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Can a four-week pedelec commuting intervention alter body composition in sedentary individuals?

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Abstract:

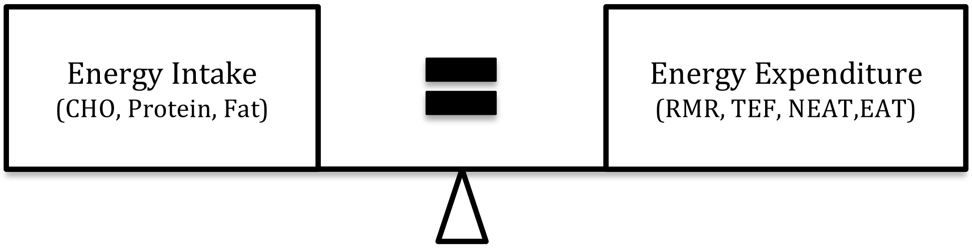
Pedelecs are a specific form of electric assist bicycles that have a modest electric motor, which provides assist only when the rider is pedaling. Such bikes may help to overcome the hurdles associated with active commuting for those individuals who are leading a sedentary lifestyle. This project was part of a larger study looking at physiological changes resulting from a pedelec intervention. The purpose of this project was to use a 4-week intervention period to study changes in body composition in a sedentary population, through the use of these bicycles. Fourteen physically inactive individuals (4 males, 11 females) visited the lab for baseline physiological testing and body composition scans. During the 4 weeks following their preliminary testing, subjects commuted to and from their work using the pedelecs while wearing a heart rate monitor and GPS device. Individualized regression equations were used to estimate energy expenditure and METS for subjects based on their VO_2max test data and their riding data from the monitoring devices. Participants were asked to ride at least 40 min/day, 3 days/week in order to fulfill the required intervention stimulus for the study. After the intervention, participants returned to the lab for repeated physiological testing and body composition scans. Multiple regression analysis and paired t tests were used to assess how starting physiological values of the individuals, and their riding tendencies effected changes in body composition. The larger study found significant changes in VO_2max, power output at VO_2max, and glucose regulation. No significant changes in body composition were observed, although an average decrease of a .53 kg and .44 kg of total mass and fat mass were lost respectively, indicating improvement patterns were present. A threshold response pattern was also indicated by fat mass loss, although not significant. Usage of a pedelec over a four-week period is a good intervention for promoting physical activity, as well as improving some physiological parameters, despite the absence of significant body compositional changes. A longer duration and more frequent riding patterns may lead to significant changes in body composition, as well as increase the significance

of other physiological findings, and should be a focus for further research regarding electric assist bicycle interventions.

Introduction:

Within the past few decades, the United States has witnessed an obesity epidemic, which has quickly become a public health crisis. Data shows that 68% of adults are overweight with a BMI > 25, and 35% are obese with a BMI > 30. Overtime, overweight and obesity can contribute to other health related problems including heart disease, diabetes, and some cancers (NIH 2012). Because of this, it is important to study weight management strategies and explore possible mechanisms to overcome the obesity epidemic.

Weight management is a balance between energy intake and energy expenditure. Energy intake is the macronutrients in our diet such as carbohydrates, proteins, and fats, and energy expenditure is the amount of energy we use for biological and mechanical work. The diagram below shows a simple version of energy balance.



Total daily energy expenditure can be calculated by this equation:

$$TDE=RMR+TEF+NEAT+EAT$$

Where RMR is resting metabolic rate, TEF is the thermogenic effect of food, NEAT is non-exercise activity thermogenesis, and EAT is exercise activity thermogenesis. Resting metabolic rate is the amount of calories an individual burns during the day when they are in a resting state. The thermogenic effect of food is the calories an individual's body expends breaking down, transporting, and storing macronutrients. Non-exercise thermogenesis is the calories that are burned doing activities that would not be considered exercise, such things as cleaning the house or manual labor. Lastly, exercise activity thermogenesis is the calories that are burned during planned exercise.

The above diagram gives an example of when an individual would be in complete energy balance, that is to say the energy they are eating is the same as the amount of energy they are expending. It follows that if energy intake is greater than energy expenditure, the scale above would tilt so the left side would be lower than the right side, showing the individual is in positive energy balance, and will gain weight. Conversely, if energy expenditure is greater than energy intake, the scale will tilt so that the right side is lower than the left side, and the individual will be in negative energy balance and will lose weight.

Individuals can reverse the obesity trend and lose weight by either decreasing dietary intake, increasing daily energy expenditure, or a combination of both. In recent years, researchers have assessed if exercise alone is an efficient method for weight loss, as well as explored its ability to improve health.

Preventative healthcare in the form of exercise has become a growing concern for both researchers and healthcare professionals alike. In 2009 the American College of Sports Medicine (ACSM) published a book titled “Exercise is Medicine”, in which they discuss the recommended doses of physical activity, as well as the responsibility of healthcare providers to implement exercise for disease prevention and treatments (Jonas 2012). Thirty minutes of moderate-intensity physical activity five times per week, or vigorous physical activity for 20 minutes three times per week, are the current ACSM recommendations for the prevention of chronic adverse health conditions like diabetes and heart disease. The ACSM has also acknowledged the negative health implications that result from too much sitting and recommend that sitting be limited during the day (Garber 2011).

Although individuals often understand the importance of physical activity, in today’s busy society, less than 31% meet the recommended exercise amounts (Kruger 2007) and many people sit for at least half their waking day (Hamilton 2007). These low levels of physical activity result in low levels of daily energy expenditure. This can then lead to changes in body composition due to increased fat storage, which can cause the development of obesity (Louis 2012).

In order to assess the effect of exercise alone on weight management and health, researchers have employed exercise interventions. During an exercise intervention changes in body composition are usually found in regards to the amount of calories that are burned, which in our study we will refer to as dosage. A greater exercise dosage is usually associated with a decrease in fat mass and an increase or maintenance of lean mass, depending on the exercise protocol. A study done by Irwin et al. in 2003 is a good example of how dosage of exercise affected decreases in fat mass in post-menopausal women. In this study, researchers found that there was a significant dose response for a greater loss in body fat, with increasing duration of exercise, over a 12-month period.

Sex may also be a factor when looking at body compositional changes through an exercise protocol. The idea that men and women respond differently to exercise is a controversial one in the literature. Donnelley et al. (2013) found that although individuals respond differently to exercise programs in terms of composition changes, when training is based on total energy expenditure instead of intensity or frequency, males and females lose similar amounts of weight. Furthermore, they found that a certain energy expenditure threshold is needed per day for there to be decreases in body mass, namely at least 400 kcals. These findings suggest that quantifying dosage by measuring the energy expenditure during an exercise bout can help predict changes in body composition that is equal for both men and women.

Another possible factor that could influence the magnitude of change in body composition may be associated with pre existing attributes of the individuals themselves. For example, age, pre-intervention fat mass, as well as pre-intervention lean mass, may have an impact on the amount of change in body composition during an exercise intervention. It is thought that those with greater starting fat mass may have more to lose than those with lower starting fat mass, thus would be expected to lose more during an intervention. Age can influence changes in body composition due to the onset of sarcopenia, which is defined as age related loss in skeletal muscle mass. Attributes such as decreased bone density and increased fat mass have been observed in connection with sarcopenia (Evans 1993). Therefore, if older individuals have a greater fat mass to lean mass ratio than younger individuals, we may expect to see greater changes in fat mass in that population through an exercise intervention.

Using exercise interventions such as these, changes in body composition and health outcomes can be evaluated and utilized in a way that can promote physical activity and prevent the development of obesity. Following, it is also important to study practical ways in which individuals can use exercise as a tool to improve their health. In this sense, novel ways in which individuals can replace sedentary behaviors with more physically active ones should be investigated.

One way that sedentary individuals can live a more physically active lifestyle is through active commuting. There are numerous forms of active commuting including walking, running, biking, skateboarding, rollerblading etc. However, these forms of active commuting often have large hurdles that can be discouraging, especially for those with lower fitness levels. For example, long distances or hilly terrain may make active commuting too difficult for some individuals. Another concern for active commuters is having a workload that is too strenuous, and forces them to sweat an excessive amount before they arrive to work for the day.

One solution to overcome these hurdles could be the use of pedelecs. Pedelecs are bicycles with a modest assist that can be thought of as a combination of your typical commuter bicycle and a fully motorized bicycle. Importantly, to receive the electrical assistance, one has to be pedaling, which helps to promote physical activity while still making the commute easier for individuals. It is thought that the utilization of these bicycles as a form of active transportation could eliminate many of the hurdles associated with active commuting, but still provide an effective way of encouraging physical activity (De Geus 2013). In this sense, these bicycles are ideal for allowing a more sedentary population to actively commute.

Other studies have assessed these bicycles and their effectiveness to promote an increase in physical activity for individuals who may need help overcoming the hurdles of active commuting. Gojanovic et al. (2011) used these bicycles in a sedentary population and found they were sufficient to allow this population to simulate a commute to their work, as well as allowing their subjects to meet physical activity guidelines. Similarly, Simons et al. (2009) found that when subjects were asked to ride a pedelec at a pace they would normally commute at, individuals chose a speed that elicited a moderate intensity in all three conditions (high assist, low assist, and the control). Importantly, although all three conditions elicited a moderate intensity, differences in energy expenditure were present and therefore may contribute to differences in responses. These studies show that pedelecs can be used to elicit workloads in which the ACSM has suggested for health maintenance, regardless of the amount of assist used. Although these studies show promise for promoting increases in physical activity for individual bouts of exercise, the studies did not perform assessments of the use of the pedelecs in the field or on a daily basis.

Our study aimed to address the applicability of pedelecs for everyday use to achieve workloads that utilize exercise as a form of weight management and health maintenance. In our study, we explored the relationship between the increase of physical activity verses body compositional changes, as well as the magnitude of these changes based on some pre-existing compositional values from the individual, before the intervention began. Body composition changes were evaluated in association with these two variables:

1. Dosage of riding
2. Starting values of the individual (age, sex, and percentage body fat)

The hypothesis of this study was divided in to two parts, of which are dependent upon the kcals that are expended by individuals during the intervention.

The first part is specific to individuals who ride less than the minimum threshold of 400 kcals/day (threshold proposed by Donnelly 2013) to induce weight loss. In these individuals, we would expect to see no change in body composition because the stimulus of a pedelec intervention would be too small to elicit these changes.

The second part of the hypothesis was that we would observe changes in body composition for individuals who exceeded the 400 kcals/day threshold, since we did not put a maximum on how much individuals could ride. Following, we would expect to see a larger change in body composition as more kcals were expended over the 400kcal/day baseline that is needed for compositional changes.

Methods:

This project was conducted as part of a larger research study investigating the effects of a pedelec intervention on health outcomes. Institutional review board approval through the University of Colorado Boulder was obtained, as well as written informed consent from each individual subject. All data collection was done at the Clinical Translational Research Center (CTRC), in Boulder. The protocol consisted of three pre-intervention visits and two post intervention visits, diagramed below:

Visit 1	**Visit 2**	**Visit 3**	**4 week Intervention**	**Visit 4**	**Visit 5**
-Informed Consent -Physical Exam -Nutrition -DXA -VO_2max	-VO_2max	-Blood Pressure -Oral Glucose Tolerance Test		-Blood Pressure -Oral Glucose Tolerance Test	-DXA -VO_2max

Table 1: The study's protocol for visits 1 through 5, as well as the intervention period. DXA=dual energy x-ray absorptiometry, VO_2max= Test of aerobic fitness

Subjects:

Twenty-one sedentary individuals participated in this study. Of the 21, only 4 males and 10 females completed the protocol and had enough GPS and heart rate data in order to estimate the energy expenditure and dosage from their regression equations. Average age of the participants was 40.21 ± 12.29.

Physiological Testing:

As Table 1 indicates the pre-intervention visits occurred on three different days. For visit 1, subjects arrived at the CTRC, and were given an overview of the protocol, after which informed consent was obtained. After this, a dual energy x-ray absorptiometry (DXA) scan was performed. Next, a physician collected the subjects' medical history and performed a physical exam. Following, subjects met with a nutritionist who educated them on the dietary restrictions and needs for the days before the oral glucose tolerance tests. The subjects were instructed on how to properly log their food intake either using paper and pencil, or using an online program called “My Fitness Pal”. After meeting with the nutritionist the subjects performed their first VO_2max test on a bicycle ergometer (Lode ergometer, Netherlands). Three minute stages were used, starting at 0 watts and going up every three minutes. Females went up 25 watts every three minutes, and males went up 40 watts every three minutes. The Borg rating of perceived exertion scale (RPE) was used to gauge how hard the subject felt they were working, and was obtained after each stage. Once an RPE of 15 was reached, the stages switched to two-minute stages until exhaustion. Heart rate was obtained using a heart rate strap (Polar), and a metabolic cart was used to perform indirect calorimetry (Parvomedics USA).

Visit 2 consisted of another identical VO_2max test, which was used in the calculations for the “pre” cardiovascular fitness values. This protocol was used in order to eliminate the potential learning curve associated with VO_2max tests.

The three days before each oral glucose tolerance test visit, the subject was instructed to eat at least 150 grams of carbohydrate, in an attempt to normalize muscle and liver glycogen levels. For visit 3, the subject was instructed to fast overnight before arriving at the CTRC. Blood pressure measurements were obtained when the subjects arrived. These measurements were taken with feet flat on the ground, at rest with no one in the room. Subjects were asked not to engage with their phones, but could read a book or magazine. Values were recorded and collected after stabilization. Next, a two-hour oral glucose tolerance test was performed. Subjects were instructed to drink a 75 gram glucose drink within the two minutes provided. Subjects then sat quietly in a room for two hours following the oral ingestion. Venipunctures were done before and after the test in order to compare insulin and glucose values pre and post intervention.

After visit 3, the subject received the pedelec, and was instructed on how to ride the bicycle safely and properly. As well as the bicycle itself, the participant also received a helmet, GPS, and heart rate monitor, and was instructed to wear these items every time they rode. A member of the research team met with each subject once a week during the four-week intervention, to download GPS data and insure all electronics were working properly.

The subject returned to the CTRC after the intervention for visit 4, which was a post blood pressure and oral glucose tolerance test. It is important to note that because of scheduling some individuals interventions were longer than four weeks exactly. Regardless of the time of the final visits, subjects were instructed to ride the pedelecs until they were able to come back in to the lab and the post intervention tests were performed.

The last visit, visit 5, was the post VO_2max test. The same protocol was used as visit 3, including the time that subjects switched to the two-minute stages. (Instead of an RPE as a marker for the switch, we used the time in visit 3 that they switched as the marker for this test). The post DXA scan was also obtained on this day, and the subjects returned the pedelecs.

Data Analysis:

DXA scans from before and after the intervention were used to compare changes in body composition within an individual. GPS data, used in conjunction with the pre-intervention VO_2max testing data, allowed us to investigate various indices of dosage of riding for each subject. A Garmin GPS monitor and a heart rate monitor were used each time the subject rode the bicycle during the intervention. Energy expenditure for each ride was estimated using a subject's individual heart rate vs. energy expenditure regression equation, determined from the submaximal portion of the pre-intervention VO_2max test, using Excel. By using each subject's individualized data it allows for predictions to be more accurate, rather than using a group's data to estimate for each individual. MET hrs (another way to determine riding dosage and intensity) was also estimated in the same way using the heart rate vs. METS regression equation from the submaximal portion of the pre-intervention VO_2max test. The heart rate data from the Garmin was plugged into these equations, which then allowed for an estimation of energy expenditure and METS. Multiple regression (R Studio software) was used to fit the best model to the average change in body composition. Adjusted R^2 values were used to determine the best fitting model. Paired t tests were used to compare changes in body composition pre and post.

Results:

Although significant results in glucose tolerance (5.53±1.18 to 5.03±0.91 mmol•L^{-1}, p<.05), VO_2max (2.21 ± 0.48 to 2.39 ± 0.52 L•min^{-1}, p<.05) and power output at VO_2max (165.1 ± 37.1 to 189.3 ± 38.2 W, p<.05), were achieved through the 4-week intervention, no statistically significant body composition results were found from t test analyses. Age and sex were found to be significant for a trend in the changes in body composition through multiple regression analysis. Table 2 shows physiological changes pre and post for VO_2max, power output, glucose tolerance, and blood pressure. Tables 3 and 4 show the data used in the regression analysis and t test analysis for changes in body composition and dosage.

In order to calculate energy expenditure and MET hrs, heart rate data collected during each ride was used for an individual's regression equations. In certain situations, the data was not present due to either subject error or instrument error. For individuals who had less then 25% of heart rate data missing from a single ride, an average for that ride was taken using the remaining heart rate data. For rides that had more than 25% of the data missing, the average from similar rides was used to estimate dosage. The average weekly dosage variables are as follows; energy expenditure was 1383.8 ± 574.1 kcals, 17.3 ± 5.3 MET hrs, time was 211.4 ± 43.0 minutes, distance was 87.0 ± 55.9 km, and average percent of max heart rate individuals chose to ride at was 72.2 ± 5.7 percent. Comparatively, the total energy expenditure was 6251 ± 2784.0 kcals, and total MET hrs were 78.0 ± 27.0. Average total time rode was 950.3 ± 216.8 minutes and average total distance was 324.0 ± 111.0 km.

Results of the DXA scans were used to assess compartmental body compositional changes from the pre and post intervention scans. Paired t-tests were run on each compartment and no significant changes in fat mass or lean mass were found. Although no significant changes were found in respect to changes in body composition pre and post, decreasing mass and fat mass were present both in a full body spectrum and compartmentally within individuals. Overall mass and fat mass changed from 76.1 ± 16.1 kg to 75.6 ± 16.1 kg ($p=0.29$) and 27.1 ± 11.8 kg to 26.7 ± 12.0 kg ($p=0.18$), respectively. Average arm fat mass changed from 2.4 ± 1.0 kg to 2.3 ± .8 kg ($p=0.43$), leg fat mass changed from 9.7 ± 4.0 kg to 9.6 ± 4.0 kg ($p=0.78$) and trunk fat mass changed from 14.2 ± 7.3 kg to 14.0 ± 7.3 kg ($p=0.37$).

Changes in fat mass corresponding to differences in average energy expenditure per day, average energy expenditure per week, and total energy expenditure are shown in figures 1,2, and 3 respectively. Similarly, figure 4 shows individual change in fat mass.

Multiple regression analysis was used to evaluate if changes in body composition varied with age, sex, dosage, and pre-existing fat mass. A regression model that included age, sex, and dosage in average kcals per week, was the model that best fit changes in fat mass, with an adjusted R^2 value of 0.6. In this model, age ($p=0.005$) and sex ($p=0.003$) were significant. For age the output means with a one unit increase in year, there was a 61 unit decrease in fat mass in grams, all else being held constant. More simply, for every increase of age in years, individuals (with the same sex and average kcals per week) saw a 61 gram loss of fat mass. Similarly for sex, individuals with the same age and average kcals per week expended, males had a 2,000 unit decrease in fat mass in grams, all else being held equal. More simply, men that were the same age and rode the same amount lost 2 kg more fat than the women at this age that expended the same amount of kcals.

Discussion:

The results from the present study were much more variable than we had predicted in terms of a threshold point for losing fat mass. Unlike the findings of Donnelly (2013), we had a variable change in fat mass that was apparent above and below the 400kcal/day threshold (this variability in our results can be seen in figure 1). One explanation for this may be that the threshold that Donnelly observed was 400 kcals/day, but also that his subjects exercised at this intensity five days per week and reached 2000 kcals/week. In our study, only two subjects reached an average over 2000 kcals/week, both of which saw fat mass loss. In this sense, our results align with Donnelly's, and we would expect that if more individuals in our study had exceeded the weekly threshold of 2000 kcals/week, we would have observed more individuals lose fat mass.

Our variable results also align with other studies besides Donnelly's that have looked at changes in body fat over an exercise intervention. Slentz et al. (2005) found that an exercise group that was prescribed 14 kcal•kg body wt^{-1}•wk did not produce significant changes in body fat but the group that expended 23 kcal•kg body wt^{-1}•wk, did produce significant changes. If you turn these values into absolute kcals per week for an individual who weighs 75 kg (the average of what our subjects weighed), it comes out to about 1050 kcals for the low exercise group and 1725 kcals for the high exercise group. On average, our subjects expended about 1383 kcals per week, which puts them right in between these two groups. In this context, our results match up with previous studies in the sense that we wouldn't expect to see significant changes in body fat because they did not reach the higher threshold in which body fat changes have been seen to occur. For our subjects that did expend over 1725 kcals/week, all three did see a decrease in fat mass. This study also shows a threshold response to exercise that results in changes in body composition.

In terms of a regression model that best explained the changes in fat mass, the model included dosage in kcals, sex, and age. In this model, energy expenditure in kcals was a non-significant variable, whereas increases in age showed an increase loss in body fat, as well as being male showed an increase loss in body fat. More frankly, this data suggests that over a four-week intervention period, regardless of average kcals expended, the greatest predictor of fat mass changes is age and sex within our subject population. That being said, if more individuals exceeded the thresholds discussed above, we would expect that age and sex would make less of a difference, and that reaching the threshold dose would be the best indicator for weight loss.

Based on the increased amount of fat mass older individuals have due to variables like decreased muscle mass that is often associated with decreased metabolic rate, we assumed they would lose more fat mass simply because they had a larger starting value. For our fourteen subjects specifically, the seven "younger" individuals, ages 22-41, had an average starting fat mass of 23 kg, whereas the "older" individuals, ages 44-55, had an average starting fat mass of 30 kg. Our regression analysis supported the idea that older individuals would lose more fat mass because they had more to begin with because when we held dosage and sex constant, older individuals loss more fat mass.

Conversely, with this logic we would expect to see females lose more fat mass compared to males, since they have a higher starting value. Females in our subject population had an average starting fat mass of 28 kg, whereas males had an average starting fat mass of 24 kg. Our regression analysis for sex actually gave us the opposite of what we would expect, being that males lost almost 2 kg more than females of the same age and dosage patterns. One possible mechanism for this may be that the females in our study could have increased their energy intake more than the males, in response to our exercise intervention. In this study we did not control for diet, so it is very possible that differences in dietary intake in response to the increase in exercise stimulus may be one explanation for why males lost more fat mass than females.

Although our subjects did not see significant changes in body composition over the four-week intervention, they did see significant improvements in other heath parameters such as glucose regulation, as well as improved cardiovascular fitness. Another study done with sedentary women found similar results. Church et al. (2004) found that through a six-month exercise intervention, their subjects saw increases in physical fitness, but no significant changes in body mass or body fat.

Strengths/Limitations:

No previous research has been done on the change in body composition after a pedelec intervention, and in this way our findings provide a novel perspective on this type of active commuting.

The strengths of this study include the acquisition of data including DXA scans, GPS, and heart rate monitors in order to estimate the predictor and outcome variables. A limitation of this study was the unequal sample size of men and women when discussing possible differences in body composition based on sex. Another weakness was our small sample size, making our comparisons of different subsets of the data difficult.

Conclusions:

In conclusion, a four-week pedelec intervention was a sufficient stimulus for changes in glucose regulation and cardiovascular fitness improvement, but did not result in significant changes in body composition. Future research should study changes in body composition over a longer period of time using a pedelec, in which we would expect to see significant changes based on how our mass loss patterns match with the data of other studies. Because our subjects saw a similar, if not higher, rate of mass loss to those in Donnelly's study (an average 1 kg loss in 4 weeks and an average 4 kg loss in ten months, respectively) we would expect that if the duration of the study was extended, we would see significant changes in body composition. Future research should consider increasing the minimum dose for at least one group of the study, to the threshold expected to result in fat mass loss (1700-2000 kcals/week). This design would allow better comparison for individuals who would exceed this threshold verses those who would not. This research should also obtain data from a much larger sample size if comparisons of subgroups such as sex and age are desired.

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Table 2: Mean and standard deviation for physiological data from pre and post intervention VO2max tests, oral glucose tolerance tests, and blood pressure measurements, as well as body mass index measurements. * indicates significance at $p<.05$. n=20

	Pre	Post
VO2max (L•min^{-1})	2.21±0.48	2.39±0.52*
Power output at VO2max (W)	165.1±37.1	189.3±38.2 *
2 hour post plasma glucose (mmol•L^{-1})	5.53±1.18	5.03±0.91*
BMI (kg•m^2)	26.8±4.9	26.7±5.0
Mean Arterial Blood Pressure (mmHg)	84.6±10.5	83.2±9.4

Table 3: Dosage of riding including average energy expenditure per week, average MET hrs per week, average time per week, average percent of max heart rate rode at, average kilometer per week, total energy expenditure, total MET hrs, total time, and total kilometers. (average and standard deviations) n=14

Dosage				
Average Weekly Values				
EE (kcals)	MET hrs	Time (mins)	Distance (km)	Average % of max HR
1383.8 ± 574.07	17.26 ± 5.28	211.4 ± 42.98	86.96 ± 55.93	72.23 ± 5.69
Average Total Values				
EE (kcals)	MET hrs	Time (mins)	Distance (km)	
6251± 2784.00	77.97 ± 27.05	950.3 ± 216.78	324.00 ± 110.97	

Table 4: Body composition including total mass, fat mass, lean mass, arm fat mass and lean mass, leg fat mass and lean mass, and trunk fat mass and lean mass. Pre and post included for each measurement as well as means and standard deviations. n=14

Total Mass (kg)		**Fat Mass (kg)**		**Lean Mass (kg)**	
Pre	Post	Pre	Post	Pre	Post
76.14 ± 16.11	75.61 ± 16.07	27.09 ± 11.76	26.65 ± 11.91	46.20 ± 6.98	46.13 ± 6.65
		Arm			
		2.41 ± .96	2.33 ± .830	5.13 ± 1.10	5.02 ± 1.08
		Leg			
		9.67 ± 3.98	9.59 ± 3.98	15.60 ± 2.78	15.77 ± 2.69
		Trunk			
		14.24 ± 7.33	13.97 ± 7.36	22.12 ± 3.50	21.98 ± 3.39

Figure 1: Individual average daily energy expenditure in kcals verses change in fat mass. An increase in daily energy expenditure corresponds with a greater loss in fat mass.

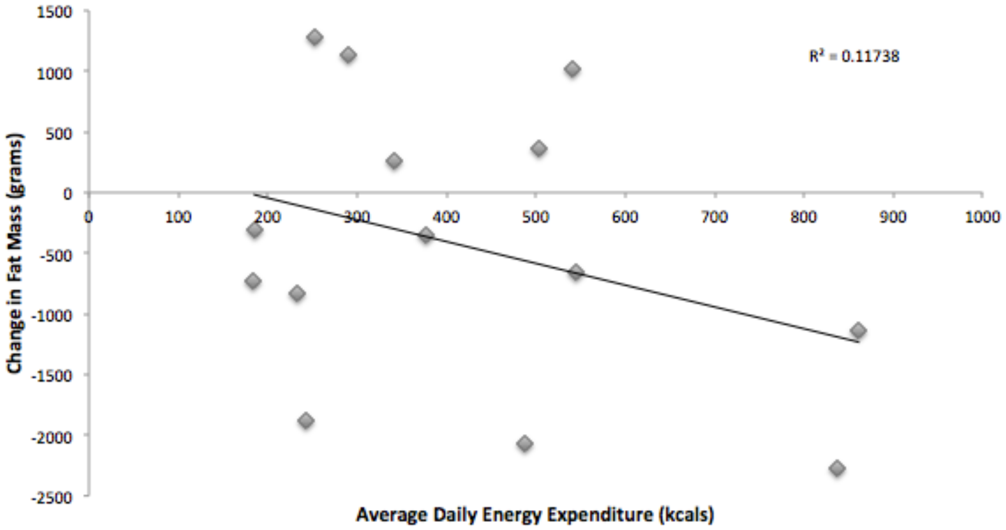

Figure 2: Individual average weekly energy expenditure in kcals verses change in fat mass. An increase in weekly energy expenditure corresponds with a greater loss in fat mass

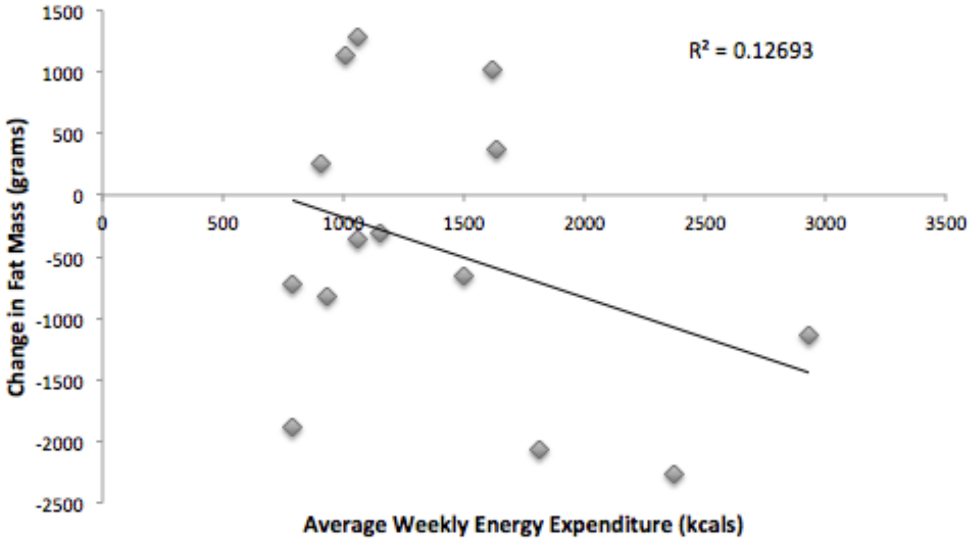

Figure 3: Individual average total energy expenditure in kcals verses change in fat mass. An increase in total energy expenditure corresponds with a greater loss in fat mass.

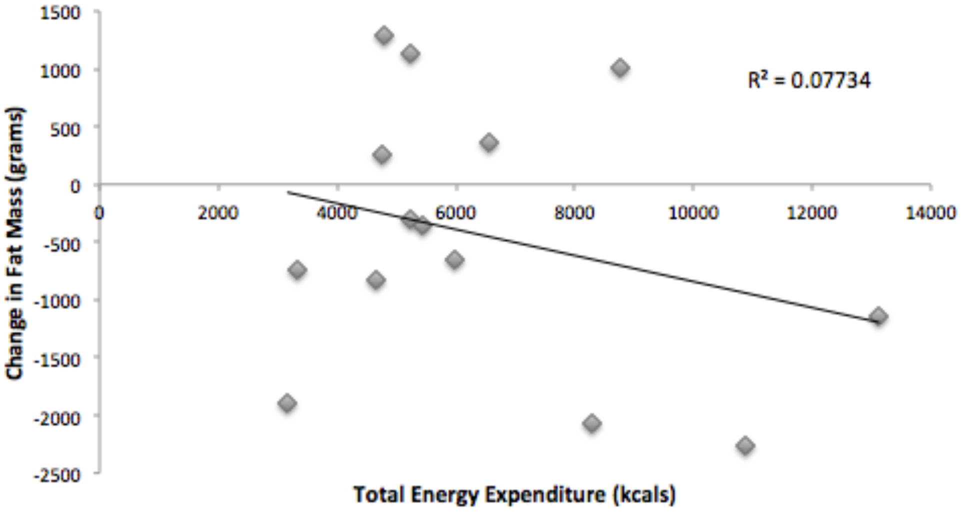

Figure 4: Individual change in fat mass over the 4 week intervention period.