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# The Effects of Xanthigen Supplementation on Body Weight, Resting Energy Expenditure, and Body Composition in an Obese Population

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# The Effects of Xanthigen Supplementation on Body Weight, Resting Energy Expenditure, and Body Composition in an Obese Population

by

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**Abstract:** Since obesity is a significant problem that is facing the American people, there has been great interest in trying to develop a successful health supplement to help counteract the effects of obesity. Xanthigen is a new supplement composed of brown seaweed extract and pomegranate seed oil and is theorized to increase resting energy expenditure and decrease BMI and body fat. This study involved a 16-week supplementation protocol to examine the effects of Xanthigen supplementation on an obese population in the Mississippi area. Testing of resting energy expenditure, BMI, and body fat percentage took place every four weeks for 16 weeks. At the end of the intervention, the results did show a significant decrease in weight loss and BMI overall; however, Xanthigen did not prove effective at accelerating these losses. Moreover, the results did not a show the expected decreases in body fat percentage or an increase in resting energy expenditure. Due to these results, further research must be done in order to find out if Xanthigen really does have the capabilities to help fight the effects of obesity. Future studies are focusing on the decreased respiratory quotient and the decreased systolic blood pressure effects from the Xanthigen supplementation found during this study.

*Keywords: obesity, fucoxanthin, pomegranate seed oil, weight loss, lipid metabolism*

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## I. Introduction

Obesity is an epidemic that has taken over the United States and many other countries. Forty-nine states in the United States have an obesity rate of twenty percent or greater. Colorado is the only state with an obesity rate lower than twenty percent ("U.S Obesity Trends," 2010). As a result, the health community is looking for a safe and effective way to counteract this obesity epidemic.

Dietary supplements have been generated specifically for counteracting obesity and preventing some of its related chronic diseases. Some supplements reduce cravings, help control appetite, increase metabolism, and maintain certain nutrient and enzyme levels to help aid in weight loss. Xanthigen is a standardized plant food supplement that is composed of two main ingredients: fucoxanthin, taken from brown seaweed, and the punicic acid that is extracted from pomegranate seed oil. Xanthigen is theorized to increase resting energy expenditure in obese individuals and also decrease body mass and body fat percentage. By increasing resting energy expenditure, fat loss should also increase thereby decreasing body mass and body fat percentage.

If the supplement Xanthigen does indeed increase resting energy expenditure, then it may be a promising new supplement for the treatment of obesity. The purpose of this study was to determine the possible effects of a diet with supplementation of Xanthigen on body mass, body composition, and resting energy expenditure in order to see if Xanthigen has promising anti-obesity properties.

## II. Literature Review

The reason this epidemic of obesity is a major concern to the health community is because of the associated risks of many diseases due to obesity. People who are obese tend

to have a higher rate of respiratory problems, cardiovascular risk factors, diabetes type 2, low back pain, and poor quality of life (Lean, Han, & Seidell, 1999). Due to the fact that obesity causes many medical problems that could lead to death, it is one of the many top preventable causes of death.

Research has also shown that there is a relationship between exercise and obesity rates. Basset, Pucher, Buehler, Thompson, and Crouter (2008) analyzed the inverse relationship between physical activity and obesity. A person lowers his or her risk of obesity by participating in physical exercise. Though exercise and a good diet would benefit an obese population, many Americans eat a poor diet and live a sedentary lifestyle. As a result, the health community is trying to create supplements that can help these individuals lose weight more effectively. Xanthigen is a new supplement on the market and has been tested very little in humans. Xanthigen is composed of brown seaweed extract and pomegranate seed oil and standardized for the active ingredients, fucoxanthin and punicic acid. In order to determine if Xanthigen is a safe and useful supplement more research must be conducted.

**Fucoxanthin**

Fucoxanthin is a carotenoid that can be extracted from brown seaweeds like *Undaria pinnatifida* and *Hijikia fusiformis*. Fucoxanthin has been a focus of recent research looking at the health benefits it could possibly possess. A study done by Yan et al. (1999) showed that fucoxanthin is a major antioxidant, which is very beneficial to the prevention of certain diseases like cancer. However, the main focus of research on fucoxanthin has been on its potential ability to help aid in safe and sustainable weight loss. Fucoxanthin has many thermogenic components that have effects on metabolic characteristics like resting energy expenditure, adipocyte differentiation, docosahexaenoic acid levels, and fatty acid oxidation.

*Effect on Mitochondrial Uncoupling Proteins:*

Maeda, Hosokawa, Sashima, Funayama, and Miyashita (2005) performed a study where they analyzed the effects of fucoxanthin on rats and mice. They found that fucoxanthin had an interesting effect on the mitochondrial uncoupling proteins expressed in white adipose tissue. Uncoupling protein 1 (UCP1) is a major factor in facultative thermogenesis and has the capability of removing extra abdominal fat. However, this particular uncoupling protein is usually only seen functioning in brown adipose tissue and most adult humans have very little brown adipose tissue. Fucoxanthin can be seen as a supplement used to help fight obesity because it has been shown to enhance expression of the UCP1 and the UCP1 mRNA in white adipose tissue as well. This allows for this protein to target and reduce excess fat in the areas in humans where fat is most abundant. Fucoxanthin was also shown to affect the UCP2 that is expressed in white adipose tissue; however, this protein is not involved in the metabolic rate. The results of this study showed that fucoxanthin not only enhanced the expression of UCP1 in white adipose tissue, but it also decreased the UCP2 mRNA expression in white adipose tissue. The study findings supported that the mice and rats in the group that were fed the fucoxanthin-containing *Undaria* had a significant decrease in their white adipose tissue weight. The reason for this response was shown to be because of the use of the UCP1 in white adipose tissue allowing fat oxidation to occur. This finding was important because it prompted more research of fucoxanthin as a supplement that could help reduce excessive fat accumulation.

Another study by the same group looked at the effect on the UCP1 in white adipose tissue; however, they looked at fucoxanthin and another substance called medium-chain triacylglycerol (MCT). Meada, Hosokawa, Sashima, Funayama, and Miyashita (2007) supported the claim that fucoxanthin helped increase UCP1 activity in white adipose tissue.

Fucoxanthin, however, is most of the time oxidized before it can actually be useful in the body. Vitamin E is an antioxidant that is most often taken with fucoxanthin in order to decrease the possibility of oxidation. There is still a problem because fucoxanthin is not very soluble in Vitamin E. In order to counter this problem, Meada et al. used MCT as an intermediate, which proved to allow fucoxanthin to be mixed with vitamin E easily. The diet that consisted just of fucoxanthin caused more of a reduction in white adipose tissue than the diet that consisted of just MCT. This shows that MCT is ineffective in reducing white adipose tissue. However, the mixture of fucoxanthin and MCT showed the highest level of anti-obesity due to the MCT allowing fucoxanthin to dissolve in Vitamin E. The main reason for this effect was due to the ability of MCT, which contains vitamin E, to increase the rate of absorption of fucoxanthin and preventing its oxidation. This allows fucoxanthin to work more efficiently and effectively to increase metabolism.

*Effect on adipocyte differentiation:*

Another study looked at the effect of fucoxanthin and its metabolic counterpart fucoxanthinol in adipocyte differentiation. Adipocyte differentiation is important because of its relatedness to obesity; obesity occurs because of preadipocytes becoming adipocytes and the growth of adipocytes in adipose tissue. Maeda et al. (2006) focused their research in one study on adipocyte differentiation in 3T3-L1 cells, which is a cell line taken for research from 3T3 cells that usually differentiate into an adipoycte phenotype that functions in increasing the creation and accumulation of triglycerides. It was found that fucoxanthin inhibited the gathering of lipids in 3T3-L1 cells in a significant and safe way. Fucoxanthin also down-regulated the activity of the enzyme glycerol-3-phosphate dehydrogenase (GPDH). This result is important because GPDH is used in order to help synthesize triacylglycerol. By stopping the activity of GPDH, fucoxanthin suppressed adipocyte

differentiation and subsequent adipose tissue accumulation. Maeda et al.'s study also focused on the metabolic counterpart of fucoxanthin because when fucoxanthin was absorbed into the body, many cells converted fucoxanthin into fucoxantinol. Fucoxanthinol (5.0 and 7.5 μm) seemed to have a greater effect on inhibiting GPDH activity in 3T3-L1 cells. The subjects treated with both fucoxantin and fucoxanthinol also had the effect of inhibiting PPARγ levels in 3T3-L1 cells. This could support one theory of the anti-obesity effect of fucoxanthin because PPARγ is an early regulator of 3T3-L1 cell differentiation. It functions as a nuclear transcription factor that determines adipogenic gene differentiation. By down-regulating PPARγ, fucoxanthin helps inhibit the differentiation of preadipocytes into adipocytes in 3T3-L1 cells. In Maeda et al.'s study, fucoxanthin was shown to have a few different anti-obesity effects, like stopping the accumulation of lipids and the activity of GPDH and PPARγ, which all aid in the progression of obesity.

*Effect on Hepatic Fatty Acid Oxidation:*

Another name for fucoxanthin is wakame; wakame is taken from a brown seaweed called *Undaria pinnatifida*. In a study done by Murata, Ishihara, and Saito (1999), the effects of wakame were observed on hepatic enzymes, focused particularly on fatty acid oxidation. The study was done in order to see if wakame could be used as a dietary product for the prevention of hyperlipidemia, another disease related to obesity. The main result of this study was that the serum and liver triacylglyerol levels were decreased in the group of rats that were fed the wakame. This result was explained by the possibility that wakame decreases the production of fatty acid and increases the use of fatty acids in the liver for energy. In order to test this hypothesis, Murata et al. looked at the enzyme levels that are used in order to build up fatty acids in the liver. The group found that wakame did in fact

decrease glucose-6-phosphate dehydrogenase; however, they found no difference in malic enzyme or fatty acid synthetase, which made them believe that fatty acid synthesis was not the major cause of the decreased serum and liver triacylglycerol levels. Next, they looked at the enzymes involved in the β-oxidation process in the mitochondria of the liver. Acyl-CoA dehydrogenase, a key enzyme in β-oxidation, activity was increased by wakame. Another important factor of the increased activity of acyl-CoA dehydrogenase is that its activity was measured to be higher than the activity of acyl-CoA oxidase, which means that wakame was shown to increase the β-oxidation of saturated fatty acids more than unsaturated fatty acids in the mitochondria. 2,4-Dienoyl-CoA reductase activity was also decreased by dietary wakame. This is important because this enzyme's main function is to aid in the oxidation of unsaturated fatty acids and it gives another possible reason why dietary wakame helped aid in the increased β-oxidation of saturated fatty acids. The research team also observed a change in malonyl-CoA, a coenzyme A derivative that inhibits carnitine palmitoyl-transferase by its regulation of mitochondrial oxidation of long-chain fatty acids. Malonyl-CoA's levels of activity decreased because of the decreased rate of fatty acid synthesis in the liver. Due to its effects on metabolic enzymes, dietary wakame reduced serum triacylglycerol levels. This is important because high serum lipid levels are indicative of hyperlipidemia.

*Effect on Docosahexanoic Acid:*

The results of a study done by Tsukui et al. (2007) demonstrated that there was an increase in docosahexaenoic acid (DHA) in the liver due to fucoxanthin and fucoxantinol. DHA is considered an essential fatty acid that has been known to help limit the accumulation of triacylglycerol and cholesterol. DHA causes a decrease in fatty acid

composition in the liver and blood. One of the purposes of Tsukui et al.'s study was to see if diets containing fucoxanthin also caused an increase in DHA and a decrease in fatty acid composition. As stated before, Tsukui et al.'s experiment supported the hypothesis that fucoxanthin could be a good supplement in helping fight obesity because of its effect on increasing the levels of DHA in the liver. The liver is extremely important in lipid metabolism, so substances like fucoxanthin that increase liver DHA levels have positive results in aiding in fat loss.

**Pomegranate seed oil**

Plant seed oils have been a part of recent research because of their possible benefits in fat reduction due to their composition of specific fatty acids. Pomegranate seed oils contain about 72% punicic acid, which is a 9cis, 11trans, 13cis-conjugated linolenic acid.

*Effect on lipid metabolism:*

Arao et al. (2004a) performed a study that dealt with pomegranate seed oil in order to see if it had benefits on lipid metabolism in a certain group of rats (OLETF) that had similar features to human obesity. The first result of this study was that the group of rats that was fed the diet containing the 5% pomegranate seed oil had a large reduction of white adipose tissue weight. The OLETF rats (the ones with biological disorders similar to human obesity) had higher levels of triacylglycerol accumulated in their liver, but with the introduction of 9c, 11t, 13c-conjugated linolenic acid, the triacylglycerol did not accumulate as much, showing that the punicic acids provided protective measures that decreased triacylglycerol accumulation in the liver. An effect of punicic acid that helps reduce fat is by decreasing the levels of monounsaturated fatty acid. By decreasing the levels of

monounsaturated fatty acid, punicic acid can be seen as beneficial in reducing fat levels and possibly assisting in the fight against obesity.

Arao, Yotsumoto, Han, Nagao, and Yanagita (2004b) also did a study on 9c, 11t, 13c-conjugated linolenic acid looking at its affect on apolipoprotein B100 secretion and triacylglycerol synthesis specifically in HepG2 cells. These cells are taken from a human liver that still contains most of the hepatocytic biochemical properties. Apolipoprotein B100 is an important protein that is responsible for transporting cholesterol to tissues. It is also the main component of the low-density lipoprotein (LDL), which allows cholesterol and triglycerides to enter and be transported through the bloodstream. LDL is known as the bad cholesterol because high levels lead to an increased risk of cardiovascular disease. The HepG2 cells that were treated with the punicic acids had lower levels of apolipoprotein B100 secretion. This result shows that punicic acids can cause less LDL to be synthesized since apolipoprotein B100 is one of the main components of LDL. This result can be explained by punicic acid's effect on triacylglycerol synthesis. Punicic acid caused a decrease in the production of triacylglycerol. Triacylglycerol is important in the regulation of apolipoprotein B100 secretion because triacylglycerol is needed in order to secrete apolipoprotein B100. By reducing the amount of triacylglycerol, punicic acid elicits a secondary effect of decreasing apolipoprotein B100. Since punicic acids caused these effects, it can be seen as providing beneficial effects on preventing cardiovascular diseases and obesity.

McFarlin, Strohacker, and Kueht (2009) did another study investigating pomegranate seed oil's effect on weight gain. Pomegranate seed oil, as stated before, possesses a high concentration of 9c, 11t conjugate linolenic acid. One major finding in this study was that mice fed the pomegranate seed oil diet exhibited a decrease in body weight.

They also showed decreased levels of leptin and insulin but increased levels of adiponectin. Leptin and insulin are hormones that are seen in high levels in obese individuals. Adiponectin is a hormone that aids in glucose and fatty acid metabolism and is seen in lower levels in obese individuals. Because of this decrease in leptin and insulin, a supplementation of pomegranate seed oil can decrease the risk of type 2 diabetes.

**Xanthigen**

Xanthigen is a fairly recent supplement that is a mixture of fucoxanthin and punicic acid taken from pomegranate seed oil. Since fucoxanthin and pomegranate seed oil have been shown to be beneficial in reduction of fat, the mixture of them is expected to elicit similar beneficial effects. Abidov, Ramazanov, Seifulla, and Grachev (2010) performed a study on human participants that tested the effect of Xanthigen on body weight, fat, and composition. The study also explored the effects of Xanthigen on resting energy expenditure. Resting energy expenditure is the amount of calories an individual would burn in a non-active period. Increasing resting energy expenditure has been shown to exhibit increased weight loss. These factors were tested because if Xanthigen provided beneficial effects, then it can be considered a promising supplement with anti-obesity properties. The participants that were given the Xanthigen supplement for 16 weeks reported to have a lower body weight and reduced body fat. The participants who were given just fucoxanthin and the patients who were given Xanthigen both showed an increase in resting energy expenditure; however, the participants given just pomegranate seed oil did not show increased resting energy expenditure. This shows that fucoxanthin is the major ingredient that affects resting energy expenditure due to its ability to excite the mitochondrial uncoupling protein 1 in white adipose tissue. However when comparing the resting energy expenditures between fucoxanthin (2.4 mg) and Xanthigen-600/2.4 mg, the resting energy

expenditure for the Xanthigen participants was higher. This shows that pomegranate seed oil serves as a catalyst for fucoxanthin allowing it to increase resting energy expenditure even more.

The Abidov et al. (2010) study is the first study investigating Xanthigen's anti-obesity effect. The results of the study show promising results and asked for more research to be done on the particular supplement. As a result, the current study will differ from the previous study because it will include more of a rural population as opposed to the urban population used in Abidov et al.'s study. The main question that will be investigated is whether Xanthigen has anti-obesity properties due to its composition of fucoxanthin and pomegranate seed oil. In past research both fucoxanthin and pomegranate seed oil has been shown to possess anti-obesity effects. Testing Xanthigen for anti-obesity effects may provide a premise for it in counteracting obesity. The current study will look at a larger group of participants in order to more effectively determine Xanthigen's effects on resting energy expenditure. Xanthigen, in the previous study, seemed to cause an increase in resting energy expenditure due to fucoxanthin with the pomegranate seed oil helping in the process, but the sample sizes of each group were quite small.

**Research Questions/Hypotheses**

This study will examine Xanthigen in order to support the claims made in the Abidov study. Resting energy expenditure is closely related to fat metabolism and obesity, thus it has an effect on body fat percentage and body mass composition. If Xanthigen is shown to help increase resting energy expenditure by the thermogenic effects of fucoxanthin and pomegranate seed oil, then it will seem to help the health community by aiding in the prevention of obesity and other health related diseases.

$RQ_1$: Will Xanthigen change resting energy expenditure?
$H_1$: Xanthigen will increase resting energy expenditure.

$RQ_2$: Will Xanthigen change body fat percentage?
$H_2$: Xanthigen will decrease body fat percentage.

$RQ_3$: Will Xanthigen change body mass index?
$H_3$: Xanthigen will decrease body mass index.

## III. Methodology

### Design

In order to test the effects of Xanthigen on resting energy expenditure, body mass, and body composition, the following experiment was a randomized, placebo-control, double blind, between group pretest and posttest design. The experiment used indirect calorimetry, a weighing scale, and dual energy X-ray absorptiometry (DEXA) in order to assess the changes that occurred during the experiment.

### Sample

The sample consisted of male and female participants from the Hattiesburg, MS region. The participants had to be between the ages of 18 and 50 years of age. The individuals also had to be considered obese meaning that they had a BMI greater than 30 $kg/m^2$. Other requirements were that participants could not have been menopausal or pregnant. They must also not have had any metabolic disorders (electrolyte abnormalities, heart disease, arrhythmias, diabetes, thyroid disease, or hypogonadism) or taken thyroid, hyperlipidmeic, hypoglycemic, anti-hypertensive, androgenic medications or nutritional supplements that manipulate fat metabolism in the past six months. The participants also could not have had a history of excessive alcohol consumption, which translates to greater than 14g of alcohol per day. Another exclusionary factor was that the participant could not

be allergic to seafood or iodine due to a health risk factor. Participants were not allowed to participate in the study if the participant acquired any of these conditions throughout the study or if they requested to withdraw from the study. The participant also had to follow all dietary or testing procedures. Approximately 60 individuals were recruited to participate in the study. The participants were also recruited from the Hattiesburg, MS region because the research team wanted to test the effects of Xanthigen on a more rural population instead of the urban population tested in Abidov et al.'s (2010) study. Flyers, electronic mail, University of Southern Mississippi announcements, and phone calls were used to recruit participants for our study.

**Procedure**

The experiment took place over a 16-week period with all procedures being conducted in the Laboratory of Applied Physiology at The University of Southern Mississippi. The University of Southern Mississippi Institutional Review Board had approved the study. The first day of the procedure consisted of an introduction to the participants telling them about the study's purpose and design. The participants were also told the risk and benefits they may encounter by participating in the study. The participants were allowed to ask questions or state their concerns at this session. If there were questions or concerns, they were addressed by the primary investigator or a project assistant. The participants were then instructed to read and sign the Informed Consent document and also complete the medical history questionnaire. After this was done, the pretest began.

During the initial testing, the participants had their resting energy expenditure (REE), body fat percentage, and body mass index (BMI) measured. At the end of the pretest, the participants were matched according to their age and body fat percentage. Then, they were randomly assigned into the supplement group or the placebo group. The participants

then listened to instructions on the supplementation protocol and their standardized diet they must consume. The standardized diet contained as many kcal/d as the patient's first measured resting energy expenditure. The diet had to be followed throughout the 16 weeks of the procedure, and in order to promote the following of this diet, four-day food logs were administered and collected every two weeks. Also, the participants were provided dietary counseling if they had questions about the standardized diet. As for the supplementation protocol, the participants were instructed to take their supplement between 15-30 minutes before each of their three meals. The participants were given a two-week supply of their supplement each time they brought in their food logs. After the instructions were given, a member of the research team gave the participants their supplements.

The next four testing sessions (T2-T5) were conducted in 4-week intervals. Each testing session the participant first had their body mass, height, waist circumference, total body water, body composition, and REE measured. During these testing sessions, the four-day food logs were collected, and the next two 2-week bottle of supplements were distributed. Each testing session took approximately an hour to complete, and each other session took approximately thirty minutes to complete. This equals to an approximated total time of 13 hours throughout the 16-week study for the participants.

Participants also completed a questionnaire each session in order to state any problems they had with the supplement or the supplementation protocol in a confidential manner. This allowed the research team to see if there were any side effects due to the supplement.

The principal investigator of this study was Geoffrey Hudson, PhD. Lisa Knecht was one of the primary co-investigators that helped with collection of body fat percentage, body mass, and REE.

Each participant was assigned a numerical code in order to keep his or her data confidential. The investigators were the only ones who knew the coding. Only the research team examined the data. Only group data, not individual data, was released after the study was completed.

**Measures**

Each participant had his or her body composition and resting energy expenditure assessed at each of the five testing sessions. Body composition consisted of body mass, waist circumference, and body fat percentage. A standard digital scale (Ohaus Champ II) was used to measure body mass (kg). Waist circumference was determined by standard anthropometric measurements. Bioelectrical impedance analysis (BIA) was used in order to measure total body water. The Tanita TBF-310GS bioelectrical impedance analyzer caused a low energy, high frequency current to spread throughout the body causing a resistance between the current and body tissues. The machine measured that resistance, which it then used to calculate the total body water. Personal information (gender, weight, and height) of the participant was inserted into the analyzer. The analyzer measured the resistance, and then it calculated the total body water content.

Body fat percentage was determined by the dual energy X-ray absorbency (DEXA). The particular brand of DEXA was the GE Lunar Prodigy. The participant lied in a supine position, while a low dose of radiation scanned his or her entire body for six to eleven minutes. In order to determine fat, bone, and muscle tissue, the DEXA separates regions of the body into these three compartments by their density. The accuracy of the DEXA is normally ±2% for fat mass when compared to hydrodensitometry and scale weight.

In order to measure resting energy expenditure, the study used the Vyasis Vmax Encore. This machine analyzed the gases that were expired by the participant while they lay

motionless in a supine position on a table with a transparent canopy placed over the participant's head and neck. The canopy was connected to the gas-mixing chamber in order to measure the resting oxygen uptake, which was used to calculate the resting energy expenditure.

The results of these analyses of body composition and resting energy expenditure were used to determine if the study's hypotheses were supported or refuted. Also in order to make sure the results are accurate as possible, the four-day food logs must be analyzed to make sure the participants were adhering to the standardized diet. The ESHA Food Processor dietary assessment software program is being used to analyze the food logs.

**Analysis**

All data was evaluated using the IBM SPSS Statistics 20 program for Windows. BMI, body composition, and REE results were analyzed specifically using separate (time X supplement) factorial multivariate, repeated measures analyses of variance (MANOVAs). Some further analysis was needed, so the main effects of the supplement were analyzed using separate univariate ANOVAs. Baseline differences between groups were determined with univariate ANOVA. The results were considered significantly different when the probability of error was 0.05 or less. All statistical analysis was performed by Geoffrey Hudson, and I interpreted the data for the purpose of this thesis.

## IV. Results

*Demographic Data*

The results presented in the following table are the general demographic data of the 29 participants that completed the study. Data from the other two participants in the study

were omitted because they were considered outliers. The information was organized into the Xanthigen and Placebo columns in order to show that there were no significant baseline differences seen for all four of the variables. All data are presented as mean plus or minus the standard deviation.

**Table 1:** Demographic data collected before the start of supplementation

| Variables | Xanthigen | Placebo |
|---|---|---|
| Age (years) | 29 ± 8 | 27 ± 8 |
| Body mass (kg) | 102.62 ± 12.95 | 105.16 ± 14.89 |
| BMI (kg/m$^2$) | 35.71 ± 3.72 | 37.24 ± 6.64 |
| Body fat percentage | 42.6 ± 8.7 | 44.4 ± 7.5 |

†Data presented as mean ± standard deviation.

*Anthropometric Measurements*

Table 2 displays the changes between the anthropometric variables over the 16-week study. A significant decrease was seen in the body mass, BMI, and waist circumference variables with no difference between groups. There were no significant changes observed in the hip circumference and the waist:hip measurements.

**Table 2:** Anthropometric changes after the 16-week supplementation

| | Xanthigen | | | Placebo | | | |
|---|---|---|---|---|---|---|---|
| Variables | Week 0 | Week 16 | 16 wk Change | Week 0 | Week 16 | 16 wk Change | |
| Body mass (kg) | 102.63 ± 12.95 | 100.79 ± 14.00 | -1.84 ( -1.8% ) | 105.16 ± 14.89 | 101.99 ± 16.16 | -3.17 ( -3.0% ) | * |
| BMI (kg/m$^2$) | 35.71 ± 3.72 | 35.06 ± 4.12 | -0.65 ( -1.8% ) | 37.24 ± 6.64 | 36.10 ± 6.88 | -1.14 ( -3.1% ) | * |
| Waist circumference (cm) | 102.2 ± 10.6 | 100.63 ± 9.54 | -1.57 ( -1.5% ) | 103.95 ± 10.59 | 101.32 ± 12.06 | -2.63 ( -2.5% ) | * |
| Hip circumference (cm) | 119.78 ± 7.23 | 118.63 ± 8.86 | -1.15 ( -1.0% ) | 125.15 ± 12.22 | 121.83 ± 13.39 | -3.32 ( -2.7% ) | |
| Waist : Hip | 0.85 ± 0.07 | 0.83 ± 0.05 | -0.02 ( -2.4% ) | 0.85 ± 0.07 | 0.83 ± 0.04 | -0.02 ( -2.4% ) | |

†Data presented as mean ± standard deviation.

*Significant change over time ($p < 0.05$).

*Body Composition*

The results of the body composition variables measured during the monthly DEXA scans are presented in Table 3. Analysis of the data showed no significant effects for time, between groups, or group*time interaction effect. Therefore, the data indicate that there was not a significant decrease in body fat percentage as was expected.

**Table 3:** Body composition changes after the 16-week supplementation

| | Xanthigen | | | Placebo | | |
|---|---|---|---|---|---|---|
| **Variables** | **Week 0** | **Week 16** | **16 wk Change** | **Week 0** | **Week 16** | **16 wk Change** |
| Bone mineral density ($g/cm^2$) | 1.292 ± 0.116 | 1.298 ± 0.115 | 0.006 ( 0.5% ) | 1.318 ± 0.088 | 1.323 ± 0.092 | 0.005 ( 0.4% ) |
| Body fat percentage | 42.6 ± 8.7 | 42.2 ± 8.7 | -0.4 ( -0.9% ) | 44.4 ± 7.5 | 43.7 ± 8.7 | -0.7 ( -1.6% ) |
| Body fat mass (kg) | 41.738 ± 9.813 | 40.713 ± 10.420 | -1.025 ( -2.5% ) | 45.193 ± 11.782 | 43.428 ± 13.948 | -1.765 ( -3.9% ) |
| Lean mass (kg) | 56.522 ± 12.023 | 55.870 ± 11.326 | -0.652 ( -1.2% ) | 55.684 ± 8.554 | 54.370 ± 8.434 | -1.314 ( -2.4% ) |

†Data presented as mean ± standard deviation.

*Hemodynamic Variables*

The changes observed in heart rate and blood pressure are organized into Table 4. Analysis showed that there were significant main effects seen for time; however, there were no significant main effects for between groups or group*time interaction effect. There was a significant decrease observed in the diastolic blood pressure and heart rate. Decreased systolic blood pressure was seen as a trend throughout the study.

**Table 4:** Changes in heart rate and blood pressure after the 16-week supplementation

| | Xanthigen | | | Placebo | | |
|---|---|---|---|---|---|---|
| **Variables** | **Week 0** | **Week 16** | **16 wk Change** | **Week 0** | **Week 16** | **16 wk Change** |
| Systolic blood pressure (mmHg) | 118 ± 15 | 108 ± 10 | -10 ( -8.5% ) | 114 ± 12 | 111 ± 11 | -3 ( -2.6% ) * |
| Diastolic blood pressure (mmHg) | 77 ± 12 | 71 ± 6 | -6 ( -7.8% ) | 76 ± 9 | 74 ± 8 | -2 ( -2.6% ) * |
| Heart rate (bpm) | 65 ± 6 | 71 ± 7 | 6 ( 9.2% ) | 74 ± 15 | 73 ± 12 | -1 ( -1.4% ) * |

†Data presented as mean ± standard deviation.

*Significant change over time ($p < 0.05$).

*Resting Energy Expenditure*

The results of the changes observed in resting energy expenditure during the 16-week supplementation are summarized in Table 5. Analysis revealed a significant main effect for time, but a similar effect was not seen for a between group or group*time interaction effect. A significant decrease was observed in REE and oxygen consumption at the end of the 16-week supplementation. There were no significant effects for $VO_2$ relative to body mass or $VO_2$ relative to lean body mass. A difference was also seen in the respiratory quotient in a between group effect but not over time. There was more of a decrease in RQ in the Xanthigen group over that of the placebo group.

**Table 5**: Resting energy expenditure changes after the 16-week supplementation

| | Xanthigen | | | Placebo | | |
|---|---|---|---|---|---|---|
| **Variables** | **Week 0** | **Week 16** | **16 wk Change** | **Week 0** | **Week 16** | **16 wk Change** |
| Resting energy expenditure (kcal/day) | 1884 ± 320 | 1846 ± 311 | -38 ( -2.0% ) | 1828 ± 220 | 1769 ± 193 | -59 ( -3.2% ) |
| Relative oxygen consumption (ml / kg-body mass · min) | 2.6 ± 0.3 | 2.6 ± 0.3 | 0.0 ( 0.0% ) | 2.5 ± 0.2 | 2.5 ± 0.3 | 0.0 ( 0.0% ) |
| Relative oxygen consumption of lean body mass (ml / kg-LBM · min) | 4.8 ± 0.5 | 4.8 ± 0.7 | 0.0 ( 0.0% ) | 4.7 ± 0.7 | 4.7 ± 0.6 | 0.0 ( 0.0% ) |
| Respiratory quotient | 0.87 ± 0.05 | 0.83 ± 0.03 | -0.04 ( -4.6% ) | 0.81 ± 0.05 | 0.80 ± 0.06 | -0.01 ( -1.2% ) ‡ |

†Data presented as mean ± standard deviation.

‡Significant difference at baseline ($p < 0.05$). Data analyzed as changes over time.

V. Discussion

As the results demonstrate, the participants did lose a significant amount of weight; however, it seems to not be from the Xanthigen supplementation. Since Xanthigen supplementation seems to have not affected the weight loss in this population, the nutritional and exercise counseling appeared to cause the weight loss and waist girth

decrease. The food and exercise logs the participants were asked to complete led to frequent accountability, which could have also aided in the weight loss. Unlike the Abidov et al. (2010) study where they saw more significant weight loss in the Xanthigen group, this study's results showed similar weight loss in both the Xanthigen and the placebo group. There are many potential reasons for this difference between the two studies. These reasons include, but are not limited to, population differences, gender differences, dietary intervention, sample size, or the statistical methods. The sample size could play a role in the reason there were different results obtained in the two studies. In the Abidov et al. study, their normal liver function group contained 38 participants, while this study only had 29 participants. This study did have 57 participants start out, but due to scheduling difficulties, non-compliance with the supplementation protocol, and other reasons unrelated to the supplement itself, 26 participants decided to withdraw from the study. One participant did withdraw due to side effects that seemed to be caused by the supplement. Statistical analysis could be another reason there were different results obtained; however, it is impossible to compare the statistical analysis because the Abidov et al. paper did not provide an appropriate description of the statistics that they used to analyze their results.

Another difference between the Abidov et al. study and this study are the results of the changes in fat mass. Though the Abidov et al. (2010) study observed a significant loss in fat mass in the Xanthigen group, this study did not see this same significant loss. Since there was significant weight loss but not significant fat mass loss, the weight loss must have resulted from not only a loss in body fat, but also a loss in lean body mass, as is commonly the case with weight loss from a hypocaloric diet.

When analyzing the hemodynamic variables, there were some significant decreases seen in diastolic blood pressure and heart rate over time. The results also showed that there

was a trend of decreased systolic blood pressure over the 16-week supplementation. Though both groups experienced a decrease in blood pressure and heart rate, the Xanthigen group did experience a greater decrease in all three categories. However, these results were expected because the Xanthigen group in Abidov's et al. (2010 study also showed a significant decrease in both systolic and diastolic blood pressure. The reason the results of decreased blood pressure are significant is because they reveal that the Xanthigen supplement may have certain health benefits.

Contrary to hypothesis 1, resting energy expenditure decreased instead of increased. Resting energy expenditure was expected to increase in this study because it increased in the Abidov et al. (2010) study. Even though, REE was expected to increase, a decrease in REE is common with weight loss, especially when that weight loss corresponds with a decrease in lean muscle mass. Abidov's et al. finding of increased REE with decreased body fat is definitely an incredible finding; however, it is hard to compare the study to another because the study only measured the REE in a special population: participants with diagnosed NAFLD and elevated liver enzymes. The sample sizes of the REE tests were also exceptionally small, only consisting of approximately 4 participants. With a small sample size, it is hard to obtain reliable results. The Abidov et al. study also did not report all the information needed to accurately compare the results between the two studies. The Abidov study did not report any changes in body mass with their REE data, so the significance and practicality of the REE increase is difficult to determine.

The more interesting result obtained from the second study is the difference of the respiratory quotient between the two groups. In both groups, the respiratory quotient did decrease; however, it decreased more in the Xanthigen group than in the placebo group. This defends the theories that Xanthigen could help in weight loss because it indicates a

change in substrate metabolism. Since the respiratory quotient decreased the most in the Xanthigen group, the patients in this group were using more fat, instead of carbohydrates, for energy. This finding would support the assertion that Xanthigen stimulates fat metabolism.

*Limitations*

The goal of this study was to analyze the effects of the supplement Xanthigen on resting energy expenditure, BMI, and body fat percentage. Xanthigen did not seem to increase resting energy expenditure or decrease body fat percentage, but more research should be done to see if it still may have any anti-obesity effects. The reason more research should be done is because there were a few limitations to our study. One of the limitations is that there is very limited research on Xanthigen. Another limitation is that though the experiment is set up to try and keep participant compliant with the diet, the research team cannot say if the participants followed the diet completely. If the diet was not followed, the results of that participant may not be accurate. The length of the study also was a limitation because since the study is long, some participants were not able to participate and others dropped out. Because many participants dropped out, the study did not have a very large sample size, which could limit the repeatability of the results.

## VI. Conclusion

Overall the results of the study were disappointing, since there was not a rise in resting energy expenditure or a significant decrease in body fat percentage in the Xanthigen group compared to the placebo group; however, there were some positive results revealed from this study. The patients, as a whole, did achieve some weight loss; however, the weight

loss was attributed to diet, exercise, and frequent accountability instead of the Xanthigen supplement. Still, the Xanthigen supplement did seem to show some possible health benefits by helping to lower blood pressure and promoting more fat utilization for energy. Due to these important findings, further research will be done to test the acute effects of the Xanthigen supplement on blood pressure and the respiratory quotient value.

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