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Level of physical activity, cardiorespiratory fitness and cardiovascular disease risk factors in a rural adult population in Sogn og Fjordane

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ABSTRACT

Background: Physical activity (PA) and high cardiorespiratory fitness (CRF) are associated with reduced risk of cardiovascular disease (CVD). Sogn og Fjordane County has the reputation of being the most healthy county in Norway. The level of PA and/or CRF may partly explain this health status. However, only one study with regional objectively measured PA data and one study with regional data on CRF currently exist. Thus, the aim of this study was to describe levels of PA, CRF and CVD risk factors in an adult population in the county of Sogn og Fjordane. ***Methods:*** In total, 314 (♀:178 ♂:136) 40-42-year-olds and 308 (♀:175 ♂:133) 53-55-year-olds participated in this cross-sectional study. PA was measured objectively by accelerometry, while CRF was measured directly. ***Results:*** There were no sex differences in total PA level. For the 40-42-year-olds, women spent 6.0 min/day [95% CI: −11.7 to −0.3] less participating in moderate PA compared to men. For the 53-55-year-olds, women were inactive for 36.0 min/day [95% CI: −55.2 to −16.8] less and they participated in light activity for 26.4 min/day [95% CI: 7.7 to 45.2] more than men. In total, 30.0% [95% CI: 24.8 to 35.2] of the 40-42-year-olds and 30.2% [95% CI: 25.0 to 35.4] of the 53-55-year-olds met the Norwegian recommendations for PA. CRF was 49.0 ml·kg^{-1}·min^{-1} for men and 41.6 ml·kg^{-1}·min^{-1} for women for the 40-42-year-olds. For 53-55-year-olds CRF was 41.2 ml·kg^{-1}·min^{-1} for men and 33.9 ml·kg^{-1}·min^{-1} for women. ***Conclusions:*** These results suggest that the level of PA and CRF are higher compared to other available data. This might explain the advantageous health status in Sogn og Fjordane.

BACKGROUND

Regular physical activity (PA) is related to important aspects of health and PA is associated with increased longevity (1) and reduced risk of cardiovascular disease (CVD) and its risk factors (1-3). Physical inactivity is the fourth leading contributing factor to death globally (4). Furthermore, high cardiorespiratory fitness (CRF) is related to lower levels of CVD risk factors (1,3) and CVD- and all-cause mortality (1,5). Due to the health benefits achieved by regular PA, health-enhancing PA recommendations have been issued both internationally (6) and nationally (7,8). Compliance with the PA recommendations has been associated with lower risk of death (9).

Monitoring PA levels is important for surveillance and assessment of the effectiveness of interventions or public health initiatives aimed at increasing PA (10). Assessments of PA have mainly been based upon self-administered questionnaires (11-16). Norwegian PA data show conflicting results (11,13,17,18). For instance, 68% of the Norwegians view themselves as physically active (19) and 33% to 61% reports participation in PA at least twice a week (18). PA is multidi-mensional and these conflicting results might be partly due to methodological weaknesses and poor assessment methods. Self-reported instruments are widely used, but these have numerous limitations with respect to difficulties in ascertaining the frequency, duration and intensity of PA, capturing all domains of PA, social desirability bias, recall bias and reactivity (10,12,20). Due to these limitations, objective assessment instruments, such as accelerometers, have been introduced to quantify PA (10,21). These motion devices are able to determine pattern and intensity of PA (10) and have been used in large population-based studies (13,22,23). In the Kan1 study, PA was assessed both by accelero-meter and self-report in a representative population of Norwegian adults. Results showed that 18% of men and 22% of women met the objectively assessed PA recommendations. However, 43% of men and 32% of women met the recommendations when PA was measured by self-report (13). Similar findings are seen in Sweden and US were physical activity is measured both by self-report (24) and by accelerometry (22,23, 25) in large population samples.

Sogn og Fjordane County has Norway's longest living population. Life expectancy among men and

women are respectively 78.2 and 83.5 years compared to a national average of 76.9 and 81.9 years (26). The county has a reputation of being the most healthy county in Norway (27) and is among the counties with lowest CVD mortality. In 2008 the county had 266 (men) and 153 (woman) deaths caused by CVD among every 100 000 persons, compared to 275 (men) and 163 (woman) nationally (28). High levels of PA and/or CRF may partly explain this advantageous health status in Sogn og Fjordane. However, only one study with regional objectively measured PA data (13) and one study with regional data on CRF currently exist (29). Thus, the aim of this study was to describe levels of objectively measured PA, directly measured CRF and CVD risk factors in an adult population in the county of Sogn og Fjordane. Based on knowledge of the association between PA, CRF and CVD risk factors, we hypothesized that the population of Sogn og Fjordane County would be more physically active and have higher CRF compared to the rest of Norway.

METHODS

Population

All men and women in three geographically close municipalities in Sogn og Fjordane County (Luster, Sogndal and Leikanger) aged 40-42-years (N=553) and 53-55-years (N=543) at baseline were invited to participate in the study.

The study was divided into two phases. In phase 1, PA was measured objectively by accelerometry between October 2008 and December 2009. Invitation was sent via mail and as a reminder in the case of no response, the subjects were contacted by phone and/or mail. When an informed consent was received, a questionnaire and an accelerometer were sent to the subjects via mail and returned after use in a prepaid envelope. In total, 314 (61%) 40-42-year-olds and 308 (62%) 53-55-year-olds participated in phase 1 (figure 1).

All subjects from phase 1 holding valid data on both questionnaire and accelerometry were considered eligible subjects for phase 2. From a random sample, 200 subjects in both age-groups were invited to participate in phase 2. In total, 107 (56%) 40-42-year-olds and 111 (62%) 53-55-year-olds participated in phase 2 (figure 1). In phase 2, CRF and CVD risk factors were measured. The physical examination was performed between March 2010 and September 2010. Tests were performed at Sogn og Fjordane University College. The same experienced test personnel performed all examinations, except for measurements of blood pressure and blood sampling, which were carried out by two experienced nurses. The subjects signed an informed consent and a health status declaration prior to testing.

The study was approved by the Regional Committee for Medical Research Ethics, the Norwegian Social Science Data Services AS and the Norwegian Tax Department.

Measures

Anthropometry

Height and weight for all subjects were self-reported through a questionnaire in phase 1. Furthermore, waist circumference was measured by anthropometric tape at midpoint between the lowest rib and crista iliaca after a normal expiration in phase 2. The mean value of three measurements was used in statistical analyses.

Blood pressure

Systolic (SBP) and diastolic (DBP) blood pressure were measured automatically using an Omron HEM-907 blood pressure monitor (Omron Healthcare, Inc, Vernon Hills, IL, US) for subjects attending phase 2. The subjects rested for five minutes and a cuff with appropriate size was placed on the left upper arm. Three repeated measures were taken at one-minute intervals. The mean value of the two last measurements was used in statistical analyses.

Blood analysis

Non-fasting intravenous blood-samples were taken from the antecubital vein for subjects attending phase 2. The samples were spun for 12 minutes at 3000 rpm within 60 minutes. The blood-samples were sent by overnight express mail and analyzed by the Department of Medical Biochemistry at Oslo University Hospital, Ullevaal (Norway). Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-c), triglycerides (TG) and glucose were measured in serum using the Cobas Integra 800 analyzer from Roche (F. Hoffmann-La Roche Ltd, Basle, Switzerland). Low-density lipoprotein (LDL-c) was estimated from TC, HDL-c and TG by the Friedewald formula (30). Blood samples are missing from one subject in the 40-42-year-old-group and three subjects in the 53-55-year-old-group due to technical problems.

Cardiorespiratory fitness

For subjects attending phase 2, a CRF (maximal oxygen uptake (VO_{2max})) test was performed on a Woodway PPS 55 treadmill (Woodway GmbH, Weihlam Rhine, Germany) and oxygen uptake was measured with a Moxus metabolic analyzer (AEI Technologies, Inc. Naperville, IL, USA) with accompanying software (Max II). A modified Balke protocol was used (31). The protocol started with constant speed and progressing inclination (2%) every minute for the first 12 minutes, then speed was increased with 0.5 km·h^{-1} each minute until voluntary exhaustion. Before testing, a Polar heart rate (HR) monitor (Polar OY, Kempele, Finland) was fitted to the chest by an elastic strap. The subjects then had two to seven minutes of adaption to the treadmill (2.0-4.8 km·h^{-1}). To collect expired air a Hans Rudolph Vmask (Hans Rudolph Inc, Kansas City, MO, USA), was attached to a Hans Rudolph two-way non re-breathable valve (HR 2700), fitted onto the subject, controlled for air tightness and connected to the metabolic analyzer. Depending on health status, the subjects performed two different test protocols.
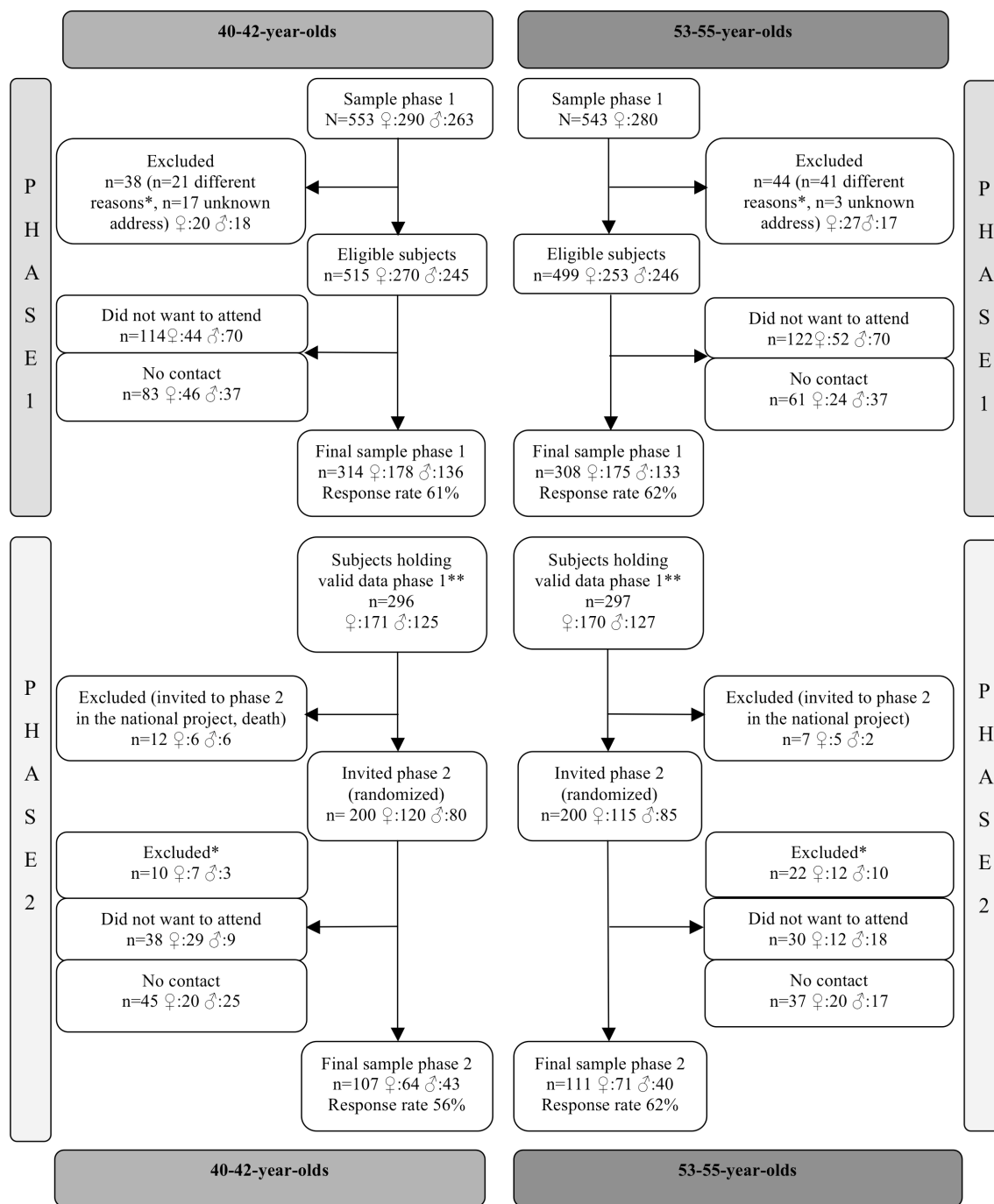
Figure 1. Overview of the study design and the subjects.
* Health situation, work situation, moved from the area
** Returned both valid accelerometer and valid questionnaire

Subjects with a low CVD risk (less than two health-risk items from the health status declaration) started at 4.8 km·h^{-1}, while subjects with a higher risk started at 3.8 km·h^{-1}. Twelve subjects in the 53-55-year-old-group used the higher-risk protocol. The Borg rating of perceived exertion (RPE) was recorded at the end of the test. If Borg RPE was ≥17 and/or RER (respiratory exchange ratio) was ≥1.10, the test was accepted as maximal. In the 40-42-year-old-group, 82 subjects had accepted recordings from the VO$_{2max}$ test. Ten subjects conducted the test, but did not meet the criteria for a maximal test; 14 subjects did not have valid data due to technical problems, while one subject did not perform the test due to poor health status. In the 53-55-year-old-group 99 subjects had valid recordings from the VO$_{2max}$ test. Nine subjects conducted the test, but did not meet the criteria for a maximal test, while three subjects did not test due to poor health status. VO$_{2max}$

was adjusted by a correction factor of 1.059 for ana-lyzer differences in the national Kan1-study by an Oxycon Pro System (13).

Physical activity

PA was measured with the ActiGraph GT1M accelerometer (ActiGraph, LLC, Pensocola, Florida, USA). The accelerometer was initialized and downloaded by the software program ActiLife (ActiGraph, Pensacola, Florida, USA). The subjects were instructed to wear the monitor above the right hip during all waking hours for seven consecutive days, except during water activities and showering. A SAS-based software (SAS-Institute Inc, Cary, North Carolina, USA) called CSA Analyser (csa.svenssonspork.dk) was used for the data reduction.

The epoch length was set at 10 seconds and later collapsed into 60-second epochs for comparisons with other studies. All night activity (between 00:00 and 06:00) and all sequences of at least 60 minutes of consecutive zero counts, with an allowance for one to two minutes of activity, were excluded from each individual's recording. Subjects with at least ten hours of PA data for at least four days were included in further analyses. A total of 300 40-42-year-olds and 298 53-55-year-olds provided valid recordings. PA is presented as overall PA (mean counts per minute, cpm) in total and split by weekday and weekend, inactivity (min/day), light activity (min/day), moderate PA (MPA, min/day), vigorous PA (VPA, min/day) and the combined moderate to vigorous PA (MVPA, min/day). The following cut-off points were used: <100 cpm for inactivity, 100-2019 cpm for light activity, 2020-5998 cpm for MPA and $\geq$ 5999 cpm for VPA (23). Adherence to PA recommendations was examined by determining the proportion of the subjects that met the current Norwegian PA recommendations. The current recommendations are to accumulate at least 30 minutes of daily moderate PA in bouts of at least 10 minutes (7). For analysis, interruptions of one or two minutes of activity counts below threshold in the sustained MVPA bout were allowed. This allows for small breaks in activity (e.g. a water break) and avoids the entire bout being deleted if a small drop in intensity occurs in a sustained bout of activity.

Other measures

A questionnaire was used to record smoking habits (self-reported) in three categories: smokes, does not smoke, smoked earlier. Level of education was recorded as one of the following categories: less than high school, high school, university <4 years and university $\geq$4 years.

Statistics

All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 17.0 (SPSS Inc, Chicago, IL, USA). The distribution of each variable was tested for normality (Shaprio-Wilk). Results are presented as mean (SD) and mean difference [95% confidence interval], unless otherwise stated. General linear modelling was used to compare group means, and chi-square analyses were used to determine differences in distribution of education level and smoking habits between selected groups. A Pearson's correlation was used to investigate the relationship between PA and CRF. Significance level was set to $p \leq 0.05$.

Results

Table 1 shows anthropometric characteristics, educational level and smoking habits by age-groups in total and by sex. In the 40-42-year-old-group significant differences between the sexes were observed in all variables except for smoking. Women had a significantly longer education compared to men (p<0.001). Furthermore, women had 1.5 kg/m^2 [95% CI: –2.4 to –0.6] lower BMI (body mass index) compared to men. Thirty-two percent of women and 47.2% of men were overweight (BMI 25.0-29.9) and 14.8% of women and 13.0% of men were obese (BMI $\geq$30.0). In the 53-55-year-old-group, significant differences between the sexes were observed in all variables except for education level and smoking. Women had 1.9 kg/m^2 [95% CI: –2.8 to –1.0] lower BMI compared to men. The percentage of overweight subjects was 35.0% for women and 50.4% for men, whereas 8.0% of women and 13.6% of men were obese. There was a significant interaction between age-group and sex for education level.

Table 2 shows levels of CVD risk factors by age-group, in total and by sex. Well-known gender differences in HDL-c and waist circumference were observed, and also lower blood pressure in women as compared to men at age below 50 years is a consistent observation in the literature (32). In addition, significant differences were observed between the two age-groups showing that the 40-42-year-old-group had 8.2 mmHg [95% CI: –11.9 to –4.5] lower SBP, 4.6 mmHg [95% CI: –7.0 to –2.1] lower DBP, 0.55 mmol/L [95% CI: –0.80 to –0.29] lower TC and 0.41 mmol/L [95% CI: –0.64 to –0.19] lower LDL-c compared to the 53-55-year-old-group.

In total, the two age-groups had 6.9 (0.8) valid days of accelerometer measurements. The mean accelerometer wear time among subjects with at least 4 days of valid measures was 14.9 (0.9) hours per day. Table 3 shows PA level by age group, in total and by sex. In the 40-42-year-old-group few significant differences between the sexes were observed. Nevertheless, women spent 6.0 min/day [95% CI: –11.7 to –0.3] less participating in MPA compared to men. In the 53-55-year-old-group, women were inactive for 36.0 min/day [95% CI: –55.2 to –16.8] less than men. In light activity, women spent 26.4 min/day [95% CI: 7.7 to 45.2] more compared to men. In addition, a significant difference was observed between the age-groups in VPA. The 40-42-year-old-group spent 2.7 min/day [95% CI: 1.6 to 3.9] more participating in VPA compared to the 53-55-year-old-group. Furthermore, for the test of interaction

Table 1. Mean (SD) or n (%) of anthropometric characteristics and educational level (phase 1) by age and sex.

	40-42-year-olds				53-55-year-olds				P for age-group	P for age-group*sex
	Men	Women	All	P for sex	Men	Women	All	P for sex		
Number (range)	123-136	169-178	292-314		124-132	163-175	288-307			
Age (yr)	40.8 (0.9)	40.7 (0.9)	40.8 (0.9)	0.705	53.7 (1.0)	53.5 (0.9)	53.6 (1.0)	0.215		0.504
Height (cm)	181.0 (7.3)	168.5 (5.6)	173.8 (8.9)	<0.001	180.0 (6.7)	166.9 (5.5)	172.5 (8.9)	<0.001	0.070	0.558
Weight (kg)	86.5 (13.1)	70.6 (11.9)	77.4 (14.7)	<0.001	86.8 (14.4)	69.6 (11.3)	77.1 (15.3)	<0.001	0.809	0.533
BMI (kg/m^2)	26.4 (3.6)	24.9 (4.3)	25.5 (4.1)	0.002	26.8 (3.8)	24.9 (3.6)	25.7 (3.8)	<0.001	0.614	0.485
Education level, n (%)				<0.001				0.919	0.001	0.002
University ≥4 yrs	23 (17.7)	66 (37.7)	89 (29.2)		31 (24.0)	41 (23.4)	72 (23.7)			
University <4 yrs	27 (20.8)	49 (28.0)	76 (24.9)		27 (20.9)	35 (20.0)	62 (20.4)			
High school	75 (57.7)	57 (32.6)	132 (43.3)		52 (40.3)	79 (45.1)	131 (43.1)			
Less than high school	5 (3.8)	3 (1.7)	8 (2.6)		19 (14.7)	20 (11.4)	39 (12.8)			
Smoking, n (%)				0.737				0.443	0.378	0.340
Smokers	23 (17.8)	29 (16.4)	52 (17.0)		23 (17.6)	33 (19.2)	56 (18.5)			
Have never smoked	76 (58.9)	107 (60.5)	183 (59.8)		77 (58.8)	92 (53.5)	169 (55.8)			
Smoked earlier	30 (23.3)	41 (23.2)	71 (23.2)		31 (23.7)	47 (27.3)	78 (25.7)			

BMI, body mass index

**Table 2.** Mean (SD) of cardiovascular disease risk factors (phase 2) by age and sex.

	40-42-year-olds				53-55-year-olds				P for age-group	P for age-group*sex
	Men	Women	All	P for sex	Men	Women	All	P for sex		
Number (range)	43-44	62-63	105-107		37-40	69-71	106-111			
SBP (mmHg)	135.7 (11.6)	124.7 (11.6)	129.2 (12.8)	<0.001	140.0 (13.9)	135.9 (15.6)	137.4 (15.0)	0.179	<0.001	0.063
DBP (mmHg)	80.8 (9.2)	76.7 (9.4)	78.3 (9.5)	0.029	84.5 (8.7)	82.0 (9.0)	82.9 (9.0)	0.151	<0.001	0.544
TC (mmol/L)	5.45 (0.98)	5.17 (0.90)	5.29 (0.94)	0.142	5.68 (0.99)	5.91 (0.93)	5.83 (0.95)	0.224	<0.001	0.058
HDL-c (mmol/L)	1.42 (0.38)	1.70 (0.43)	1.58 (0.43)	0.001	1.33 (0.38)	1.82 (0.52)	1.64 (0.53)	<0.001	0.386	0.093
TG (mmol/L)	1.67 (1.01)	1.01 (0.50)	1.28 (0.82)	<0.001	1.99 (1.46)	1.27 (0.57)	1.53 (1.04)	0.006	0.055	0.819
LDL-c (mmol/L)	3.29 (0.74)	3.01 (0.84)	3.12 (0.81)	0.090	3.58 (0.87)	3.52 (0.83)	3.54 (0.84)	0.729	<0.001	0.365
Glucose (mmol/l)	5.41 (1.18)	5.24 (1.07)	5.31 (1.11)	0.434	5.20 (0.88)	5.38 (1.00)	5.31 (0.96)	0.355	0.963	0.231
Waist (cm)	92.2 (12.5)	82.9 (12.0)	86.7 (13.0)	<0.001	94.5 (10.5)	83.5 (10.5)	87.5 (11.7)	<0.001	0.661	0.619

SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; HDL-c, high density lipoprotein; LDL-c, low density lipoprotein;
TG, triglyceride

Table 3. Mean (SD) of physical activity (phase 1) by age and sex.

	40-42-year-olds				53-55-year-olds				P for age-group	P for age-group*sex
	Men	Women	All	P for sex	Men	Women	All	P for sex		
Number (range)	127-129	168-171	295-300		125-128	169-170	294-298			
Overall PA (cpm)	424.0 (161.3)	402.9 (142.4)	412.0 (150.9)	0.229	382.7 (144.3)	402.9 (143.9)	394.2 (144.2)	0.230	0.142	0.103
Inactivity (min/day)	516.5 (86.7)	513.0 (74.0)	514.5 (79.6)	0.700	546.2 (85.2)	510.2 (81.8)	525.7 (85.0)	<0.001	0.098	0.014
Light activity (min/day)	340.9 (77.5)	336.4 (75.2)	338.3 (76.1)	0.610	311.4 (80.1)	337.8 (82.3)	326.5 (82.3)	0.006	0.068	0.017
MPA (min/day)	41.2 (27.3)	35.2 (21.0)	37.8 (24.0)	0.039	38.9 (22.7)	41.5 (24.4)	40.4 (23.7)	0.362	0.188	0.040
VPA (min/day)	4.6 (8.2)	5.4 (9.5)	5.1 (9.0)	0.404	2.7 (5.7)	2.1 (4.3)	2.3 (4.9)	0.265	<0.001	0.176
MVPA (min/day)	45.8 (30.0)	40.7 (25.1)	42.9 (27.4)	0.119	41.7 (25.0)	43.5 (25.9)	42.7 (25.5)	0.534	0.947	0.141
PA weekdays (cpm)	415.2 (162.8)	390.6 (146.3)	401.2 (153.9)	0.170	365.7 (146.0)	396.0 (149.9)	383.0 (148.7)	0.082	0.142	0.032
PA weekends (cpm)	448.5 (249.1)	435.7 (205.6)	441.2 (225.1)	0.629	431.8 (211.8)	421.7 (198.9)	426.0 (204.2)	0.674	0.391	0.941

PA, physical activity; MPA, moderate physical activity; VPA, vigorous physical activity; MVPA, moderate-to-vigorous physical activity;
cpm, counts per minute
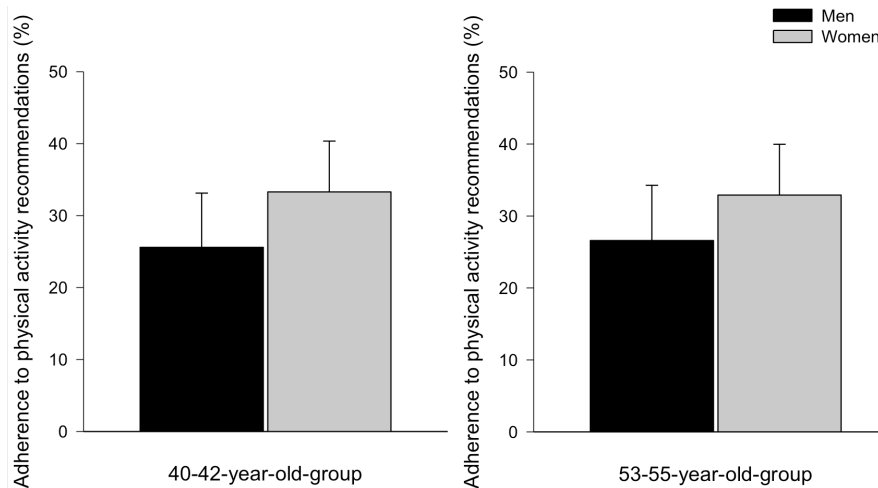
Figur 2. Adherence (%) to physical activity recommendations (phase 1) by age and sex. For 40-42-year-olds n=300 (♂:171 ♀:129), for 53-55-years-olds n=298 (♂:170 ♀:128).
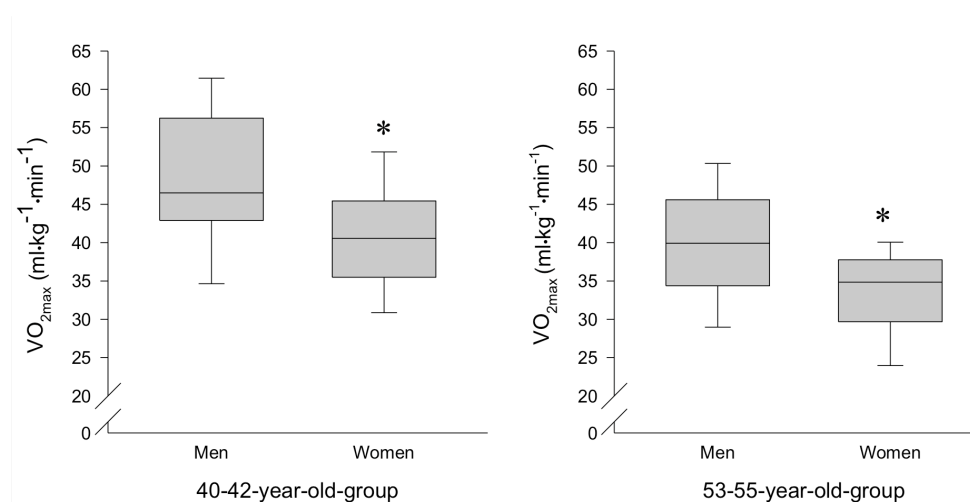
Figure 3. Box plot of cardiorespiratory fitness (ml·kg^{-1}·min^{-1}) by age and sex. For 40-42-year-olds n=82 (♂:35 ♀:47), for 53-55-years-olds n=99 (♂:37 ♀:62). The box covers the range between the lower and the upper quartiles; the whiskers cover the range between the 5th and the 95th percentiles, and the horizontal bar dividing the box indicates the mean.*p <0.001 between sexes in both age-groups and between age-groups.

between age-groups and sex, significant findings were made regarding inactivity (p=0.014), light activity (p=0.017), MPA (p=0.040) and PA during weekdays (p=0.032). Women had 35.6 cpm [95% CI: 16.1 to 55.0] and men had 48.9 cpm [95% CI: 23.3 to 75.0] higher overall PA levels during weekends than on weekdays.

Figure 2 shows adherence to the PA recommendation. In the 40-42-year-old-group 30.0% [95% CI: 24.8 to 35.2] met the recommendations, while 30.2% [95% CI: 25.0 to 35.4] met the recommendations in the 53-55-year-old-group. There were no significant differences between the sexes or age-groups.

Figure 3 displays CRF by age-group, in total and by sex. In the 40-42-year-old-group, women had 7.4 ml·kg^{-1}·min^{-1} [95% CI: −11.0 to −3.8] lower VO$_{2\ max}$ compared to men, whereas women in the 53-55-year-old-group had 7.3 ml·kg^{-1}·min^{-1} [95% CI: −10.4 to−4.1]

lower VO$_{2\ max}$ compared to men. Furthermore, the 40-42-year-old-group had 8.2 ml·kg^{-1}·min^{-1} [95% CI: 5.6 to 10.7] higher VO$_{2\ max}$ compared to the 53-55-year-old-group.

There was a medium, positive correlation between overall PA level (cpm) and CRF (ml·kg^{-1}·min^{-1}) in both sexes. For men r=0.40 [95% CI: 0.18 to 0.58] and for women r=0.42 [95% CI: 0.25 to 0.56], with high overall PA level associated with high CRF.

DISCUSSION

Physical activity

The present study shows higher overall PA level and adherence to the PA recommendations compared to the national sample in Kan1 (13). Furthermore, when comparing our data to international studies such as the National Health and Nutrition Examination Survey

(NHANES) and the Attitude Behaviour and Change Study (ABC-study), the same conclusions can be drawn (25). However, it is difficult to compare these studies due to the difference in cut-off points for age-groups in all four studies, and slightly different methods of data reduction and definitions of PA recommendations in the NHANES and ABC-study compared to Kan1 and the present study. Adherence to PA recommendations in the present study is in contrast to previous studies which used self-reporting and found higher adherence to the recommendation (13,17). On the other hand, Haakstad and Bø (15) found markedly lower degrees of adherence to PA recommendations using self-report. Discrepancies between studies are most likely due to differences in the questions and the limitations of self-report as mentioned earlier. Although there is a higher adherence to the PA recommendations in Sogn og Fjordane compared to the national sample, from a public health perspective, 30% is not satisfactory taken into account the convincing evidence of health outcomes for those who meet the PA recommendations (9). This emphasizes the importance of implementing effective strategies to increase the daily PA level.

The higher overall PA level on weekends compared to weekdays found is consistent with the findings in Kan1 (13). However, the difference reported in Kan1 is minimal compared to the present study. The present study shows higher PA levels on both weekdays and weekends compared to Kan1, but the difference is more marked during weekends (p=0.013). This indicates that 40-42-year-olds and 53-55-year-olds in Sogn og Fjordane are especially active during weekends compared to the national sample. This might be due to easy access to outdoor-life, which is supported by the fact that 88% reported walking and hiking, a typical Norwegian weekend activity, as activities done on a regular basis (data not shown), compared to 79% in the national sample in Kan1 (13).

The present study shows no sex difference in overall PA. This is in line with Kan1 (13), but in contrast with NHANES and the ABC-study, where men were found to be more physically active than women (22, 23). However, sex differences in different intensities of PA were found in the present study, indicating that in the 40-42-year-old-group men spent more time in MPA than women, and that in the 53-55-year-old group men spent more time on inactivity and less time in light activity than women. These results are in agreement with those reported in the Kan1 study (13) and partly in line with the results of the NHANES and ABC-study (25). In contrast to Kan 1, results in the present study revealed age-group differences showing more time spent in VPA among 40-42-year-olds compared to the 53-55-year-olds.

Cardiorespiratory fitness

Few comparable studies investigating CRF in a representative population exist. Findings from the present study show higher CRF for both sexes and age-groups compared to the national sample in Kan1 (29). Furthermore, the same conclusion was reached when compared to a study by Haakstad and Bø (15), however, this study used an indirect measure of CRF. In both age-groups in the present study, men had higher CRF than women. This is in agreement with the existing literature, claiming a 15-30% lower VO_{2max} for women compared to men (33). As expected, the 40-42-year-old-group has higher CRF compared to the 53-55-year-old-group. This finding is consistent with the yearly age-related 1% decline in VO_{2max} for adults described in the literature (33), indirectly validating data representativeness.

As expected, positive correlations between PA and CRF in both sexes were found. These findings are supported by Løchen et al. (14), who found a correlation coefficient of 0.18 in men and 0.39 in women. The stronger correlation in the present study might be due to more accurate measurements, as PA is measured objectively and CRF is measured directly. Løchen et al. (14) explained the sex difference by the fact that the fitness test truly was maximal in most women while the load was too low for many men. The fact that direct measurement of CRF was used in the present study might explain the small difference in correlation with sex.

Cardiovascular disease risk factors

BMI is marginally lower compared to the national sample in Kan1 (13) and marginally higher for the 40-42-year-old-group compared to previous collected BMI data from the population in Sogn og Fjordane (34). For women, BMI is lower compared to data from the HUNT study (35) and the Tromsø study (36). For men, the BMI results are in line with the HUNT data in both age-groups and slightly higher compared to the Tromsø data for the 53-55-year-olds. BMI is not a direct measurement of body fatness and does not distinguish between fat and muscle mass, but is a surrogate for adiposity and an applicable measure to use in population based studies (37).

For the 40-42-year-olds, SBP is marginally lower, especially for women, compared to results from the National Health Screening Service in Sogn og Fjordane in the mid-nineties, while DBP is higher in the present study in both sexes (38). When comparing blood pressure with previous studies one should bear in mind that different measuring devices for blood pressure have been used. The present study used an automatic Omron HEM-907 BP monitor, while the National Health Screening Services used an automatic Dinamap (39).

In the present study, both sexes in the 40-42-year-old-group have lower prevalence of daily smokers, lower TC and higher HDL-c compared to the National Health Screening Services in Sogn og Fjordane in 1996 (38). These findings are consistent with the findings of Jenum et al. (40), which show a decrease in TC

and smoking habits through thirty years. There is no difference in the prevalence of daily smokers in the present study compared to Kan1. However, the percentages of 'have never smoked' is higher and 'smoked earlier' is lower in the present study compared to Kan1 (13).

Sogn og Fjordane County has Norway's longest living population (26). The county has a reputation of being the most healthy county in Norway (27) and is among the counties with lowest CVD mortality (28). Furthermore, the observation of the population of Sogn og Fjordane being more PA and having higher CRF underscores this statement.

Strength and limitations

Objectively measured PA, high compliance with the protocol and directly measured CRF strengthen the findings reported in this study. Also, the high response rate from a narrow age sample is a strength. However, these findings should be interpreted in light of the following limitations. First, this cross-sectional study does not allow explanations of causality. Second, the accelerometer is not able to accurately assess non-ambulatory activity, such as cycling or swimming (41). For people who cycle or do upper-body exercises on a regular basis, PA is underestimated. However, Kan1 shows that people mostly do ambulatory activities (13). Third, the uniaxial Actigraph used in the present study does not register high-speed activity satisfactory, such as running over 10 km/h. However, the large majority of people carry out little regular running at this speed (41). Fourth, the PA intensity thresholds vary widely between studies (41). This hampers study comparability and underlines the uncertainty of the cut-off points. The present study uses the same cut-off points as were used in Kan1 and NHANES (13,23). Fifth, non-fasting blood samples were taken in phase 2, which gives higher values of glucose and triglycerides than if they had been taken in the fasting state. However, this was done to facilitate comparison with previous studies using non-fasting blood samples (39). Sixth, although the response rate was high compared to recent similar studies, almost 40% chose not to participate, and we cannot rule out the possibility of a selection bias. Because the aim of the study was to assess levels of PA and CRF, it is likely that the most physically active participated. If this is correct, there are reasons to believe that several of our findings may be overestimated.

Conclusions

The aim of this cross-sectional study was to describe levels of objectively measured PA, directly measured CRF and CVD risk factors in an adult population in the county of Sogn og Fjordane. These results support the hypotheses that the population of Sogn og Fjordane County are more physically active and have higher CRF compared to the rest of the Norwegian population. However, from a public health perspective, taken into account the convincing evidence of health outcomes for those who meet the PA recommendations, 30% adherence to the PA recommendations is not satisfactory. Therefore, it is necessary to implement effective strategies aiming to increase daily PA level.

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