Lifestyle Modification in the Management of Metabolic Syndrome: Statement From Korean Society of CardioMetabolic Syndrome (KSCMS)

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Author's Summary

Metabolic syndrome (MetS) is highly prevalent and is associated with worse cardiovascular outcome. Lifestyle modification is the most effective way to reduce the incidence of cardiovascular complications caused by MetS. Here, we would like to review the effects and specific methods of the 6 lifestyle modifications (weight control, smoking cessation, alcohol drinking in moderation, diet control, exercise and physical activity, and cognitive behavioral therapy) and control of blood pressure, dyslipidemia, and blood sugar based on evidence in the management of MetS.

Abstract

With the recent rapid increase in obesity worldwide, metabolic syndrome (MetS) has gained significant importance. MetS is a cluster of obesity-related cardiovascular risk factors including abdominal obesity, atherogenic dyslipidemia, high blood pressure and impaired glucose tolerance. MetS is highly prevalent and strongly associated with an increased risk of developing diabetes and cardiovascular disease, putting a great burden on human society. Therefore, it is very important to reduce MetS risk, which can improve patients’
cardiovascular prognosis. The primary and most effective strategy to control each component of MetS is lifestyle change such as losing body weight, keeping regular exercise, adopting a healthy diet, quitting smoking and alcohol drinking in moderation. Many studies have shown that lifestyle modification has improved all components of MetS, and reduces the incidence of diabetes and cardiovascular disease. Here, the Korean Society of CardioMetabolic Syndrome has summarized specific and practical methods of lifestyle modification in the management of MetS in the healthcare field.

**Keywords:** Alcohol intake; Diet; Exercise; Lifestyle; Metabolic syndrome; Smoking

### INTRODUCTION

Metabolic syndrome (MetS) is a clinical condition characterized by a clustering of obesity-associated cardiovascular risk factors including abdominal obesity, hypertriglyceridemia, decreased high-density lipoprotein (HDL) cholesterol, high blood pressure, and/or impaired glucose tolerance (Table 1 and Figure 1). Recognizing and understanding MetS is clinically important because of its high prevalence and potential harmful effects on the cardiovascular system. As the prevalence of obesity gradually increases, the number of patients with MetS is increasing worldwide. National Health and Nutrition Examination Survey (NHANES) data showed that the overall prevalence of MetS in the United States increased from 32.5% in 2011–2012 to 36.9% in 2015–2016. According to the data analyzing the Korean National Health and Nutrition Examination Survey (KNHANES), the overall age-standardized prevalence of MetS slightly increased from 21.6% in 2007 to 22.9% in 2018 in South Korea. In subjects in their 60s, the prevalence of MetS gradually decreased from 47.5% in 2007 to 41% in 2018, but in

| Table 1. Diagnostic criteria of metabolic syndrome suggested by Korean Society of CardioMetabolic Syndrome |
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| Risk factor | Defining level |
| Central obesity | Waist circumference |
| Men ≥90 cm |
| Women ≥85 cm |
| Triglyceride | ≥150 mg/dL |
| High-density lipoprotein cholesterol | Men <40 mg/dL |
| Women <50 mg/dL |
| Blood pressure | ≥130/88 mmHg or taking antihypertensive drugs |
| Fasting glucose | ≥110 mg/dL or taking antidiabetic drugs |

Metabolic syndrome is defined as having 3 or more of the 5 risk factors shown in Table 1.

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**Figure 1.** Risk factors for MetS. MetS = metabolic syndrome.

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men in their 30s (from 19% to 24.7%) and 40s (from 25.2% to 36.9%), the prevalence of MetS has increased rapidly over the past 12 years. As each component of MetS is a risk factor for cardiovascular disease, it is obvious that the combination of these risk factors substantially augments cardiovascular risk. Many clinical studies have shown that MetS is associated with the risk of developing diabetes mellitus, cardiovascular disease and mortality. Therefore, efforts should always be made to prevent the occurrence of cardiovascular complications related to MetS. Lifestyle modification is the most important and effective strategy to manage the MetS, improving cardiovascular prognosis. In this review, we address specific lifestyle modification for each risk factor in the management of MetS.

WEIGHT CONTROL

Abdominal obesity is associated with systemic inflammation, insulin resistance, and increased cardiovascular risk. It is the main diagnostic criterion for MetS. According to the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III), abdominal obesity was defined as a waist circumference ≥102 cm in men and ≥88 cm in women. In Korea, waist circumference ≥90 cm in men and ≥85 cm in women are used as diagnostic criteria for MetS.

Increased body weight is associated with MetS prevalence and incidence. According to the NHANES III, MetS was present in 5% of subjects with normal weight, 22% of those who were overweight, and 60% of those who were obese. In the Framingham Heart Study cohort, the weight increase by 2.25 kg or more over 16 years was associated with a 21% to 45% increase in the risk of developing MetS. A large waist circumference alone predicts up to 46% of individuals who will develop MetS within 5 years. The prevalence of rapidly increasing obesity among adults will lead to higher rates of MetS in the near future. Therefore, the importance of preventing obesity and improving physical activity should be emphasized. The key management strategies for MetS are aggressive lifestyle modification and increased physical activity focused on weight reduction. A 15-year follow-up study showed that young adults who maintained stable body weight had minimal progression of risk factors and lower MetS incidence. On the other hand, individuals with increased body mass index during the follow-up period had a higher incidence of impaired glucose tolerance and diabetes mellitus than those with stable or decreased body mass index. A moderate decrease in weight induced by a very low calorie diet resulted in substantial reductions in systolic/diastolic blood pressure, glucose, triglycerides and total cholesterol at 4 weeks. Also, a greater weight loss, as achieved by lifestyle modification, was associated with a greater reduction in the prevalence of MetS. Because sustained weight loss can improve all elements of the MetS, it not only reduces the risk of developing MetS, but also the reverse of the metabolic complications related to the MetS. It has been suggested that the effect of weight loss on reducing the risk of developing MetS was more effective with lifestyle therapy than with diet pills. Therefore, it is more important to maintain an appropriate body weight through lifestyle modifications such as exercise and diet control rather than through taking weight-loss medications. A realistic goal for weight reduction is to reduce body weight by ~7% to 10% over a period of 6 to 12 months.
SMOKING CESSION

The smoking rate of men in Korea is the highest among major Organization for Economic Cooperation and Development (OECD) countries. Various toxic substances, such as nicotine, carbon monoxide and oxidizing gas from cigarette, cause abnormalities in lipoprotein metabolism, endothelial cell dysfunction and insulin resistance, which increase the risk of MetS. Nicotine stimulates the release of adrenaline, which increases blood pressure and heart rate. It has been suggested that nicotine induces lipolysis in adipose tissue, increases triglyceride, and low-density lipoprotein (LDL) cholesterol, and decrease HDL cholesterol in the blood. Insulin resistance by smoking alters the distribution of body fat and exacerbates central obesity. Smokers generally drink too much and do not exercise well, and thus these poor lifestyle habits further increase the risk of MetS. According to a meta-analysis of 56,691 people from 13 studies, smoking increased the risk of MetS by 1.26 times. The risk of MetS due to smoking increases in proportion to the amount of smoking. Smoking cessation reduces the risk of developing MetS, cardiovascular disease and mortality, so smoking cessation should be emphasized. However, for some time after quitting smoking, weight gain may occur, so lifestyle modification should be implemented more thoroughly after smoking cessation. Individuals are also required to avoid second-hand smoke or e-cigarettes as they also increase the risk of MetS and cardiovascular disease. Willingness and motivation of the patient to quit smoking are very important for successful smoking cessation. In particular, since strong and clear advice from doctors is known to increase the success rate of smoking cessation, doctors should motivate patients to stop smoking. Cognitive-behavioral therapy can be effective in stopping habitual thought and behavior associated with smoking and in accepting positive thought about smoking cessation. Specific methods of cognitive behavioral therapy include: 1) specifying and avoiding smoking-provoking situations (eating, coffee or alcohol drinking, etc.), 2) notifying people around when starting smoking cessation, 3) taking action to delay smoking (taking a deep breath, drinking water, brushing teeth, taking a walk, etc.), 4) using alternatives to smoking (such as chewing gum or vegetables). After quitting smoking, moderate-intensity aerobic exercise (jogging, cycling, dancing, swimming, mountaineering, etc.) lowers stress, suppresses the desire to smoke and reduces withdrawal symptoms; therefore, it is effective in maintaining smoking cessation. Since weight gain after smoking cessation usually occurs, it is important to maintain appropriate weight through regular exercise and healthy eating habits. Avoiding fatty, sweet and high-calorie foods as well as making a habit of eating vegetables and fruits every day is helpful in smoking cessation. The guidelines proposed by the American Heart Association recommend the following smoking cessation steps: 1) collection of information about smoking conditions, 2) assessment of withdrawal symptoms or attempts to quit smoking, 3) recommendation of smoking cessation, 4) explanation on the specific methods of smoking cessation and selection of the method, and 5) thorough follow-up.

ALCOHOL DRINKING IN MODERATION

As of 2017, alcohol consumption per person in Korea was 8.7 liters, which is similar to the OCED average. Among risk factors related to MetS, light to moderate drinking has been demonstrated to reduce cardiovascular disease, diabetes and mortality. However, blood pressure rises and blood triglyceride level increases in proportion to the amount of alcohol consumption. Therefore, guidelines for drinking behavior are needed. The
amount of alcohol consumption per person is steadily increasing in Korea. A J-shaped association between the amount of alcohol drinking and MetS risk has been reported: compared with nondrinking, light or moderate drinking was associated with decreased risk of MetS, while heavy drinking was associated with increased risk of MetS. In addition, blood pressure and alcohol intake are generally known to have a linear relationship between them, but it is reported that drinking less than 3 glasses a day lowers blood pressure. Lipid profile and alcohol intake are also non-linear and have a relationship between U- and J-types. Moderate drinking is known to improve insulin sensitivity, and reduce the risk of diabetes. On the other hand, a large amount of alcohol does not affect the development of diabetes, so diabetes also has a J-type association with alcohol consumption. According to a study that analyzed 7,962 subjects using data from the KNHNES, drinking less than 15 g per day lowered the risk of MetS in men by 29% in men and by 20% in women. However, drinking 30 g or more per day increased the risk of high blood pressure (blood pressure >130/80 mmHg) and hypertriglyceridemia (triglyceride >150 mg/ dL) by 20–30%. According to a recent meta-analysis, drinking less than 5 g per day reduced the risk of MetS by 14%, whereas drinking more than 35 g per day increased the risk of MetS by 1.8 times. Collectively, light to moderate alcohol consumption has a beneficial effect on MetS components as well as on MetS. The World Health Organization (WHO) recommends limiting alcohol consumption to less than 40 g per day for men and 20 g per day for women. Reflecting this in Korea, it is recommended to limit intake to less than 4 glasses of soju for men a day and 2 glasses of soju a day for women.

**DIET CONTROL**

The goal of MetS prevention and treatment is to reduce cardio-cerebrovascular disease and death. Among various prevention strategies, a proper diet plays a crucial role. The type and total amount of fat intake are important. There exists a good correlation between blood lipid concentration and the progression of arteriosclerosis. The consumption of saturated fat in Korea is gradually increasing due to the Westernization of lifestyle. The risk of cardiovascular disease decreases when saturated fatty acids are replaced with polyunsaturated fatty acids. Trans-fat is mainly found in breads, sweets, and processed foods such as milk and meat. Trans-fat increases total cholesterol and decreases HDL cholesterol. It is also known that eating more than 2% of total calories in trans-fat increases the risk of cardiovascular disease by 23%. Therefore, it is recommended to consume unsaturated fatty acids, and minimize trans-fat intake. Carbohydrate is converted to glucose in the body and used as an energy source, but after excessive consumption, it is converted to fat, which increases triglycerides and reduces HDL cholesterol. In particular, it was reported that Koreans consume more carbohydrate and have a stronger association with MetS than in do Westerners. Therefore, patients with MetS should reduce carbohydrate intake. Koreans consume 2- to 3-fold amount of salt recommended by the WHO. Excessive intake of sodium increases body fluid content along with blood pressure. A low sodium diet may lower blood pressure. Although vitamin intake is believed to slow vascular aging through its anti-oxidative effect, there have been few studies confirming the preventive effect of cardiovascular disease through vitamin intake. Dietary fibers are not digested and absorbed by the body; however, they can absorb various ingested substances thus can improve hyperlipidemia and prevent constipation. However, excessive fiber consumption can interfere with nutrient absorption. The Dietary Approaches to Stop Hypertension (DASH)
diet is one developed by doctors and nutritionists to control the diet of hypertensive patients with the aim of eating various nutrients in a balanced manner. It consists of fresh vegetables, fruits, low-fat dairy products, brown rice, whole grains, fish, and lean chicken, which can significantly lower systolic blood pressure.\(^{73}\)

**EXERCISE AND PHYSICAL ACTIVITY**

Exercise is essential for weight loss along with diet control.\(^ {74}\) In addition, exercise has the effect of lowering the risk of cardiovascular disease and increasing life expectancy.\(^ {75}\) It is clear that there is an inverse correlation between the total amount of moderate-intensity exercise and the incidence or mortality of cardiovascular disease, and these effects become more apparent as the amount of exercise increases.\(^ {77}\) It is recommended that at least 150 minutes of moderate intensity exercise (fast walking, biking at least 8 kilometers per hour, active yoga, light swimming, etc.) or more than 75 minutes of high intensity exercise (jogging, running, cycling at least 15 kilometers per hour, tennis, intensive swimming, etc.) every week for the prevention of cardiovascular disease.\(^ {77}\) There is also a negative dose-response relationship between physical activity and the prevalence of MetS.\(^ {76}\) Exercise and increased physical activity not only decrease waist circumference, blood pressure, and body fat mass, but also improve insulin resistance and lipid profiles.\(^ {78}\) For the primary prevention of obesity, about 150–250 minutes of moderate intensity exercise per week, along with an energy equivalent of 1,200 to 2,000 kcal per week, can help prevent weight gain.\(^ {81}\) The recommended amounts of physical activity to promote clinically significant weight loss and to prevent weight gain after successful weight loss is 225–420 minutes and 200–300 minutes per week, respectively.\(^ {82}\) Both aerobic and strength exercise are important. Aerobic exercise clearly reduces the risk of cardiovascular disease,\(^ {75}\) and resistance exercise not only improves physical function, but also reduces blood glucose and blood pressure. Although resistance exercise alone contributes to body fat loss, the effect on overall weight loss is minimal.\(^ {83}\) It has been suggested that combined aerobic and resistance exercise is more effective in controlling blood glucose than aerobic or resistance alone.\(^ {84}\) Since exercise alone is less effective in losing weight, it is necessary to combine with an appropriate calorie restriction diet.\(^ {85}\) Regular exercise also plays a crucial role in maintaining weight after weight loss.\(^ {86}\) The sedentary lifestyle is prevalent in modern society. Energy consumption in this lifestyle is only 1.5 times higher than that during rest (energy consumption during exercise is 10 to 20 times higher than during rest). It has been demonstrated in many studies that this sedentary lifestyle is a major cause of MetS, cardiovascular disease or diabetes. Therefore, it is very important to increase the amount of physical activity and reduce the amount of time sitting in everyday life.\(^ {75}\)

**COGNITIVE BEHAVIORAL THERAPY**

The behavior pattern that lasts over a long period of time since childhood is likely to persist even into adulthood. These environmental factors interact with genetic factors to form a lifestyle. In addition, exposure to wrong medical common sense through the advice of non-medical professionals can lead to an improper lifestyle. Therefore, the role of primary healthcare providers who can continuously manage patients is more emphasized in cognitive behavioral therapy to prevent MetS. Medical professionals should build positive relationships with patients consistent in their attitude to behaviors. When patients’ medical condition, life
environment, knowledge level, experience and interests over a long period of time are widely understood, motivation for appropriate counseling and desirable behaviors tailored to each patient can be successfully achieved and sustained. It has been suggested that motivational interviewing with doctors is very effective in inducing smoking cessation. In addition, if decision-making is shared not only with the patient but also with the neighboring family, this can lead to more continuous and consistent changes. Since it is not easy to correct a wrong lifestyle that the patient has maintained for a long time, clinicians should ask whether they are able to follow the decision-making. Moreover, if positive changes are seen, clinicians encourage them to maintain and reinforce those behavioral changes. However, since it is necessary to maintain the lifestyle and behaviors that the patient judges to be correct, it is most important to help control and monitor them by themselves. Through these positive interactions, the patient must eventually set long-term goals for himself, and based on confidence through changed behaviors, he/she must be able to set new improved goals.

**BLOOD PRESSURE CONTROL**

Hypertension is one of the most important diseases that threaten global human health. According to the factsheet of hypertension published by the Korean Society of Hypertension in 2020, the prevalence of hypertension among Koreans aged >20 years is up to 29%, and 61.6% of hypertensive patients have diabetes or dyslipidemia as well. According to Korean data, among the components of MetS, hypertension is the most important factor, which is observed in 39.9% of men with MetS, and in 25.4% of women with MetS followed by low HDL cholesterol. To prevent the occurrence of atherosclerotic cardiovascular disease in patients with MetS, management of high blood pressure is essential. The priority treatment for blood pressure control is lifestyle modifications including salt restriction, diet, weight loss, exercise, smoking cessation, and reducing alcohol consumption. The salt intake of Koreans is higher than the recommended amount of the WHO. Reducing salt intake to less than 5 g/day is effective in lowering blood pressure. According to a recent meta-analysis, reducing salt intake by 4.4 g per day had an average blood pressure lowering effect of 5.4/2.8 mmHg in hypertensive patients. The DASH diet is recommended for blood pressure control. It can reduce salt intake, and promotes the consumption of vegetables, fruits, lean meats, whole grains such as whole wheat, brown rice and the inclusion of micronutrients in the menu. The DASH diet has been proven to have a substantial blood pressure-lowering effects. It was reported that the group that maintained the DASH diet showed a blood pressure lowering effect of 11.4/5.5 mmHg during the 8-week observation period. Overweight is also an important causative factor of hypertension, and it is known that a loss of 1 kg in body weight has a blood pressure-lowering effect of about 1 mmHg. Since Koreans have a higher incidence of abdominal obesity than Westerners, it is recommended to keep waist circumference below 90 cm for men and 85 cm for women along with low body mass index. Exercise lowers blood pressure as well as reduces body weight and blood sugar/cholesterol, thereby decreasing the occurrence of cardiovascular diseases and death. A meta-analysis has demonstrated that an average weight loss of 5.1 kg has a blood pressure-lowering effect of about 4.5/3.6 mmHg, which can be explained by a 1 mmHg drop in blood pressure when 1 kg of body weight is lost. The Korean Society of Hypertension recommends performing aerobic exercise 5 to 7 times a week, 30 minutes or more at a time to lower blood pressure, and the aerobic exercise includes breaking walk, jogging, cycling, swimming, jumping rope, and aerobic gymnastics. Smoking raises blood pressure through sympathetic hyperactivity, so it is recommended to quit smoking. Excessive drinking is associated with an increase in blood pressure or
cardiovascular disease, so it is recommended to reduce alcohol consumption to less than 40 g per day for men and 20 g per day for women.\textsuperscript{63}

**DYSLIPIDEMIA CONTROL**

To achieve satisfactory therapeutic outcomes in patients with dyslipidemia, non-pharmacologic interventions, such as diet, exercise, limited consumption of alcohol, and smoking cessation, should be the first-line therapy.\textsuperscript{100-102} The Korean dietary pattern is typically a high-carbohydrate and low-fat diet. High-carbohydrate diet intake is associated with increased risk of hypertriglyceridemia and hypo-HDL cholesterolemia.\textsuperscript{66,67} Therefore, total carbohydrate intake should not exceed 65% of total energy, and sugar intake should be reduced below 10–20%.\textsuperscript{60} It is recommended to consume energy at a level to maintain appropriate weight and to reduce total fat intake below 30% of total energy.\textsuperscript{102} Saturated fatty acid is a dietary factor that has the most significant effect on serum LDL cholesterol levels. A 1% increase in the proportion of saturated fatty acids in total energy intake has been reported to increase LDL cholesterol levels by 0.8–1.6 mg/dL.\textsuperscript{103} Thus, it is recommended to keep saturated fatty acids <10% of total energy and should be further reduced (<7% of energy) in the presence of hypercholesterolemia.\textsuperscript{101} The evidence relevant for the intake of unsaturated fatty acids in dyslipidemia is not yet sufficient, but LDL cholesterol levels decrease when saturated fatty acids are replaced with monounsaturated fatty acids or omega-6 polyunsaturated fatty acids.\textsuperscript{102} Trans-fat intake is associated with increased LDL:HDL cholesterol ratio and cardiovascular risk.\textsuperscript{65} Hence, it is advisable to avoid trans-fat intake. A daily fiber intake of 25 g or more is recommended since dietary intake of fibers can reduce the risk of cardiovascular disease by decreasing blood glucose and LDL cholesterol levels.\textsuperscript{72,104} Alcohol consumption can increase serum triglycerides by reducing the activity of lipoproteinase, so alcohol is limited to 1–2 glass a day in hypertriglyceridemic patients.\textsuperscript{102,105,106} In patients with dyslipidemia, it is recommended to increase physical activity and perform moderate-intensity aerobic exercise regularly 4–6 times a week for at least 30 minutes.\textsuperscript{102,107} Resistance exercise is recommended to be performed at least twice a week.\textsuperscript{108} In general, it is known that the effect of exercise or weight loss to control dyslipidemia is not better than in hypertension or diabetes.\textsuperscript{101} Smoking causes abnormalities in reverse cholesterol transport and increases free fatty acids in the blood by promoting fatty acid breakdown,\textsuperscript{109} which results in increases in total and LDL cholesterol and triglyceride and decreases in HDL cholesterol.\textsuperscript{110} As a significant risk factor for cardiovascular disease, smoking cessation is strongly recommended in patients with dyslipidemia.\textsuperscript{102} Quitting smoking provides many benefits especially in terms of increasing HDL cholesterol and reducing cardiovascular risk.\textsuperscript{111}

**BLOOD GLUCOSE CONTROL**

Patients with MetS have 2-fold higher risk of developing cardiovascular disease and 5-fold higher risk of developing type 2 diabetes.\textsuperscript{102-109} Therefore, it is important to lead a healthy lifestyle with a balanced diet. According to the United States NHANES, there was a significant relationship between physical activity and insulin sensitivity,\textsuperscript{112} and the American Heart Association (AHA) recommends regular moderate-intensity exercise at least 5 times a week and 30 minutes or more at a time.\textsuperscript{113} Increased physical activity can prevent the development of diabetes,\textsuperscript{114-115} which is more effective in preventing diabetes than an oral
hypoglycemic agent, metformin, that improve insulin sensitivity. Maintaining proper dietary habits is also crucial for preventing diabetes. Basically, it is important to reduce calorie intake, and lowering the proportion of carbohydrates among nutrients is effective in lowering plasma triglycerides, blood glucose, and visceral fat. A low-fat diet also has the effects of reducing calorie intake, which can lower blood pressure, blood cholesterol, inflammatory indices, and insulin sensitivity. High intakes of saturated and trans fatty acids increases the risk of insulin resistance and diabetes. Otherwise, consuming monounsaturated fatty acids or polyunsaturated omega-3 fatty acids helps improve abdominal obesity, insulin resistance and dyslipidemia. It is inconclusive how the daily level of protein intake affects blood glucose control; however, ingestion of protein from fish rather than meat is more helpful in improving insulin resistance and inflammation. The Mediterranean diet is known to be effective not only in lowering blood glucose, but also in controlling hypertension, dyslipidemia, and inflammation. It consists of fruits, vegetables, nuts, legumes, whole grains, and fish with a larger amount of monounsaturated fatty acids or polyunsaturated omega-3 fatty acids. The Mediterranean diet has a similar weight loss benefit, but lowers the blood levels of glucose and C-reactive protein more significantly when compared to a low-fat diet. Legumes is effective in controlling blood glucose after a meal by reducing the absorption rate of carbohydrates. There is no evidence that routine supplementation with antioxidants (vitamin C, vitamin E, carotene, etc.), herbal supplements and micronutrients (cinnamon, curcumin, vitamin D, aloe vera, chromium, etc.) improve glycemic profiles.

Dairy products, eggs and fibers have favorable effects of lowering blood sugar, so it is recommended to consume their appropriate amounts for individuals with diabetes mellitus or high blood glucose levels. Moderate alcohol intake is known to have beneficial effects on glycemic control and insulin sensitivity, but excessive drinking causes hyperglycemia and weight gain. No more than 2 drinks per day for men and no more than 1 drink per day for women is recommended in patients with diabetes.

**CONCLUSIONS**

The most fundamental and effective way to manage MetS is lifestyle modification such as smoking cessation, regular exercise and proper eating habits. Key points of lifestyle modifications are shown in Table 2. A healthy lifestyle can prevent or delay the onset of MetS in susceptible subjects. In patients with MetS, lifestyle modification improves profiles of each component of MetS, and reduces the risk of developing diabetes and cardiovascular disease.

| Table 2. Summarization of lifestyle modification methods for MetS management |
|---------------------------------------------------------------|
| **Lifestyle modification** | **Specific recommendation** |
| Weight control | Reduce body weight by ~7% to 10% over a period of 6 to 12 months through exercise and diet control. |
| Smoking cessation | Smoking cessation is strongly recommended. Exposure to second-hand smoke or e-cigarettes also should be avoided. |
| Alcohol drinking in moderation | Limit alcohol consumption to less than 4 drinks per day for men and less than 2 drinks for women. |
| Diet control | Consume unsaturated fatty acids, and minimize trans-fat intake. Reduce carbohydrate and salt intake. DASH diet is helpful in reducing blood pressure. |
| Exercise and physical activity | Regular aerobic exercise with 150–250 minutes of moderate intensity per week is recommended. Even better when strength training is combined. Avoid sedentary lifestyle. |
| Cognitive behavioral therapy | Physicians build good doctor-patient relationship to gain trust and motivate patients to follow lifestyle modification well. |

DASH = The Dietary Approaches to Stop Hypertension; MetS = metabolic syndrome.
Therefore, leading a healthy lifestyle should be emphasized for cardiometabolic health, regardless of MetS. In order to maximize benefits from lifestyle modification, it is important to change a lifestyle based on the results of many studies. We summarized practical methods for lifestyle modifications based on published data, which will help clinicians manage MetS.

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REFERENCES

1. Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. *Lancet* 2005;365:1415-28. [PUBMED | CROSSREF]
2. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the national cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). *JAMA* 2001;285:2486-97. [PUBMED | CROSSREF]
3. Nam GE, Kim YH, Han K, et al. Obesity fact sheet in Korea, 2018: data focusing on waist circumference and obesity-related comorbidities. *J Obes Metab Syndr* 2019;28:236-45. [PUBMED | CROSSREF]
4. Huh JH, Kang DR, Jang JI, et al. Metabolic syndrome epidemic among Korean adults: Korean survey of Cardiometabolic Syndrome (2018). *Atherosclerosis* 2018;277:47-52. [PUBMED | CROSSREF]
5. Saklayen MG. The global epidemic of the metabolic syndrome. *Curr Hypertens Rep* 2018;20:12. [PUBMED | CROSSREF]
6. Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. *Lancet* 2011;378:804-14. [PUBMED | CROSSREF]
7. Hirode G, Wong RJ. Trends in the Prevalence of metabolic syndrome in the United States, 2011-2016. *JAMA* 2020;323:2526-8. [PUBMED | CROSSREF]
8. Huh JH, Kim JY, Koh KK. Metabolic syndrome fact sheet 2021: executive report. *Cardiometab Syndr J* 2021;1:125-34. [CROSSREF]
9. Sperling LS, Mechanick II, Neeland II, et al. The cardiometabolic health alliance: working toward a new care model for the metabolic syndrome. *J Am Coll Cardiol* 2015;66:1050-67. [PUBMED | CROSSREF]
10. Galassi A, Reynolds K, He J. Metabolic syndrome and risk of cardiovascular disease: a meta-analysis. *Am J Med* 2006;119:812-9. [PUBMED | CROSSREF]
11. Isomaa B, Almgren P, Tuomi T, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. *Diabetes Care* 2001;24:683-9. [PUBMED | CROSSREF]
12. Lakka HM, Laaksonen DE, Lakka TA, et al. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. *JAMA* 2002;288:2709-16. [PUBMED | CROSSREF]
13. Malik S, Wong ND, Franklin SS, et al. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. *Circulation* 2004;110:1245-50. [PUBMED | CROSSREF]
14. Del Brutto OH, Zambrano M, Peñaherrera E, Montalván M, Pow-Chon-Long F, Tettamanti D. Prevalence of the metabolic syndrome and its correlation with the cardiovascular health status in stroke- and ischemic heart disease-free Ecuadorian natives/mestizos aged ≥40 years living in Atahualpa: a population-based study. *Diabetes Metab Syndr* 2013;7:218-22.

15. Dragsbæk K, Neergaard JS, Laursen JM, et al. Metabolic syndrome and subsequent risk of type 2 diabetes and cardiovascular disease in elderly women: challenging the current definition. *Medicine (Baltimore)* 2016;95:e4806.

16. Guembe MJ, Fernandez-Lazaro CI, Sayon-Orea C, Toledo E, Moreno-Iribas C; RIVANA Study Investigators. Risk for cardiovascular disease associated with metabolic syndrome and its components: a 13-year prospective study in the RIVANA cohort. *Cardiovasc Diabetol* 2020;19:195.

17. Hanson RL, Imperatore G, Bennett PH, Knowler WC. Components of the “metabolic syndrome” and incidence of type 2 diabetes. *Diabetes* 2002;51:3120-7.

18. Laaksonen DE, Lakka HM, Niskanen LK, Kaplan GA, Salonen JT, Lakka TA. Metabolic syndrome and development of diabetes mellitus: application and validation of recently suggested definitions of the metabolic syndrome in a prospective cohort study. *Am J Epidemiol* 2002;156:1070-7.

19. Mottillo S, Filion KB, Génést J, et al. The metabolic syndrome and cardiovascular risk: a systematic review and meta-analysis. *J Am Coll Cardiol* 2010;56:1113-32.

20. Despres JP, Lemieux I, Bergeron J, et al. Abdominal obesity and the metabolic syndrome: contribution to global cardiometabolic risk. *Arterioscler Thromb Vasc Biol* 2008;28:1039-49.

21. Park YW, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988-1994. *Arch Intern Med* 2003;163:427-36.

22. Wilson PW, Kannel WB, Silbershatz H, D'Agostino RB. Clustering of metabolic factors and coronary heart disease. *Arch Intern Med* 1999;159:1104-9.

23. Palaniappan L, Carnethon MR, Wang Y, et al. Predictors of the incident metabolic syndrome in adults: the Insulin Resistance Atherosclerosis Study. *Diabetes Care* 2004;27:788-93.

24. Lloyd-Jones DM, Liu K, Colangelo LA, et al. Consistently stable or decreased body mass index in young adulthood and longitudinal changes in metabolic syndrome components: the Coronary Artery Risk Development in Young Adults Study. *Circulation* 2007;115:1004-11.

25. Case CC, Jones PH, Nelson K, O'Brian Smith E, Ballantyne CM. Impact of weight loss on the metabolic syndrome. *Diabetes Obes Metab* 2002;4:407-14.

26.菲尔an S, Wadden TA, Berkowitz RJ, et al. Impact of weight loss on the metabolic syndrome. *Int J Obes* 2007;31:1442-8.

27. Ferland A, Eckel RH. Does sustained weight loss reverse the metabolic syndrome? *Curr Hypertens Rep* 2011;13:456-64.

28. Grundy SM, Hansen B, Smith SC Jr, Cleeman JI, Kahn RA; American Heart Association; National Heart, Lung, and Blood Institute; American Diabetes Association. Clinical management of metabolic syndrome: report of the American Heart Association/National Heart, Lung, and Blood Institute/American Diabetes Association conference on scientific issues related to management. *Circulation* 2004;109:551-6.

29. Korean Statistical Information Service. Daejeon: Statistics Korea; 2021 [cited 2021 December 10]. Available from: https://kosis.kr/index/index.do.

30. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease: an update. *J Am Coll Cardiol* 2004;43:1731-7.
31. Harris KK, Zopey M, Friedman TC. Metabolic effects of smoking cessation. *Nat Rev Endocrinol* 2016;12:684. [PUBMED] [CROSSREF]

32. Ishizaka N, Ishizaka Y, Toda E, Hashimoto H, Nagai R, Yamakado M. Association between cigarette smoking, metabolic syndrome, and carotid arteriosclerosis in Japanese individuals. *Atherosclerosis* 2005;181:381-8. [PUBMED] [CROSSREF]

33. Oh SW, Yoon YS, Lee ES, et al. Association between cigarette smoking and metabolic syndrome: the Korea National Health and Nutrition Examination Survey. *Diabetes Care* 2005;28:2064-6. [PUBMED] [CROSSREF]

34. Sun K, Liu J, Ning G. Active smoking and risk of metabolic syndrome: a meta-analysis of prospective studies. *PloS One* 2012;7:e47791. [PUBMED] [CROSSREF]

35. Cryer PE, Haymond MW, Santiago JV, Shah SD. Norepinephrine and epinephrine release and adrenergic mediation of smoking-associated hemodynamic and metabolic events. *N Engl J Med* 1976;295:573-7. [PUBMED] [CROSSREF]

36. Kong C, Nimmo L, Elatrozy T, et al. Smoking is associated with increased hepatic lipase activity, insulin resistance, dyslipidaemia and early atherosclerosis in Type 2 diabetes. *Atherosclerosis* 2001;156:373-8. [PUBMED] [CROSSREF]

37. Facchini FS, Hollenbeck CB, Jeppesen J, Chen YD, Reaven GM. Insulin resistance and cigarette smoking. *Lancet* 1992;339:1128-30. [PUBMED] [CROSSREF]

38. Kawachi I, Colditz GA, Stampfer MJ, et al. Smoking cessation and time course of decreased risks of coronary heart disease in middle-aged women. *Arch Intern Med* 1994;154:169-75. [PUBMED] [CROSSREF]

39. Rigotti NA, Clair C. Managing tobacco use: the neglected cardiovascular disease risk factor. *Eur Heart J* 2013;34:3259-67. [PUBMED] [CROSSREF]

40. Kim BI, Kim BS, Sung KC, Kang JH, Lee MH, Park JR. Association of smoking status, weight change, and incident metabolic syndrome in men: a 3-year follow-up study. *Diabetes Care* 2009;32:1314-6. [PUBMED] [CROSSREF]

41. Bauman RS, Rigotti NA, Benowitz NL, et al. Cardiovascular effects of exposure to cigarette smoke and electronic cigarettes: clinical perspectives from the prevention of cardiovascular disease section leadership council and early career councils of the American College of Cardiology. *J Am Coll Cardiol* 2015;66:1378-91. [PUBMED] [CROSSREF]

42. Lancaster T, Stead L. Physician advice for smoking cessation. *Cochrane Database Syst Rev* 2004:CD000165. [PUBMED]

43. Marcus BH, Albrecht AE, King TK, et al. The efficacy of exercise as an aid for smoking cessation in women: a randomized controlled trial. *Arch Intern Med* 1999;159:1229-34. [PUBMED] [CROSSREF]

44. Parsons AC, Shriml M, Inglis J, Aveyard P, Hajek P. Interventions for preventing weight gain after smoking cessation. *Cochrane Database Syst Rev* 2009:CD006219. [PUBMED]

45. Filozof C, Fernández Pinilla MC, Fernández-Cruz A. Smoking cessation and weight gain. *Obes Rev* 2004;5:95-103. [PUBMED] [CROSSREF]
50. Vergnaud AC, Norat T, Romaguera D, et al. Fruit and vegetable consumption and prospective weight change in participants of the European Prospective Investigation into cancer and nutrition-physical activity, nutrition, alcohol, cessation of smoking, eating out of home, and obesity study. *Am J Clin Nutr* 2012;95:184-93.
PUBMED | CROSSREF

51. Koppes LL, Dekker JM, Hendriks HF, Bouter LM, Heine RJ. Moderate alcohol consumption lowers the risk of type 2 diabetes: a meta-analysis of prospective observational studies. *Diabetes Care* 2005;28:719-25.
PUBMED | CROSSREF

52. Thun MJ, Peto R, Lopez AD, et al. Alcohol consumption and mortality among middle-aged and elderly U.S. adults. *N Engl J Med* 1997;337:1705-14.
PUBMED | CROSSREF

53. Yoon YS, Oh SW, Baik HW, Park HS, Kim WY. Alcohol consumption and the metabolic syndrome in Korean adults: the 1998 Korean National Health and Nutrition Examination Survey. *Am J Clin Nutr* 2004;80:217-24.
PUBMED | CROSSREF

54. Jeon YJ, Pyo J, Park YK, Ock M. Health behaviors in major chronic diseases patients: trends and regional variations analysis, 2008–2017, Korea, *BMC Public Health* 2020;20:1813.
PUBMED | CROSSREF

55. Choi J, Choi JY, Shin A, et al. Trends and correlates of high-risk alcohol consumption and types of alcoholic beverages in middle-aged Korean adults: results from the HEXA-G study. *J Epidemiol* 2019;29:125-32.
PUBMED | CROSSREF

56. Alkerwi A, Boutsen M, Vaillant M, et al. Alcohol consumption and the prevalence of metabolic syndrome: a meta-analysis of observational studies. *Atherosclerosis* 2009;204:624-35.
PUBMED | CROSSREF

57. Sun K, Ren M, Liu D, Wang C, Yang C, Yan L. Alcohol consumption and risk of metabolic syndrome: a meta-analysis of prospective studies. *Clin Nutr* 2014;33:596-602.
PUBMED | CROSSREF

58. Vieira BA, Luft VC, Schmidt MI, et al. Timing and type of alcohol consumption and the metabolic syndrome - ELSA-Brasil. *PLoS One* 2016;11:e0163044.
PUBMED | CROSSREF

59. Bellin LJ, Puddey IB. Alcohol and hypertension: an update. *Hypertension* 2006;47:1035-8.
PUBMED | CROSSREF

60. De Oliveira E Silva ER, Foster D, McGee Harper M, et al. Alcohol consumption raises HDL cholesterol levels by increasing the transport rate of apolipoproteins A-I and A-II. *Circulation* 2000;102:2347-52.
PUBMED | CROSSREF

61. Vu KN, Ballantyne CM, Hoogeveen RC, et al. Causal role of alcohol consumption in an improved lipid profile: the atherosclerosis risk in communities (ARIC) study. *PLoS One* 2016;11:e0148765.
PUBMED | CROSSREF

62. van de Vliet A. Diabetes mellitus and alcohol. *Diabetes Metab Res Rev* 2004;20:263-7.
PUBMED | CROSSREF

63. Rehm T. The risks associated with alcohol use and alcoholism. *Alcohol Res Health* 2011;34:135-43.
PUBMED

64. Jakobsen MU, O’Reilly EJ, Heitmann BL, et al. Major types of dietary fat and risk of coronary heart disease: a pooled analysis of 11 cohort studies. *Am J Clin Nutr* 2009;89:1425-32.
PUBMED | CROSSREF

65. Mozaffarian D, Katan MB, Ascherio A, Stampfer MJ, Willett WC. Trans fatty acids and cardiovascular disease. *N Engl J Med* 2006;354:1601-13.
PUBMED | CROSSREF

66. Carnethon MR, Loria CM, Hill JO, Sidney S, Savage PJ, Liu K; Coronary Artery Risk Development in Young Adults study. Risk factors for the metabolic syndrome: the Coronary Artery Risk Development in Young Adults (CARDIA) study, 1985–2001. *Diabetes Care* 2004;27:2707-45.
PUBMED | CROSSREF

67. Mirmiran P, Noori N, Azizi F. A prospective study of determinants of the metabolic syndrome in adults. *Nutr Metab Cardiovasc Dis* 2008;18:567-73.
PUBMED | CROSSREF

68. Ha K, Kim K, Chun OK, Joung H, Song Y. Differential association of dietary carbohydrate intake with metabolic syndrome in the US and Korean adults: data from the 2007-2012 NHANES and KNHANES. *Eur J Clin Nutr* 2018;72:848-60.
PUBMED | CROSSREF
69. Kim BK, Lim YH, Kim SG, Kim YM, Shin J. Relationship between sodium intake and blood pressure according to metabolic syndrome status in the Korean National Health and Nutrition Examination Survey. Blood Press Monit 2012;17:120-7.

70. He FJ, MacGregor GA. Effect of modest salt reduction on blood pressure: a meta-analysis of randomized trials. Implications for public health. J Hum Hypertens 2002;16:761-70.

71. Vivekananthan DP, Penn MS, Sapp SK, Hsu A, Topol EJ. Use of antioxidant vitamins for the prevention of cardiovascular disease: meta-analysis of randomised trials. Lancet 2003;361:2017-23.

72. Weickert MO, Pfeiffer AF. Metabolic effects of dietary fiber consumption and prevention of diabetes. J Nutr 2008;138:439-42.

73. Azadbakht L, Mirmiran P, Esmaillzadeh A, Azizi T, Azizi F. Beneficial effects of a Dietary Approaches to Stop Hypertension eating plan on features of the metabolic syndrome. Diabetes Care 2005;28:2823-31.

74. Weickert MO, Pfeiffer AF. Metabolic effects of dietary fiber consumption and prevention of diabetes. J Nutr 2008;138:439-42.

75. Nacon M, Hiemann T, Müller-Riemenschneider F, Thalau F, Roll S, Willich SN. Association of physical activity with all-cause and cardiovascular mortality: a systematic review and meta-analysis. Eur J Cardiovasc Prev Rehabil 2008;15:239-46.

76. Arnett DK, Blumenthal RS, Albert MA, et al. 2019 ACC/AHA guideline on the primary prevention of cardiovascular disease: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. Circulation 2019;140:e596-646.

77. Bertrais S, Beyme-Ondoua JP, Czernichow S, Galan P, Hercberg S, Oppert JM. Sedentary behaviors, physical activity, and metabolic syndrome in middle-aged French subjects. Obes Res 2005;13:936-44.

78. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK; American College of Sports Medicine. American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. Med Sci Sports Exerc 2009;41:459-71.

79. Church TS, Blair SN, van Baak MA, et al. How much physical activity is enough to prevent unhealthy weight gain? Outcome of the IASO 1st Stock Conference and consensus statement. Obes Rev 2003;4:101-14.

80. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK; American College of Sports Medicine. American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. Med Sci Sports Exerc 2009;41:459-71.

81. Church TS, Blair SN, van Baak MA, et al. How much physical activity is enough to prevent unhealthy weight gain? Outcome of the IASO 1st Stock Conference and consensus statement. Obes Rev 2003;4:101-14.

82. Church TS, Blair SN, van Baak MA, et al. How much physical activity is enough to prevent unhealthy weight gain? Outcome of the IASO 1st Stock Conference and consensus statement. Obes Rev 2003;4:101-14.

83. Swift DL, Johannsen NM, Lavie CJ, Earnest CP, Church TS. The role of exercise and physical activity in weight loss and maintenance. Prog Cardiovasc Dis 2014;56:441-7.

84. Swift DL, Johannsen NM, Lavie CJ, Earnest CP, Church TS. The role of exercise and physical activity in weight loss and maintenance. Prog Cardiovasc Dis 2014;56:441-7.

85. Dunkley AJ, Charles K, Gray LJ, Camosso-Stefinovic J, Davies MJ, Khunti K. Effectiveness of interventions for reducing diabetes and cardiovascular disease risk in people with metabolic syndrome: systematic review and mixed treatment comparison meta-analysis. Diabetes Obes Metab 2012;14:616-25.

86. Melkary RA, Feskanich D, Hu FB, Willett WC, Field AE. Physical activity in relation to long-term weight maintenance after intentional weight loss in premenopausal women. Obesity (Silver Spring) 2010;18:167-74.
87. Armstrong MJ, Mottershead TA, Ronksley PE, Sigal RJ, Campbell TS, Hemmelgarn BR. Motivational interviewing to improve weight loss in overweight and/or obese patients: a systematic review and meta-analysis of randomized controlled trials. *Obes Rev* 2011;12:709-23.

88. Rubak S, Sandbaek A, Lauritzen T, Christensen B. Motivational interviewing: a systematic review and meta-analysis. *Br J Gen Pract* 2005;55:305-12.

89. Rodriguez-Gutierrez R, Gionfriddo MR, Ospina NS, et al. Shared decision making in endocrinology: present and future directions. *Lancet Diabetes Endocrinol* 2016;4:706-46.

90. Ockene IS, Hebert JR, Ockene JK, et al. Effect of physician-delivered nutrition counseling training and an office-support program on saturated fat intake, weight, and serum lipid measurements in a hyperlipidemic population: Worcester Area Trial for Counseling in Hyperlipidemia (WATCH). *Arch Intern Med* 1999;159:725-31.

91. Murray CJ, Aravkin AY, Zheng P, et al. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020;396:1223-49.

92. Kim HC, Cho SM, Lee H, et al. Korea hypertension fact sheet 2020: analysis of nationwide population-based data. *Clin Hypertens* 2021;27:8.

93. Appel LJ, Champagne CM, Harsha DW, et al. Effects of comprehensive lifestyle modification on blood pressure control: main results of the PREMIER clinical trial. *JAMA* 2003;289:2083-93.

94. Kim HC, Ihm SH, Kim GH, et al. 2018 Korean Society of Hypertension guidelines for the management of hypertension: part I-epidemiology of hypertension. *Clin Hypertens* 2019;25:16.

95. Grundy SM, Stone NJ, Bailey AL, et al. 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASH/ASPC/NMA/PCNA guideline on the management of blood cholesterol: a report of the American College of Cardiology/American Heart Association Task Force on clinical practice guidelines. *Circulation* 2019;139:e139-350.

96. Williams B, Mancia G, Spiering W, et al. 2018 ESC/ESH guidelines for the management of arterial hypertension. *Eur Heart J* 2018;39:3021-404.

97. He FJ, Li J, Macgregor GA. Effect of longer-term modest salt reduction on blood pressure. *Cochrane Database Syst Rev* 2013:CD004937.

98. Neter JE, Stam BE, Kok FJ, Grobbee DE, Geleijnse JM. Influence of weight reduction on blood pressure: a meta-analysis of randomized controlled trials. *Hypertension* 2003;42:878-84.

99. Mensink RP, Zock PL, Kester AD, Katan MB. Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. *Am J Clin Nutr* 2003;77:1146-55.
104. Brown L, Rosner B, Willett WW, Sacks FM. Cholesterol-lowering effects of dietary fiber: a meta-analysis. *Am J Clin Nutr* 1999;69:30-42.

105. Griswold MG, Fullman N, Hawley C, et al. Alcohol use and burden for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2018;392:1015-35.

106. Razay G, Heaton KW, Bolton CH, Hughes AO. Alcohol consumption and its relation to cardiovascular risk factors in British women. *BMJ* 1992;304:80-3.

107. Kraus WE, Houmard JA, Duscha BD, et al. Effects of the amount and intensity of exercise on plasma lipoproteins. *N Engl J Med* 2002;347:1483-92.

108. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation* 2007;116:1081-93.

109. Hellestein MK, Benowitz NL, Neese RA, et al. Effects of cigarette smoking and its cessation on lipid metabolism and energy expenditure in heavy smokers. *J Clin Invest* 1994;93:265-72.

110. Imperatore G, Cheng YJ, Williams DE, Fulton J, Gregg EW. Physical activity, cardiovascular fitness, and insulin sensitivity among U.S. adolescents: the National Health and Nutrition Examination Survey, 1999–2002. *Diabetes Care* 2006;29:1567-72.

111. Young DR, Hivert MF, Alhassan S, et al. Sedentary behavior and cardiovascular morbidity and mortality: a science advisory from the American Heart Association. *Circulation* 2016;134:e262-79.

112. Pan XR, Li GW, Hu YH, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. *Diabetes Care* 1997;20:537-44.

113. American Diabetes Association. 5. Facilitating behavior change and well-being to improve health outcomes: standards of medical care in diabetes-2021. *Diabetes Care* 2021;44 Suppl 1:S53-72.

114. Vessby B, Uusitupa M, Hermansen K, et al. Substituting dietary saturated for monounsaturated fat impairs insulin sensitivity in healthy men and women: the KANWU Study. *Diabetologia* 2001;44:312-9.

115. Martínez-González MA, Salas-Salvadó J, Estruch R, Corella D, Fitó M, Ros E; PREDIMED INVESTIGATORS. Benefits of the Mediterranean diet: insights from the PREDIMED Study. *Prog Cardiovasc Dis* 2015;58:50-60.
122. Venn BJ, Mann JJ. Cereal grains, legumes and diabetes. *Eur J Clin Nutr* 2004;58:1443-61.
PUBMED | CROSSREF

123. Papathanasopoulos A, Camilleri M. Dietary fiber supplements: effects in obesity and metabolic syndrome and relationship to gastrointestinal functions. *Gastroenterology* 2010;138:65-72.e1.
PUBMED | CROSSREF

124. Blesso CN, Andersen CJ, Barona J, Volek JS, Fernandez ML. Whole egg consumption improves lipoprotein profiles and insulin sensitivity to a greater extent than yolk-free egg substitute in individuals with metabolic syndrome. *Metabolism* 2013;62:400-10.
PUBMED | CROSSREF

125. Akter S, Kurotani K, Nanri A, et al. Dairy consumption is associated with decreased insulin resistance among the Japanese. *Nutr Res* 2013;33:286-92.
PUBMED | CROSSREF