Promoting Physical Activity in a Low-Income Multiethnic District: Effects of a Community Intervention Study to Reduce Risk Factors for Type 2 Diabetes and Cardiovascular Disease

A community intervention reducing inactivity

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OBJECTIVE — The aim was to assess the net effects on risk factors for type 2 diabetes and cardiovascular disease of a community-based 3-year intervention to increase physical activity.

RESEARCH DESIGN AND METHODS — A pseudo-experimental cohort design was used to compare changes in risk factors from an intervention and a control district with similar socioeconomic status in Oslo, Norway, using a baseline investigation of 2,950 30- to 67-year-old participants and a follow-up investigation of 1,776 (67% of those eligible, 56% women, 18% non-Western immigrants) participants. A set of theory-based activities to promote physical activity were implemented and tailored toward groups with different psychosocial readiness for change. All results reported are net changes (the difference between changes in the intervention and control districts). At both surveys, the nonfasting serum levels of lipids and glucose were adjusted for time since last meal.

RESULTS — The increase in physical activity measured by two self-reported questionnaires was 9.5% ($P = 0.008$) and 8.1% ($P = 0.02$), respectively. The proportion who increased their body mass was 14.2% lower in the intervention district ($P < 0.001$), implying a 50% relative reduction compared with the control district, and was lower across subgroups. Beneficial effects were seen for triglyceride levels (0.16 mmol/l [95% CI 0.06–0.25], $P = 0.002$), cholesterol–to–HDL cholesterol ratio (0.12 [0.03–0.20], $P = 0.007$), systolic blood pressure (3.6 mmHg [2.2–4.8], $P < 0.001$), and for men also in glucose levels (0.35 mmol/l [0.03–0.67], $P = 0.03$). The net proportion who were quitting smoking was 2.9% (0.1–5.7, $P = 0.043$).

CONCLUSIONS — Through a theory-driven, low-cost, population-based intervention program, we observed an increase in physical activity levels, reduced weight gain, and beneficial changes in other risk factors for type 2 diabetes and cardiovascular disease.

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Physical inactivity is an important risk factor for type 2 diabetes (1,2). Clinical trials (3,4) in high-risk individuals have demonstrated the importance of healthy lifestyle programs to prevent diabetes but are rather expensive and not likely to have much impact on the total burden of disease (5,6). Therefore, community-based strategies are urgently needed to stem the worldwide epidemic of obesity and type 2 diabetes, especially in low-income communities (6). Such strategies have a considerable potential effect on public health if they manage to reduce modifiable risk factors even to a small degree in a large proportion of the population.

Disappointing results in previous community-based research on cardiovascular risk factors may be due to methodological weaknesses in the theoretical framework, the intervention itself, the assessment of outcomes, and beneficial secular trends for the risk factors addressed (7–10). The development of theories and models has enhanced our understanding of the processes underlying behavioral changes. A broad set of factors influencing behavior has been identified (11–17). The most promising theories and models hypothesize that behavior is influenced by intrapersonal, social, and physical environmental factors (12,14,15,18–20). Furthermore, intervention efforts should not be expected to change behavior directly but need to address the mediators of behavior change, as these would have to be influenced to obtain changes in behavior (14,18,19,21).

Very few community-based interventions have addressed behavioral risk factors for type 2 diabetes, and most study designs are flawed (6). Hence, we developed and implemented a low-cost community-based intervention program to promote physical activity in a low-income, urban district with high total and

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cardiovascular disease mortality rates (22) and a high prevalence of diabetes, obesity, and physical inactivity (23). The aim of this pseudo-experimental study was to evaluate the effects on physical activity levels, body mass, and other risk factors for diabetes and cardiovascular disease after 3 years.

RESEARCH DESIGN AND METHODS

— All individuals aged 30–67 years in Romsås, a low-income district in Oslo, Norway, with 6,700 inhabitants of multiethnic origin, were invited by letter to the baseline health survey, and as control subjects, an age-matched population-based sample was selected from a similar population in a neighboring district (Furuset) (24). The intervention district had the highest mortality rates of all the 25 administrative districts in Oslo and was the most disadvantaged by measures of socioeconomic status such as education. Both districts comprised self-owned apartment blocks built in the 1970s, had similar infrastructure and local services, were served by the same hospital, but had no common borders. The National Health Screening Service collected data from questionnaires, a physical examination, and blood samples (24) according to strict protocols in mobile units in each district between March and May 2000, with follow-up surveys 3 years later. The invitation contained brief information in the languages of the main immigrant groups, and the questionnaires were translated (English, Urdu, Turkish, Vietnamese, and Tamil). The attendees signed an informed consent form and were offered counseling while completing the questionnaire. A total of 2,950 people (48% of the invited cohort) were examined at baseline (Fig. 1), 22% of non-Western origin (24). Based on demographic and socioeconomic variables, the attendees were fairly representative of the invited cohort (23,24). Attendees consenting to follow-up contact and future use of their data and still living in the Oslo area were invited for the follow-up tests ($n = 2,644$). The regional ethics committee and the Norwegian Data Inspectorate approved the study protocol.

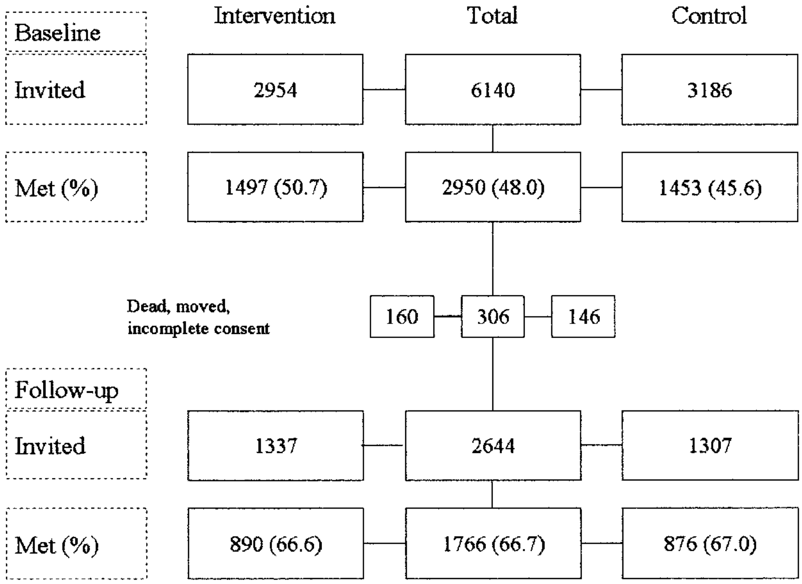

Figure 1—*Flow chart of participants from baseline to follow-up, showing invited cohort, nonattendees, and study participants.*

The intervention

We developed a comprehensive intervention program comprising an orchestrated set of strategies based upon social-psychological and ecological models and perspectives on empowerment and participatory approaches (12,14,15,19,20,25). According to these models, health-related behaviors are influenced by proximal intrapersonal psychological factors and more distal social and physical environmental factors surrounding individuals in their daily life. Intrapersonal psychological factors include attitudes, efficacy and control beliefs, and perceived social support. Social and physical environmental factors comprise objective influence from family and social networks, organizations, communities, and societies (18,21). Expectancy-value and social cognitive learning theories and models of behavior change highlight the importance of altering intrapersonal beliefs and attitudes in order to enhance changes in physical activity (11). Social-cognitive learning theory complemented by social-ecological models have emphasized the need for changes in the social and physical environment, in order to enable and reinforce changes in intrapersonal psychological factors thought to mediate individual physical activity behavior change (15,16,26). Furthermore, the psychological readiness for changes in physical activity behavior varies in the general population, and behavior change seems to be stage based (13,27). Accordingly, all these factors, stated as mediators, seem like targets for intervention efforts. In the light of perspectives on empowerment, it also appears to be important to install a sense of intervention ownership within the local population and improve the sociocultural climate for physical activity (12). Some intervention strategies aimed primarily to change the distal physical and social environmental factors. Others were targeted toward changing the proximal personal psychological mediators of behavior change directly, whereas changes in the distal factors would possibly work indirectly to reinforce a change in the proximal mediators.

To induce a participatory approach, we included local political and lay leaders and health and welfare workers in the planning and implementation of the intervention (12,17,18,21). A local resource group consisting of lay people in the community was established. The intervention was launched in an orchestrated manner, expected to lead to a synergistic and reinforcing effect in changing physical activity behavior in the community (17,25,28–30). The intervention efforts were mainly tailored toward physically inactive groups with low psychosocial readiness for behavior change. The program included strategies intended to increase awareness, improve knowledge, and change attitudes toward physical activity (11), implemented through the use of specially designed leaflets, reminders of the health benefits of using stairs compared with lifts, local meetings, stands, and mass media communication activities. To increase self-efficacy (31) and perceived behavioral control (11) for physical activity, we provided people with individual counseling during the biannual fitness tests (UKK

Table 1—*Baseline characteristics of the cohort study attendees compared with those reinvited but not attending the follow-up by district*

	Attending follow-up			Not attending follow-up			Nonattendants versus attendants, control district versus intervention district
Characteristics	Intervention district	Control district	*P* value (χ^2/*t* test)	Intervention district	Control district	*P* value (χ^2/*t* test)	Net difference (95% CI)
Background variables							
n	890	876		447	431		
Age (years)	49.0 ± 10.0	48.9 ± 9.0	0.72	44.6 ± 9.9	46.8 ± 9.7	0.001	2.4 (0.8–3.9)
Women	507 (57.0)	473 (54.0)	0.21	256 (56.6)	249 (57.2)	0.86	3.6 (−4.4 to 11.6)
Non-Western immigrants	147 (16.5)	172 (19.6)	0.09	138 (30.5)	126 (29.0)	0.61	−4.6 (−11.6 to 2.4)
Years of education	11.6 ± 3.9	12.5 ± 3.8	<0.001	11.2 ± 3.7	11.5 ± 3.7	0.39	−0.7 (−1.3 to 0.0)
Full-time work	527 (60.2)	619 (72.7)	<0.001	276 (61.7)	255 (60.7)	0.76	−13.5 (−21.4 to −5.7)
Disability pension*	156 (19.9)	87 (11.5)	<0.001	67 (17.4)	64 (18.8)	0.62	9.8 (3.1–16.5)
Antropometry variables							
BMI (kg/m^2)	27.1 ± 4.6	26.5 ± 4.3	0.003	27.1 ± 5.2	26.9 ± 4.8	0.52	0.4 (−0.4 to 1.2)
Obesity (BMI >30 kg/m^2)	206 (23.2)	150 (17.1)	0.002	114 (25.4)	91 (21.3)	0.15	2.0 (−4.7 to 8.7)
Daily smoking	315 (35.6)	264 (30.6)	0.03	202 (45.4)	173 (40.5)	0.15	0.1 (−7.8 to 8.0)
Physically inactive							
No heavy physical activity in leisure time or commuting†	362 (41.9)	282 (37.9)	0.10	200 (45.9)	181 (51.4)	0.12	9.5 (1.0–18.0)
Stages of change‡§	282 (37.3)	224 (30.7)	0.007	125 (37.5)	123 (41.8)	0.26	10.9 (1.9–20.0)
Disease prevalence							
Self-reported diabetes	40 (4.6)	24 (2.8)	0.05	21 (4.7)	22 (5.2)	0.75	2.3 (−1.1 to 5.7)
All diabetes	71 (8.0)	45 (5.2)	0.02	28 (6.2)	37 (8.6)	0.18	5.2 (1.0–9.4)

Data are *n* (%) or means ± SD, as appropriate. The net difference between districts with respect to selection is the difference between nonattendees and attendees in the control district versus the intervention district. *Disability pension: *n* = 783/386 and 759/341 for attendees versus nonattendees in intervention and control district, respectively. †Heavy physical activity, *n* = 863/436 and 744/352 in intervention and control district, respectively. ‡Stages of change: *n* = 755/334 and 730/294 in intervention and control district, respectively. All other numbers are identical with or close to the *n* reported at the top of each column. §Sum of precontemplative and contemplative stages.

Walk Test) (32) and organized walking groups and group sessions for indoor activity at no cost for participants during the whole intervention period. These group-based activities were also expected to enhance perceived social support for physical activity through family and friends (33) and promote physical activity identity (34). For those working in the local community organization, social support was also expected to be elicited through encouragement of physical activity communicated by the district administration staff. For the immigrants attending the classes teaching the Norwegian language, information about physical activity and health was given, and specially designed activity groups were organized to make activities more culturally suitable and to increase the participants' identity for physical activity. Also, the labeling of walking trails within the district, improving street lighting, and gritting of pavements and trails in the winter were conducted to increase the accessibility to areas for physical activity (15) and thereby reinforce self-efficacy and perceived behavioral control. Participants identified at baseline as high-risk individuals according to the protocol were offered individual counseling, including advice on dietary and smoking habits, applying the same principles to address the psychosocial mediators for change in behavior.

Measurements

Nonfasting blood samples were analyzed for serum total cholesterol, HDL cholesterol, triglycerides, and glucose (24,35). Time since last meal was registered. Resting blood pressure and heart rate (Dinamap, model no. 8,100/8,101; Criticon, Tampa, FL) were measured according to established standards (24,35). Body mass and height were measured in light clothes with the same electronic device (DS 102; Arctic Heading, Tønsberg, Norway) at both surveys (24,35). Obesity was defined as BMI >30 kg/m^2. Subjects with nonfasting serum glucose ≥6.1 mmol/l were asked to return for a fasting blood sample to identify participants with undiagnosed diabetes (23,24).

A question used in several Norwegian surveys (35) quantified the duration of "heavy physical activity making you sweat and feel out of breath" in leisure time and commuting to work in hours per week on a four-category scale. Those reporting no such activity were categorized as inactive. Furthermore, we used the "stages of change" construct (13) related to physical activity (from a questionnaire returned by post, giving a lower response rate): *1*) precontemplation (physically inactive, no intentions to change), *2*) contemplation (physically inactive, intentions to change), *3*) preparation (physically active, but not regularly), *4*) action (regularly active, but only recently), and *5*) maintenance (regularly active for more than 6 months).

Statistical methods

The baseline values are reported as numbers (proportions) for categorical variables and mean ± SD for the continuous variables. For each subject, the changes in outcome variables were calculated as the difference between baseline and follow-up. Net changes for the intervention versus the control district are reported, defined as the difference in changes from baseline to follow-up between the two districts. The nonfasting serum levels of lipids and glucose were adjusted for time

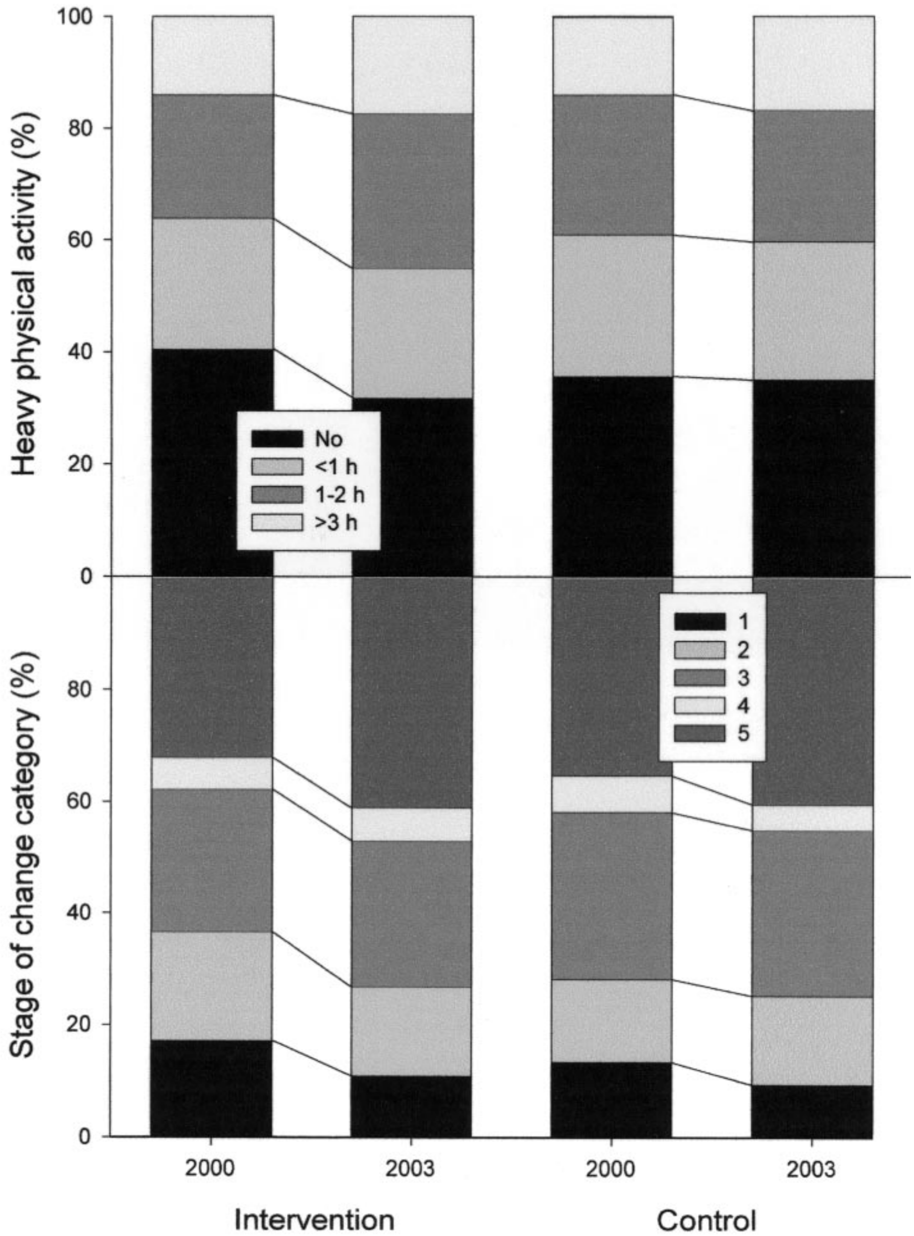

Figure 2—*Change in physical activity from baseline to follow-up, showing the intervention versus control district by two ordinal measures. Net differences between districts in change were tested by Mann-Whitney: the heavy physical activity measure (no activity or hours per week,* P = 0.008*) and stages 1–5 of the change variable (1–2: inactive; 3: active, but not regularly; 4: regularly active, but only recently; 5: regularly active for* >*6 months,* P = 0.024*).*

since last meal (ANOVA), as this differed significantly between the districts at baseline. For categorical data, the proportion in each district with negative change was subtracted from the proportion with positive change. Group differences were tested by nonparametric tests (Mann-Whitney) for categorical ordinal data, by *z* tests for dichotomous variables, and by multiple linear regression analysis for the continuous variables, using districts as a dichotomized independent variable. We assessed the vector of change for the two categorical ordinal physical activity variables together by MANOVA (general linear model) using Wilks' λ. Interaction tests were performed for all outcome variables for district/sex, district/age (dichotomized by </>50 years), and district/ethnicity. Significant interactions are reported. Before adjusting the physical activity outcomes by potentially confounding variables in logistic regression analyses, change in physical activity was dichotomized: increased activity versus no change/reduced activity. Similar adjustments for changes in the continuous variables were performed by multiple regression analyses. A significance level of $P = 0.05$ was used and the 95% CI given when appropriate.

RESULTS — Of 2,644 baseline attendees who were reinvited, 1,766 met, 67% in both districts (Fig. 1). Background factors (education, work participation, and disability pension) and mean BMI were less favorable in the intervention district at baseline (Table 1). No district differences between the nonattendees were found, except for age. However, when comparing the nonattendees and attendees in each district, and calculating the net difference between the control and intervention district (Table 1), there was a slight selection of study participants more active at baseline in the control district at reattendance.

At baseline, the proportion reporting no heavy activity was 40.5% in the intervention district versus 35.7% in the control district, with a net reduction during the intervention period in favor of the intervention district of 8.1% (95% CI 2.4–13.8; $P = 0.005$) (Fig. 2). The net reduction in the proportion of inactive people measured by the stages of change instrument was 6.9% (1.2–12.6; $P = 0.019$) in favor of the intervention district (Fig. 2). The proportion reporting to be active increased correspondingly in the intervention district, with minor changes in the control district. Measured by the heavy activity question, the net increase in favor of the intervention district was 9.5% ($P = 0.008$) and by the stages of change 8.1% ($P = 0.024$). Including the two variables with all categories as a vector in a MANOVA, the increase in physical activity was highly significant ($P = 0.004$), equally for both sexes.

In the intervention district, body mass was reduced in 23.7% and increased in 37.9% of the participants, compared with 15.6 and 44.5% in the control district. The net proportion who increased their body mass (Fig. 3) was significantly lower in the intervention district versus the control district. This was found overall (14.2%, $P < 0.001$) and across subgroups (27.5% for non-Western immigrants, $P = 0.001$). Mean body mass (in kilograms) increased less in the intervention district compared with the control district, but a significant interaction for district/sex and district/age was found,

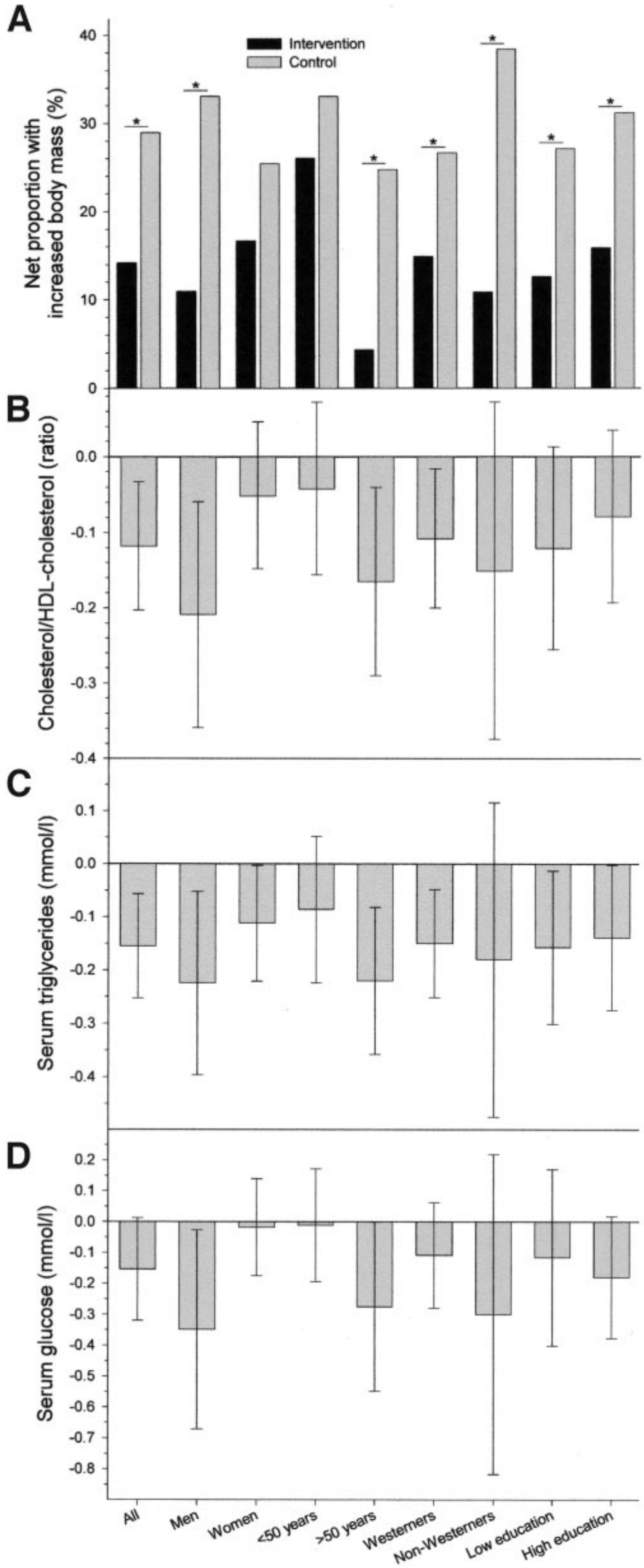

Figure 3—*Net proportion with increase in body mass by districts* (A) *and net change (difference between changes in the intervention and control district) overall and in subgroups, in cholesterol–to–HDL cholesterol ratio* (B)*, triglycerides* (C)*, and glucose* (D)*. Changes in body mass were assessed in categories gain (>2 kg), stable, or loss (>2 kg), and the proportion with reduction was subtracted from the proportion with increase. The net difference between districts in this ordinal change variable was tested by Mann-Whitney.* *$P < 0.01$*. The nonfasting blood samples were adjusted for time since last meal both at baseline and follow-up (ANOVA) and net change by multiple regression analyses. Net changes with 95% CIs are given.*

with district differences most marked in men and participants aged >50 years (Table 2). In men, a net reduction of 1.2 kg (95% CI 0.6–1.9) was found, while there was no net reduction in women (0.3 kg [−0.4 to 0.9]). In participants aged >50 years, the net reduction was 1.0 kg (0.4–1.6; $P = 0.001$) and in non-Westerners 1.0 kg (0.1–1.9; $P = 0.04$).

At baseline, the prevalence of daily smokers was highest in the intervention district (Table 1). The net proportion quitting smoking was 2.9% (0.1–5.7; $P = 0.043$) in favor of the intervention district, with the largest net change in women aged <50 years (6.8% [1.5–12.1]; $P = 0.012$). Favorable changes were also found for both sexes in systolic blood pressure and serum triglyceride levels and for men in resting heart rate, serum total cholesterol–to–HDL cholesterol ratio, and glucose (Table 2 and Fig. 3).

Men increased their self-reported heavy physical activity more than women, and mean resting heart rate was also reduced among men. Women aged <50 years had the poorest results for physical activity and body mass. The reported effect estimates for the physical activity outcomes were slightly reduced but remained significant after adjustments for differences between the districts at baseline with respect to education, work participation, disability pension, BMI, and prevalence of diabetes (heavy physical activity: β unadjusted/adjusted: 0.178, $P = 0.001/0.157$, $P = 0.007$; stages of change: β unadjusted/adjusted: 0.22, $P < 0.001/0.152$, $P = 0.014$). The significant estimates for net changes in body weight (men, β unadjusted/adjusted: −1.2, $P < 0.001/-1.1$, $P = 0.005$), systolic blood pressure (both sexes), resting heart rate, and mean levels of lipids (men) remained fairly stable after similar adjustments but also included the stages-of-change construct.

CONCLUSIONS— After applying a low-cost, theory-based, multicomponent and multilevel intervention to promote physical activity, we observed a net increase in physical activity of 9%, corresponding to 25% relative reduction in the proportion of inactive people in the intervention district compared with a 5% reduction in the control district. The net proportion with an increase in body mass was reduced by 50%. Although there was an increase in mean body mass in both districts, the increase in the intervention district was only half of that seen in the

Table 2—*Biological variables at baseline and net change between districts from baseline to follow-up*

	Baseline values*			Change during 3 years	
	Intervention district (n = 890)	Control district (n = 876)	Group difference *P* value	Net change intervention versus control district	*P* value
Resting heart rate (beats/min)					
Men	73.9 ± 12.9	71.3 ± 12.1	0.003	−1.70 (−3.31 to −0.10)	0.038
Women	76.6 ± 11.4	74.9 ± 11.4	0.02	−0.27 (−1.51 to 0.98)	0.68
Body mass (kg)†					
Men	86.1 ± 15.6	84.8 ± 14.6	0.22	−1.24 (−1.88 to −0.60)	<0.001
aged <50 years	84.8 ± 15.8	82.9 ± 15.3	0.26	−1.11 (−2.01 to −0.21)	0.02
aged >50 years	87.2 ± 15.3	86.5 ± 13.7	0.61	−1.30 (−2.21 to −0.39)	0.005
Women	72.3 ± 13.5	70.0 ± 12.8	0.006	−0.25 (−0.86 to 0.35)	0.41
aged <50 years	71.3 ± 14.0	69.3 ± 13.4	0.11	0.36 (−0.49 to 1.22)	0.41
aged >50 years	73.3 ± 13.0	70.8 ± 11.9	0.03	−0.73 (−1.57 to 0.12)	0.09
BMI (kg/m^2)					
Men	27.5 ± 4.3	27.0 ± 3.9	0.07	−0.42 (−0.63 to −0.21)	<0.001
Women	26.8 ± 4.8	26.0 ± 4.6	0.01	−0.06 (−0.29 to 0.17)	0.61
Systolic blood pressure (mmHg)†					
Men	134.5 ± 17.2	129.4 ± 17.2	<0.001	−3.79 (−5.74 to −1.84)	<0.001
aged <50 years	129.0 ± 13.3	126.8 ± 16.0	0.15	0.22 (−2.27 to 2.70)	0.86
aged >50 years	138.7 ± 18.7	131.7 ± 18.0	<0.001	−7.13 (−10.01 to −4.24)	<0.001
Women	127.3 ± 16.5	119.5 ± 17.7	<0.001	−3.52 (−5.17 to −1.86)	<0.001
aged <50 years	120.8 ± 13.1	114.9 ± 16.6	<0.001	−2.49 (−4.55 to −0.42)	0.02
aged >50 years	133.0 ± 17.1	124.8 ± 17.4	<0.001	−4.45 (−7.06 to −1.85)	0.001
Cholesterol (mmol/l)‡					
Men	5.8 ± 1.0	5.8 ± 1.0	0.96	−0.10 (−0.23 to 0.02)	0.11
Women	5.6 ± 1.1	5.6 ± 1.0	0.59	−0.03 (−0.14 to 0.07)	0.53
HDL cholesterol (mmol/l)‡					
Men	1.26 ± 0.33	1.30 ± 0.35	0.08	0.024 (−0.005 to 0.053)	0.10
Women	1.54 ± 0.39	1.54 ± 0.40	0.86	0.009 (−0.022 to 0.040)	0.56
Cholesterol-to-HDL cholesterol ratio‡					
Men	4.86 ± 1.41	4.73 ± 1.41	0.17	−0.21 (−0.36 to −0.06)	0.006
Women	3.86 ± 1.09	3.87 ± 1.16	0.85	−0.05 (−0.15 to 0.05)	0.30
Triglycerides (mmol/l)‡					
Men	2.4 ± 1.5	2.1 ± 1.2	0.005	−0.22 (−0.40 to −0.05)	0.01
Women	1.7 ± 1.1	1.6 ± 1.0	0.04	−0.11 (−0.22 to 0.00)	0.046
Glucose (mmol/l)‡					
Men	6.0 ± 2.9	5.7 ± 1.9	0.12	−0.35 (−0.67 to −0.03)	0.03
Women	5.4 ± 1.4	5.4 ± 1.5	0.47	−0.02 (−0.18 to 0.14)	0.82

Data are means ± SD or means (95% CI). *All numbers are identical with or close to the *n* reported at the top of each column. †Reported also by age due to interaction. ‡Serum levels of lipids and glucose are adjusted for time since last meal both at baseline and follow-up.

control district. The changes were most pronounced in subgroups at highest risk of type 2 diabetes (men, participants aged >50 years, those with low education, and non-Western immigrants). Furthermore, small, but significant, beneficial effects were seen in serum lipids and smoking habits.

Recent reviews of community-based interventions that include promotion of physical activity reveal few controlled studies of similar duration reporting positive results (6,29,30). Differences in the intervention programs, their duration, and measures of effect size make direct comparison of outcomes difficult. To our knowledge, no other comparable community-based study has reported a similar net increase in physical activity and relative protection against the trend of increasing body mass, consistent across the most susceptible subgroups targeted. Our results can be evaluated against the U.S. Healthy People 2010 goals of reducing the inactive proportion from 40% in 2000 to 20% 10 years later, achieving nearly 50% of this target in the intervention district in 3 years (30). Most other studies have addressed additional risk factors, and few are based on a multilevel approach (6). Favorable trends in cardiovascular risk factors or "contamination" of the control population attenuate the net effects, especially after long-time follow-up (7,10,28).

The changes in behavioral habits and biological outcomes were not restricted to those reached by individual counseling, but sex differences were observed. The increased self-reported physical activity and reduced mean resting heart rate among men suggest improved fitness. The group with the poorest results with respect to physical activity and body mass, women aged <50 years, included a high proportion of single mothers. Smoking habits, however, changed more in women and participants aged <50 years. Adjusting for changes in smoking, or restricting the analyses to those still living in the intervention district, increased the net change in body mass in favor of the intervention district for both sexes (data not shown). The changes in lipids and blood pressure for men and those aged >50 years were comparable with those reported in the Diabetes Prevention Study and the Diabetes Prevention Program (36–38) and could not be explained by differences between the districts with respect to changes in dietary habits or drug treatment. This may indicate that the beneficial effects observed on biological risk factors were related to increased physical activity.

A weakness of our study is the lack of available fasting blood samples for analyses. However, postprandial levels of glucose and lipids are increasingly recognized as potential important independent risk factors, and adjustments for time since last meal increase their validity as pseudo–end points, even though the meals were not standardized (39,40).

Although we would argue that a pseudo-experimental controlled cohort design is a reasonable approach at this stage of research on community interventions (6), the main limitations of the study are related to the nonrandomized design and the risk of selection biases. Since individual randomization is not possible in a community-based intervention, we made every effort to select a control population that matched the intervention group on key factors. At baseline, the districts were comparable on most variables (24). A detailed examination of background factors for the nonattendees based on registry information from Statistics Norway revealed only minor differences between the attendees and nonattendees (23,24). In an urban population with high mobility, we achieved a reattendance rate of 67% in both districts. The attendees in the intervention district were representative of those who met at baseline with respect to obesity, physical activity, and socioeconomic variables. A slight reattendance selection of healthier and better-off participants was seen in the control district, but the main results were robust and did not change when adjusting for these differences. On the other hand, although successful promotion of physical activity has a greater potential to improve health in populations with high risk, the task is recognized as more challenging in groups with low socioeconomic status (6,29,30). The intervention district had the highest mortality rates and the lowest educational level of the districts in Oslo in the 1990s. Thus, the slight selection of more healthy attendees in the control district at follow-up may imply that we have underestimated the beneficial effects in the intervention district.

Unfortunately, it is difficult to measure physical activity levels objectively in large studies, and our data are based on self-reports. The correlation between self-reported and objective measures of physical activity is low, reflecting the difficulties of correctly capturing those with moderate or nonregular activity levels through self-reports (41). Misclassification attenuates true effect measurements. Moreover, "contamination" in the control district may well have occurred, due to exposure to some of the same media information that was part of the intervention, indicated by a weak positive trend in the stages of change instrument (10).

Several of these factors indicate that the observed effect on physical activity is likely to be an underestimate. Furthermore, the effects on biological measurements that are known to be related to physical activity levels indicate that the intervention was effective. The inclusion of potential psychosocial mediators and variables measuring exposure to different intervention components enables us to assess further how the intervention worked (19,42), an important issue for future research (6). Restricting the focus to physical activity only may have made the exposure to the intervention sufficiently intense to result in behavioral change at the community level, even with the limited resources used. Other benefits of this approach, also with the potential to improve health, may be increased collective self-efficacy, sense of cohesion, and the building of social capital in the community (30).

In conclusion, the results indicate that the community-based intervention led to significant health effects on risk factors for type 2 diabetes and cardiovascular disease. Further studies are needed to assess whether changes like those observed translate into a reduction in the incidence of type 2 diabetes and its complications in the longer run and to develop strategies that to a larger degree are feasible for younger women.

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