CHANGES IN BODY FAT PHENOTYPE AFTER FOUR-MONTH WALKING INTERVENTIONS

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Abstract

Walking is an excellent health-promoting activity for obese, sedentary individuals. Visceral fat is linked to cardiovascular disease and mortality. We hypothesized that walking (steps/day) would decrease visceral adiposity and improve laboratory markers of cardiometabolic health in a dose-dependent manner. In the primary study, 79 sedentary, overweight subjects (77% female, 65% Caucasian) were enrolled in a 2x2 factorial randomized controlled walking intervention, with steps measured using a wearable Fitbit fitness tracking device. Participants underwent dual x-ray energy absorptiometry and basic cardiometabolic laboratory measurements (glucose, insulin, total cholesterol, HDL, LDL, triglycerides) before and after the intervention. Lean mass increased from 49.9 ± 9.5 to 50.3 ± 9.4 (p=0.05). No significant changes were observed in any of the cardiometabolic outcomes or localization of fat. The change in steps had no correlation with weight, visceral fat, lean mass, and VO_2 peak, refuting the original hypothesis. When analyzing common laboratory markers and demographic characteristics, there were no significant predictors for visceral or total fat mass change, with significant heterogeneity of change in the group. Our study supports the likely contribution of genetic and environmental factors to the physical and laboratory changes seen following a walking intervention in sedentary and insufficiently active overweight people.

Key words: weight loss, physical activity, heterogeneity, obesity, sedentary, visceral fat

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Introduction/Significance

A vast amount of research emphasizes the benefits of regular physical activity, specifically walking, with regards to cardiometabolic health and chronic conditions [6, 8, 16, 17, 19, 22]. Sedentary and insufficiently active individuals are at increased risk for cancer, cardiovascular, and all-cause mortality than the general population [5, 14]. Light-intensity physical activity, such as walking, has been recommended to help people increase movement and improve health outcomes [2, 7, 10, 19]. Given the growing obesity epidemic in the United States [3, 12, 17, 20, 23], there has been a specific need to understand how physical activity programs contribute to changes in body weight and visceral fat, as these have a major influence on the development of cardiovascular disease [13].

In a recent study, Sawyer *et al.* examined heterogeneity of body fat and fat mass responses in sedentary premenopausal women following a 12-week aerobic exercise training program [20]. No significant reductions in body weight, body fat, or waist circumference were observed in the cohort over 12 weeks, but considerable heterogeneity was observed in body weight, fat mass, and lean mass responses. However, this study was an exercise program conducted in a fully supervised laboratory and did not assess changes in the localization of fat mass, two limitations that we will address in our analysis. Localization of fat mass is particularly important because increased visceral fat, more than the other fat depots, has been closely linked associated with metabolic abnormalities that lead to significantly altered cardiovascular structure and function [1]. Fully supervised laboratory-based exercise has the potential for selection bias for those willing to attend several laboratory visits, and for overestimating potential changes in physical activity and subsequently the impact on fat levels when subjects return to their day-to-day lifestyle.

The primary study from which the data in this analysis was derived was the Walking Interventions Through Texting (WalkIT) trial conducted from late 2014-early 2015 [11]. In this study overweight/obese participants were enrolled in a 2x2 factorial randomized controlled trial over a four-month period. The intervention aimed at increasing physical activity while studying the effects of adaptive vs. static physical activity goals and immediate vs. delayed financial

reinforcement. The purpose of our secondary analysis of this study was to examine changes in weight, fat mass, and localization of fat over the study timeframe, with the data pooled across the original cohorts. In addition, we further examined the associations between responses in visceral fat and markers of cardiometabolic health, such as total cholesterol, HDL, LDL, and triglycerides. This study addresses the limitations of similar previous studies by 1) assessing subjects in their daily routines, as opposed to supervised in a laboratory, and 2) investigating the localization of fat mass changes, with particular emphasis on visceral fat.

Research Methods and Materials

Experimental Approach to the Problem

The current study was a secondary analysis of data obtained from the Walking Interventions Through Texting (WalkIT) trial conducted from late 2014-early 2015 [11].

The primary study design, intervention details, and main outcomes of WalkIT have been published previously [11]. Briefly, sedentary, overweight/obese participants were recruited and enrolled in a 2x2 factorial randomized controlled trial administered over a four-month period. Participants attended 2-hour office visits, once before and once after the intervention. The initial visit was used to measure baseline values on health outcomes and used as a training session for the Fitbit and texting system. Before the onset of the intervention, there was a ten-day baseline period in which subject pre-intervention activity was recorded using a commercially available accelerometer (Fitbit Zip). During the intervention period, participants were instructed to self-report their number of steps nightly via text message and were given daily step goals based on their intervention group. All participants were asked to wear a Fitbit Zip during all waking hours for the entire duration of the study. The data from the four groups were pooled and reanalyzed based on number of steps.

Subjects

The inclusion criteria for the study were: 1) healthy 18-60 year old individuals, 2) living in Maricopa County, Arizona, 3) BMI between 25 and 55 kg/m^2, 4) no contraindicated conditions as assessed via the Physical Activity Readiness Questionnaire (PARQ+), 5) not meeting or exceeding physical activity recommendations defined as >10,000 steps on >5 days/week, 6) not currently in a physical activity/diet/weight loss program, 7) not planning to leave for 10 or more days or live outside Maricopa County in the next 4 months, 8) not taking supplements or medications that prohibit a moderate intensity physical activity program or testing, 9) not pregnant or planning to become pregnant in the next 4 months, 10) access to a personal computer/phone/internet on a daily basis, 11) access to email and the Internet daily, 12) access to a mobile phone with text messaging and willing to send and receive up to 3-5 texts per day, 13) no supplements or over

the counter medication at least 4 days prior to visits, and 14) females within 7 days of onset of menses of greater than 12 months post-menopause at time of visits [11].

Procedures

In this study, we utilized a pooled cross-sectional cohort analysis to assess patients based on the number of steps completed without referencing the initial experimental groups from the primary study design (adaptive vs. static, immediate vs. delayed) to assess the effect of the change in number of steps on the DXA and cardiometabolic parameters post-intervention.

Fixed factors such as gender, smoking status, and race/ethnicity were taken from the baseline assessment. The following metrics were measured pre-intervention and post-intervention [11]: height & weight (m & kg, measured using digital stadiometer and scale Seca 284 measuring station, SecaGmbH & co. KG), fat/visceral/lean mass (kg, from DXA), blood glucose/insulin, & total cholesterol & lipids (from venous blood samples for cardiovascular risk; post centrifugation samples archived in aliquots at -80 degrees Celsius), and pre-post step counts (measured using Fitbit Zip, Fitbit Inc.). The following metrics were calculated pre-intervention and post-intervention: BMI (kg/m^2, calculated using weight (kg) divided by height (m) squared) and body fat (%, calculated using fat mass divided by weight).

Statistical Analyses

After reviewing descriptive statistics, multiple statistical analyses were utilized to evaluate outcomes depending on the distribution of the outcome variable. Based on the Shapiro-Wilk tests, none of the dependent variables were normally distributed. Therefore, Wilcoxon Signed Rank tests were used in lieu of paired t-tests and Spearman's correlations were used in lieu of Pearson's correlations to compare pre/post changes across the pooled sample on changes in visceral fat mass and other variables. Stepwise linear regression analysis was used to determine predictors of visceral fat mass. The independent variables were change in steps, demographic characteristics, and lab markers such as glucose, insulin, total cholesterol, HDL, LDL, and triglycerides. The dependent variables were total weight, lean mass, fat mass, and visceral fat mass.

Results

Sample characteristics

Ninety-six participants were randomized into the intervention groups. By the end of the trial, 79 (82.3%) participants had complete data on DXA and cardiometabolic outcomes. Participant attrition was mostly attributed to dropout, with one participant excluded due to receiving a diagnosis of Type 2 diabetes during the study period. The final sample consisted of 79 participants with complete pre/post data. The average age of the cohort was 41.94 ± 9.55. There were 61 females and 18 males, 51 Caucasian and 28 other race/ethnicities, and 6 subjects with a history of smoking.

Changes in DXA and cardiometabolic variables

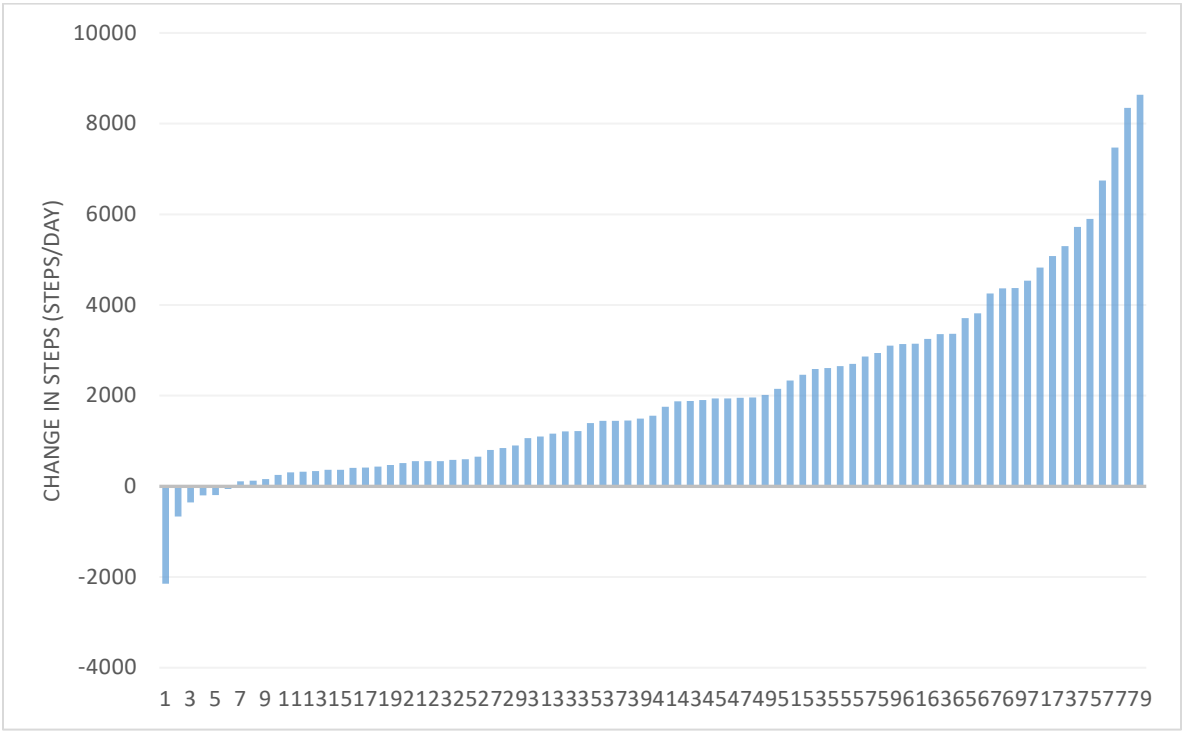
Table 1 shows outcome variables pre- and post-intervention. No significant changes were observed in any of the DXA and cardiometabolic outcomes in the pooled sample. Lean mass increased from 49.9 ± 9.5 to 50.3 ± 9.4 ($p = 0.05$).

There were no statistically significant correlations between change in lean mass and other variables. Figure 1 plots the change in number of steps pre- and post-intervention as the baseline plot and further plots weight, visceral fat, lean mass, and VO_2peak with the same order of subjects. In each subplot of Figure 1, the bold line is the line of unity, with every value above it representing an increase and every value below it representing a decrease. As shown in Figure 1, the change in the number of steps had no significant correlation with weight, visceral fat, and lean mass. The plots portray the heterogeneous responses in weight, visceral fat, and lean mass as compared to increasing steps. Stepwise regression models yielded no meaningful predictors for total fat mass change or visceral fat mass change in the overall cohort, female cohort, or male cohort.

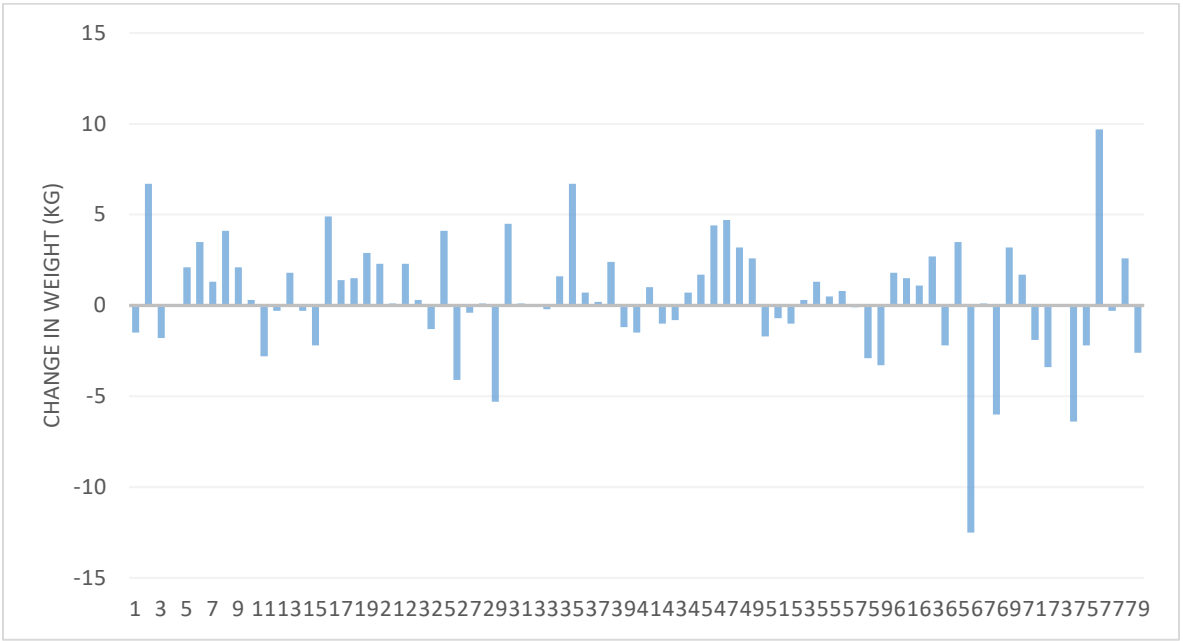
Variable	Pre	Post	Effect size	p-value
Average steps	5272.50 ± 1529.9	7355.33 ± 2500.9	2.1	0.00
BMI (kg/m^2)	33.9 ± 6.3	34.0 ± 6.4	0.014	0.40
Weight (kg)	94.9 ± 19.4	95.3 ± 20.0	0.14	0.088
Total fat mass (kg)	42.3 ± 13.4	42.3 ± 13.8	0.00037	0.77
Visceral fat mass (kg)	1.5 ± 0.9	1.5 ± 0.9	0.059	0.76
Lean mass (kg)	49.9 ± 9.5	50.3 ± 9.4	0.26	0.054
Glucose (mg/dL)	94.1 ± 13.6	92.5 ± 12.1	0.25	0.071
Insulin (µIU/mL/mL)	14.5 ± 9.0	14.0 ± 9.7	0.019	0.41
Total Cholesterol (mg/dL)	173.8 ± 31.6	174.4 ± 31.6	0.027	0.55
HDL (mg/dL)	48.2 ± 14.3	48.4 ± 13.6	0.099	0.50
LDL (mg/dL)	119.8 ± 29.8	122.2 ± 32.3	0.089	0.19
Triglycerides (mg/dL)	111.6 ± 55.4	113.8 ± 54.0	0.064	0.55

Table 1: Subject outcome variables pre- and post-intervention. No significant changes were observed in any of the DXA and cardiometabolic outcomes in the pooled sample.

A)


CHANGE IN STEPS (STEPS/DAY)
10000
8000
6000
4000
2000
0
-2000
-4000
1 3 5 7 9 11131517192123252729313335373941434547495153555759616365676971737577 79

B)


CHANGE IN WEIGHT (KG)
15
10
5
0
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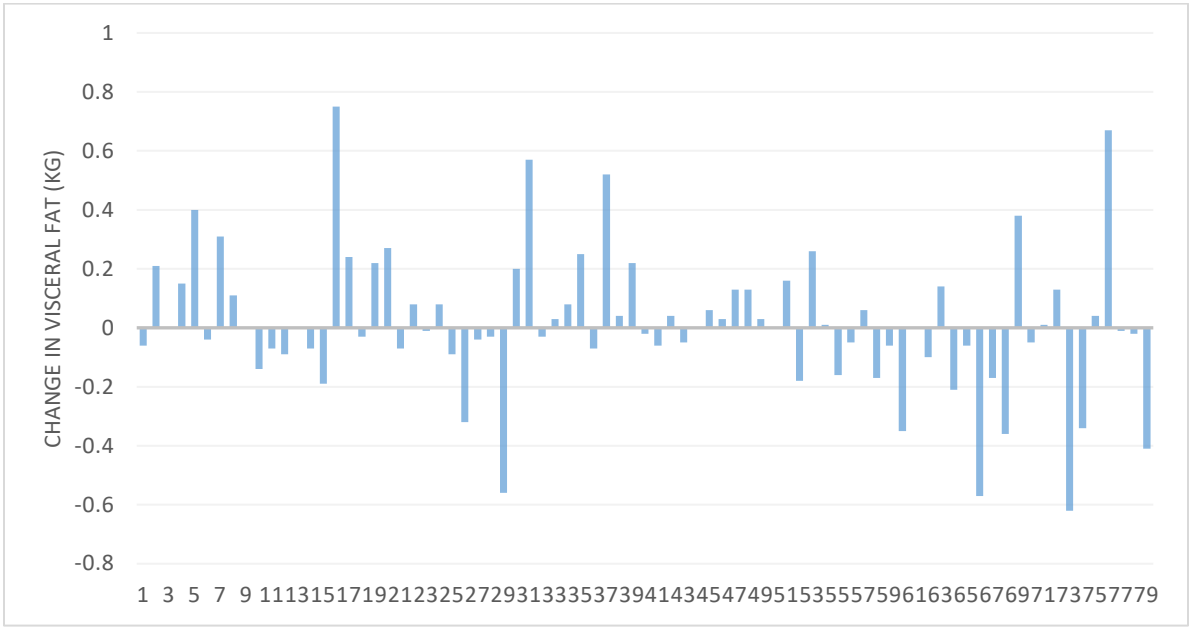
1 3 5 7 9 11131517192123252729313335373941434547495153555759616365676971737577 79

C)



D)

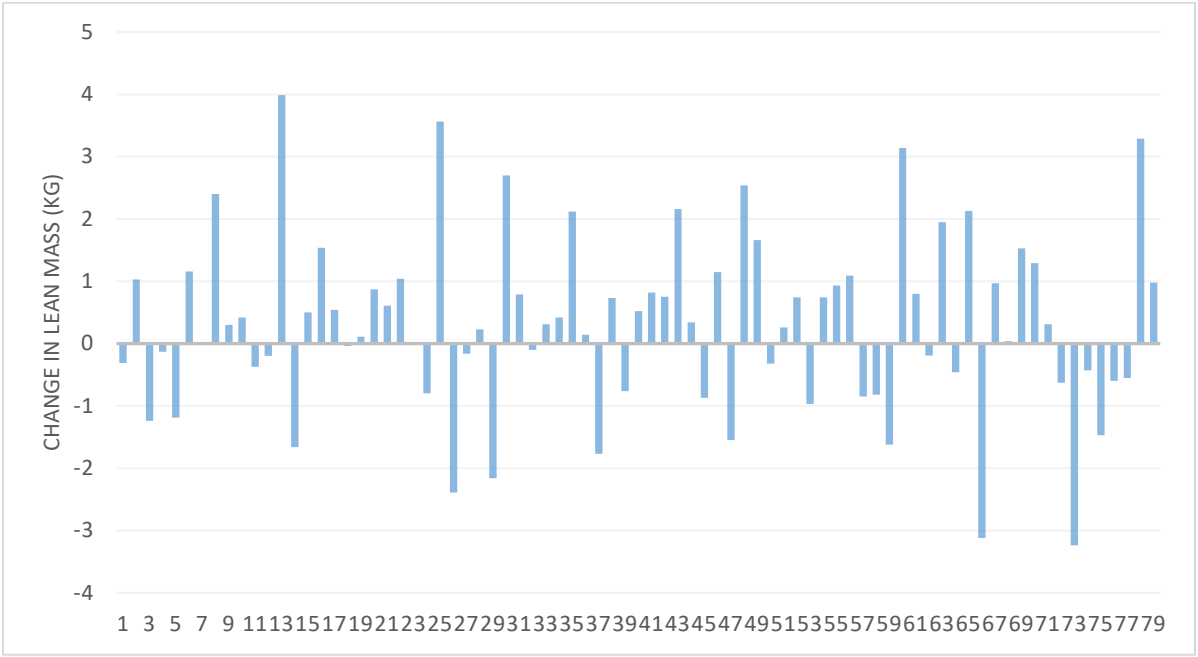


Figure 1: Individual changes in (A) total steps, (B) weight, (C) visceral fat, and (D) lean mass are on the y-axis. Individual subjects are in the same position for each panel, and each bar on the x-axis represents one subject.

Discussion

As demonstrated by the results of the secondary analysis, no significant changes in visceral or total fat mass were observed following the prescribed walking intervention. In addition, there was found to be no major predictors of visceral or total fat mass change. Furthermore, the responses on an individual level appeared to be heterogeneous, with many subjects losing and many subjects gaining fat. This suggests the presence of other contributing factors, such as genetic polymorphisms or differing end organ responses [9]. From a clinician's perspective, this means that having a patient that is unable to lose weight or fat mass does not mean they are not engaging in health physical activity. In fact, it is possible that they are experiencing weight gain during a prescribed physical activity program. However, walking programs improve various surrogates for cardiovascular risk in previously inactive but healthy adults [19]. It is important to have these discussions with patients to outline various factors that can affect changes in weight and explain that the benefit may lie in the improvement of cardiometabolic parameters much more than weight alone. This is challenging because there is evidence to suggest that moderate, intentional weight loss does have benefit on quality of life and functional status provided the individual also implements regular activity [4]. Therefore, body weight is poorly related to health-promoting behaviors. There are two possible hypotheses for certain subjects gaining mass, specifically fat mass, during the study despite an increase physical activity level. First, some subjects may see an increased activity level as a reason to increase their caloric intake, and ended up yielding a net caloric gain during the study. The other possible explanation is the concept of adaptive thermogenesis, which is a slowing of the body's metabolism under conditions of standardized physical activity in response to a decreased energy intake, which is independent of body weight or composition [18].

To the best of our knowledge, this is the first paper that has examined a physical activity intervention such as increased steps as it relates to markers of visceral adiposity. These measures include body weight, BMI, body fat %, and visceral fat measured by dual-energy x-ray absorptiometry. We have previously reported a heterogeneity in fat mass response due to a supervised exercise intervention [20]; however, similar conclusions can now be expanded to

physical activity interventions as well as it relates to changes in weight, fat mass, and visceral fat mass.

One limitation to the study by Sawyer *et al.* was that it did not directly assess the response of localization of fat mass and the exercise program was conducted in a fully supervised laboratory. Localization of fat mass is particularly important because increased visceral fat, more than the other fat depots, has been closely linked to negative health outcomes such as metabolic syndrome and cardiovascular disease [16, 21]. Fully supervised laboratory-based exercise has the potential for selection bias for those willing to attend several laboratory visits, and for overestimating potential responses in physical activity and subsequently the impact on fat levels when subjects return to their day-to-day lifestyle. Therefore, the overall net effect is unclear.

While the results of our study did not yield a specific prescriptive program that can be applied clinically, there were multiple strengths that can be expanded upon in future research. With the use of technologically advanced wearable activity monitors, research is much more scalable than with laboratory research. This is a more practical and realistic solution for the average sedentary person, a solution integrated into real life as opposed to a relatively contrived laboratory setting. Another strength was the length of the trial; over 4 months, the possible confounders of potential changes in activity habits due to the Hawthorne effect become drastically reduced compared with short term interventions. Finally, the fact that this study is a secondary analysis of data acquired during the course of a behavioral economics-based walking intervention strengthens the findings because neither the researchers nor the participants were focusing on optimizing the measured outcomes.

The limitations of this study primarily deal with the demographics of the experimental cohort. The study may have lacked the power to detect significant differences, with a small overall cohort and men only comprising 18 of the subjects. The most important limitation is that the study operates under the assumption that dietary patterns remained the same throughout the entirety of the intervention. There were no dietary logs for the subjects throughout the intervention; however, they have previously been shown not to be useful in such studies [15].

Furthermore, the majority of self-reported dietary logs cannot be reliable because many of them have been shown to be incompatible with life.

Future Directions

In future studies, it would be desirable to evaluate the groups that gained visceral fat and the groups that lost visceral fat separately. This would allow for examination of predictors of these entities separately which would reduce the effect of random individual variation on the results. In addition, future randomized controlled trials with more varied racial and increased male representation would allow for strengthened conclusions. Based on the identified limitation of dietary control, future studies could be strengthened with strict dietary logging as an adjunct to the prescribed physical activity intervention to ensure that dietary patterns are not changing drastically to alter the results.

Conclusions

Walking is a widely utilized approach for sedentary individuals looking to increase physical activity and improve overall health. While walking produces cardiometabolic benefits as outlined in many previous studies, it appears to yield no significant changes in weight, fat mass, or localization of fat mass in sedentary overweight/obese individuals. Therefore, it should not be considered the primary weight or fat loss modality in sedentary Caucasian individuals.

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