.

Hokuriku Institute of Wellness and Sports Science provided research field and obtained funding management of the project.

Shunichi Fukuhara advised research plan, design and management of the project, and also obtained funding for this study.

Furthermore, all authors helped to interpret the findings and review the drafts of this paper.

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ORIGINAL ARTICLE

Prevalence of Visual Impairment in the Adult Japanese Population by Cause and Severity and Future Projections

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ABSTRACT

Purpose: To present a comprehensive estimate of the total number of people with visual impairment in the adult Japanese population by age, gender, severity and cause, and to estimate future prevalence based on population projections and expected demographic changes.

Methods: Definitions of visual impairment used in this study were based on the United States criteria. Total visual impairment was calculated as the sum of low vision and blindness. The prevalence estimates were based on input from a number of Japanese epidemiological surveys, census material and official population projections.

Results: There were an estimated 1.64 million people with visual impairment in 2007 in Japan. Of these, 187,800 were estimated to be blind. The prevalence of visual impairment in Japan increased with age and half of the people with visual impairment were aged 70 years or older. The leading causes of visual impairment in Japan were glaucoma (24.3%), diabetic retinopathy (20.6%), degenerative myopia (12.2%), age-related macular degeneration (10.9%), and cataract (7.2%). These five major causes comprised three-quarters of all visual impairment. The prevalence of visual impairment was projected to increase from 1.3% of the population in 2007 to 2.0% by 2050.

Conclusions: This comprehensive study presents the prevalence of total visual impairment in the adult Japanese population. The projected increases in the prevalence of visual impairment over time reflect the demographic changes of a declining and aging Japanese population. These projections highlight that the burden of disease due to visual impairment and imposed on society is likely to increase.

KEYWORDS: Burden of disease; Epidemiology; Eye disease; Prevalence; Visual impairment

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INTRODUCTION

It is well known that prevalence and causes of visual impairment change over time and across regions.[1-8] Several environmental factors such as sanitation, employment, diet, and health care as well as ethnicity and demographic composition are major factors of such changes. In recent years, there have been great changes in the demographic composition of the Japanese population, principally reflecting low birthrates and an aging of society. According to statistics compiled by the Ministry of Internal Affairs and Communications, the elderly (aged 65 or older) was merely 5% of the total Japanese population in 1950. The ratio increased to over 10% two decades ago and now is approximately 20%, and is projected to further increase to nearly 30% in 20 years.[9]

Visual impairment is a major issue even in developed nations where advanced medical services are available. In these nations, the prevalence of visual impairment is reported to be higher among the elderly.[1–6] It is also estimated that demographic changes and an aging population in Japan are significantly affecting both the prevalence and the causes of visual impairment. In population-based epidemiological studies, the prevalence of certain ocular diseases among the population in Japan has been reported.[10–21] There is also a report that examines the frequency and causes of visual impairment among those certified as visually impaired according to welfare law for the physically disabled.[22,23] These reports, however, have not comprehensively represented the total number of people with visual impairment in Japan nor the severity or causes of total visual impairment. This is largely due to such issues as regional factors, sample size, and the rate of issuance for physical disability certificates (ie, significant numbers of people have not been certified even though they meet the criteria as the visually impaired).

In this study, the authors calculated the prevalence of visual impairment in Japan by age, gender, severity and cause based on input from Japanese epidemiological surveys, census material and official population projections. Prevalence was estimated for the total number of the visually impaired in Japan as of 2007, and future prevalence estimates were based on projected demographic changes. Although this study is based on secondary data, it is considered to be valuable as it draws together the results of several epidemiological studies using a number of modeling techniques to provide a complete picture of the prevalence of visual impairment in Japan.

METHODS

Definitions of Visual Impairment

Common definitions of visual impairment used world wide are based on the United States criteria or the World Health Organization (WHO) criteria. They both use best-corrected visual acuity (BCVA) in the better-seeing eye for their definitions. The United States criteria defines low vision as BCVA of less than 20/40 but better than 20/200, and blindness as BCVA of 20/200 or worse, both in the better-seeing eye. The 10th Revision of the WHO International Statistical Classification of Diseases, Injuries and Causes of Death (ICD-10) defines low vision as BCVA of less than 20/60 but 20/400 or better in the better-seeing eye, and blindness as BCVA of worse than 20/400 in the better-seeing eye. In this study, prevalence data were derived from epidemiological studies and statistics based on the US criteria for visual impairment.

Estimation of Prevalence

The prevalence of visual impairment in Japan was estimated by constructing a comprehensive dataset that was stratified by gender, age and severity. In addition, data were disaggregated by the five key causes of visual impairment—age-related macular degeneration (ARMD), cataract, diabetic retinopathy, glaucoma and degenerative myopia—along with all other causes (calculated as the residual) which included such conditions as optic neuropathy, retinitis pigmentosa, other retinal disorder, traumatic injury, congenital anomaly, cortical blindness, and corneal opacity. In total, 13 key Japanese prevalence sources and 3 official database sources were examined to derive the splits between age, gender, severity and cause (Table 1).[9–24] While no single study provided a complete picture of the prevalence of visual impairment in Japan, all surveys provided valuable input.

Following extensive analysis of the epidemiological data from Japan, it was concluded that to overcome any sampling issues it was necessary to construct individual datasets by age, gender and severity for each individual cause of visual impairment and then re-aggregate the data.

In constructing these individual datasets, the overall total by age was based on Iwase and associates[11] and the splits between the causes of visual impairment were based on data from Ministry of Health, Labor, and Welfare.[23] The split between severities (that is, low vision and blindness) was calculated as the ratio provided by Iwase and associates[11] for each of the five main causes of visual impairment and was then applied to the individual data sets. The splits by gender were derived from the individual epidemiological data sets by cause of visual impairment where possible. Where data on prevalence by gender were not available, the gender ratios by cause from Nakae and associates[22] were applied.

TABLE 1 Japanese prevalence sources and official database sources used in the study

Epidemiological Studies			
Authors	Years and location	Population	Prevalence of main causes
Iwano[10]	1997–2000, Aichi	2263, 40–79 years	visual impairment: blindness 0.18%, low vision 1.63% (U.S. criteria)
Iwase[11]	2000–2001, Tajimi	3021, ≤40 years	visual impairment: blindness 0.14%, low vision 0.98% (U.S. criteria)
Yamamoto[12]	2000–2001, Tajimi	3021, ≤40 years	glaucoma: 5.0% (male 5.0%, female 5.0%)
Miyazaki[13]	1998, Hisayama	1637, 40–79 years	diabetic retinopathy: 2.3%
JCMA[14]	1998, multi hospitals survey	12821, ≤20 years	diabetic retinopathy: 23.3% (male 22.8%, female 23.8%) in diabetic patients
Miyazaki[15]	1998 and 2003, Hisayama	1482, 40–79 years	ARMD (5-year incidence): 0.8% for late ARMD (male 1.9%, female 0.2%)
Oshima[16]	1998, Hisayama	1486, 40–79 years	ARMD: 0.87% for late ARMD (male 1.7%, female 0.33%)
Yuzawa[17]	1994, multi hospitals survey	6878, ≤50 years	ARMD: 0.53% for late ARMD (male 0.53%, female 0.20%)
Sasaki[18]	1995, Noto, Hokkaido, Okinawa	2521, ≤40 years	cataract (grade III*): 17.4% in 60', 28.2% in 70', 59.9% in 80' years
Sasaki[19]	1995, Noto, Hokkaido, Okinawa	1615, ≤40 years	any cataract: 58.1% in 60', 77.2% in 70', 85.5% in 80' years
Shimizu[20]	1997–2000, Aichi	2168, 40–79 years	all myopia: 42.0% (male 45.7%, female 38.3%), high myopia: 0.6% (male 0.5%, female 0.6%)
Matsumura[21]	1984–1996, Nara	9420, 12–17 years	all myopia: 43.5% at 12 year-old, 66.0% at 17 year-old
Nakae[22]	2001–2004, 6 cities in Japan	2034, ≤18 years	numbers of legal blindness (Japanese criteria) by age, gender, and causes main causes: glaucoma 20.7%, diabetic retinopathy 19.0%, RP 13.7%, ARMD 9.1%, degenerative myopia 7.8%, and cataract 3.2%
Official Databases			
Sources	Years	Data	Description
NHLW[23]	2004	legal blindness (Japanese criteria)	numbers of legal blindness (Japanese criteria) by age, severity, and causes
MIAC[24]	2007	census data	2007 census estimates based on 2005 population census data for Japan
NHLW[9]	2006	population projections	population projections over time (2006–2055) for Japan

JCMA = Japanese Clinical Medicine Association; ARMD = age-related macular degeneration; RP = retinitis pigmentosa; NHLW = Ministry of Health, Labour and Welfare, Japan; MIAC = Ministry of Internal Affairs and Communications, Japan.
*grade III cataract was defined as advanced lens opacity with deterioration of visual acuity, by the Japanese Co-operative Cataract Epidemiology Study Group.

Prevalence estimates by age, gender, severity and cause were standardized to the 2005 population based official population census data for Japan. The resulting prevalence rates were then applied to 2007 census estimates[24] to derive the current prevalence of visual impairment in Japan. These same prevalence rates were then applied to official population projections[9] to estimate visual impairment in Japan up to the year 2050. Therefore, changes in prevalence, developments of prevention measures, and new treatment modalities were not included in our estimation. As the prevalence rates were also disaggregated by age and gender, it was possible to capture the expected demographic changes in the official population projections. Total visual impairment for 2007 and for the years to 2050 was calculated as the sum of low vision and blindness.

The guidelines of the World Medical Association Declaration of Helsinki were followed. The protocol was approved by the review board of National Tokyo Medical Center.

RESULTS

It was estimated that there were almost 1.64 million people with visual impairment (visual acuity of the better-seeing eye is less than 20/40) in 2007 in Japan, and of these almost 187,800 were estimated to be blind (visual acuity of the better-seeing eye is less than 20/200) (Table 2). Of those visually impaired, approximately 850,000 were males comprising 52% of the total. There were slightly more males than females in each age cohort, but the difference in gender was not significant. The prevalence of visual impairment, however, was higher in males aged 70 or older and reaching 7.1% among those aged 80 or older. Since the prevalence of visual impairment is highly correlated with age for both males and females, half of those visually impaired were aged 70 or older and those aged 60 or older accounted for 72% of the total number of the visually impaired.

Table 3 and Figure 1 present the prevalence of visual impairment by cause and gender. The leading causes of visual impairment in Japan are glaucoma (24.3%), diabetic retinopathy (20.6%), degenerative myopia (12.2%), ARMD (10.9%) and cataract (7.2%) and these five causes comprise 75% of total visual impairment. There were no significant differences by gender in the prevalence of visual impairment caused by glaucoma and diabetic retinopathy; however, prevalence of visual impairment due to ARMD was higher for men and was higher for women due to cataract.

Figure 2 presents the prevalence of visual impairment by cause and severity according to low vision and blindness. As the majority of the people with visual impairment have low vision, there are no significant differences in the leading causes for low vision and for visual impairment as a whole. However, the leading causes for blindness are quite different. The leading causes of blindness were glaucoma (27.6%), degenerative myopia (12.9%), diabetic retinopathy (10.5%), ARMD (5.5%), cataract (0.6%), and other causes (42.8%). While diabetic retinopathy and cataract were the leading causes of visual impairment, they were not the main causes of blindness. Meanwhile, the rate of "other causes" of blindness was greater than for low vision, indicating that diseases that have no effective treatment, such as optic neuropathy, retinitis pigmentosa, traumatic injury and congenital anomaly, play a crucial role as causes of blindness.

Based on census data and demographic projections for Japan, prevalence of visual impairment in 2007 and the results of the future projections for the years 2010, 2020, 2030, 2040, and 2050 are shown in Figure 3. Due to the aging of the Japanese population, prevalence of visual impairment is projected to increase from a currently estimated 1.64 million people in 2007 (1.3% of the population) to almost 2 million people (2.0%) by 2050. Similarly, blindness is projected to increase by 17.6% over the next four decades to around 221,000 people. Changes in the chart reflect projected demographic changes in the Japanese population. Principally, it reflects a population that is not only aging, but is also declining.

TABLE 2 Number and prevalence (%) of blindness (≤0.1 in the better-seeing eye) and all visual impairment (<0.5 in the better-seeing eye) by age and gender in Japan, 2007

	Blindness			Visual Impairment		
	Male	Female	Total	Male	Female	Total
Age	Number (Prevalence)	Number (Prevalence)	Number (Prevalence)	Number (Prevalence)	Number (Prevalence)	Number (Prevalence)
<40	6,600 (0.02%)	6,100 (0.02%)	12,700 (0.02%)	58,000 (0.20%)	53,000 (0.19%)	111,000 (0.19%)
40–49	5,200 (0.06%)	4,800 (0.06%)	10,000 (0.06%)	45,000 (0.56%)	42,000 (0.53%)	87,000 (0.55%)
50–59	15,100 (0.16%)	13,900 (0.15%)	29,000 (0.16%)	132,000 (1.43%)	122,000 (1.31%)	253,000 (1.37%)
60–69	21,100 (0.27%)	19,600 (0.23%)	40,700 (0.25%)	184,000 (2.34%)	170,000 (2.02%)	355,000 (2.17%)
70–79	30,300 (0.54%)	28,100 (0.41%)	58,400 (0.47%)	264,000 (4.73%)	245,000 (3.55%)	509,000 (4.08%)
80≤	19,200 (0.81%)	17,800 (0.37%)	37,000 (0.52%)	167,000 (7.10%)	155,000 (3.24%)	322,000 (4.52%)
Total	97,500 (0.16%)	90,300 (0.14%)	187,800 (0.15%)	850,000 (1.37%)	787,000 (1.20%)	1,637,000 (1.28%)

TABLE 3 Prevalence and number of all visual impairment (<0.5 in the better-seeing eye) by cause and gender in Japan, 2007

	Male		Female		Total	
Cause	Number	Prevalence	Number	Prevalence	Number	Prevalence
Glaucoma	183,000	0.29%	215,000	0.33%	398,000	0.31%
Diabetic Retinopathy	163,000	0.26%	175,000	0.27%	338,000	0.26%
Degenerative Myopia	76,000	0.12%	122,000	0.19%	198,000	0.16%
ARMD	125,000	0.20%	53,000	0.08%	178,000	0.14%
Cataract	45,000	0.07%	73,000	0.11%	118,000	0.09%
All others	258,000	0.41%	149,000	0.23%	407,000	0.32%
Total	850,000	1.37%	787,000	1.20%	1,637,000	1.28%

ARMD = Age-related macular degeneration.

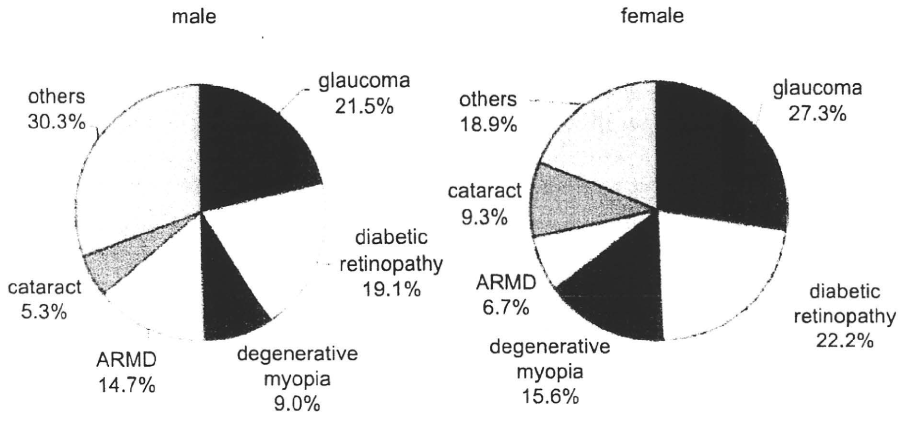

FIGURE 1 Causes of all visual impairment by gender in Japan, 2007. ARMD = Age-related macular degeneration.

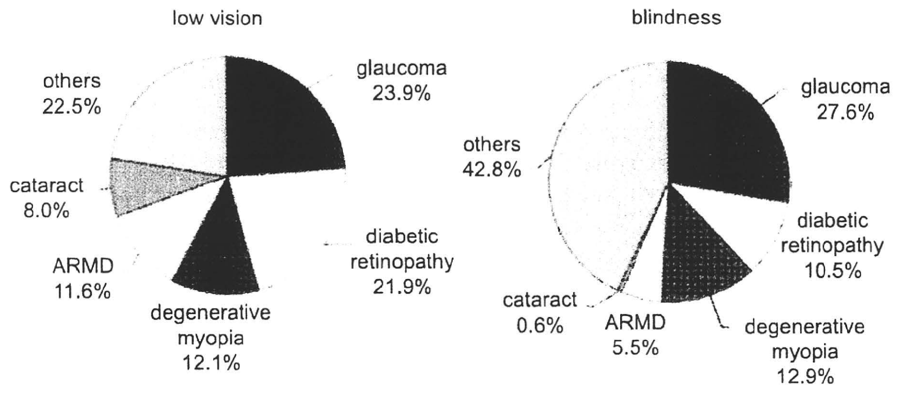

FIGURE 2 Causes of visual impairment by severity in Japan, 2007. ARMD = Age-related macular degeneration.

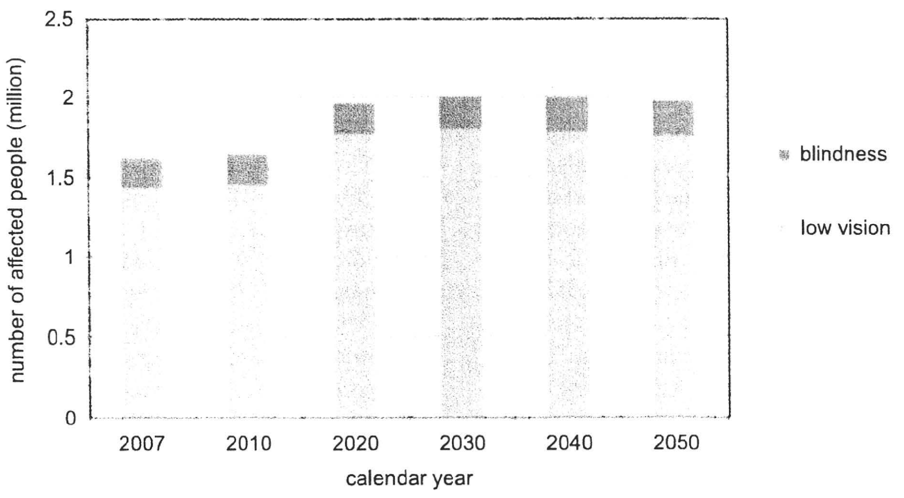

FIGURE 3 Number of all visual impairment by severity, 2007–2050.

DISCUSSION

In the current study, the prevalence of visual impairment was calculated following extensive analysis of Japanese epidemiological data, census material and population projections. It was estimated that 850,000 males and 787,000 females (1,637,000 in total) were visually impaired in Japan in 2007. Of these, 98,000 males and 90,000 females (188,000 in total) were estimated to be blind. These prevalence numbers are greater than those in the report by Nakae and associates, that were based on the number of people certified as visually impaired.[22] Our estimation is considered to be appropriate, because different criteria were used to define visual impairment. In addition, as mentioned by Nakae, significant numbers of the people were not certified even though they met the criteria for visual impairment under Japanese welfare law.[22] Prevalence of visual impairment and blindness in Japan estimated in this study were 1.28% and 0.15%, respectively, and they were comparable or lower compared with the epidemiological studies conducted in developed nations where advanced medical services are available, such as the United States, the Netherland, and Australia.[1–6]

By gender, males comprised 52% and females 48% of visual impairment, with males slightly exceeding females in age cohorts. The prevalence of visual impairment in females is the same or slightly higher than in males in epidemiological studies conducted in other nations.[1–8] The discrepancy may be explained by the significant differences in prevalence of ARMD between males and females observed in our study. The relatively low prevalence of cataract as a cause of visual impairment in our study may be of significance, because women are predominantly affected by cataract.[1–8,25] Prevalence of visual impairment was found to increase with age, more than half of the visually impaired were 70 years or older and 72% of the total number of the visually impaired were 60 years or older. Such correlation between the prevalence of visual impairment and age has been a common feature of epidemiological studies conducted in other nations.[1–8]

The leading causes of visual impairment were glaucoma, diabetic retinopathy, degenerative myopia, ARMD and cataract, and they comprised almost 75% of total visual impairment. Glaucoma has also been reported to be the most frequent cause of visual impairment among other Asian nations such as Singapore and Mongolia.[7] As were reported by Nakae and Iwase[11,22] glaucoma was the leading cause of visual impairment in Japan and it accounted for almost one quarter of all cases of low vision and all cases of blindness.

Among the five leading causes, significant differences in prevalence between males and females were observed in ARMD, degenerative myopia and cataract. The higher prevalence for men than women of visual impairment from ARMD women was a constant feature of the Japanese epidemiological surveys,[15–17] but no such significant differences in the prevalence of ARMD between men and women were found in the Rotterdam Study, the Melbourne Visual Impairment Project and the Blue Mountains Eye Study.[4,5] The reason for higher prevalence of ARMD for men than women is not clear. It may be partly explained by smoking rates among men being significantly higher than those among women in Japan, because smoking is known as a major risk factor for ARMD.[15,16,26,27] The incidence and demographic features of idiopathic polypoidal choroidal vasculopathy, a subtype of ARMD, are reported to vary in different ethnic groups.[28] Idiopathic polypoidal choroidal vasculopathy, which is more common in Japan than in Western countries, predominantly affects men.[28,29] This may also partly explain higher prevalence of ARMD for men than women in Japan.

On the contrary, the prevalence rates of degenerative myopia and cataract were higher for women than men. The slightly higher prevalence of visual impairment from cataract among females was corresponding to past epidemiological studies,[1–8] but the higher prevalence of degenerative myopia in Japan is noteworthy. While a relatively high prevalence of degenerative myopia as a major cause of low vision has been reported rarely in White persons, higher prevalence of the disease among Chinese, Japanese, Middle Eastern, or Jewish descent has been reported.[7] An additional notable feature of the Japanese epidemiological data was that high rates of myopia were more prevalent among younger Japanese women.[21]

When categorizing visual impairment by severity according to low vision and blindness, there were significant differences in the prevalence of cataract and diabetic retinopathy. While cataract accounted for 8.0% of all causes of low vision, it only accounted for 0.6% of all causes of blindness. This is likely the result of cataract surgery being undertaken in cases of advanced loss in visual acuity. Nakae noted that advances in surgical procedures have mitigated the impact of cataract as a major cause of visual impairment.[22] Although diabetic retinopathy accounted for 21.9% of the people with low vision in Japan, it only accounted for 10.5% of blindness. It still remained, however, to be the second leading single cause of visual impairment in Japan in both categories of severity. Iwase noted that the prevalence of diabetes is relatively high in Japan and that diabetic retinopathy as a major cause of bilateral low vision may be compatible with the relatively high prevalence of the disease.[11] The reason for diabetic retinopathy not being the leading cause of blindness is probably because ophthalmological treatment such as photocoagulation and vitreous surgery are developed and common in Japan. Additionally, access to good medical services in Japan through its universal health care system enables people with diabetes to have better systemic control.[14]

Most of "the other" causes of visual impairment in Japan were attributed to conditions such as retinitis pigmentosa, optic nerve disease, traumatic injury, and congenital anomaly. These diseases comprised 22.5% of the causes of low vision, but a significantly high 42.8% of blindness. This is probably due to lack of effective treatment for most of the diseases under this category, and therapeutic developments for these intractable optical diseases and enhancement in low vision care are needed.[30,31]

In this study, prevalence projections of visual impairment were estimated up to the year 2050. The prevalence of visual impairment was projected to increase from an estimated 1.64 million people in 2007 (1.3% of the population) to almost 2 million Japanese (2.0%) by 2050, and blindness was projected to increase by 17.6% over the next four decades to around 221,000 people. The present study indicates that the prevalence of visual impairment is higher among the elderly and the major cause of the impairment is ARMD. As Japanese society continues to age, the number of the elderly with visual impairment is estimated to increase if the level of ophthalmological intervention, such as prevention measures and treatment modalities, remains as it is now. Visual function is an extremely important factor of retaining quality of life for the elderly.[32,33] The burden of disease due to visual impairment is expected to increase and the impact of visual impairment and significance of ophthalmic treatment are expected to also increase over time.[30,31] It is concluded that further efforts will be essential in preventing diseases that can cause visual impairment and in detecting such diseases at an early stage as well as developing cures for them.

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ORIGINAL ARTICLE

Geographical Distribution of Ophthalmologists Before and After the New Postgraduate Training Program in Japan

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ABSTRACT

Purpose: To assess the geographical distribution of ophthalmologists in Japan before and after the start of a new postgraduate training program, which was suggested to exacerbate the uneven distribution of physicians.

Methods: The number of physician per million population was calculated for ophthalmologists by using adjusted municipal boundaries and the data from physician censuses performed in 1996 and 2006, as well as the population censuses performed in 1995 and 2005, respectively. The Gini coefficients, income inequality measure that ranges from 0 (perfect equality) to 1 (perfect inequality), and 95% confidence intervals (95%CIs) were computed from the Lorenz curves for the 2 periods.

Results: The total number of ophthalmologists increased from 10,982 to 12,362 over the last decade. The Gini coefficient (95%CI) for ophthalmologists was 0.405 (0.314–0.496) and 0.353 (0.272–0.434) in 1996 and 2006, respectively.

Conclusions: The geographical distribution of ophthalmologists in 2006 was better than that in 1996, although there was no statistically significant change. There is no evidence that the new postgraduate training program encouraged an imbalance in the geographical distribution of ophthalmologists.

KEYWORDS: Inequality; Geographical distribution; Gini coefficient; Japan; Ophthalmologist

INTRODUCTION

Maldistribution of physicians across geographical or geopolitical units is always a significant public health issue worldwide.[1–15] Urban areas almost invariably have a substantially higher concentration of physicians than rural areas,[16] because of more opportunities for professional development, better educational facilities, social ties, and other amenities for physicians and family members in urban areas. Japan is no exception to this trend. Despite the increase of practicing physicians between 1980 and 1990, the inequality of their distribution did not improve.[1] Thus, a lack of physicians in rural areas is a serious problem.[1,17]

Generally, most hospitals in Japan have some association with a department of a medical school,

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and physicians are dispatched to these hospitals under the supervision of that department.[18] Most medical graduates used to undergo postgraduate training at a hospital of the university from which they graduated. The Japanese government changed this training program in April 2004, and made it compulsory to do at least 2 years of training focused on primary care in teaching hospitals. This new program has been reported to encourage a more uneven distribution of physicians, because new medical graduates selected urban hospitals for their training rather than university hospitals and physicians working in rural areas returned to the university hospitals to fill the void left by the lack of new medical graduates. According to Japan Medical Association Research Institute, after the new residency training program launched, 79.6% of all university hospitals have cut back the dispatch of physicians to other medical institutions, and 44.6% of these institutions have stopped receiving any physicians from university hospitals.[19]

The main objective of this study was to assess whether the new postgraduate training program encouraged a more uneven geographical distribution of ophthalmologists. This was done mainly by calculating Gini coefficients, which were traditionally used to analyze income inequality and applied to evaluating the geographical distribution of health services.[1,4,6–8,10,11,14,15,20]

METHODS

Data and Data Sources

The number of ophthalmologists and all physicians in each municipality in the years 1996 and 2006 were obtained from the website of the Ministry of Health, Welfare, and Labor.[21] These data were thought to be the most credible for assessing the location of physicians, because each physician in Japan has the obligation to report to the public health department under the medical practitioners law with respect to their working categories, workplaces, and departments or specialties on December 31 of every second year. Population data for the municipalities were obtained from the national censuses held in the years 1995 and 2005. The 1995 and the 2005 censuses were used because they provided more precise data than that from the vital statistics registration system in 1996 and 2006.

Data Analysis

Japan consists of 47 prefectures, and prefectures are divided into cities, towns, and villages, in accordance with population size. In addition, major cities are subdivided into wards. Japan is currently undergoing administrative re-organization by large-scale merger and absorption of municipalities to cut administrative costs. Thus the total number of municipalities dramatically decreased during the study period.

First, the number of physicians and the population of the municipality in every data set were adjusted for the new municipal boundaries. Older municipal boundaries, however, were utilized for municipalities that newly separated in the study period, because the number of physicians or population in each area before separation was not available. Second, the number of physicians per million population (PMP) in the years 1996 and 2006 was calculated across 1,959 municipalities using the national census data for 1995 and 2005, respectively. Third, PMP was compared in 7 different population subgroups which were categorized by Kobayashi et al[1] (populations of 5,000 or less, 5,001–10,000, 10,001–30,000, 30,001–50,000, 50,001–100,000, 100,001–300,000 and 300,001 or more) between 1996 and 2006. Fourth, Lorenz curves were drawn by plotting the cumulative frequency of physicians on the vertical axis and the population on the horizontal axis in ascending orders of PMP across all municipalities. Finally, the Gini coefficient (defined as twice the area between the Lorenz curve and an intersecting diagonal line drawn at 45 degrees) was calculated. The principles of this measure have been explained elsewhere[10,14,20,22] or summarized on the World Bank website.[23] Its 95% confidence interval (95%CI) was calculated using the linearization method proposed by Kovacevic and Binder.[24] The Gini coefficient is 0 when a distribution is completely even and it reaches 1 when a distribution is perfectly uneven. The coefficient of variation (CV), calculated by dividing the standard deviation by its mean, and the 75th/the 25th percentile ratio were also computed. These statistical analyses were performed with Stata/SE10.0 for Windows (Stata Corp LP, Texas, USA).

In accordance with Japanese law, Juntendo University ruled the study was officially exempt from review, because of the use of publicly released data by the Japanese government. The study was consistent with the Declaration of Helsinki.

RESULTS

According to the census, total population of Japan in the 1995 was 125.6 millions, and increased to 127.8 millions in 2005. The number of all physicians was 230,297 and 263,540, in 1996 and 2006, respectively. Ophthalmologists also increased from 10,982 to 12,362 over the last decade. Mean (± standard deviation) of