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A Lifestyle intervention: Effect of a Total Vegetarian Diet and Physical Activity on Selected Markers of Metabolic Syndrome within a Scandinavian Population

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Abstract

Background: Metabolic syndrome has become a worldwide problem reaching a prevalence of 25%. Though there is an agreement that lifestyle changes are the first-line approach, there is not a consensus as to which type of diet and lifestyle is most effective. The purpose of this study is to determine the effect of a short lifestyle intervention composed of a total vegetarian diet and physical activity on MetS risk factors within the Norwegian, Scandinavian population.

Methods: Data were obtained by reviewing medical records of 154 adults (21 years and older) who were guests at the Fredheim Health Center for 7 - 14 days between August 1, 2013 and July 31, 2014.

Results: A short-term total vegetarian intervention improved most coronary heart disease risk factors for metabolic syndrome: body mass index decreased 2.8% (P = <0.001); systolic blood pressure decreased by 7.5% (P = <0.001); diastolic blood pressure decreased 6.9% (P = <0.001); low-density lipoprotein, total cholesterol and triglycerides decreased by 14% - 16% (P = <0.001). However high-density lipoprotein also decreased by 12% (P=<0.001).

Conclusions: These data show that a short intervention consisting of a total vegetarian diet and exercise benefit most coronary heart disease risk factors for metabolic syndrome.

Keywords: Lifestyle intervention, vegetarian, vegan, metabolic syndrome, plant-based diets, Norway, Scandinavia

Introduction

Metabolic syndrome (MetS) is a multifaceted risk factor for cardiovascular disease (CVD), as well as type 2 diabetes (T2D) (Grundy, Brewer, Cleeman, Smith, & Lenfant, 2004). This syndrome represents serious health risks. According to Alberti et al. (2009), MetS presents a 5-fold increase in the risk of T2D and a 2-fold increase in the risk of CVD within 5 to 10 years compared with individuals not having MetS. Additionally, those with MetS have a risk of dying from heart attack or stroke that is twice that of those without MetS and they are three times as likely to have a heart attack or stroke in the first place (International Diabetes Federation [IDF], 2014). Furthermore, there are other conditions that present themselves more often in those with MetS, namely: polycystic ovary syndrome, fatty liver, cholesterol gallstones, asthma, sleep disturbances, as well as some forms of cancer (Grundy et al., 2004).

MetS is a cluster of different risk factors that occur simultaneously. Though there are several different variations of a definition for MetS given by different organizations, all agree that there are five components that constitute the syndrome (Kaur, 2014). These are: central obesity (increased waist circumference), elevated triglycerides, reduced HDL cholesterol, elevated blood pressure, and elevated fasting glucose (Alberti et al., 2009). A commonly used definition in clinical practice is the National Cholesterol Education Program Adult Treatment Panel III (ATP III). The ATP III classifies individuals as having MetS when they have at least three out of the five above-mentioned components (Alberti et al., 2009). Another internationally recognized definition is given by the International Diabetes Federation (IDF). This definition requires that an individual must have central obesity, plus any two of the four remaining factors (IDF, 2006).

MetS has become a worldwide problem. The prevalence of MetS ranges from less than 10% to up around 84% in the different regions of the world, depending on the diagnostic criteria used (as cited by Kaur, 2014). On a worldwide basis according to the IDF about 25% of the population has MetS (IDF, 2014). Looking more locally, a study from 2007 found that the prevalence of MetS in Norway was 29.6% using the IDF definition or 25.9% using the ATP III definition (Hildrum, Mykletun, Hole, Midthjell, & Dahl, 2007). Either percentage represents a serious health problem that needs to be addressed. Additionally, the prevalence of MetS increases with age (Hidlrum et al., 2007). With an increasingly aging population, the prevalence of MetS can only be expected to increase.

The economic burden that MetS presents is substantial. As MetS is a cluster of components, each component adds its burden to the increased risk for future health care costs (Nichols & Moler, 2011). Overall, Bourdreau et al. (2009) found that healthcare costs increased by 24% with the addition of each component of the MetS. Additionally, individuals with MetS had a statistically higher usage and cost for health care services than those without (Bourdreau et al., 2009). The average annual cost in the US for those with MetS was 1.6 greater than those not having the syndrome (Bourdreau et al., 2009).

Looking at several of the individual components of MetS or related problems, we can get a better understanding of the global costs. Gaziano, Bitton, Anand, Weinstein and the

International Society of Hypertension (2009) found that globally the direct cost of hypertension in 2001 was $370 billion. They further estimated that over a 10-year period this amount could rise to $1.0 trillion and with the addition of all indirect costs adding up to a whopping $3.6 trillion (Gaziano et al., 2009). Though not specifically abdominal obesity, the global economic cost for caring for all types of obesity is an incredible $2.0 trillion (Dobbs et al., 2014). According to the IDF (2013), global spending to treat and manage diabetes in 2013 was $548 billion and this figure is expected to rise to over $627 billion by 2035. Prediabetes or elevated fasting glucose levels, a component of MetS, comes to a cost of $44 billion in the US alone, according to a press release from the American Diabetes Association (Trimble, 2014). These figures represent a considerable economic cost for MetS.

The increased health risk factors, the existing health problems and the financial burden of MetS cry out for a solution for this public health problem. According to conference participants from the National Heart, Lung, and Blood Institute/American Heart Association Conference of 2004, "therapeutic lifestyle change, with emphasis on weight reduction, constitutes first-line therapy for metabolic syndrome" (Grundy et al., 2004, p. 438). The NIH is in agreement with this and states that aggressive lifestyle changes include weight loss, dietary improvement, physical activity and smoking cessation (NIH, 2011). If lifestyle changes are insufficient, medicines may be prescribed to control one or more of the different components of MetS (NIH, 2011). However, lifestyle changes are both cost-effective and relatively simple to perform. Unfortunately, according to Zivkovic, German and Sanyal (2007) there is no consensus as to the best diet or lifestyle approach to prevent or treat MetS and further study needs to be done.

One dietary approach that presents several promising aspects for MetS is a whole-food, plant-based diet. This type of diet emphasizes eating unrefined plant foods such as fruits, vegetables, legumes, seeds and nuts, while limiting or eliminating animal products and refined, processed foods (Tuso, Ismail, Ha & Bartolotto, 2013). This type of diet can be found in a well-balanced vegetarian or vegan diet.

Well-balanced vegetarian diets provide high quality nutrition while being low in energy (Clarys et al, 2014; Turner-McGrievy & Harris, 2014) and they tend to have a high level of satiety similar to that of animal origin (Neacsu, Fyfe, Horgan & Johnstone, 2014). Additionally, Lea, Crawford and Worsley (2006) found that the perceived barriers to eating a plant-based diet were low. These features make adoption and sustainability of this type of dietary easier and suitable to be used in interventions for MetS.

Therefore the purpose of this study to determine the effect of a short lifestyle intervention composed of a total vegetarian diet and physical activity on MetS risk factors within the Norwegian, Scandinavian population.

Materials and Methods

Subjects

Data were obtained by reviewing medical records of adults (21 years and older) who were guests at the Fredheim Health Center, Kongsberg, Norway for 7 - 14 days between August 1, 2013 and July 31, 2014.

Both the ATP III and IDF criteria were used to identify subjects with metabolic syndrome. As waist circumference was not available, body mass index (BMI) was used to categorize subjects as obese. They were categorized as having MetS if they had ≥3 criteria as defined by the ATP III and if they had a BMI of ≥30 and 2 additional criteria as defined by IDF. There were too few subjects that qualified as having MetS (n=6 baseline) to use only those as the basis of this study, so we looked at the individual markers of MetS in all 154 subjects.

Body weight; BMI; blood pressure; and serum HDL-C, triglycerides, total cholesterol, and LDL-C concentrations were recorded at the beginning and end of the intervention. For many subjects, there were variations in the length of time between these measurements, so all measurements that were <7 days and >14 days between baseline and postintervention were excluded from the analysis.

BMI was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Laboratory measurements were taken in the morning, before breakfast and processed at Fürst Medisinsk Laboratorium, Oslo, Norway. Height and weight were taken in light clothing without shoes.

The Institutional Review Board for Andrews University approved this study protocol.

Treatment Intervention

The program at the Fredheim Health Center is a 12-day intervention, however, participation varied from between 4 to 48 days. The majority of participants were present between 7 – 14 days and these are the ones that are part of this study. A total vegetarian diet (vegan) consisting of vegetables, fruits, whole grains, nuts and seeds was provided, with an emphasis on whole, raw foods (sprouts). Though no specific macronutrient percentages are available for this diet, a similar dietary used in another intervention consisted of about 60% of energy from carbohydrates, 15% from protein and 25% from fat (Kahleova et al., 2011). There was a moderate use of olive oil and nuts in the food prepared. Olive oil and ground seeds were provided at every meal for subjects to use as desired. All foods were served ad libitum. In addition to three meals a day, green drinks (consisting of wheat grass juice, sunflower sprouts, cucumbers, broccoli and other green vegetables) were offered.

Arranged walk/hikes or cross-country ski trips (depending on the time of year) for between 1 – 1.5 hours were arranged 6 days per week where the participants were often divided into two groups (a faster and slower group). Morning gymnastics for 30 minutes were arranged 5 days a week and an afternoon chair gymnastics of 30 minutes for 2 days a week. Additionally participants were encouraged to walk after every meal. All exercise was encouraged as much as possible, but was not regulated.

Additionally, health lectures, cooking classes, massage and counseling options, for those with emotional stress, were available.

Statistical Analysis

The Student *t* test for paired samples was used to analyze the effect of treatment on the selected markers of MetS. A Pearson correlation between the changes in body weight and blood lipids and blood pressure was performed. Statistical analysis was performed using SPSS 23 for Mac software (SPSS Inc., Chicago, IL, USA). A *P* value of less than 0.05 was considered statistically significant.

Results

Out of a total of 277 medical records for this period, only 156 (45 male and 109 female) had blood lipid testing at both baseline and postintervention. Out of those, two were excluded as the subjects were under age (<21 years). The total number of medical records included in this study is 154. The age range was from 24 – 94 with the mean age being 64.4±13.2 years.

Though no blood values were available for glucose levels, the remaining MetS markers were evaluated. Six individuals qualified as having metabolic syndrome at baseline and only two postintervention according to both the ATP III and the IDF (based on MetS markers without measurements for glucose). More subjects may had classified as having MetS had the glucose measurements been available.

The effect of the Fredheim Health Center intervention on metabolic CVD risk factors is shown in Table 1. A BMI of 28.4±5.4 at baseline indicate that on average these subjects were overweight. The decrease in weight in the subjects was 2.8%±1.8%. Their BMI, as well, decreased by 2.8%±2.8%.

All measured risk factors except HDL cholesterol improved significantly postintervention. Systolic blood pressure decreased by 7.5% and diastolic by 6.9%. Total cholesterol decreased by 15.2%, LDL cholesterol by 14.5%, and trigyclerides by 16%. HDL cholesterol decreased by 12%. The HDL/Total Cholesterol ratio improved by 4.1%. A Pearson correlations between the changes in body weight and blood lipids and blood pressure showed only that blood pressure was significantly related to weight change, ($r = .20$, $p = 0.05$)

Discussion

MetS has become a worldwide problem with prevalence rates of up to 84% in some countries (as cited by Kaur, 2014). It presents serious health risk problems (IDF, 2014; Grundy et al, 2004) and carries considerable economic costs (Bourdreau et al., 2009). Diet and lifestyle changes are the chosen treatment plan (Gurndy et al., 2004, NIH, 2011), but there is not a unity as to which diet or lifestyle presents the best results (Zivkovic, German and Sanyal, 2007). Previous studies have shown positive results with the use of a short-term plant-based diet and exercise for MetS markers (Macknin et al., 2014; Balliett & Burke, 2013; Chen, Roberts & Barnard, 2006; Sullivan & Klein, 2006). Therefore the purpose of this study was to determine the effectiveness of a short lifestyle intervention composed of a total vegetarian diet and physical activity on MetS risk factors within the Norwegian, Scandinavian population.

This short intervention (7 – 14 days) improved most of MetS CVD markers (BMI, blood pressure, and serum triglyceride, total cholesterol and LDL-C concentrations), and though a small number (n=6), two-thirds (n=4) of the subjects that were classified as having MetS at baseline no longer met that classification postintervention. These data are similar to previous studies investigating MetS in adults (Sullivan and Klein, 2006) and children (Chen, Roberts & Barnard, 2006).

However, the intervention caused a significant decrease in HDL cholesterol. Our results with HDL cholesterol are similar to other plant-based programs (Razavi et al., 2014; Macknin et al., 2014; Sullivan & Klein, 2006). Vegan diets in general are typically associated with lower levels of HDL (Macknin et al., 2014) and some even argues the validity of using HDL as a risk factor for MetS when using plant-based diets, as these diets improve other CVD risk factors while lowering the HDL (Kent et al., 2013). However, another study saw HDL levels drop in participants on both a plant-based diet and the American Heart Association diet, though more so on the plant-based diet (Macknin et al., 2014). This drop is likely associated with early weight loss (Macknin et al., 2014; Sullivan and Klein, 2006). It is interesting to see that HDL levels can be increased on a vegetarian diet by the introduction of exercise, but this was seen during a 24 week intervention where the first 12 weeks didn't contain an exercise component (Kahleova et al., 2011). The absence of an increase in HDL in our study maybe due to the exercise not being regulated in this intervention or due to the shortness of the intervention.

In spite of the increase in HDL, these data demonstrate that a short intervention with a total vegetarian diet and physical activity program can positively impact the CVD markers of MetS.

The total vegetarian diet probably contributes to the favorable outcomes seen in this study. Previous studies have shown that vegetarian diets positively impact several of the components of MetS. It is effective for weight loss regardless of exercise (Berkow & Barnard, 2006) and vegetarians tend to have a lower BMI than omnivores as adults (Fraser, 2003; Rosell, Appleby, Spencer & Key, 2006) and as children (Sabaté & Wien, 2010). Vegetarians also have a lower risk of fatal heart disease (Fraser, 2003) and vegetarian diets are associated with lower systolic and diastolic blood pressure (Agriculture Research Service, 2010).

The specific components of this intervention may have been the reason for the beneficial results. In general, vegetarian diets that are high in dietary fiber and fruit and vegetable intake, while low in saturated fat have been shown to reduce the risk of developing MetS in the first place (Turner-McGrievy & Harris, 2014). Vegetarian diets tend to cause weight loss (Berkow & Barnar, 2006) and weight loss can cause a reduction in blood pressure, LDL cholesterol and triglycerides (Sullivan & Klein, 2006). A high fiber, unrefined carbohydrate diet and regular physical activity, as this intervention has, have been seen to improve triglyceride levels (Chen, Roberts & Barnard, 2006). A total vegetarian diet, as presented in this intervention, is low in saturated fat. Diets that are high in saturated fats are associated with an increased risk of MetS in some studies (Riccardi, Giacco, & Rivellese, 2004; Vessby, 2003). Exercise can also decrease triglycerides and blood pressure (Sullivan & Klein, 2006).

What is interesting to note in this study is that we have a total vegetarian diet where fat intake is not limited in contrast to many studies looking at MetS risk factors where there is little or no added fat used (Ornish et al. 1998; Esselstyn, Gendy, Doyle, Golubic & Roizen, 2014; Razavi et al., 2014; Macknin et al, 2014; Barnard et al., 2006; Chen, Roberts & Barnard, 2006; Sullivan & Klein, 2006). When comparing studies that are similar in length, we see that there are differences in percentage of decrease of CVD risk factors (Chen, Roberts & Barnard, 2006; Sullivan & Klein). See Table 2. Weight loss was less compared to both Chen et al. (2006) and Sullivan and Klein (2006). There was not as great a change in blood pressure and triglycerides compared to both Chen et al. (2006) and Sullivan and Klein (2006). However, LDL cholesterol and total cholesterol are mixed. The decrease in HDL cholesterol was much greater in this study than either Chen et al. (2006) or Sullivan and Klein (2006). However, significant changes are still seen on a higher fat diet, which may be easier to maintain long-term due to its high palatability and satiety (Mayneris-Perxachs et al., 2014). A previous study found that a Mediterranean diet with the use of olive oil and nuts produced fatty acid compositions that are favorable when looking at MetS (Mayneris-Perxachs et al., 2014). Further studies could be done to compare a low-fat plant-based diet with a moderate-fat plant based diet to see the effect on the markers of MetS.

There are several limitations with this study. This is a retrospective observational study and not a clinical trial. So these results warrant further studies in a clinical trial setting. Additionally, very few subjects in our study actually qualified as having MetS, therefore the results may not be able to be generalized to populations with MetS. Larger samples with MetS are needed to further see the effectiveness of this program. Furthermore, subjects attending Fredheim Health Center may not be representative of other patients with MetS. As they must pay to attend this health center in a country that has socialized medicine, they would tend to be more highly motivated and interested in their health than the general population. Finally, this was a short-term intervention, between 7 to 14 days. In this short amount of time, it is not possible to predict of long-term outcomes. Further studies need to see if this type of intervention is sustainable over longer periods of time.

Conclusions

The results of this study show that significant changes can be made in MetS markers as a result of a short-term total vegetarian diet and exercise intervention, such as Fredheim Health Center offers. Sixty-six percent of individuals in this program that presented themselves with MetS at baseline experienced remission in two weeks. Therefore, this is a very promising program for

MetS. Additionally, this study shows that these results can be achieved with a diet that includes moderate amounts of olive oil, nuts and seeds.

Competing Interests

The author has nothing to declare.

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Tables

Table 1

Anthropometric and metabolic measures in subjects undergoing a short-term diet and exercise intervention

Risk factor	Preintervention	Postintervention	Pre-post difference	*P* value	% Decrease
Body Weight (kg) (n=102)	82.6±17.1	80.3±16.3	2.3±1.5 95% CI 2.02 – 2.58	<0.001	2.8%
BMI (kg/m^2) (n=82)	28.4±5.4	27.6±5.2	0.8±0.5 95% CI 0.71 – 0.92	<0.001	2.8%
Systolic BP, mm Hg (n=120)	139.6±20.6	129.2±17.0	10.5±15.2 95% CI 7.7 – 13.2	<0.001	7.5%
Diastolic BP, mm Hg (n=120)	82.5±9.7	76.8	5.7±8.0 95% CI 7.2 – 7.1	<0.001	6.9%
Triglyceride (mmol/L) (n=140)	1.50±0.73	1.25±0.47	0.24±0.60 95% CI 0.14 – 0.34	<0.001	16.0%
HDL cholesterol (mmol/L) (n=140)	1.50±0.42	1.32±0.37	0.18±0.19 95% CI 0.15 – 0.21	<0.001	12.0%
LDL cholesterol (mmol/L) (n=140)	3.30±0.85	2.81±0.74	0.48±0.46 95% CI 0.40 – 0.56	<0.001	14.5%
Total cholesterol (mmol/L) (n=140)	5.54±0.87	4.70±0.87	0.84±0.60 95% CI 0.74 – 0.94	<0.001	15.2%
Total/HDL cholesterol ratio (n=140)	3.89±1.02	3.73±0.91	0.16±0.53 95% CI 0.07 – 0.26	<0.001	4.1%

Table 2

Comparison between studies of percentage of Decrease in Measurements

Risk factor	Nybo-Jakobsen (2015)	Chen, Roberts & Barnard (2006)	Sullivan & Klein (2006)
Body Weight	2.8%	4.3%	3%
BMI	2.8%	4.3%	3.4%
Systolic BP	7.5%	10.4%	14.9%
Diastolic BP	6.9%	10.6%	8.9%
Triglyceride	16.0%	39.5%	35.9%
HDL cholesterol	12.0%	3.4%	3.3%
LDL cholesterol	14.5%	25.3%	10.9%
Total cholesterol	15.2%	23.3%	14.7%

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