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Healthy Life Centres: a 3-month behaviour change programme's impact on participants' physical activity levels, aerobic fitness and obesity: an observational study

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ABSTRACT

Objectives Individuals with low socioeconomic status and multimorbidity tend to have lower physical activity (PA) levels than the general population. Primary care is an important setting for reaching high-risk individuals to support behaviour change. This study aimed to investigate the impact of behaviour change interventions delivered by Norwegian Healthy Life Centres (HLCs) on participants' PA levels, aerobic fitness and obesity, and furthermore to investigate possible predictors of change.
Design An observational study with a pre–post design and a 3-month follow-up.
Setting Thirty-two HLCs in Norway were included.
Participants A total of 713 participants (72% of the participants included at baseline), 71% women, with a mean age of 51 (18–87 years) and body mass index (BMI) of 32 (SD 7) met to follow-up.
Intervention Individual consultations and tailored individual and group-based exercise and courses organised by the HLCs and cooperating providers.
Outcome measures The primary outcome was time spent in moderate to vigorous PA (MVPA, min/day) (ActiGraph GT3X+ accelerometer). The secondary outcomes were light PA (LPA, min/day), number of steps per day, time spent sedentary (SED, min/day), aerobic fitness (submaximal treadmill test, min), BMI (kg/m^2) and waist circumference (WC, cm).
Results There was no change in MVPA (B 1.4, 95% CI −0.4 to 3.1) after 3 months. The participants had improved LPA (4.0, 95% CI 0.5 to 7.5), increased number of steps (362, 95% CI 172 to 552), reduced SED (−5.6, 95% CI −9.8 to −1.3), improved fitness (0.8, 95% CI 0.6 to 1.0), reduced BMI (−0.2, 95% CI −0.1 to −0.3) and reduced WC (−1.7, 95% CI −2.0 to −1.3). Positive predictors of change were number of exercise sessions completed per week, duration of adherence to HLC offers and participation in exercise organised by HLC.
Conclusion Participation in the HLC interventions had small positive impacts on participants' PA levels, aerobic fitness and obesity. Further research to develop effective behaviour change programmes targeting individuals with complex health challenges is needed.
Trial registration number NCT03026296.

Strengths and limitations of this study

- This is a large-scale observational study of 32 Healthy Life Centres, which strengthens the external validity of this study.
- We used objective measurements of physical activity (PA) level by accelerometers, which enabled us to measure intensity-specific PA and overall PA more precisely than subjective measurement methods.
- Characteristics of completed intervention components were measured and analysed as possible predictors of change, which might enhance the development of future effective behaviour change interventions; however, the prospective measurement might hamper the results by recall bias.
- The observational design limits the interpretation of causality.

INTRODUCTION

Physical inactivity is recognised as one of the main modifiable risk factors for non-communicable diseases (NCDs) and premature death.[1] Furthermore, physical activity (PA) is effective in secondary and tertiary prevention of several chronic conditions.[2] Despite this knowledge, individuals with multiple chronic conditions, as well as individuals with low socioeconomic status (SES), generally have low PA levels.[3 4] Convincing evidence shows that PA of any intensity reduces the risk of mortality, specifically for those who are the least active.[5] Hence, it is important to target individuals with chronic conditions, low SES and low PA levels to reduce the risk of future disease and premature mortality.

Primary care is an important setting to reach high-risk individuals with behaviour change interventions.[6] A variety of programmes and schemes aiming to promote PA among individuals who are referred from general practitioners, or other health professionals, to a third-party provider of exercise interventions have been developed across countries.[7 8] Exercise referral schemes (ERS) in the UK and PA on prescription (PAP) in Sweden are examples of such programmes.[7] Previous systematic reviews show minor effects of 12-week ERS or similar programmes on self-reported PA levels.[8–11] However, subjective PA assessment is hampered by recall bias and social desirability bias and is thus prone to overestimation of PA levels.[12] Furthermore, there is a heterogeneity in the components of the programmes, such as provider and duration of the follow-up, and reasons for referral and interventions are often poorly described.[7–9] This limits the interpretation of their effectiveness and development of future effective behaviour change programmes.

A Norwegian behaviour change programme comparable with ERS or PAP is the Healthy Life Centres (HLCs). HLCs are organised within primary care in 60% (266 out of 426) of the municipalities of Norway and provide support to diet change and smoking cessation in addition to PA promotion. However, HLCs differ in types of offers, staff competence and resources available according to local adoption and implementation.[13 14] Furthermore, knowledge about the impact of the HLC model is sparse.[10] In a recently published randomised controlled trial (RCT) including six HLCs, Samdal *et al*[15] found no overall effect on objectively measured PA level after a 6-month intervention. A few observational studies have investigated the HLC programme's impact on the participants' objectively measured health status and showed small improvements with regard to glycated haemoglobin and diabetes type 2 status[16] and aerobic fitness.[17] However, the external validity from these above-mentioned studies is limited due to small samples. Hence, there is a need for a large-scale study about the impact of the HLC model. Furthermore, studies using thorough descriptions of the programme are also needed to further develop effective behaviour change interventions targeting high-risk groups.

Therefore, we aimed to investigate a 3-month HLC programme's impact on objectively measured intensity-specific PA level and overall PA level, aerobic fitness, and obesity in a large sample of HLCs and participants. A secondary aim was to investigate possible predictors of change in these outcomes, including demographic factors and chronic health conditions, as well as intervention components.

METHODS

Study design, setting and participants

This study is an observational study with a pre–post design investigating the impact of a 3-month HLC programme in four different geographical regions of Norway. The Strengthening the Reporting of Observational Studies in Epidemiology cohort guidelines were used to guide the presentation of methods and results.[18] To be included, the HLCs had to follow the guideline for implementation, organisation and basic offers of HLCs, published by The Norwegian Directorate of Health.[19] Out of 60 HLCs established in the four regions, 46 were eligible for inclusion in the study and 32 agreed to participate. Individuals ≥18 years of age referred or who self-referred to one of the HLCs were invited to participate in the study in the period from August 2016 to January 2018. The only exclusion criterion was a previous enrolment in an HLC intervention during the last 6 months. All individuals provided written informed consent prior to participation. Additional information about the study protocol, including sample size calculations, has been described previously.[20]

Patient and public involvement

User representatives and representatives from HLCs were included in the design of the study. The questionnaire and protocol of the aerobic fitness test were piloted and adapted according to feedback from participants. Continuous feedback throughout data collection was received from HLCs through email, telephone, social media groups and yearly meetings. User representatives were included in yearly meetings. The study's results will be communicated to the HLCs after publication.

Intervention

According to The Norwegian Directorate of Health's guidelines, the HLCs provide tailored support to change PA, diet and smoking behaviours consisting of individual consultations at the start and end of a 3-month follow-up period, as well as additional consultations if needed, and group-based courses and exercise throughout the period.[19] The interventions are based on the salutogenic theory by Antonovsky,[21] which emphasises the importance of strengthening individuals' resources and capacity to promote good health instead of focusing on illness, risks and diseases. A central concept of this theoretical framework is to promote a sense of coherence through elements such as autonomy and social support. Consultations and courses are primarily delivered with motivational interview (MI) as methodology.[22] Important components of the consultations are to set personal goals and to make a tailored plan aiming to change one or several behaviours.

The HLCs included in this study offered group-based healthy eating courses ('Good food for better health') five times for 2 hours, smoking cessation courses (6–10 meetings), group-based meetings covering themes like clothing when exercising, motivation and so on, and supervised exercise groups at least twice a week. The exercise was mainly outdoor-based cardiorespiratory fitness and strength training. Some HLCs offered high-intensive interval training, water gymnastics, spinning, yoga and walking groups. Depending on the tailored plan, participants had access to one or several of these offers during a 3-month intervention period, in addition to guidance to unsupervised exercise such as home-based training and outdoor walking, as well as a more active everyday lifestyle such as choosing active transportation, for example walking or biking instead of driving. Furthermore, the

HLCs were cooperating with additional local providers of exercise in which the participants could engage, including non-governmental organisations and fitness centres. HLC staff delivering the offers were mainly physiotherapists, or exercise and health professionals. Those who delivered consultations had at least a 6-hour course or more comprehensive education in MI. The HLC consultations were free of charge; however, courses and group offers had a cost of up to 500 Norwegian kroner (≈€50).

Measurements

Baseline measurements were undertaken at the first consultation—before the start of further intervention—and follow-up measurements were performed after a 3-month intervention period.

Participant characteristics

Participant characteristics were assessed by self-reported questionnaires and interviews performed by HLC staff at baseline. Demographic and SES variables included age, gender and educational status (primary school max 10 years, high school max 13 years, college/university ≤3 years and college/university >3 years, dichotomised into lower (max high school) and higher (college/university)). Occupational status was reported as working, sick leave, disability pension, retiree, student and others, either full time or graded, with possibilities of reporting several statuses.

Chronic health conditions were reported (yes or no) as overweight/obese, hypertension, diabetes, cardiovascular disease, lung/respiratory disease and cancer (current or former), categorised into NCDs and risk factors for NCDs; mental problems and mental disease categorised into mental conditions; muscle/skeletal problems; others; and no condition, with possibilities of reporting several conditions. Chronic health conditions were calculated as the sum of conditions reported.

Risk-related behaviours were registered as smoking status (reported as never, former, sometimes, daily), dichotomised into not smoking and smoking. Meeting diet recommendations was reported as the frequency of eating fruits/berries and eating vegetables on a 7-point scale from 'never' to 'five or more times daily' and transformed into eating ≥5 fruits/vegetables per day. Meeting PA recommendation was measured by accelerometer as described in the following section.

PA level

PA level was assessed by ActiGraph GT3X+ accelerometer (ActiGraph, Pensacola, Florida, USA) over 7 consecutive days using a 10 s epoch setting and a 30 Hz sampling rate. Participants received the accelerometer by mail and were instructed to wear it in a belt around the waist (right side) all waking hours, except when showering or doing water activities. The accelerometer measures acceleration, which is reported as 'counts'. The number of counts per minute (cpm) over a given period provides information about the total activity level. Measurement of PA level by ActiGraph accelerometers has been found to correlate well with energy expenditure as estimated by the doubly labelled water technique, which could be considered a 'gold-standard' measurement method of free-living total energy expenditure.[23] Recorded data were downloaded by the ActiLife software (ActiGraph) using a normal filtering option. Non-valid wear time was defined as 60 min of consecutive zero counts, with an allowance of up to 2 min periods of non-zero counts. Data were manually inspected to validate wear time resulting from variation in postal delivery. Criteria for a valid PA assessment were 600 min of wear time per day and at least 4 valid days. Results are reported as overall PA level from the vertical axis (cpm), steps per day, sedentary time (SED, 0–99 cpm), light PA (LPA, 100–2019 cpm), moderate to vigorous PA (MVPA, ≥2020 cpm) (primary outcome) and vigorous PA (VPA, ≥5999 cpm).[24] To measure adherence to current PA recommendations, which include PA of moderate and vigorous intensities accumulated over 10 continuous minutes,[25] we also calculated time spent in 10 min bouts of MVPA per day, with an allowance of 2 min drop time. Meeting the current recommendations for PA was defined as having an average daily sum of 10 min MVPA bouts that was ≥21.4 min/day, corresponding to 150 min/week.[26] The monitoring season was defined as winter (December–February), spring (March–May), summer (June–August) and autumn (September–November).

Aerobic fitness

Aerobic fitness was assessed by a standardised submaximal treadmill walking protocol, modified from the maximal Balke protocol[27] to suit participants with various chronic conditions. After a 1–7 min familiarisation on a flat treadmill, participants walked with a progressive increase in inclination every minute from 0% to 12% at 4 km/hour. Thereafter, the speed increased by 0.5 km/hour until participants reached a perceived exertion of at least 17 (very hard) on the Borg 6–20 scale.[28] At the end of the test, the perceived exertion and time to exhaustion were registered. Only individuals reaching Borg ≥17 at both pre- and post-test were included in the analysis. The test protocol was validated against a maximal Balke protocol with direct measurement of maximal oxygen consumption (VO_{2max}) in a sample of 18 individuals with multiple chronic conditions and was found to perform well (R^2=0.78, standard error of the estimate=3.14 mL/kg/min).

Obesity

Body mass index (BMI, kg/m^2) was calculated from the measured height (in cm; Seca 206, Seca, Birmingham, UK) and body mass (in kg; unspecified digital scale). Waist circumference (WC) was measured with a measuring tape (in cm; Seca 201) at the midpoint between the lowest rib and the top of the iliac crest at least twice and until the results differed less than 1 cm. The mean of the two nearest measurements (cm) was used for analysis. Hip circumference was measured in a line over the trochanter majors bilaterally. Waist to hip ratio (W:H ratio) was calculated as WC (cm)/hip circumference (cm).[29]

Characteristics of intervention components

Intervention components were registered through interviews by HLC staff together with the participant. At baseline the primary reason for HLC participation (PA promotion, diet change or tobacco cessation), personal behaviour goal(s) set (yes/no), and tailored plan made (yes/no) were registered. Intervention components completed were registered retrospectively at the 3-month follow-up. The following components were reported: completion of personal goals and adherence to tailored plan (yes/partly/no); duration of adherence to HLC offers (number of weeks participated at one or several of the HLC offers); number of individual consultations; and participation in group-based courses ('Good food for better health', smoking cessation and/or theme-specific meetings). Type of exercise performed was reported as free text and categorised based on an estimation of energy expenditure according to the compendium of physical activities[30] as high-intensity interval training, cardiorespiratory exercise with unspecified intensity, low-intensity training (eg, yoga and stretching), walking, strength training, and water gymnastic or swimming. Frequency of exercise completed was registered as the mean number of training sessions per week within each exercise type. If less than one session per week was reported (eg, six exercise sessions over 12 weeks), this was calculated as 0.5 exercise sessions per week. Organiser of the exercise was registered as by HLC, other providers or unsupervised exercise.

Statistics

Descriptive categorical data are presented as numbers (n) and frequencies (%). Continuous variables are presented using mean and SD if normally distributed, otherwise as median and IQR. Sensitivity analyses were performed using independent samples t-tests (continuous data), Mann-Whitney U test (ordinal data) and χ^2 test (dichotomous data) between the participants attending 3-month follow-up (completers) and those not attending follow-up (dropouts).

To analyse change over time we used a linear mixed model with the outcome of interest as the dependent variable and time as the independent variable (fixed effect), including random intercepts of subject and HLC. Models for PA were adjusted for wear time and season. Effects of time are presented as unstandardised regression coefficients (B), 95% CI and statistical significance (p values). Standardised effect sizes (Cohen's d) were calculated as mean difference over time/pooled SD. We also report intraclass coefficients for subjects and HLCs. Change in the proportion of participants who accumulated the recommended level of MVPA was analysed by McNemar's test.

To analyse predictors of change in MVPA, fitness and BMI, we performed linear mixed models fitting change scores for each outcome as dependent variables and HLC as the clustering variable. Possible predictors were investigated in three different models as follows. Model 1: demographic and SES variables (including sex, age and educational level). Model 2: health-related variables (including chronic health conditions and BMI), and all variables from model 1 were included in model 2. Model 3: intervention components (including referred/self-referred, duration of adherence at HLC offer(s), number of individual consultations, number of exercise sessions per week, organiser of the exercise (HLC/others/unsupervised exercise) and participation in theme-specific meetings), and all variables from model 1 and BMI from model 2 were included in model 3. All three models were adjusted for the baseline level of the outcome variable. The models for MVPA were additionally adjusted for change in wear time. Results are presented as unstandardised regression coefficient (B), 95% CI and p values.

We considered p values ≤0.05 as statistically significant. All statistical analyses were performed using IBM Statistics for Windows V.25.0.

RESULTS

Characteristics of participants and dropouts

A total of 1022 individuals (56% of eligible individuals) agreed to participate in the study. Among these, 25 did not complete any tests, leaving 997 individuals as the total baseline sample. Individuals completing the 3-month follow-up (*completers*) (n=713, 72%) were included in the descriptive analysis. Figure 1 shows the flow of participants through the study.

The participants attending the 3-month follow-up were mainly women (71%) with a mean (SD) age of 51 (15) years, ranging from 18 to 87 years. The mean BMI was 32 (7) kg/m^2 and 63% of the participants reported multimorbidity of two or more chronic conditions, while 10% reported having no diagnosis. Detailed information about participants' SES, health status and risk behaviours is reported in table 1.

The participants lost to follow-up were younger (p<0.001), more likely to have disability pensions (p=0.014), more likely to smoke (p=0.011), more likely to have 'other chronic conditions' (p=0.014) and less likely to be retired (p<0.001) compared with the completers. Sex, educational level, source of referral, PA level, obesity status or aerobic fitness status at baseline did not differ significantly between completers and dropouts (p>0.158). Detailed information on participant characteristics for completers compared with dropouts is reported in online supplemental table 1.

Characteristics of intervention components performed and goal achievement

The most frequent primary reason for participating in the HLC programme was wanting to increase PA (92%), followed by changing diet (35%) and tobacco cessation (3%). At baseline, most participants had set specific

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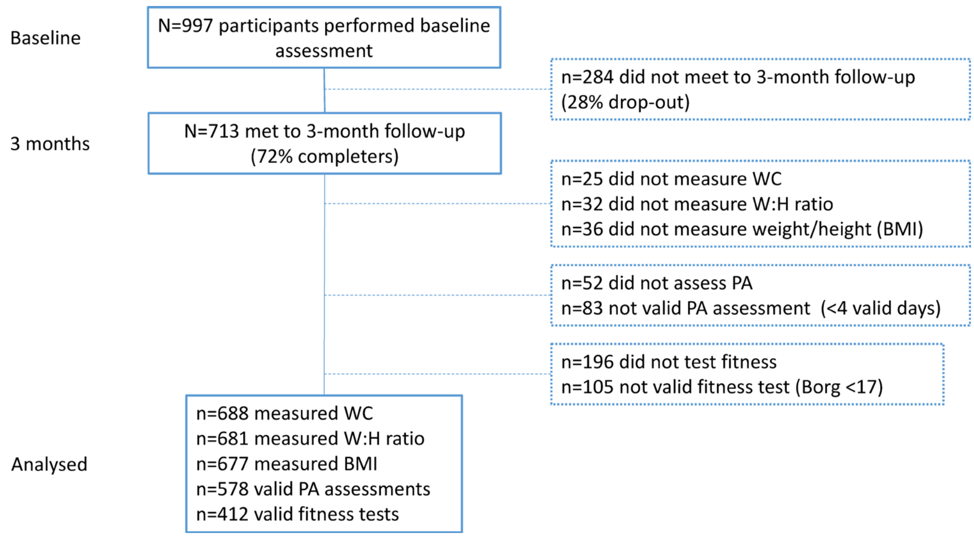

Figure 1 Flow chart of included participants and number of cases with valid assessments on each outcome. BMI, body mass index; PA, physical activity; WC, waist circumference; W:H ratio, waist to hip ratio.

personal behaviour goals (97%) and made a tailored plan for behaviour change (95%). At follow-up, 38% reported having achieved their goals, 42% had partly achieved their goals and 20% had not achieved their goals. Half of the participants (51%) reported having followed their plan, 34% had partly followed their plan and 15% had not followed their plan. The median duration of active participation at one or several HLC offers was 12 weeks (IQR 4), and participants attended a median of 2 (IQR 1) individual consultations during the intervention period. The participants engaged in a median of 3 (IQR 3.5) exercise sessions per week, including exercise provided by the HLC (65%), other providers (17%) and unsupervised exercise activities (64%). Further details on exercise type and attendance in courses are presented in table 2.

Three-month change in outcomes

Changes in PA, anthropometry and aerobic fitness over the 3-month intervention period are shown in table 3. The participants had a small improvement of time spent in LPA corresponding to 28 min/week and a small decrease in time spent sedentary corresponding to 42 min/week. Furthermore, overall PA increased, while there was no significant change in MVPA, MVPA accumulated in 10 min bouts or VPA. The frequency of participants meeting the recommended level of MVPA changed from 16.4% (95) at baseline to 19.4% (112) at follow-up (p=0.125). The effect sizes for significant changes in all PA variables were very small (d=0.03, d=0.01, d=0.09 and d=0.13 for change in LPA, SED, cpm and steps, respectively). Aerobic fitness increased, while BMI, WC and W:H ratio decreased significantly. However, all effect sizes were small or very small (d=0.22, d=0.03, d=0.08 and d=0.08 for aerobic fitness, BMI, WC and W:H ratio, respectively).

Predictors of changes in MVPA, aerobic fitness and BMI

Table 4 describes the predictors of change in MVPA concerning demographic factors, health-related factors and intervention components. Number of exercise sessions completed per week predicted improvement in time spent in MVPA per day. There were no other significant predictors of change in MVPA.

Higher BMI predicted less improvement in aerobic fitness, while number of exercise sessions per week and attendance in exercise groups organised by HLC predicted improvement in aerobic fitness. There were no other individual factors or intervention components that predicted change in aerobic fitness. For detailed information on predictors of change in aerobic fitness, see online supplemental table 2.

Participants of older age had a greater reduction in BMI, while no other individual factors predicted change in BMI. The only intervention component predicting a reduction in BMI was the duration of adherence to HLC offers (number of weeks). Online supplemental table 3 provides detailed description of possible predictors of change in BMI.

DISCUSSION

We aimed to investigate the impact of a 3-month lifestyle intervention, implemented at Norwegian HLCs, on participants' objectively measured PA level, aerobic fitness and obesity. The results showed positive but small changes in LPA, overall PA level, aerobic fitness, BMI, WC and W:H ratio. There were no improvements in MVPA, VPA or 10 min bouts of MVPA. Furthermore, we found that several intervention components predicted positive changes.

Our findings of small improvements in PA levels are in line with studies of similar international programmes and schemes (ERS, PAP and so on), which have found small to moderate positive effects on participants' PA levels after interventions of 3–6 months.[7 9–11 31 32] Despite our hypothesis that previous results from similar studies could have

Table 1 Characteristics of the participants completing the 3-month follow-up (n=713)

Variables	% (n)
Socioeconomic status	
Educational level (n=704)	
Primary school, 0–10 years	18.9 (133)
High school, 11–13 years	48.0 (338)
College/university, ≤3 years	19.6 (138)
College/university, >3 years	13.5 (95)
Occupational status*	
Disability pension, full or graded	39.3 (280)
Working, full or graded	39.6 (282)
Sick leave, full or graded	17.0 (121)
Retired	16.3 (116)
Student	1.4 (10)
Other†	4.2 (30)
Health status	
Chronic conditions*	
No diagnosis	10.0 (70)
NCDs and risk factors for NCD	67.7 (477)
Muscle/skeletal	41.6 (291)
Mental conditions	28.0 (196)
Other‡	14.3 (100)
Source of referral/self-referred (n=705)	
Self-referred	17.4 (123)
General practitioner	54.0 (381)
Other health services	23.7 (167)
Norwegian labour and welfare administration	4.8 (34)
Risk behaviours	
Smoking status (n=697)	
Not smoking	77.8 (542)
Smoking	22.2 (155)
Meeting dietary guidelines (n=693)	
(eating five fruits/vegetables per day)	22.7 (157)
Meeting PA guidelines§ (n=655)	
(≥150 min MVPA in 10 min bouts per week)	15.9 (104)

*Possible to report more than one occupational status and chronic condition; some individuals have combinations.
†Other occupational statuses include maternity leave, homemakers i.a
‡Other chronic conditions include fatigue, headache, hypothyroidism, rheumatic diseases, neurologic conditions, psoriasis, syndromes, hypercholesterolemia, allergy.
§Individuals with ≥4 valid days of PA assessment at baseline.
MVPA, moderate to vigorous PA; NCD, non-communicable disease; PA, physical activity.

Table 2 Characteristics of intervention components (n=599–712)

Intervention components	% (n)
Exercise type performed at least once per week*	
Strength training	59.8 (360)
Walking	47.2 (284)
Cardiorespiratory fitness (unspecified intensity)	45.3 (273)
High-intensity interval training	23.0 (139)
Water gymnastics/swimming	13.1 (79)
Low intensity (eg, yoga, stretching)	8.7 (52)
No exercise	4.3 (26)
Courses and theme meetings attended*	
Theme meetings	25.8 (170)
'Good food for better health-course'	9.4 (60)
Tobacco cessation	0.8 (5)
Attendance in exercise organised by*:	
HLC	65.3 (465)
Unsupervised exercise	63.9 (455)
Other cooperating providers†	16.7 (119)

*Possible to attend in more than one exercise type, course/theme meeting and exercise organised by several providers/unsupervised.
†For example, fitness centres and NGOs.
HLC, Healthy Life Centre; NGO, non-governmental organisation.

been biased by imprecise measurements of PA, caused by subjective assessment methods, our objectively measured change in PA confirms the previous findings of small effects. A previous meta-analysis found an increase in subjectively measured PA of 6.8 min of MVPA per week and 55.1 min of total PA at 6–12 months of follow-up of ERS versus advice only.[9] These findings correspond well to our findings of an increase of 9.8 min of MVPA per week (1.4 min/day for 7 days) and 37.8 min of total PA per week (1.4 min/day MVPA+4.0 min/day LPA for 7 days) after 3 months of intervention. Furthermore, our findings are similar to the results from two previous RCTs using accelerometers to investigate the effect of the Swedish PAP[33] and the Norwegian HLCs[15] on time spent on MVPA. Both studies found a non-significant increase in MVPA time of 1 min after 3 months[33] and 1–3 min after 6 months.[15 33] In line with our findings with an effect size of 0.22 in aerobic fitness, the Swedish PAP study found a significant increase in aerobic fitness after 3 and 6 months compared with controls.[33] Previous studies on the impact of behaviour change interventions have mainly focused on PA of moderate and vigorous intensities.[9 31] Interestingly, recent research shows that the total volume of PA matters and even light-intensity PA might substantially reduce the risk of mortality.[5] Hence, the small increase in overall PA and LPA found in the current study might have benefits, as there are potentially great public health gains if the least physically active individuals manage to increase their PA level even with small amounts.[34]

Previous studies of existing programmes and schemes aiming to improve PA (eg, ERS and PAP) vary extensively regarding types and content of interventions, such as duration of follow-up, frequency of exercise sessions, settings of delivery, type of offers delivered and characteristics of

Table 3 Changes in physical activity levels, fitness and obesity over the 3-month intervention period

	n	Baseline	Follow-up	Mean (95% CI) change*	P value	ICC subject	ICC HLC
Physical activity levels	578						
MVPA (min/day)		35.4 (21.6)	37.3 (23.3)	1.4 (–0.4 to 3.1)	0.131	0.63	0.02
VPA (min/day)		0.9 (2.4)	1.0 (2.2)	0.0 (–0.2 to 0.2)	0.854	0.48	0.00
LPA (min/day)		177.0 (51.6)	182.4 (54.9)	4.0 (0.5 to 7.5)	0.025	0.65	0.07
SED (min/day)		616.7 (72.4)	611.2 (79.3)	–5.6 (–9.8 to -1.3)	0.010	0.68	0.05
Overall PA (cpm)		281 (116)	294 (126)	11 (1 to 20)	0.023	0.67	0.01
Steps (number/day)		6070 (2513)	6496 (2760)	362 (172 to 552)	<0.001	0.67	0.02
10 min MVPA bouts (min/day)		10.6 (14.7)	11.5 (14.4)	0.5 (–0.9 to 1.8)	0.507	0.48	0.03
Fitness, TTE (min)	412	12.3 (2.9)	13.1 (3.0)	0.8 (0.6 to 1.0)	<0.001	0.59	0.23
Obesity							
BMI (kg/m^2)	677	32.3 (6.7)	32.0 (6.6)	–0.2 (–0.1 to –0.3)	<0.001	0.94	0.04
WC (cm)	688	105.7 (17.1)	104.0 (16.4)	–1.7 (–2.0 to –1.3)	<0.001	0.96	0.04
W:H ratio (cm)	681	0.95 (0.10)	0.94 (0.10)	–0.01 (–0.00 to –0.01)	<0.001	0.83	0.08

p values ≤0.05 are considered as statistically significant changes.
*All estimates were adjusted for random intercepts of HLCs (setting) and subjects. Physical activity estimates were additionally adjusted for wear time and season.
BMI, body mass index; cpm, counts per minute; HLC, Healthy Life Centre; ICC, intraclass correlation coefficient; LPA, light PA; MVPA, moderate to vigorous PA; PA, physical activity; SED, sedentary time; TTE, time to exhaustion; VPA, vigorous PA; WC, waist circumference; W:H, waist to hip ratio.

target groups.[7] Thus, this study aimed to explore whether certain characteristics of the intervention components predicted improvements in the outcomes. We found that the frequency of exercise sessions completed was a positive predictor of MVPA and aerobic fitness. Furthermore, participation in exercise organised by HLC was a positive predictor of fitness, in contrast to participation in exercise organised by other providers or unsupervised exercise, which did not predict any change. Furthermore, a longer duration of adherence to HLC offers predicted reduction in BMI. Although these factors predicted small differences of change, our results are in line with previous findings of better effects of comprehensive schemes with longer duration.[32] Furthermore, they confirm existing knowledge of the importance of enhancing exercise adherence in order to improve PA behaviour and other health outcomes.[7 35]

Previous reviews of the effect of ERS have pointed out the need for research on whether there are subgroups that benefit more from such programmes.[32] In line with this recommendation, we investigated whether the impact differed between subgroups of participants. We found no differences between sex, educational level or specific chronic conditions, which are in contrast to a previous randomised study of change in HLC participants PA levels finding that low educational level predicted less improvement in MVPA.[15] The conflicting results could possibly be attributed to different sample sizes included, as the previous study only included 6 HLCs and 118 participants in contrast to the current study including 32 HLCs and 997 participants.

The HLC population is heterogeneous and comprises individuals with low educational levels, a high proportion with multimorbidity, mental disorders and obesity, a high degree of unemployment, as well as substantially lower health-related quality of life compared with the general population.[36] Previous qualitative studies have revealed that the HLC participants experience great psychological distress from earlier life experiences and many have complex health challenges. Furthermore, they are expressing low self-efficacy, and are seeking dignity and integrity.[37 38] As the HLC participants struggle with complex physical and emotional challenges, a 3-month intervention might be a too short time to expect large behaviour changes. A longer duration of the programme might be beneficial to improve their PA levels.[8] The HLCs offer possibilities to engage in several subsequent follow-up periods,[19] and the impact of longer follow-up duration needs further investigation.

The strengths of the current study were the large number of participants (n=997) and HLCs (n=32) included, and the low dropout rate (28%), compared with similar observational studies.[17 35] Furthermore, the use of objective measurements of PA, in addition to fitness and anthropometry, extends previous research in this field. However, there are also several limitations. First, we had no control group, which limits our ability to draw conclusions about causality. Second, the follow-up was only 3 months, and

Table 4 Possible predictors of change in MVPA regarding demographic factors, health-related factors and intervention components

	Model 1		Model 2		Model 3	
	B (95% CI)	P value	B (95% CI)	P value	B (95% CI)	P value
Demographic factors						
Sex, female vs male (reference)	0.79 (–2.37 to 3.95)	0.624	– 0.34 (–3.71 to 3.02)	0.842	–1.70 (–5.57 to 2.17)	0.388
Age (years)	–0.05 (–0.15 to 0.06)	0.403	–0.03 (–0.15 to 0.09)	0.664	–0.09 (–0.24 to 0.05)	0.188
Educational level, low vs high (reference)	0.18 (–2.76 to 3.12)	0.906	0.75 (–2.27 to 3.76)	0.626	0.45 (–3.15 to 4.04)	0.807
Health-related factors						
Chronic health conditions						
No disease			2.16 (–3.24 to 7.56)	0.431		
NCDs/hypertension/overweight			–3.26 (–6.96 to 0.44)	0.084		
Mental disorders			1.83 (–1.76 to 5.42)	0.318		
Muscle/skeletal disorders			–0.56 (–3.70 to 2.58)	0.728		
Other diseases			0.42 (–3.52 to 4.35)	0.836	–	–
BMI			–0.11 (–0.35 to 0.13)	0.351	–0.26 (–0.54 to 0.02)	0.068
Intervention components						
Self-referred vs referred (reference)					–0.14 (–4.48 to 4.16)	0.948
Duration of adherence to HLC offers (weeks)					0.15 (–0.31 to 0.61)	0.523
Number of individual consultations					–0.96 (–2.47 to 0.54)	0.210
Number of exercise sessions per week					1.27 (0.67 to 1.87)	<0.001
Attended in exercise organised by:						
HLC					0.33 (–4.16 to 4.86)	0.879
Other cooperating providers					–0.07 (–4.81 to 4.67)	0.977
Unsupervised exercise					1.13 (–3.26 to 5.51)	0.614
Attended in theme-specific group meetings					1.38 (–3.10 to 5.85)	0.541

Predictors reported as regression coefficient (B) and 95% CI. All estimates were adjusted for MVPA at baseline, wear time change and season.
p values ≤0.05 are considered as statistically significant changes.
BMI, body mass index; HLC, Healthy Life Centre; MVPA, moderate to vigorous physical activity; NCD, non-communicable diseases.

a longer follow-up time is needed to investigate possible long-term effects. Furthermore, the assessment of intervention components completed by each participant was retrospective, which might have hampered the results by recall bias.

In conclusion, we found that a 3-month lifestyle intervention at Norwegian HLCs led to small improvements in the participants' overall and light-intensity PA levels, aerobic fitness and obesity, and no improvements in MVPA levels. Further research is necessary to study whether there might be long-term effects of this intervention, or whether a longer intervention period might be needed to effectively change behaviour and health in this high-risk population. As the population attending these programmes is characterised by complex health challenges, future research should investigate psychosocial predictors of change, patient-reported outcomes like health-related quality of life, and furthermore which intervention components are beneficial to improve PA and health among such high-risk groups.

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