The Fasting Hyperglycaemia Study: II. Randomized Controlled Trial of Reinforced Healthy-Living Advice in Subjects With Increased But Not Diabetic Fasting Plasma Glucose

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Self-referred subjects (N = 227) thought to be at risk of developing non–insulin-dependent diabetes mellitus (NIDDM) and with fasting plasma glucose (FPG) in the range of 5.5 to 7.7 mmol · L^{-1} on two consecutive tests 2 weeks apart were randomized to reinforced or basic healthy-living advice. They were simultaneously allocated either to a sulfonylurea group or a control group in a two-by-two factorial design. A total of 201 subjects in three English and two French centers completed 1 year's follow-up study. Reinforced advice recommending dietary modification and increased exercise was given every 3 months, and basic advice was given once at the initial visit. Glycemia was monitored by FPG, dietary compliance by body weight and food diaries, and fitness compliance by bicycle ergometer assessment and exercise diaries. Both reinforced and basic advice groups had a significant mean reduction in body weight (1.5 kg) at 3 months, although the weight subsequently returned to baseline. After 1 year, subjects allocated to reinforced advice versus basic advice (1) reported a lower fat intake (34.1% *v* 35.8%, *P* = .04) with no difference in lipid profiles, (2) had improved fitness as shown by increased calculated maximal oxygen uptake ([$\dot{V}O_2max$] 2.39 *v* 2.18 L · min^{-1}, *P* = .007) with no change in insulin sensitivity, (3) showed no change in FPG, glucose tolerance, or hemoglobin A_{1c} (HbA_{1c}), and (4) showed a greater tendency to withdraw from the study (16% *v* 7%, *P* = .03). In conclusion, reinforced healthy-living advice given to self-referred subjects with increased FPG did not encourage sufficiently pronounced life-style changes for significantly greater effects on body weight and glycemia in a 1-year study than basic healthy-living advice.

DIETARY AND EXERCISE ADVICE are a first-line therapy for patients with newly diagnosed non–insulin-dependent diabetes mellitus (NIDDM). No randomized clinical trials have investigated healthy-living advice in subjects with persistently increased fasting plasma glucose (IFG) levels less than those defined by the World Health Organization (WHO) as indicative of diabetes. Several groups[1-6] have reported on the effects of an intervention program in Caucasian subjects with impaired glucose tolerance (IGT), but in these studies either the numbers were small[1,2,4,5] or no randomized parallel untreated group was used.[3,6] There is therefore little information on the value of healthy-living advice in westernized populations, although recent studies in less westernized populations in Chinese[7] or Tanzanian Hindu[8] subjects with IGT, which included control groups, showed a reduced incidence of diabetes among those on intervention programs involving diet and exercise.

We have studied whether healthy-living advice involving diet and exercise would have any significant effects on glycemia and fitness parameters of a group of people with IFG, fasting plasma glucose (FPG) 5.5 to 7.7 mmol · L^{-1} on two occasions, thought to be at increased risk of progression to NIDDM. The Fasting Hyperglycaemia Study (FHS) is a randomized controlled trial designed to study the effects of both life-style changes and sulfonylurea therapy in a factorial two-by-two design. Reinforced and basic healthy-living advice are compared here.

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SUBJECTS AND METHODS

Subject Recruitment and Randomization

Local ethics committee permission was obtained to recruit subjects in two French (Lyon and Toulouse) and three English (Exeter, Leicester, and Oxford) centers. In brief, 1,580 self-referred subjects with at least one risk factor for NIDDM had FPG measured. Those with IFG were retested.[9] A total of 293 subjects had IFG on two occasions, and 227 (78%) of these were randomized into this prospective study (Fig 1). Thirty-nine (13%) did not wish to enroll in the study, and 27 (9%) met the exclusion criteria. Those who joined the study were similar to those who did not: (mean ± SD) age, 50 ± 9 versus 50 ± 10 years (nonsignificant [NS]); 41% versus 39% male (NS); and median (interquartile range) FPG, 6.0 (5.8 to 6.4) mmol · L^{-1} versus 6.0 (5.8 to 6.4) mmol · L^{-1} (NS). Subjects were randomized (Table 1) to reinforced (50%) or basic (50%) healthy-living advice in a factorial design with allocation to sulfonylurea group (50%) or a control group (50%), who received either placebo (25%) or no tablets (25%). A total of 201 subjects (89%) completed 1 year's follow-up.

After recruitment, subjects had a standard 75-g 2-hour oral glucose tolerance test (OGTT) for assessment based on WHO criteria for diabetes,[10] and a continuous infusion of glucose with model assessment (CIGMA) to assess β-cell function (%β) and insulin sensitivity (%S).[11] Before all OGTT and CIGMA tests, subjects were requested to have normal meals for 3 days, to avoid strenuous exercise, and to attend fasting without taking any medication. CIGMA tests consisted of a continuous intravenous infusion of glucose (5 mg · kg^{-1} ideal body weight/min) with three venous blood samples taken at 5-minute intervals at baseline and at 1 hour.

After therapy was instituted, subjects were seen at 6 weeks, at 3 months, and thereafter every 3 months for determination of body weight, FPG, and blood pressure (BP). HbA_{1c}, insulin, triglyceride, cholesterol (ie, total, low-density lipoprotein [LDL], and high-density lipoprotein [HDL] cholesterol) levels were measured at baseline and repeated at 1 year together with a repeat OGTT and CIGMA. All subjects were required to complete an initial 3-day diary of food consumption. Fitness levels were assessed by measuring the heart rate response to a submaximal graduated-exercise test on a bicycle ergom-

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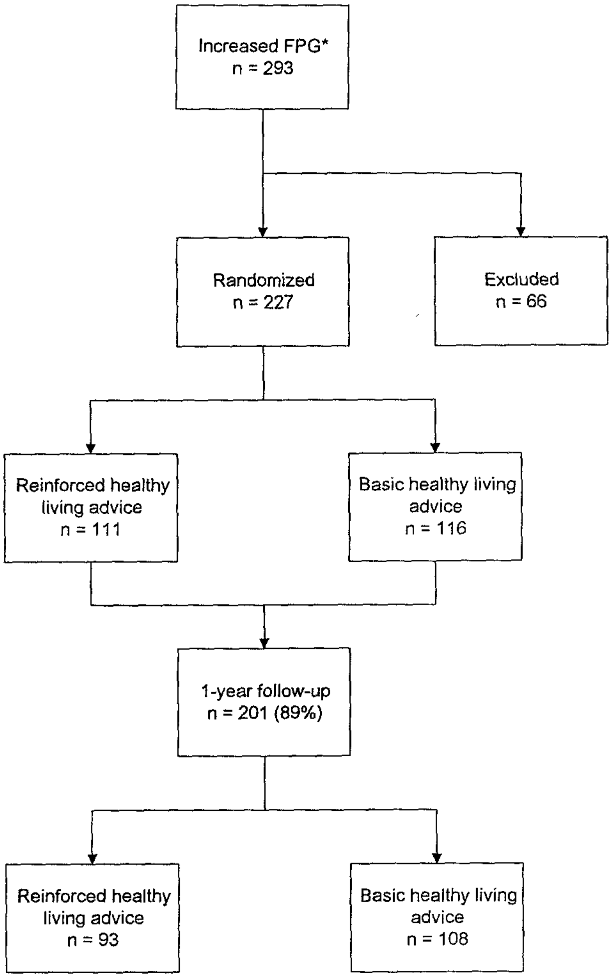

Fig 1. Subject recruitment and randomization. *On 2 consecutive occasions 2 weeks apart.

eter (Ergometer 814E; Monark, Vaburg, Sweden) and calculating maximal oxygen uptake ($\dot{V}O_2$max) using a nomogram.[12]

Basic Healthy-Living Advice

Subjects allocated to basic dietary and exercise advice were given written dietary information and seen by a physician who advised weight loss (if the body mass index [BMI] was >25 kg · m^{-2}) and increased physical activity. Patients were seen every 3 months for assessment of glycemia, but healthy-living advice was not reiterated.

Reinforced Healthy-Living Advice

A dietary and exercise "package," potentially applicable in the long term to a free-living older and often sedentary population, was devised for subjects allocated to reinforced advice. They were seen by a dietitian and advised to change their diet in line with the nutritional recommendations of the British Diabetic Association (BDA).[13] All subjects were given specific advice on limiting total fat intake and increasing consumption of unrefined carbohydrate and dietary fiber. Individual energy requirements were calculated using the formula outlined by the Nutritional Subcommittee of the BDA.[13] Subjects with a BMI over 22 kg · m^{-2} were advised to lose weight and were given an energy prescription providing 500 to 700 kcal · d^{-1} less than their calculated energy expenditure rather than following their habitual energy intake, as this is reported to produce more successful weight loss than a standard 1,000-kcal · d^{-1} diet.[14] Subjects with a BMI of 22 kg · m^{-2} or less received dietary advice appropriate for weight maintenance and were given a diet sheet with instructions to choose freely from the section on starchy foods. Consumption of low-fat products containing sugar was allowed in moderation. Subjects were seen by a dietitian and a fitness instructor every 3 months and were required to complete food and exercise diaries before each clinic visit.

Subjects were encouraged to increase physical activity gradually during the first 3 months in a structured fashion. The exercise program encouraged continuous rhythmic movements involving the large muscle groups (eg, swimming, cycling, brisk walking, skipping, jogging, and low-impact aerobics). Subjects were advised to exercise initially for 20 to 30 minutes two to three times per week at a rate sufficient to increase the pulse rate to 70% to 85% of their calculated maximum. The frequency of exercise sessions was to be gradually increased to five to six times per week by the end of the year. Specific advice was given on warming up and cooling down, and subjects were advised not to exercise when unwell.

Table 1. Factorial Randomization to Healthy-Living Advice Groups Plus Sulfonylurea or Control Group

	Healthy-Living Advice		
Group	Reinforced	Basic	Total
Sulfonylurea	56	56	112
Control	55	60	115
Total	111	116	227

Three-Day Food Diary

Subjects were asked to record their dietary intake over 3 consecutive days (Sunday, Monday, and Tuesday). A self-explanatory diet diary was sent by mail for completion before randomization and at the end of 1 year. In addition, subjects receiving reinforced advice completed food diaries every 3 months. The diary contained questions relating to usual intake of foods (eg, type of bread, biscuits, spreading fat, and milk), an example detailing how the diary should be completed, and a section in which food and drink consumption was to be recorded in detail over the 3-day period. No weighing of food was required; portion sizes were recorded in household measures or as discrete items (eg, slices of bread or no. of biscuits). Each diary was reviewed with the subject by a dietitian in the clinic to resolve ambiguities. Completed diaries were coded using standard UK food composition tables[15] and standard food portion sizes[16] by a single dietitian blinded to the subject's therapy allocation. Mean daily intakes of energy, protein, fat, carbohydrate, and dietary fiber were calculated using Dietplan 5.[17]

Fitness Assessment

Physical fitness, assessed as $\dot{V}O_2$max, was calculated using a nomogram from the heart rate response to a 10-minute bicycle ergometer test.[12] Subjects were fitted with a heart rate monitor and asked to cycle at 50 to 60 W initially depending on their fitness; the workload was increased at 2-minute intervals with the aim of achieving a heart rate approaching the subject's calculated maximum (220 − age in years) over 10 minutes. Two habituation tests were performed to assess each subject's level of fitness and to calculate the workload required to produce a heart rate approaching the calculated maximum during the baseline test. This same workload was used for all subsequent tests. Fitness assessments were stopped if the heart rate exceeded the calculated maximum or if the subject complained of discomfort or breathlessness. Baseline and 1-year fitness assessments were completed for 112 subjects (56%). Twenty-two subjects (11%)

were excluded from fitness tests because they either had an abnormal electrocardiogram or exhibited atrial fibrillation or because they were taking β-blockers, and 67 (33%) completed only one or neither assessment due to a recent transitory illness (eg, respiratory or cardiac) or musculoskeletal complaints that would be exacerbated by exercise.

Exercise Diary

Subjects allocated to reinforced healthy-living advice were encouraged to keep a daily record of the type and duration of exercise in a diary collected at each 3-month visit. Diaries were assessed at the coordinating center using activity levels recommended by the Allied Dunbar National Fitness Survey (NFS).[18]

Biochemical Methods

HbA_{1c} was assayed by high-performance liquid chromatography (Diamat; Bio Rad, Herts, UK; laboratory normal reference range, 4.5% to 6.2%). Fructosamine, fasting lipids, triglycerides, total, HDL- and LDL-cholesterol, C-peptide, and insulin levels were measured initially and at 1 year at a central laboratory.[9,19] C-peptide levels were used to assess β-cell function.[11]

Statistical Methods

The protocol-defined outcome compared the reinforced and basic healthy-living groups as a whole irrespective of the factorial allocation to sulfonylurea or control groups. To rule out the effects of sulfonylurea therapy on weight and glycemia,[20] a secondary analysis was performed comparing reinforced and basic advice in subjects allocated to the control group. Data are presented as the mean ± SD. Glucose and HbA_{1c} are shown as the median (interquartile range), and insulin, C-peptide, CIGMA %β and %S, and triglyceride as the geometric mean (±1 SD range). Baseline and 1-year values within the basic or reinforced advice groups were compared using the paired *t* test or Wilcoxon signed-rank test for continuous variables, with the sign test for categorical variables. Mean changes over 1 year were compared between groups using the two-sample *t* test or Mann-Whitney *U* test for continuous variables and the Cochran-Mantel-Haenszel test (allowing for baseline category) for categorical variables.[21] Fitness changes over 1 year were categorized as (1) deterioration such that the year-end test could not be completed, (2) greater than 10% change in $\dot{V}O_2$max, and (3) improvement in fitness such that the maximal heart rate was too low to calculate $\dot{V}O_2$max. Categorical fitness changes were compared with the mean exercise diary NFS scores using the Spearman rank correlation coefficient.[21] All analyses were performed on an intention-to-treat basis using SAS.[22]

RESULTS

There were no significant baseline differences between subjects allocated to reinforced or basic healthy-living advice groups for any reported measures apart from triglyceride (1.34 *v* 1.11 $mmol \cdot L^{-1}$, respectively, $P = .03$). The 11% who withdrew from the study had similar values for body weight, waist to hip ratio, measures of glycemia, lipid profiles, and BP compared with subjects who were evaluated for 1 year, although significantly fewer subjects were male (23% *v* 44%, $P = .04$) and more had been allocated to reinforced advice than to basic advice (69% *v* 46%, $P = .03$).

Dietary Intake and Body Weight

Baseline estimated energy intake was 2,110 ± 546 $kcal \cdot d^{-1}$ with calories derived 42% ± 6% from carbohydrate, 37% ± 6% from fat, and 17% ± 4% from protein. Mean baseline fiber

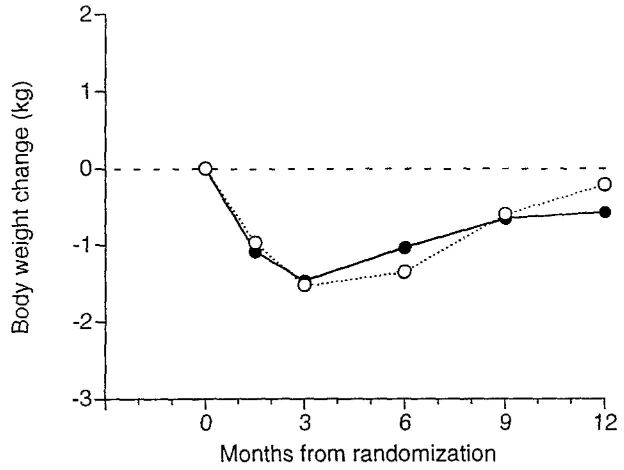

Fig 2. Mean body weight change from baseline with (●) reinforced and (○) basic advice.

intake was 22 ± 8 $g \cdot d^{-1}$. Eighty (86%) of the reinforced advice group and 85 (79%) of the basic advice group were advised to lose weight. After 3 months, the mean body weight in both groups showed a significant decrease (1.5 kg, $P < .001$), but after 1 year the change from baseline was no longer significant (Fig 2). After 1 year, both reinforced and basic advice groups reported a similar significant reduction in energy intake. The reinforced advice group reported a significantly greater reduction in fat intake than the basic advice group (Table 2). In a secondary analysis at 1 year excluding subjects allocated to sulfonylurea, there was a significant reduction in mean body weight of 1.2 kg ($P < .01$) with no difference between those allocated to reinforced or basic healthy-living advice (80.7 to 79.4 kg *v* 82.2 to 81.1 kg, respectively).

Physical Fitness and BP

$\dot{V}O_2$max could be calculated at both baseline and 1 year in 93 subjects. A further eight subjects had improved their fitness to such an extent that the achieved heart rate was too low to derive a $\dot{V}O_2$max, and 11 had decreased their fitness to such an extent that they could not complete the 1-year test. A categorical analysis of all 112 subjects showed that the reinforced advice group had a greater trend toward increasing fitness than the basic advice group ($P = .01$). In the 93 subjects with calculated $\dot{V}O_2$max values (Table 2), the reinforced advice group showed a significantly greater increase in $\dot{V}O_2$max than the basic advice group. Fifty-one (55%) of 93 subjects allocated to reinforced advice returned at least three of their four exercise diaries, and only 15 (16%) failed to return any. The $\dot{V}O_2$max increase seen in the reinforced advice group was positively correlated with the mean level of exercise reported in the diaries ($r_s = .39$, $P = .005$). No significant changes in BP occurred in either group.

Metabolic Assessment

The median FPG did not change significantly in the reinforced advice group but decreased in the basic advice group, with no significant difference in FPG between the two groups

Table 2. Dietary Intake and Physical Fitness in Healthy-Living Advice Groups After 1 Year

	Reinforced Advice				Basic Advice				Comparison	
Parameter	No.	Baseline	1 Year	Δ (95% CI)	No.	Baseline	1 Year	Δ (95% CI)	Net Difference§	P‖
Weight (kg)	91	81.3	80.8	−0.4 (−1.4-0.5)	107	82.0	81.8	−0.2 (−1.0-0.7)	−0.2	NS
Waist to hip ratio	91	0.88	0.87	0.00 (−0.01-0.01)	108	0.86	0.86	0.00 (−0.01-0.01)	0.00	NS
$\dot{V}O_2max$ (L · min^{-1})	42	2.22	2.39	0.17 (0.06-0.27)†	51	2.21	2.18	−0.03 (−0.11-0.05)	0.20	.007
Energy (kcal · d^{-1})	78	2,106	1,823	−283 (−394-−173)‡	100	2,112	1,909	−203 (−313-−93)‡	−80	NS
Carbohydrate (%)	78	41.9	44.2	2.3 (0.7-3.9)†	100	42.6	43.8	1.2 (−0.2-2.7)	1.1	NS
Protein (%)	78	17.5	18.8	1.3 (0.1-2.6)*	100	16.9	17.4	0.4 (−0.4-1.2)	0.9	NS
Fat (%)	78	37.6	34.1	−3.5 (−5.3-−1.7)‡	100	37.2	35.8	−1.4 (−3.0-0.2)	−2.1	.04
Fiber (g · d^{-1})	78	21.8	22.7	0.9 (−0.5-2.4)	100	22.0	21.3	−0.7 (−2.1-0.6)	1.6	NS
Systolic BP (mm Hg)	91	122	120	−2 (−5-1)	108	121	121	0 (−3-2)	−2	NS
Diastolic BP (mm Hg)	91	78	77	0 (−2-2)	108	76	76	0 (−1-2)	0	NS
Hypertensive (%)¶	91	18	19	1	108	19	19	0	1	NS

*$P < .05$, †$P < .01$, ‡$P < .001$: paired *t* test, Wilcoxon signed-rank test, or sign test.
§Net difference between groups (Δ reinforced − Δ basic).
‖*t* test, Mann-Whitney *U* test, or Cochran-Mantel-Haenszel test to compare differences between groups in changes over 1 year.
¶Systolic BP ≥150 mm Hg or diastolic BP ≥90 mm Hg or treated for hypertension.

(Table 3). There was no significant difference between those receiving reinforced advice or basic advice when subjects allocated to sulfonylurea therapy were excluded from the analysis. (ie, 6.0 to 6.0 mmol · L^{-1} *v* 6.0 to 6.1 mmol · L^{-1}, NS, respectively). The median 1-hour CIGMA plasma glucose was reduced from 10.1 mmol · L^{-1} to 9.9 mmol · L^{-1} ($P < .05$) in the reinforced advice group, with no significant change in the basic advice group and no difference between the two groups. The median HbA_{1c} showed a small but significant reduction in both reinforced and basic advice groups, with no difference between the groups, and if those allocated to sulfonylurea were excluded, there was no change in median HbA_{1c} in either group. Insulin sensitivity as assessed by CIGMA increased significantly in the reinforced advice group (51% to 61%, $P < .01$) but not in the basic advice group (54% to 57%, NS); the change was not significantly different between the two groups (Table 3). Both reinforced and basic advice groups showed a significant reduction in total plasma cholesterol, with no difference between the groups and no change in HDL cholesterol in either. The reinforced advice group also showed a significant reduction in circulating triglyceride, although this was not significantly different compared with the basic advice group (Table 3).

DISCUSSION

Reinforced healthy-living advice compared with basic healthy-living advice resulted in increased physical fitness and a reduction in self-reported fat intake at 1 year, although it should be kept in mind that more subjects in the reinforced group withdrew from the study. Both reinforced advice and basic advice groups lost weight during the first 3 months of the study,

Table 3. Glycemia Parameters and Lipids in Healthy-Living Advice Groups After 1 Year

	Reinforced Advice				Basic Advice				Comparison	
Parameter	No.	Baseline	1 Year	Δ (95% CI)	No.	Baseline	1 Year	Δ (95% CI)	Net Difference§	P‖
FPG (mmol · L^{-1})#	91	5.9	5.8	−0.1 (−0.2-0.1)	106	6.0	5.9	−0.2 (−0.3-−0.1)‡	0.2	NS
HbA_{1c} (%)#	85	5.7	5.6	−0.1 (−0.2-0.0)*	103	5.7	5.6	−0.1 (−0.2-0.0)†	0.0	NS
OGTT 2-h glucose (mmol · L^{-1})#	89	8.7	8.9	0.4 (−0.2-1.0)	104	8.9	8.7	−0.1 (−0.5-0.3)	0.5	NS
Diabetic (%)¶	88	27	26	−1	104	25	25	0	−1	NS
CIGMA 1-h glucose (mmol · L^{-1})#	92	10.1	9.9	−0.3 (−0.6-0.0)*	106	10.2	9.9	−0.2 (−0.4-0.0)	−0.1	NS
CIGMA β-cell function (%β)**	90	61	64	6 (0-11)	104	63	67	5 (−1-10)	1	NS
CIGMA insulin sensitivity (%S)**	91	51	61	11 (5-18)†	104	54	57	0 (−11-10)	11	NS
Cholesterol (mmol · L^{-1})	92	5.0	4.8	−0.2 (−0.3-−0.1)†	104	4.9	4.7	−0.2 (−0.3-0.0)‡	0.0	NS
Cholesterol >6.5 mmol · L^{-1} (%)	92	4	7	3	104	6	3	−3	6	NS
LDL cholesterol (mmol · L^{-1})	92	3.2	3.1	−0.1 (−0.2-0.0)†	104	3.2	3.0	−0.2 (−0.3-−0.1)‡	0.1	NS
HDL cholesterol (mmol · L^{-1})	92	1.1	1.1	−0.01 (−0.04-0.02)	104	1.1	1.1	0.00 (−0.04-0.04)	0.0	NS
Triglyceride (mmol · L^{-1})**	92	1.34	1.22	−0.13 (−0.34-0.07)*	104	1.11	1.10	0.01 (−0.10-0.11)	−0.14	NS

*$P < .05$, †$P < .01$, ‡$P < .001$: paired *t* test, Wilcoxon signed-rank test, or sign test.
§Net difference between groups (Δ reinforced − Δ basic).
‖*t* test, Mann-Whitney *U* test, or Cochran-Mantel-Haenszel test to compare differences between groups in changes over 1 year.
¶OGTT 2-h glucose ≥11.1 mmol · L^{-1} or FPG ≥7.8 mmol · L^{-1}.
#Median at baseline and 1 year.
**Geometric mean at baseline and 1 year.

but this difference was not maintained overall at 1 year, nor was there any effect on glycemia. In subjects not receiving sulfonylurea therapy, the mean body weight was reduced by 1.2 kg at 1 year, with no difference between reinforced and basic advice groups. It is worth noting that basic advice may have been more effective than anticipated, as the subjects were seen every 3 months for blood sampling and this could have provided subtle reinforcement. The improvement achieved in the basic advice group may have been sufficient to mask the benefit obtained in the reinforced advice group, and thus, in these self-referred subjects, an initial reduction in body weight was seen with both basic and reinforced advice. However, the absence of any difference in glycemia between reinforced and basic advice groups relates to a lack of glycemic improvement in either group. It is unlikely that further gain would be obtained from even more intensive advice, as there was already a higher dropout rate among those allocated to reinforced compared with basic advice.

Weight loss in response to dietary advice is seldom maintained in the long term.[23] Although Eriksson and Lindgarde[3] and Bourn et al[6] have reported significant improvements in clinical and metabolic variables with a diet and exercise intervention program in subjects with IGT over 5 and 2 years, respectively, the absence of a randomized control group precludes firm conclusions. Both groups reported a maintained weight reduction of approximately 2 kg. Bourn et al reported decreased body weight over 21 months, although by 24 months the effect was less marked. Eriksson et al included only those willing to participate in a program involving regular supervised exercise sessions. Bitzen et al,[2] reporting on their observational study of 10 weeks' duration, stated that weight loss induced a significant reduction in FPG in diabetic subjects who had a high initial FPG (12.3 to 7.6 $\text{mmol} \cdot L^{-1}$, $P = .001$), but no significant change in those with only mildly elevated FPG (5.7 to 5.8 $\text{mmol} \cdot L^{-1}$, NS).

Subjects entering the FHS had lower baseline fat intake and higher baseline dietary fiber intake than are reported for the British adult population,[24] suggesting that these self-referring volunteers were health conscious and may already have modified their diet before entering the study. The reinforced advice group reported a reduced total fat intake at 1 year, but were unable to achieve either a fat intake of less than 30% of daily energy intake or a fiber intake of more than 30 $g \cdot d^{-1}$ recommended by the BDA; this is in accordance with previous reports.[6,25,26] The 3-day food diary was chosen as the method of reporting intake, since it has been shown to be less intrusive than but as accurate as a 7-day weighed intake.[27] No difference was seen in circulating lipid concentrations between subjects receiving reinforced or basic advice, although mean total cholesterol and LDL cholesterol were reduced in all subjects. In a pilot study, reinforced healthy-living advice decreased cholesterol levels in subjects identified by screening families of patients with NIDDM (who were probably less health conscious than these self-referred volunteers), but only in those who were compliant with the advice.[5]

Physical fitness, assessed by the heart rate response to exercise, was significantly improved in subjects in the reinforced advice group who completed the bicycle ergometer test. The test was chosen as being more suited to a large-scale study than the more invasive direct measurement of oxygen consumption. Increased physical fitness was reflected in increased insulin sensitivity as measured by CIGMA, although this improvement was not significantly different from that in the basic advice group. The improvement in physical fitness had no apparent effect on FPG or HbA_{1c} levels over 1 year. Page et al,[4] using a similar regimen, also reported improved fitness over 6 months without any change in glycemia, but at 2 years' follow-up evaluation, FPG was increased. Recent studies[28-30] have suggested that being physically active over many years can protect against development of NIDDM. However, the effect of physical activity was less marked if the degree of obesity was taken into account, but physical fitness was still an independent predictor of NIDDM.[29,31] It should be noted that these observational studies involved a population whose fitness ranged from very fit to inactive. The fact that a complete change of life-style can be effective was shown when town-dwelling Aborigines reverted to their traditional life-style,[33] but within Western civilizations it is not easy to alter the life-style to such a degree.

The small effect of healthy-living advice among Caucasian subjects in Western societies contrasts with two studies in developing countries in which diabetes is also more common. Pan et al,[7] in a randomized controlled trial on 577 Chinese subjects with IGT, showed that intervention with diet or exercise either alone or in combination reduced the incidence of diabetes over 6 years, and Ramaiya et al[8] have reported that the simple advice to "eat less" and "walk for about 30 minutes a day" reduced the rate of development of diabetes in Indian subjects in Tanzania. It is possible that in Western societies it is difficult to change the customary low level of physical activity and the relatively high energy intake, whereas in developing societies it is easier to reinforce healthy-living advice.

The present study suggests that the life-style changes required to produce a significant reduction in glycemia in subjects with IFG are difficult to achieve in Western society, but some realistic and feasible changes, including increasing physical fitness and reducing fat intake, are possible and should be encouraged. These changes may provide beneficial effects for cardiovascular fitness independent of glucose tolerance. Since diabetes is a chronic progressive disease, a longer period of study of reinforced healthy-living advice is required in Western societies to determine the possible benefits.

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