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MAINTENANCE OF WEIGHT LOSS AND AEROBIC CAPACITY ONE YEAR AFTER THE END OF A LIFESTYLE INTERVENTION FOCUSING ON NUTRITIONAL GUIDANCE AND/OR EXERCISE

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ABSTRACT

The aims of this study were to: 1) investigate to what extent participants in a lifestyle intervention program, including nutritional guidance and two weekly intensive running sessions, maintain improvements in aerobic capacity and health parameters one year after the end of an intervention; and 2) identify common determinants for those participants who succeeded in weight loss maintenance. A total of 51 participants completed the 33-week intervention. One year after the end of the intervention period (1YA) 34 participants completed anthropometric measurements, 12 (8 women) in the training group (TG) and 22 (13 women) in the nutritional guidance and training group (NTG). A total of 13 participants (9 women) in the TG and 11 participants (7 women) in the NTG completed a 3000 m running test. There were no significant differences in body mass index, 3000 m running time or waist circumference between the groups 1YA. There was however, substantial variation in both groups as to what extent participants had maintained their weight loss. Higher self-efficacy and self-control in relation to food and exercise characterized those who best maintained their weight loss.

Keywords: *lifestyle intervention follow up, 3000 m running time, BMI, diet, visceral fat, muscle mass*

INTRODUCTION

This study is a follow-up of the study *"Aerobic training combined with nutritional guidance as an effective strategy for improving aerobic fitness and reducing BMI in inactive adults"* by Helland, Nordbotten, Hagum and Tjelta [17].

Worldwide, 39% of adults are overweight and 13% are obese, and these numbers are gradually increasing [40]. The primary challenges are abundance of food and/or a sedentary lifestyle. Physical activity is a crucial factor in weight loss maintenance [32], and a systematic review of 67 articles highlighted the importance of both reduced energy intake and increased physical activity [37]. According to Miller et al. [25], restricted energy intake without exercise results in a more consistent weight loss compared to exercise training alone. The majority of participants who take part in a lifestyle intervention program achieve an 8–10% weight reduction after 6–12 months [14, 17]. Most individuals regain some of this weight after finishing the intervention but have on average 3–6% lower body weight after two years, compared to before the intervention [9, 35]. Lifestyle intervention programs that achieve a minimum of 10% weight loss, and maintain it for 6–12 months after the intervention, are classified as successful weight loss interventions [10, 41], while a 5% reduction in body weight two years after the intervention is defined as successful long-term weight loss [7]. A moderate weight reduction of 5% improves metabolic function in multiple organs and adipose tissue and reduces the risk of developing cardiovascular disease and Type 2 diabetes [23]. During exercise, interleukin-6 is released from skeletal muscle leading to reduced gastric emptying and enhanced insulin secretion [22]. Regular exercise also stimulates lipolysis of visceral adipose tissue mass, resulting in improved metabolic health [39].

To manage behavioural changes, weight loss programs have to focus on self-efficacy (SE) [10, 16], defined by Bandura [1] as "*a person's perceived ability to produce a behaviour*". High SE often implies high self-control (SC) described as the ability to resist temptations and impulses [3]. The ability to resist temptations and impulses appears to depend on an individual's overall SC capacity, which has been shown to fluctuate over time [4]. According to the Strength Model of Self-Control [2], fluctuations in SC capacity may be caused by depletion of willpower (defined as a type of strength or energy), which appears to be a limited resource. SC is also linked to avoiding temptations [11]. Self-control must be seen in association with reduced intake of unhealthy, energy-dense foods such as sugar-sweetened beverages and fatty snacks, increased fruit and vegetable intake and portion size control [37].

The objectives of the present study were to: 1) investigate to what extent participants in the lifestyle program described by Helland et al. [17] maintained their aerobic capacity (assessed via a 3000 m running test) and health parameters (BMI, visceral fat, body fat percentage) one year after the end of the project; and 2) identify common determinants for those participants who succeeded in weight loss maintenance versus those who failed.

MATERIALS AND METHODS

Design

A total number of 51 participants completed the 33-week intervention, 24 (17 women) in the Training Group (TG) and 27 (17 women) in the Nutritional guidance and Training Group (NTG). Additional details regarding recruitment and the intervention have been previously described [17].

One year after the intervention period (1YA), 34 participants completed anthropometric measurements, 12 (8 women) in the TG and 22 (13 women) in the NTG. A total of 13 participants (9 women) in the TG and 11 participants (7 women) in the NTG completed the 3000 m running test. All participants provided signed, written, informed consent to take part in the study. The Regional Committees for Medical and Health Research Ethics in Norway approved the study.

Training and nutritional guidance

Participants from the TG maintained their normal diet during the 33-week intervention period and were offered theoretical and practical lessons after this period, consisting of two hours of theoretical group lessons containing a summary of highlights from the theoretical themes, plus a three-hour practical cooking session. They were also given access to all recipes and notes shared with the NTG during the intervention period and were free to change their diet.

After the intervention period, all participants were given the opportunity to attend the same training as they did during the intervention period (supervised interval running and strength training sessions twice a week). Two years after the intervention this is still organized as free supervised, outdoor training, available for everyone twice a week (no matter weight). The weekly exercise program is published on Facebook once a week.

Tests

Measurements of BMI, waist circumference (WC), body fat percentage (body fat%), muscle mass, and visceral fat were performed 1YA.

Anthropometric measurements

Height and weight were measured with participants lightly clothed and without shoes. Participants were in a standing position during all body measurements. Waist circumference was measured from the point midway between the inferior margin of the last rib and the crest of the ilium. InBody 720 (Biospace Co., Ldt, Seoul, Korea) was used for the measurement of weight, body fat%, muscle mass and visceral fat.

3000 m running test

Aerobic capacity was assessed via a 3000 m running test around a local lake. The surface was firm cinder and the difference between the highest and lowest points less than 3 meters.

SurveyXact

SurveyXact (Rambøll Management Consulting) was used as an online survey platform to develop a questionnaire to gather information regarding participants' thoughts and attitudes concerning food/diet and exercise. This questionnaire consisted of five sections; 1) questions regarding demographic variables (gender, level of education, occupation, age, country of residence and household size); 2) questions related to food intake (estimated consumption of healthy and unhealthy foods/ingredients, meal frequency, SE and SC); 3) strength training (frequency, duration, type); 4) endurance training (frequency, duration, type) and 5) how to cope with daily life. Participants were asked to report their usual intake (i.e. "How often do you normally eat or drink the following foods?"). Healthy foods assessed were fruits, vegetables, legumes, fish and wholemeal bread. Unhealthy foods were sugar-sweetened beverages (SSB), junk food (pizza, hamburgers, french fries, etc.), sweets (candy/chocolate), snacks (salty snacks such as potato chips), wheat bread and sweet pastries (cakes, cookies, etc.). Consumption of healthy and unhealthy foods were expressed as a frequency (0–1 times/month, 2–3 times/month, 1–3 times/week, 4–6 times/week and 1–2 times/day). Participants were asked if they still exercised (one year after the intervention). In addition to reporting frequency, duration, type and volume of endurance and strength training, participants also reported important aspects related to exercise. The five most important aspects were as follows: 1) I am able to take responsibility for my own health, 2) I believe that physical activity is good for my health, 3) exercise is important to many aspects of life, 4) it is important to live as healthy a life as possible, 5) I wish to be role model for my children. Participants were also asked if they used any type of mobile phone application (APP) to keep track of calories and exercise. Twenty-three in the NTG and 19 in the TG answered the questionnaire.

Food related SC was measured by a five-item questionnaire based on Tangney et al. [18; 33]: "I have a hard time breaking bad food habits", "I wish

I had more self-discipline when it comes to unhealthy food", "Sometimes I can't stop myself from eating unhealthy food, even if I know it's wrong", "I avoid food that is not good for me" and "People would say that I have good self-discipline when it comes to unhealthy food". Each of the five items were scored on a 5-point Likert scale (1 = totally disagree, 2 = partly disagree, 3 = neutral, 4 = partly agree, 5 = totally agree). The first three items were reverse-coded so that higher numbers indicate stronger self-control.

The questionnaire was distributed electronically at project start (2016), after the 33wk intervention period (2017) and one year after the intervention period (2018). Seventy-five respondents completed the questionnaire in 2016 (34 in NTG), 55 in 2017 (28 in NTG) and 52 in 2018 (23 in NTG) respectively.

Statistical analyses

All analyses were performed using IBM SPSS Statistics Version 25.0. Preliminary analyses were performed to ensure that assumptions of normality, linearity and homoscedasticity were not violated. Values for skewness and kurtosis were between ±2, indicating a normal univariate distribution for all parametric data. Data are presented as mean (M) ± standard deviation of the mean (SD). The alpha level for significance was set to $p < 0.05$. Effect size for non-parametric scores was calculated with Wilcoxon test (r) and defined according to Cohens's criteria as small (<0.3), medium (0.3–0.5), or large (>0.5) effect [12]. Kendall's tau-b (τ_b) correlation coefficient was used to measure the relationship between non-parametric measures (bootstrapped). The Wilcoxon signed-rank test was used to test the differences between the intake of healthy food choices (fruits, vegetables, legumes, fish, whole meal bread/rolls) and unhealthy food choices (sugar-sweetened beverages, junk food, sweets, snacks, cake, wheat rolls/bread/buns) both during the intervention period and after the intervention period.

RESULTS

The main finding in this follow up-study is that there were small, non-significant changes in anthropometric parameters (BMI, waist circumference, visceral fat, muscle mass and body fat%), and 3000 m running time from 33 wk (the end of the intervention) to 1YA.

BMI, 3000 m running time and WC

Figures 1, 2 and 3 show estimated marginal means plots for body mass index (BMI), 3000 m running time (in s) and WC. No significant difference was found between the groups 1YA.

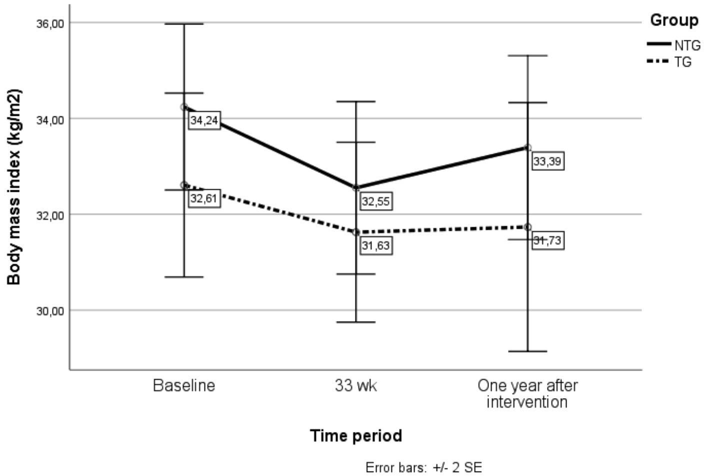

Figure 1. Estimated marginal means plot for data on BMI for both groups at baseline, after the intervention (33 wk) and one year after the intervention. Error bars indicate 95% CI.

Both groups showed a significant improvement in running time during and after the intervention period. On average, participants were significantly faster runners 1YA than when entering the intervention project (p=0.03).

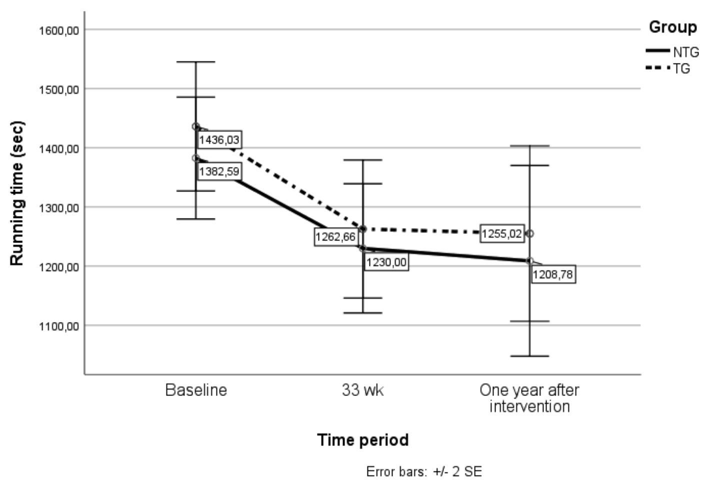

Figure 2. Estimated marginal means plot for data on running time for both groups at baseline, after the intervention (33 wk) and one year after the intervention. Error bars indicate 95% CI.

Data from 1YA showed a correlation between running time and both BMI ($r = 0.465$, $p < 0.01$), WC ($r = 0.412$, $p < 0.01$), visceral fat ($r = 0.368$, $p < 0.01$) and body fat% ($r = 0.479$, $p < 0.01$). Faster runners had lower weight and WC, lower amounts of visceral fat and a lower body fat%.

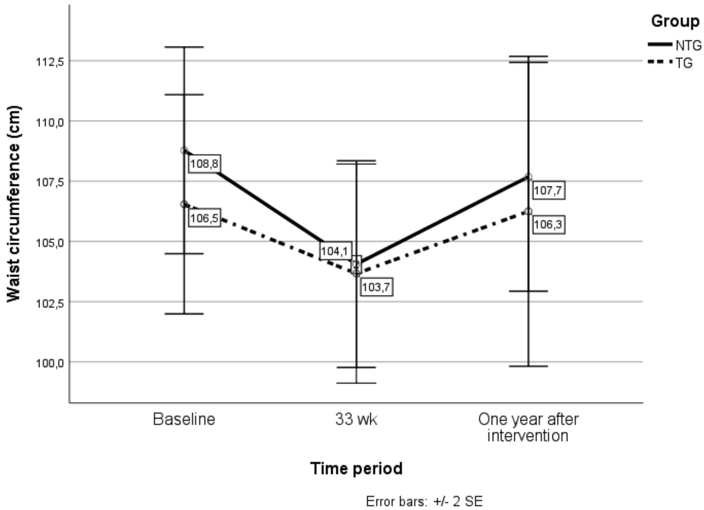

Figure 3. Estimated marginal means plot for data on WC for both groups at baseline, after the intervention (33wk) and one year after the intervention. Error bars indicate 95% CI.

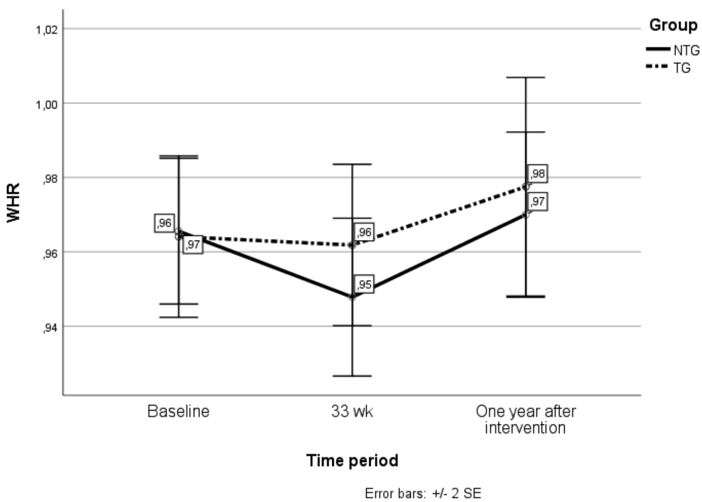

Figure 4. Estimated marginal means plot for data on WHR for both groups at baseline, after the intervention (33wk) and one year after the intervention. Error bars indicate 95% CI.

Body fat percentage, muscle mass and visceral fat

Table 1 shows descriptive statistics for both groups, while table 2 shows pair-wise comparisons based on descriptive statistics.

Table 1. Descriptive Statistics, Marginal means for each test for both Groups

Measure	Group	M ± SD
Body fat %	TG (n=12)	36.5±8.5
	NTG (n=22)	37.2±8.4
Muscle mass	TG (n=12)	33±7.9
	NTG (n=22)	35±7.1
Visceral fat	TG (n=12)	133.0 ±38.7
	NTG (n=22)	140.4±32.1

Table 2. Pairwise comparisons based on estimated marginal means

Measure	33wk (I)	1YA(J)	Mean Difference ± SD	Sig.[b]	95% CI[b]
Body fat %	3	4	0.864±1.91	0.653	−2.94–4.67
Muscle mass	3	4	−1.315±1.62	0.420	−4.54–1.91
Visceral fat	3	4	2.901±10.15	0.776	−17.3–23.1

Based on estimated marginal means
*. The mean difference is significant at the 0.05
b. Adjustment for multiple comparisons: Bonferroni

Estimated marginal means of Time x Group for data on muscle mass are shown in figure 5.

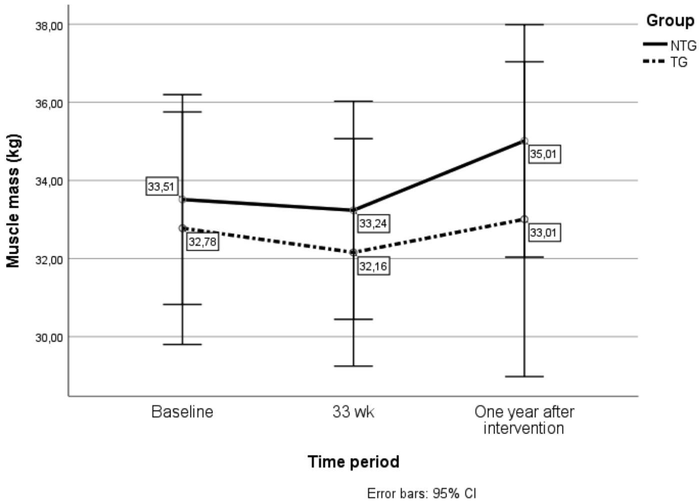

Figure 5. Estimated marginal means plot for data on muscle mass for both groups at baseline, after the intervention (33wk) and one year after the intervention. Error bars indicate 95% CI.

Data 1YA show a correlation between muscle mass and WC (r = 0.408, p <0.01), weight (r = 0.585, p <0.01) and visceral fat (r = 0.274, p <0.05). A small, but non-significant interaction effect for group x time between 33wk and 1YA was observed for these variables (p = 0.082).

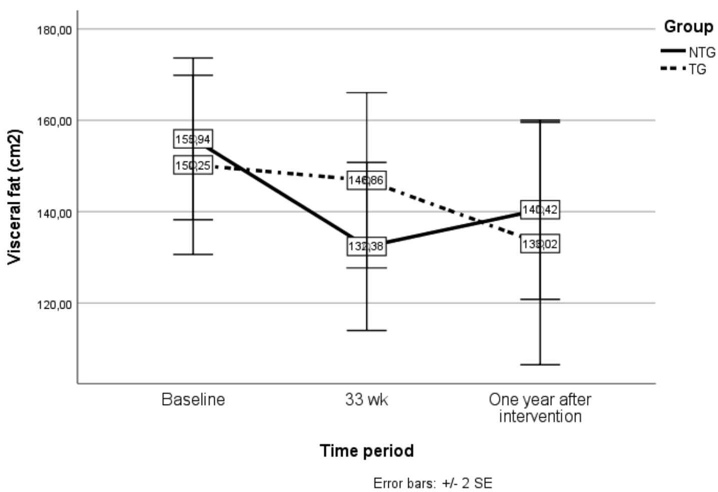

Figure 6. Estimated marginal means plot for data on visceral fat for both groups at baseline, after the intervention (33wk) and one year after the intervention. Error bars indicate 95% CI.

Visceral fat in NTG increased after the intervention, while it decreased in TG (Figure 6). However, there was no statistically significant difference between measurements at 33wk and 1YA ($p = 0.776$) or between the groups ($p = 0.728$), nor was a significant interaction effect observed ($p = 0.284$).

Self-control and self-efficacy

There were no significant differences between males and females at any timepoint ($p > 0.05$). Irrespective of group, participants increased their SC related to diet during the intervention period ($p = 0.041$, $z = -2{,}039$, $r = 0.29$), indicating a small to medium effect for the SC data. After the intervention period, most participants significantly increased their consumption of fruit, from 4–6 times a week to 1–2 times a day ($p = 0.042$, $z = -2.032$, $r = -0.32$), indicating small effects. Although consumption of other foods also indicated small changes towards a healthier diet, these were not significant ($p > 0.05$).

A Kendall's tau-b correlation was run to determine the relationship between SC and consumption of different foods amongst the participants (n=40). There was a strong, positive, statistically significant correlation between the consumption of vegetables and high SC ($\tau_b = 0.3$, $p = 0.02$) and a strong, significant negative correlation between SC and consumption of sweets ($\tau_b = -0.404$, $p = 0.002$). Self-efficacy was strongly, significantly and negatively correlated with the consumption of both sweets ($\tau_b = -0.316$, $p = 0.019$) and snacks ($\tau_b = -0.297$, $p = 0.027$). A positive correlation was also found between SC related to exercise and amount of time spent weekly on exercise 1YA (both strength and endurance training were combined) ($r = 0.246$, $p < 0.05$).

About half of the participants from the TG attended practical and theoretical sessions after the 33-week intervention.

DISCUSSION

Maintenance of aerobic capacity

Running time for 3000m can be used to estimate aerobic capacity (VO_2max) [17]. Unchanged running time for both TG and NTG indicates that aerobic capacity was maintained from 33wk until 1YA. High intensity interval training is a time-efficient training method and may be an important factor in maintaining aerobic capacity and energy expenditure. Nevertheless, evaluation of exercise intervention studies indicates only a small effect on weight loss. Thomas et al. [34] conclude that this is most likely due to low energy expenditure during exercise and a concomitant increase in energy intake. However, increased aerobic capacity is associated with beneficial health effects, independent of weight loss [19]. Estimated marginal means in the current study support this by showing a correlation between running time and WC ($r = 0.412$, $p < 0.01$), visceral fat ($r = 0.368$, $p < 0.01$) and body fat% ($r = 0.479$, $p < 0.01$) 1YA intervention.

Maintenance of body fat persentage, muscle mass, visceral fat and WHR

Estimated marginal means for muscle mass indicate a small, but insignificant interaction effect for group and time between 33wk and 1YA ($p = 0.082$). The greatest change in muscle mass was shown for the NTG. Strength training is important for maintaining muscle mass [6] and reducing the risk of injuries [20] and regardless of BMI, greater muscle mass is associated with better health [21]. In this study, good health may be related to data 1YA that show a correlation between muscle mass and WC ($r = 0.408$, $p < 0.01$), weight ($r = 0.585$, $p < 0.01$) and visceral fat ($r = 0.274$, $p < 0.05$). No correlation was observed between the volume of self-reported training and visceral fat, but unchanged aerobic capacity may indicate more exercise for NTG than reported.

Maintenance of weight loss

This study indicates that weigh loss can be maintained for at least one year after the end of a weight loss intervention, which is in line with the findings of Franz et al. [14]. The long intervention period of 33 weeks may have contributed to this maintenance, since a longer intervention period may help participants establish new lifestyle habits [13].

Reduced energy intake appears to be the most important factor for weight loss and factors related to weight, while physical activity is an important contributor [8]. For this reason, a larger weight loss could be expected when combining training with a nutritional intervention, compared to training alone. However, in the study of Helland et al. [17] there was no significant difference in weight loss between TG and NTG after the 33wk intervention, and in the present study, there were still no significant differences between the two groups 1YA. Helland and Dyrstad [16] suggested that the lack of a significant difference between the groups may be due to the fact that it is difficult to change both energy intake and physical activity simultaneously. Previous research suggests that it is easier to increase physical activity than to reduce food intake. Accordingly, some participants in the present study reported greater challenges related to food habits, than in implementing physical activity in their daily life. While food and meal habits have to be implemented 24 hours a day, every day, physical activity was limited to less than four hours per week. One of the challenges surrounding diet was related to consumption of food characterized as healthy. Several of the participants thought they could eat unlimited amounts of healthy foods, despite the fact that several ingredients are energy rich, such as unsaturated fat for cooking and nuts.

The NTG received guidance and education regarding nutrition through practical cooking classes and theoretical lectures. They did not follow a specific diet but were given the appropriate knowledge about healthy foods and how to limit their energy intake. Over time, this may help participants become more aware of their choices and consumption of food and maintenance of bodyweight [10]. It was intended that the TG would, during the intervention, continue to eat as they had done when entering the project. However, results from SurveyXact indicate that some of the participants in the TG also made unauthorized changes to their diet during the intervention period, towards healthier foods. This is not an unknown phenomenon in such interventions and should be taken into account when interpreting the results [26, 36].

Physical activity contributes towards maintaining weight loss [35] and provides numerous health benefits even in the absence of weight loss [32]. Ostendorf et al. [28] observed higher levels of both high- and low-intensity physical activity, as well as decreased sedentary time, in participants with successful weight loss maintenance. Both TG and NTG ran the 3000 m test significantly faster after the intervention period, and this improvement was maintained. From 33wk to 1YA none of the groups improved their running time significantly, but TG had a small, non-significant improvement. This indicates that participants maintained their training volume one year after the intervention period, although this may only be the case for the 24 of the original 51 participants who agreed to run the 3000m test again one year after the intervention. If training volume was maintained, a reduction in visceral fat would also be expected. According to a simple main effect's analysis, neither time, nor group, had any significant effect on the amount of visceral fat. Working muscles produce interleukin-6 that is one possible reason for reduction in visceral fat and better health [29, 39]. The training volumes reported by participants in the current study are inconsistent, in line with previous findings that self-report is often an unreliable measure of training [5]. Nevertheless, the improvement in 3000 m running time indicates higher aerobic capacity than at baseline and is an important contributor to improved health [15, 27, 30, 38].

Self-efficacy and self-control

High intensity interval exercise twice a week over a long period provided participants with a routine of pushing themselves during physical activity, which in turn may have helped to strengthen their willpower and SE. For participants taking part in a weight loss program, continued effort and attention to weight loss strategies appears necessary during the first years of weight loss. Even though the active intervention period only lasted 33 weeks, all participants were aware that measurements would also be taken 1YA, and this may have provided extra motivation that was helpful when establishing permanent changes to diet and exercise during the year following the intervention. After two years of weight loss maintenance, new habits are largely established, and weight loss strategies become less important [35]. Conversely, prolonged and close follow-up may lead to participants viewing obesity as a chronic disease, and thereby cause them to lose the motivation required to take responsibility for their own lifestyle changes [10]. Nevertheless, the underlying causes of obesity are complex and individual. Dandanellet al. [8] underline that the same treatment is not appropriate for everyone, and that lack of individual follow-up might be the reason why a relatively small number of participants who take part in weight loss programs succeed in long-term weight loss maintenance.

Characterizations of the most and least successful participants

Despite several of the participants increasing their weight after the end of the 33wk intervention, the majority (n=24) had a lower weight 1YA compared to before the intervention. The high dropout in the TG (50%) 1YA may indicate that participants with unfavorable increases in weight did not return for measurements. The majority of the participants in the NTG (dropout=19%) met for both anthropometric measurements and the running test 1YA, indicating that a close follow-up creates a closer relationship, which likely made them more committed to a healthy diet and exercise also after the intervention period.

On the other hand, the participant who lost the most weight was a female from the TG (1.5 kg during the 33wk intervention period and another 11.5 kg the following year). This participant was also among those with the best improvement in running time (421 s), the highest increase in consumption of vegetables, and was among the five participants who ate least junk food and ate a high amount of legumes (4–6 times/week). Results from the questionnaire also showed a high SE concerning healthy food. Among the four participants who lost most weight during this two-year period, two participants were from the TG and two from the NTG. They all weighed approximately 85–92 kg upon entering the project. The four participants who gained most weight during the same period had a higher weight at baseline, typically above 100 kg. For one of these participants, a combination of low SE with regards to healthy food, low consumption of fish (2–3 times/month), no consumption of vegetables and a low consumption of fruit led to an increased weight from 103 kg to 111 kg during these two years. One of the four participants with the slowest running time and highest increase in running time from 33wk to 1YA reported eating small amounts of fruit and vegetables, and large amounts of soda and sweets, indicating the importance of a healthy diet. High SE and SC related to food and exercise is important to be able to lose weight and establish permanent routines.

The outcomes of this study are based only on completers of the weight loss program, which in this case may have given better results for the TG than if based on all participants enrolled in the program, since only 12 participants (50%) in the TG met for anthropometric measurements 1YA. A few more answered the questionnaire about exercise, but only 11 of these exercised regularly 1YA (n=19). This dilemma has also been discussed by Franz et al. [14], and it is reasonable to assume that the 12 participants who returned for measurements 1YA were also those who had been most committed to training and/or diet. On average, these 12 participants gained 0.55±5.64 kg the year following the intervention period. In the original NTG, 22 participants (81.5%) completed all measurements one year after the intervention period, and results show that they had an average weight gain of 1.34±3.77 kg. A high participation rate may indicate a closer connection to the project through weekly meetings during the 33wk intervention period. This shows the importance of a close follow-up. There were no significant differences in weight gain between TG and NTG, and despite a marginally larger weight gain, 18 participants in the NTG answered that they exercised regularly 1YA (n=23). Only 9 in the NTG (n=23) and 8 in the TG (n=19) used APPs to keep track of food and exercise, although this, preferably MyFitnesspal, was highly recommended during the intervention period. According to Mateo et al. [24], such APPs have a positive effect on weight loss, although Rivera et al. [31] underline the importance of health care experts during the app development process and the involvement in formal scientific research.

Limitations of the study

One limitation of the current study is the absence of a control group, and the relatively small number of participants. However, limited resources in the active part of the intervention study made it impossible to enrol more participants, and this, combined with the high secession rate in the TG, meant that the number of completers was low. Despite these limitations, this exploratory, randomized trial helps to identify important associations between running time, anthropometric measurements and SC.

CONCLUSIONS

A long intervention period is a contributing factor to accomplishing permanent, positive changes related to diet and/or physical activity. Although small differences were observed in anthropometric measurements and running time between NTG and TG 1YA, none of these reached statistical significance. High SE and SC related to food and exercise is important for a successful outcome when establishing permanent training routines and changes in diet. The rate of success in terms of achieving and maintaining weight loss might be higher in those with lower initial body weight (<100 kg).

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