Title page:

TITLE: Effect of a Long Bout versus Short Bouts of Walking on Weight Loss during a Weight Loss Diet, a Randomized Trial

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- **AUTHOR CONTRIBUTIONS:**

  Experiments in this study were conducted in NovinDiet Clinic, Tehran. AM: contributed to the initial study design, study protocol setup, data collection, data analysis, and writing of the first draft of the manuscript; MAT: refined the study design and contributed to data interpretation and redrafting of the manuscript, AM and MAT contributed to this article as co-first authors. HRF: designed the research, conducted the research, contribution to data interpretation, revision of the manuscript and provided medical supervision; IAM: refined the study design and contributed to data interpretation and redrafting of the manuscript. RM and AD: provided advice and consultation for the study design, conducted the research. All authors read and approved the final manuscript.

Answer the Study Importance Questions:

What is already known about this subject?

- Physical activity is the main component of many weight loss plans.
- Lack of time has been frequently cited as a barrier to achieve the daily recommended duration of physical activity.
- Available evidence is insufficient and contradictory to determine whether accumulated exercise is as effective as continuous exercise for weight loss.

What does our study add?

- Physical activity undertaken in 2 shorter-bouts per day could be more effective for weight loss than when undertaken in a daily longer-bout.
- It may indicate that shorter-bouts of exercise performed twice during the day may increase long-term exercise adherence.
- This may be helpful for busy people who are not able to schedule time for a daily longer-bout physical activity to achieve weight loss.

Objective: To evaluate the effect of different daily physical activity (PA) frequencies while maintaining the same daily volume of PA on weight loss, carbohydrate and lipid metabolism, in women with overweight/obesity throughout a 24- week intervention.

Methods: 65 women [BMI = 27- 35 kg/m²; age= 18-40 y] who had a sedentary lifestyle were randomly allocated to include either a longer-bout of PA (LBP), 50 min/d moderate-intensity PA, or two shorter-bouts of PA (SBP), two 25 min/d moderate-intensity PA, 6 d/week during their weight loss plan. Anthropometric and blood measurements were taken at baseline and 24 weeks.

Results: Compared with the LBP group, the SBP group had a greater decrease in weight (SBP: -8.08 ± 2.20 kg; LBP: -6.39 ± 2.28 kg; $P = 0.019$), BMI (SBP: -3.11 ± 0.87 kg/m²; LBP: -2.47 ± 0.86 kg/m², $P=0.027$) and waist circumference (SBP: -8.78 ± 2.62 cm; LBP: -5.76 ± 2.03 cm; $P = 0.026$). No significant differences were seen in carbohydrate and lipid metabolism characteristics after the 24 weeks.

Conclusion: PA undertaken in 2 shorter-bouts per day could be more effective for weight loss than when undertaken in a daily long-bout in adult women on a 24 wk weight loss program.

Introduction

The worldwide epidemic of obesity has resulted in calls for prevention and treatment strategies. Clinical trials on weight reduction through diet only have shown modest long-term efficacy (1). It is recommended that PA should be an integral part of the management of weight loss, weight maintenance (2) and the treatment of abdominal obesity (3). It appears that weight-loss interventions containing PA are more effective than dietary instruction alone, for long-term weight management (4, 5).

There is evidence of the need to maintain a physically active lifestyle which should be more than150 min/wk of PA to manage body weight (6, 7), while 200-300 min/wk is recommended for long-term weight loss (8, 9). Since 1995, PA guidelines included the concept that gaining health benefits of exercise or PA may be accumulated in bouts spread over the course of the day (10). A lack of time was frequently cited as a barrier to PA (11), which led to short bouts of activity throughout the day being recommended rather than a continuous time-slot in a busy schedule (12).

The results of studies of the impact of accumulated versus continuous exercise on weight loss are contradictory and inconclusive. Some studies indicated that weight loss was similar between accumulated and continuous exercise training (13-15), whereas other studies indicated superior health benefits gained from PA in multiple bouts (16, 17), and some studies indicated more weight loss and superior health benefits gained from one continuous PA bout (18-20). Available evidence was also insufficient and contradictory to determine whether accumulated exercise was as effective as continuous exercise for outcomes such as adiposity, blood lipids, and indicators of psychological well-being (21).

To our knowledge, clinical studies that have looked at continuous vs. multiple short bouts of exercise during weight loss intervention are scarce. So, the primary objective of the present study was to compare the effect of a daily brisk walking program with a fixed total duration/day undertaken either over 50 continuous minutes (longer bout) or two 25-minute periods (shorter bouts), on weight loss and anthropometric measures in healthy women with obesity or overweight while following a comprehensive 24 week weight loss programme. The secondary objective was to examine the effect of the daily pattern of PA on biochemical indicators of cardiometabolic risk.

Methods

Participants

Healthy women with overweight or obesity were recruited between February and July 2015 from participants attending the NovinDiet Clinic, Tehran, Iran to lose weight. Inclusion criteria were: female, 18-40y of age, BMI = 27 -35 kg/m², sedentary lifestyle (reported exercising fewer than 3 d/week, <20 min/d for the previous 6 months (22, 23)) and ready to introduce a dietary change to lose weight. Inclusion criteria included that participants were required to be nonsmokers, free of established cardiovascular diseases, stroke, diabetes, liver, kidney, depression, cancer or autoimmune disease. Only participants with BMI 27 -35 kg/m² were selected to reduce the effect of confounding factors of more extreme diet and physical activity behaviours, since it is likely that food intake behaviours and PA abilities of those in other classes of obesity may influence the results. Moreover, participants were only included if they could show that they were able to keep an adequate 4- day food record as part of the screening process, to record details of their total daily steps, and who were considered by the

study physician to be fit to participate in the physical exercise program. Exclusion criteria were pregnancy or lactation during the prior 6 months or planned pregnancy in the next 6 months, depression defined using the Beck Depression Inventory (24), weight loss ≥10% of body weight within the 6 months before enrollment in the study, participating in any weight loss research project in the last 6 months, taking medication to lower lipids/ cholesterol or that could affect metabolism or change body weight, a self-reported history of heart disorders, frequent chest pains, or faintness or dizziness on the Physical Activity Readiness Questionnaire (PAR-Q) (25).

The study was approved by the Ethical Committee of The Digestive Research Institute**,** Tehran University of Medical Science. All participants provided their signed consent before study enrollment. This trial was registered at https://clinicaltrials.gov as NCT02387827.

Study design and interventions

The study was a 24-week**,** 2-arm randomized clinical trial. Eligible participants were randomly assigned, after baseline measurements, by the project director and using a computer-generated random-numbers method. The allocation was obscured from the participants and dietitians until randomization was revealed to the study participants at the first intervention clinic appointment. To control the effects of menstrual cycle on measurements, participants started the study at the same phase of their menstrual cycle. Sixty five participants were randomly assigned to one of the two study groups; 1. Diet+ shorter-bouts of moderate PA (SBP), (n=32) and 2. Diet+ Longer-bouts of moderate PA (LBP), (n=33). Participants in the LBP group were requested to perform 50 min/day brisk walking, 6 days a week (300 min/week) while participants in SBP were

instructed to have brisk walking in two 25 min bouts per day on 6 days a week (300 min/week) (9, 26).

To become conditioned to the level of exercise, a week before the start of the study, participants were asked to increase their daily step count and record the step count in a diary. To standardize the intensity of the PA sessions participants were asked to walk at least 100 steps/min during the brisk walking sessions (27) and to do the walking on a flat surface outdoors in their neighborhood or a park with loose fitting and comfortable clothing appropriate for the weather conditions.

To encourage participants to achieve the requested PA goal, they were encouraged to recruit one PA partner from their group of friends and family members to participate in the PA part of the study with them. Weekly visits to the dietitian and exercise coach were required in order to promote adherence to the hypo-energetic diet and recommended PA protocol. To promote adherence to the PA intervention, participants were provided with a 3D pedometer (Model: JT 626, Sunnylife, UK) and instructed to wear the pedometer for the whole day except when bathing/showering or going to bed, and to write their daily step counts and time of the their structured PA in their log book. Both groups were guided on the hypo-energetic diet according to the NovinDiet Protocol (see below).

Dietary and activity intervention sessions

The NovinDiet Clinic is a private weight-loss clinic that uses an integrated approach (dietary, behavioral, exercise, and medical treatments).The NovinDiet Protocol is based around helping each member develop their own problem solving approach. In this study the program was designed to enable weight loss of 7-10% of initial body weight, at a

rate of 0.5-1 kg/week over 24 weeks. The individual diet programs were based on the participant's food diary records as a reflection of their food preferences. Gradual modifications were made to bring their diet in line with the NovinDiet protocol. Participants were instructed to consume a hypoenergetic diet with a mainly high-carbohydrate, low–saturated fat content [15% of energy from protein, 30% from fat, <10% from saturated fat), and 55% from carbohydrate]. The diet program was designed to introduce a 500-600 kcal/day energy deficit based on estimated energy requirements at the start of the study.Participants were encouraged to eat mainly foods with low energy density to achieve satiety, some low fat dairy products, fiber-rich foods and controlled amounts of high energy dense foods. The main behavior change strategies applied included assessing and discussing stages of change, goal setting, self-monitoring with food diaries and giving feedback on waist measurement changes (7). At weekly sessions, the participants discussed with their dietitian any problems they had complying with their weight loss program. Resources were provided as home booklets for each participant which indicated their dietary and PA goals. During the intervention period, participants completed a feedback form regarding their adherence to diet and PA. At weekly clinic visits, the dietitian reviewed their progress, also checked their PA adherence and their log during the previous week. Participants also had access to a website, weekly internet magazines, and one to one telephone/ online support from a physician, if they felt that they had difficulty with compliance.

Measurements

Anthropometric measurements of all subjects were taken at baseline and 24 weeks (except height which was taken only at the screening visit), by the dietitian.

Energy and macronutrient intake at baseline and the last week of the intervention (week 24) was analyzed by Nutritionist IV software (version 4.1; Hearst). Estimated daily PA measurements of all participants were taken at the start, Week 4, 8, 12, 16, 20, and 24 by using the 3D pedometer. Blood samples were taken from all subjects after an overnight (10- 12 h) fast, between 07:00 and 09:00, at the baseline and after 24 weeks. Blood samples from an antecubital vein via a venipuncture were taken while the participants were in a sitting position, according to the standard protocol, and were centrifuged within 30–45 min. Blood samples were also taken 2 hours after ingesting 75g of glucose according to the standard method for 2 hour post prandial glucose(2hpp) (28). Blood samples were analyzed for biochemical, cellular and hormonal variables

Anthropometric measurements

Body weight was measured to the nearest 0.1 kg using a digital calibrated scale (Omron Health Care, Hoofddorp, Netherland), while the participant wore light clothing, with no shoes. Body height was measured to the nearest 0.1 cm by using a wall-mounted stadiometer (SECA, Hamburg, Germany) while participants were shoeless, and in a free-standing position. Waist circumference (WC) was measured with a flexible but non-stretching measuring tape and recorded to the nearest 0.5 cm. WC was measured at the halfway between the lower rib and the iliac crest (29). BMI was calculated from measured weight in kilogram divided by the square of height in meters.

Blood sample measurements

Fasting plasma glucose (FPG) and 2hpp glucose levels were measured using an enzymatic colorimetric method. Insulin was measured by using a radioimmunoassay with ^{125}I-labeled human insulin and a human insulin antiserum in an immunoradiometric

assay (IRMA) (Biosource, Dorest, Belgium) with a gamma-counter system (Gamma I; Genesys). Fasting insulin resistance was evaluated by homeostasis model assessment of insulin resistance (HOMA-IR), which was calculated by using the following formula:

HOMA-IR = [fasting insulin (mU/l) × FPG (mmol/l)]/22.5 (30)

Glycated hemoglobin (Hb A_{1c}) was measured by a colorimetric method after an initial separation by ion exchange chromatography (Biosystem, Barcelona, Spain).

Biochemical analysis of the serum total cholesterol (TC), triglyceride (TG), and high-density lipoprotein (HDL) cholesterol were carried out on a Selectra E auto analyzer (Vita Laboratory, Netherlands) following standard procedures of the Pars Azmoon diagnostic kits (Iran). The LDL cholesterol was calculated using the Friedewald formula.

LDL cholesterol = TC – HDL cholesterol + (TG ÷ 2.2) (31).

Statistical methods

Baseline values of cardiovascular risk factors (including weight, waist circumference, LDL-c, HDL-c, TC, FPG, TG), fasting insulin, HOMA IR, HbA1C, 2hpp glucose, food intake and step counts data were compared between the SBP and LBP groups using unpaired *t*-tests.

At baseline, distribution was normal for all variables. All participants who were randomly assigned and completed an initial assessment were included in the final results by using an intention-to-treat analysis. Multiple imputations with the use of linear regression were used to impute missing values from 24 weeks and were based on the assumption that data were missing at random. We used analysis of covariance (ANCOVA) to compare the means of post-intervention outcomes between the two groups using baseline values as covariates. Repeated measures 2-factor ANOVA with intervention groups (SBP and

LBP) and time (weeks 0, 4, 8, 12, 16, 20 and 24) as a within-subject factor was used to assess the effects of the interventions on the PA level measured by using the step counts data between the groups over time.

The primary outcome addressed in this study was the difference in body weight loss after the 24 week weight loss program. The power calculation was based on the prior data ($\alpha = 0.05$, power $(1- \beta) =0.9$), which was based upon expected differences in weight loss between the intervention groups = 1.3 and SD =2.1 kg to determine the targeted final sample size ($n = 57$). Considering a dropout rate of 10% the sample size required was 63. So, 65 subjects were randomly assigned in the 2 groups of the intervention.

Statistical significance was set at $p \leq 0.05$. All data are presented as mean ± SD unless otherwise stated. All statistical analyses were performed using SPSS 22.0 for Windows.

Results

Baseline characteristics

Of 65 participants with overweight/obesity recruited, 57 completed the 24-wk intervention (88% of the randomly assigned population, **Figure 1**). At screening 5 people decided that they were not interested in being in the study, 1 participant was excluded from the study because of the results of Beck depression questionnaire. Five were excluded because they failed to keep the dietary record reliably. Blood test results at screening shown that 9 were ineligible due to having one or more of the exclusion criteria.

The remaining 65 eligible participants gave written consent and then 32 participants were allocated randomly to the SBP and 33 to the LBP group. After starting the

intervention, a total of 8 participants dropped out for different reasons (1 in the LBP group due to illness, 4 because of loss of interest in completing the study (3 in LBP group and 1 in SBP group), 1 in the LBP group experienced an unexpected pregnancy, 1 from the SBP group left the study due to relocation and 1 participant in SBP group withdrew without giving any reason).

At baseline, there were no statistically significant differences in physical characteristics or biochemical measurements between the two groups (**Table 1**).

Body weight, BMI and Waist circumference (WC)

As shown in **Table 2**, there was a significant weight reduction in both groups (P< 0.001) and a significant difference in body weight between the groups (P=0.019) after 24 weeks of the intervention. The weight change (mean ± SD) was - 8.08 ± 2.20 kg in the SBP Group and - 6.39 ± 2.28 kg in the LBP group.

BMI reduction in each group was in the expected direction with significant effects over 24 weeks for both groups (P< 0.001). However, the decline in BMI was larger in the SBP group than the LBP group after 24 weeks (*P*=0.027, **Table 2**).

In both groups, WC had decreased significantly after 24 weeks of the intervention (P<0.001). There was a significant difference in the decrease in WC between the two groups after 24 weeks (- 8.78 ± 2.62 cm in SBP group and - 5.76 ± 2.03 cm in LBP group, P=0.026), as shown in **Table 2**.

Lipid profiles

Reductions in total cholesterol, LDL cholesterol, and triglyceride concentration and an increase in HDL cholesterol were seen over the 24 weeks in each group (P<0.001).

However, there were no significant differences in these results between the groups (**Table2**).

Glucose metabolism measurement

Fasting plasma glucose, 2 hours postprandial (2hpp) glucose, HbA1C, fasting serum insulin and HOMA-IR all declined over the 24 weeks of study in each group ($P < 0.001$). However, there were no significant differences in the reductions of these glucose metabolism variables between the two groups at 24 weeks (**Table 2**).

Food intake

At baseline, there was no significant difference in energy and macronutrient intakes **Table 3**. Estimated energy intakes showed a significant reduction over time in both groups (P< 0.001 for time effect) but there were no significant differences between the 2 groups at the end of the 24-week intervention.

Physical activity measurements

As shown in **Figure 2**, at baseline both groups had a similar mean (±SD) daily steps of (3990 ± 651 in the SBP and 3925± 701 in the LBP group). Compared with baseline, both groups had higher mean daily steps over time (P< 0.001 for time effect). Furthermore, the step count increase (mean ± SD) was higher in the SBP Group compared with the LBP group over 24 weeks of intervention (SBP: +2965± 795 steps/day; LBP: +2196 ± 789 steps/day, P<0.001, two way ANOVA).

Regarding the PA adherence of participants, the mean values calculated from the exercise log book showed that the SBP group attended 92% of the prescribed 288 sessions while the LBP group 89% of the 144 prescribed sessions. In addition, total duration for the structured PA was 280 +/- 65 min/week in the SBP group vs 247 +/- 54

min/week in the LBP group, which was not significantly different between the two groups.

Discussion

The aim of the current study was to evaluate the effect of different daily PA frequencies while aiming to maintain the same total period of activity on weight loss and anthropometric measures in healthy women with obesity or overweight while following a comprehensive 24 week weight loss programme. The secondary objective was to examine the effect of the daily pattern of PA on biochemical indicators of cardiometabolic risk. The main finding of the present study was that those in the SBP group with two 25 min PA sessions/day for 6 d/week had significantly greater weight loss than the LBP group with 50 min/d PA for 6 d/week, even though they were prescribed to have the same total of 300 min/week PA. However, no significant differences in the changes in carbohydrate metabolism characteristics and lipid profiles were seen after the weight loss intervention between the groups.

In the current study, participants in the SBP group, who were asked to perform two 25 minutes bouts of PA on 6 days a week, lost 1.7 kg more weight than those in the LBP group, who performed one bout of 50 min/d 6 days a week. Our results are consistent with previous studies which resulted in a greater weight loss in short-bouts vs. long-bouts of exercise (16, 17). However, our results were in contrast with others showing either no differences in weight loss between accumulated and continuous exercise training (13-15), or more weight loss when activity is performed in one continuous PA bout (18-20). The contrast between our results and previous studies may be related to

the different design in terms of the duration of PA, which was less in the previous studies than the current guideline recommendations (8, 9,) and/ or the absence of an integrated weight loss diet in their program (13-15, 18-19).

In the present study, the average percentage of weight loss during a 6 month intervention was similar to other behavioral lifestyle modification programs (32-34) and our previous study that encompassed similar dietary component and similar PA weekly duration (i.e. 300 min/w) program (35). Furthermore, the results of the present study are in agreement with the Jakicic et al study indicating that the combination of changes in eating and PA behaviors can improve long-term weight loss compared with changing either behavior alone (36). The participants of the present study were walking ≤5,000 steps/day which is proposed as a 'sedentary lifestyle". They increased PA during the intervention, and the increase was significantly higher in the SBP Group compared with the LBP group over the 24 weeks of the intervention (SBP: +2965± 795 step/day; LBP: +2196 ± 789 steps/day, $P<0.001$). The present results are also consistent with previous evidence that small changes in daily physical activity (a 3,000 step a day increase accrued across time) as a part of nutritional changes program is linked with modest consistent and sustained weight loss (37). However, the majority of our participants, especially in the LBP Group, did not achieve 7,000-8,000 steps/day and so were below the threshold of free-living physical activity recommended in current public health guidelines (38).

The results of the current study also showed a higher overall PA, assessed by mean daily steps, in the SBP group compared to the LBP group. These results are consistent with previous studies (39) indicating that prescribing short bouts of PA may increase

long-term exercise adherence or may actually lead to participants undertaking higher intensity PA and/or more than the prescribed exercise duration. However, these results are inconsistent with the outcome of the study by Jakicic et al (20) which showed the duration of PA was only significantly greater in the SBP compared with LBP in the first 4 weeks, while no significant differences were seen among groups after that. It seems that further studies are required to measure the adherence to PA recommendations in the longer term.

There were no significant differences in estimated energy intake between the groups. Therefore, the significant difference in weight loss after 24 weeks between the groups may be due to a difference of PA energy expenditure between the two groups, but finding an accurate explanation for the greater weight loss in the SBP group than in the LBP group needs further studies.

In the present study, as would be expected according to the weight loss during the intervention, significant potentially beneficial changes in lipid profiles and carbohydrate metabolism characteristics were observed but these changes were similar in both groups over time.

The findings of the present study may have clinical implications for the prescription of PA that are consistent with the current guidelines which indicate combining >250 min/week PA with an energy-restricted diet for weight loss management. In addition to overcoming the lack of time for doing continuous PA in a busy lifestyle, the current study suggests that having two shorter bouts of PA rather than one continuous bout during a day may lead to more weight loss. However, further research is required to examine

whether the weight loss benefits of SBP compared with LBP are sustained in the long term.

The principal strength of this study is that it was a randomized, outpatient clinical trial while participants were on a comprehensive diet plan for weight control in a longer-term intervention (i.e., 24 week). Second, participants wished to lose weight and included middle-aged women who were overweight or obese and able to comply with a weight-loss plan; hence, they demonstrated that they were motivated to adhere to the weight-loss diet protocol (40).

There are some limitations to this study that should be considered when interpreting the results. First, this study was designed to test whether LBP would result in greater weight loss than would SBP. However, accurate objective measurements of PA characteristics, e.g., intensity and length of PA in the intervention groups, were not made during the structured PA sessions or over the rest of the day. These should be included in future studies. Second, because the majority of PA attained in this study was brisk walking, the effect of other forms of activity on weight loss could not be determined. Third, not measuring energy expenditure is a limitation of this study and further studies using more robust objective measurements of energy expenditure are certainly indicated. Also, the method used to measure energy intake may also be a limitation and this would be an important component of future work.

In conclusion, PA performed in 2 short-bouts per day appears to have a beneficial impact on weight loss in women who were overweight or obese and adhered to a weight-loss diet. Longer-term studies are now required to investigate whether these differences are sustained.

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Table 1

Baseline characteristics of the study groups[1]

	SBP Group(n=32)	LBP group(n=33)	P value
Age, mean, (SD), y	27.9 (4.4)	27.6 (4.7)	0.79
Married, %	44%	48%	0.68
Anthropometric measures, mean (SD)			
Body weight(kg)	81.44 (6.61)	81.07 (6.44)	0.82
Height(cm)	161.3 (3.97)	160.8 (4.0)	0.97
BMI(kg/m²)	31.33 (2.55)	31.90 (2.61)	0.75
WC (cm)	97.84 (10.84)	98.58 (7.34)	0.61
Biochemical measures, mean (SD)			
TC, mmol/l	4.44 (0.35)	4.33 (0.43)	0.26
HDL-C, mmol/l	1.16 (0.14)	1.20 (0.17)	0.35
LDL-C, mmol/l	2.60 (0.38)	2.44 (0.47)	0.14
TG, mmol/l	1.48 (0.19)	1.51 (0.17)	0.61
FPG, mmol/l	5.05(0.36)	5.06 (0.37)	0.94
2hppG, mmol/l	6.24 (0.50)	6.26 (0.63)	0.86
HA1C,%	5.20 (0.50)	5.22 (0.37)	0.82
Insulin, m U/l	13.02 (2.14)	12.73 (2.88)	0.62
HOMA-IR	2.93 (0.57)	2.88 (0.67)	0.73

Data are presented as mean ± SD

[1]Group difference, P > 0.05. There were no significant differences between groups at baseline.

SBP: Diet+ short-boat PA, LBP: Diet+ Long-bout PA

Body mass index: BMI, Waist circumference: WC

Total cholesterol: TC, Triglyceride: TG, Fasting plasma glucose: FPG,

2 hour post prandial glucose: 2hppG, Glycated haemoglobin: HA1C,

Table 2. Anthropometric and blood measurement characteristics in SBP and LBP groups before and after the 24-week intervention[1]

	SBP Group (n=32)		LBP Group (n=33)		P value[2]
	Baseline	week 24	Baseline	week 24	
Weight[3] , kg	81.44 (6.61)	73.25 (6.31)	81.07 (6.44)	74.12 (6.06)	0.019
BMI[3], kg/m²	31.33 (2.55)	28.17 (2.42)	31.34 (2.02)	28.65(1.89)	0.027
WC[3], cm	97.84 (10.84)	90.03 (10.18)	98.58 (7.34)	91.70 (7.50)	0.026
TC[3], mmol/l	4.44 (0.35)	3.83 (0.49)	4.33 (0.43)	3.81 (0.47)	0.233
HDL-C[3], mmol/l	1.16 (0.14)	1.34 (0.15)	1.20 (0.17)	1.35 (0.19)	0.259
LDL-C[3], mmol/l	2.60 (0.38)	1.95 (0.48)	2.44 (0.47)	1.82 (0.53)	0.54
TG[3], mmol/l	1.48 (0.19)	1.28 (0.12)	1.51 (0.17)	1.28 (0.20)	0.834
FPG[3], mmol/l	5.05(0.36)	4.78 (0.36)	5.06 (0.37)	4.76 (0.35)	0.658
2hpp[3], mmol/l	6.24 (0.50)	6.26 (0.63)	6.26 (0.63)	5.71 (0.43)	0.841
HA1C[3],%	5.20 (0.50)	4.76 (0.49)	5.22 (0.37)	4.74 (0.47)	0.51
Insulin[3], m U/l	13.02 (2.14)	12.73 (2.88)	12.73 (2.88)	11.50 (2.70)	0.422
HOMA[3]	2.93 (0.57)	2.88 (0.67)	2.88 (0.67)	2.41 (0.66)	0.476

[1] Data are presented as mean [38] for the 65 participants

[2] P values are for SBP group relative to LBP group with the use of ANCOVA with baseline values as covariate.

SBP: Diet+ short-boat PA, LBP: Diet+ Long-bout PA

Total cholesterol: TC, Triglyceride: TG, Fasting plasma Glucose: FPG, Homeostasis model assessment of insulin: HOMA-IR. 2 hour post prandial glucose: 2hpp, Glycated haemoglobin: HA1C,

[3]Significant main effect of time, P <0.001.

Table 3. Self-reported dietary intake in SBP and LBP Groups before and after the 24-week interventions[1]

Intake	SBP Group(n=32)		LBP Group(n=33)		P value[2]
	Baseline	week 24	Baseline	week 24	
Total Energy (kcal)[3]	2417 (249)	1945 (195)	2385 (249)	1894 (232)	0.379
Protein (g)[3]	88.5 (9.5)	80.2 (8.5)	86.5 (8.6)	77.9 (9.7)	0.213
Protein (%)	14.8% (2.5)	16.5% (1.9)	14.7% (2.1)	16.5% (1.9)	
Fat (g)[3]	94.9 (17.2)	68.6 (9.4)	93.2 (16.6)	65.2 (11.2)	0.632
Fat (%)	35.1% (3.1)	31.7% (1.9)	34.9% (3.5)	30.8% (2.1)	
Carbohydrate (g)[3]	302.2 (33.5)	251.8 (28.2)	300 (32.5)	249.1 (29.9)	0.792
Carbohydrate (%)	50.1% (1.8)	51.7% (1)	50.4% (2.4)	52.6% (1.7)	
Fiber(g)	21.2 (5.4)	22.7 (5.2)	20.8 [39]	22.2 (3.1)	0.101

[1] Data are presented as mean ± SD for the 65 participants

[2] P values are for SBP relative to LBP group by using an ANCOVA with baseline values as covariate.

[3]Significant main effect of time, P <0.001.

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Figure 1. Screening, enrollment, randomization and follow up of study participants

Figure 2. Mean ± SEM step calculations with the use of a 3D pedometer

over the 24 wk of the intervention. At baseline, there were no differences in step counts between the SBP (n = 32) and LBP (n = 33) groups. There was a significant group × time interaction for mean daily steps over 24 wk (P = 0.001; 2-factor ANOVA). SBP, Diet plus short-bout PA; LBP, Diet plus long-boat PA.

Figure 1.

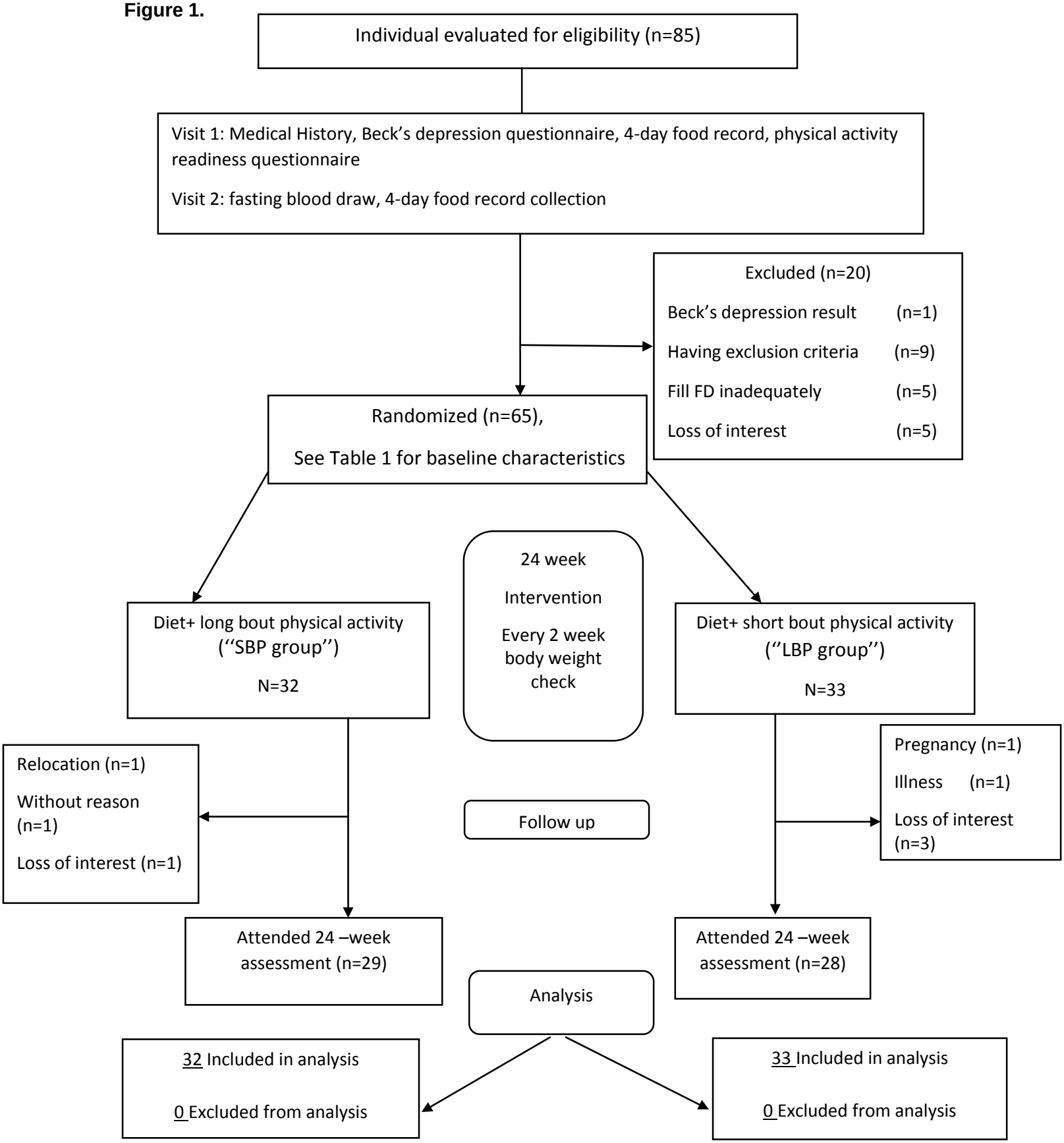
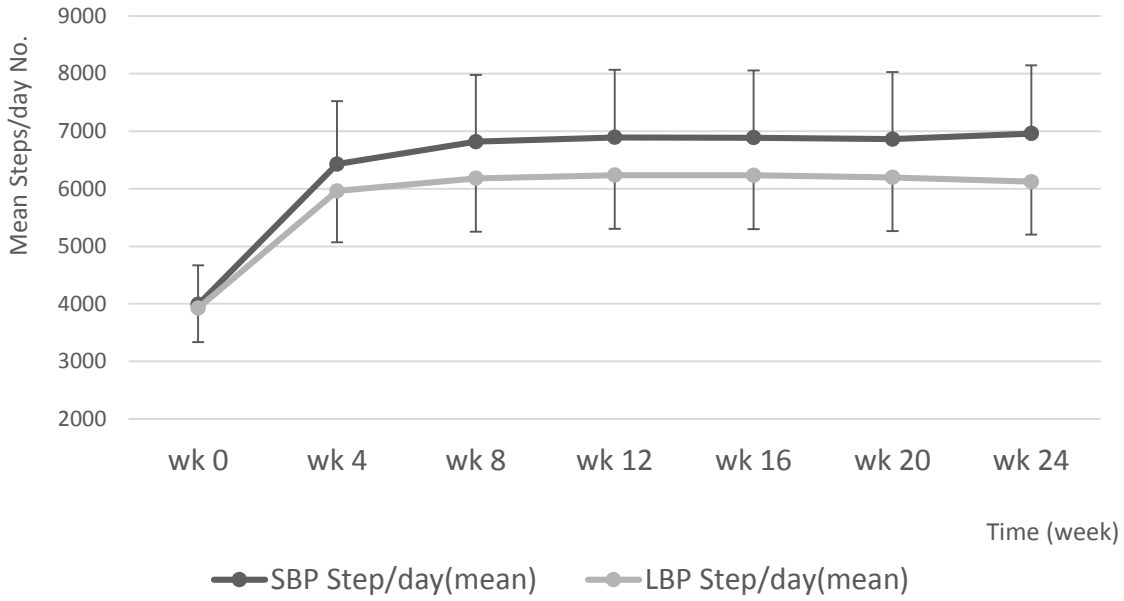

Individual evaluated for eligibility (n=85)
Visit 1: Medical History, Beck's depression questionnaire, 4-day food record, physical activity readiness questionnaire
Visit 2: fasting blood draw, 4-day food record collection
Excluded (n=20)
Beck's depression result (n=1)
Having exclusion criteria (n=9)
Fill FD inadequately (n=5)
Loss of interest (n=5)
Randomized (n=65),
See Table 1 for baseline characteristics
24 week
Intervention
Every 2 week body weight check
Diet+ long bout physical activity (''SBP group'')
N=32
Diet+ short bout physical activity (''LBP group'')
N=33
Relocation (n=1)
Without reason (n=1)
Loss of interest (n=1)
Pregnancy (n=1)
Illness (n=1)
Loss of interest (n=3)
Follow up
Attended 24 –week assessment (n=29)
Attended 24 –week assessment (n=28)
Analysis
32 Included in analysis
0 Excluded from analysis
33 Included in analysis
0 Excluded from analysis

Figure 2.


9000
8000
7000
6000
5000
4000
3000
2000
Mean Steps/day No.
wk 0
wk 4
wk 8
wk 12
wk 16
wk 20
wk 24
Time (week)
SBP Step/day(mean)
LBP Step/day(mean)