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Dietary management of the metabolic syndrome – one size fits all?

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Diagnosis of metabolic syndrome includes a set of laboratory and physical findings, including central adiposity, elevated TAG, reduced HDL-cholesterol, hypertension and elevated fasting glucose or insulin resistance. While definitions have varied slightly, from a practical point of view, identifying dietary and lifestyle factors, including low levels of physical activity, are important in designing a diet and exercise programme that can help individuals with the metabolic syndrome to reduce the associated detrimental health consequences. Specific features of the metabolic syndrome require intervention, whether dietary or otherwise, to move towards normal ranges. It is important to remember that no one size or treatment fits all. While central obesity is perceived as the hallmark of the metabolic syndrome, other features need to be treated independently if they do not respond to lifestyle change. The future may hold treatments for the metabolic syndrome that involve modulation of inflammation.

Metabolic syndrome: Dietary management: Lifestyle changes

The initial proposal for the metabolic syndrome came from studies of Professor Vague in France published in 1947 and in English in 1956[1]. Later, Bjorntorp and colleagues in Sweden[2] and Kissebah and his associates in the United States[3] showed that waist circumference divided by hip circumference was an easy way to diagnose central adiposity in their countries. These investigators found that some of the complications of obesity, i.e. diabetes, hypertension, insulin resistance and heart disease were more clearly related to the central distribution of fat than to the overall level of obesity. This and other information led Reaven in 1988 to propose the name 'Syndrome X' to describe these findings that also tended to cluster with insulin resistance[4]. Some components of the metabolic syndrome are hyperinsulinaemia, hypertension, abnormal blood lipids (dyslipidaemia), a procoagulant state, vascular abnormalities, inflammatory markers and hyperuricaemia[5–11]. The metabolic syndrome has also been called the dysmetabolic syndrome[12] or Syndrome X, and a number of other terms. Two of the hallmarks of the metabolic syndrome are central adiposity and insulin resistance; the latter may be closely tied to low grade inflammatory responses to diet[13].

Defining the metabolic syndrome

Over the years since its first description, it has become clear that the metabolic syndrome encompasses more than just insulin resistance and its associated consequences[13]. Diagnosis of the metabolic syndrome has been difficult to define due to the large number of symptoms and signs; however, many groups have attempted to provide more precise diagnostic criteria. The early groups included the WHO[14], the American Association of Clinical Endocrinologists[15] and the National Cholesterol Education Program through the Adult Treatment Panel III (ATP III) recommendations[16,17]. In 2004, Grundy *et al.*[18] reviewed the definition of the metabolic syndrome, noting that CVD was the primary clinical outcome and further that diabetes risk is higher and may require additional testing. Later, Grundy *et al.*[19] published an American Heart Association/National Heart, Lung and Blood Institute Scientific Statement recommending lowering of the fasting glucose criteria from >110 mg/dl to >100 mg/dl, which was the same recommendation proposed by the International Diabetes Consensus definition that same year[20]. However, central obesity in the definitions was the focus of the

Abbreviations: ATP III, Adult Treatment Panel III; IDF, International Diabetes Federation; LDL-C, LDL-cholesterol.

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new International Diabetes Federation (IDF) definition[20], since it is a driving force for both CVD as well as diabetes.

In 2009, a Joint Interim Statement by the IDF updated the metabolic syndrome definition primarily revising the central obesity definition[21]. This proposed that central obesity could not be standardised with one set of criteria, but that different ethnic groups presented unique criteria for the diagnosis. Some of the differences in diagnostic criteria for central adiposity are as follows: Europids, men >94 cm and women >80 cm; South Asians, Chinese and Japanese, men >90 cm and women >80 cm; United States and Canada, men >102 cm and women >88 cm.

Prevalence of the metabolic syndrome

Based on earlier criteria, Ford *et al.*[22] evaluated the prevalence of the metabolic syndrome in the United States using data from the National Center for Health Statistics, National Health and Nutrition Examination Survey III. These investigators calculated the percentage of Americans in various age groups who met the criteria for the earlier ATP III definition of the metabolic syndrome. For men, the approximated prevalence was 8% for those aged 20–29 years, 11% for those aged 30–39 years, 24% for those aged 40–49 years, 34% for those aged 50–59 years, 43% for those aged 60–69 years and 40% for those aged over 70 years. For women, the approximated prevalence was 6% for those aged 20–29 years, 14% for those aged 30–39 years, 20% for those aged 40–49 years, 32% for those aged 50–59 years and 43% for those aged over 60 years. Overall prevalence of the metabolic syndrome in individuals older than 20 years was 24% after adjusting for age. There were variations in the prevalence of the metabolic syndrome by sex and race, but, overall, the individuals were more alike than dissimilar across these groups[22].

Current estimates from the United States are that approximately 34% of adults meet the latest definition of metabolic syndrome[21] and that adults 40–59 years of age are three times more likely than those 20–39 years of age to have metabolic syndrome[23]. In Australia, the prevalence of metabolic syndrome varied between 13% and 31% depending on the definitions used. For example, Cameron *et al.*[24] reported a prevalence of 22% according to the ATP III diagnostic criteria. Using the ATP III criteria, Sidorenkov *et al.*[25] estimated that 19·8% of women and 11·5% of men in Russia had the metabolic syndrome.

A recent paper by Okafor[26] reported on the prevalence of the metabolic syndrome in Africa from several studies using definitions from the ATP III, the WHO and the IDF. The countries included Seychelles, Nigeria, Ethiopia, Congo and Botswana. Estimates of metabolic syndrome in these different countries varied from 12·5% to 62·5% based on ATP III, from 18·9% to 59·1% based on WHO, and from 15·9% to 63·6% using the IDF Consensus Definition 2009[20]. Okafor[26] also noted that the studies reported from Africa found that prevalence was increasing and that the prevalence increased with age, with obesity more common among females and hypertension more common among males.

Several studies have been reported from South Africa. Motala *et al.*[27] noted in a rural community of Zulu descent that the age-adjusted prevalence of metabolic syndrome was 22·1% on average, with a higher prevalence in women at 25% compared with men at 10·5%. They noted that the highest overall prevalence of metabolic syndrome was 26·5% using the Joint Interim Statement definition compared with the ATP III criteria at 18·5% or the older IDF criteria at 23·3%. Kalk and Joffe[28] evaluated 500 African and white diabetic patients for metabolic syndrome and reported that the frequency was higher in whites at 73·1% than Africans at 52·9%.

Risks associated with metabolic syndrome

As can be seen from the previous discussion, the prevalence of metabolic syndrome seems to be increasing globally, alarmingly so in the African continent. The increase brings about concern over risks associated with this entity. Data from national health agencies report that CVD is twice as likely to develop in those individuals with metabolic syndrome and that type 2 diabetes is five times as likely to develop[29]. Metabolic syndrome increases risk for non-alcoholic fatty liver disease[30], hyperuricaemia[31] and obstructive sleep apnoea[32]. Almost 50% of women with polycystic ovary syndrome have metabolic syndrome[33].

Inflammation and the metabolic syndrome

Both rats and mice placed on a high fat diet rapidly develop evidence of neuronal damage in the arcuate nucleus along with changes in inflammatory cells in the brain (microglia and astrocytes)[13]. This inflammatory response to the high fat diet occurred before obesity appeared. Using MRI techniques in obese human beings detected evidence of inflammatory responses in the hypothalamus. This suggests that hypothalamic inflammatory responses can occur in both animals and human beings in response to a high fat diet which also induces the metabolic syndrome and obesity. A similar process may operate in human subjects[13].

A similar line of research in mice showed that disabling one of the key inflammatory pathways (NF-κB) would prevent the development of obesity in mice eating a high fat diet[34]. Knowing that this inflammatory pathway seemed to play a critical role in the development of insulin resistance, obesity and the metabolic syndrome, these authors searched for molecules that might inhibit the pathway pharmacologically. They identified one such molecule, amlexanox, which would both prevent the development of obesity and reverse it in mice that were already fat. This suggests that modulation of inflammatory pathways may provide future strategies for treating the metabolic syndrome, insulin resistance and obesity[34].

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Treatment of metabolic syndrome

Treatment of the metabolic syndrome begins with effective lifestyle management. Three areas are the targets[18,19]:

1. Obesity/weight management primarily focusing on a low fat, high fibre diet to reduce energy intake by 2142–4184 kJ/d (500–1000 kcal/d). The main goal is to provide a 7–10% reduction of body weight over a 6–12-month period and achieve an ideal BMI $<25\,kg/m^2$.
2. Increasing physical activity by achieving 30–60 min or more of moderate intensity exercise on most days of the week as appropriate to the individual and to self-monitor activity levels.
3. Nutritional recommendations in addition to fat, fibre and energy for weight management include: low intake of saturated and *trans* fat and cholesterol; reduced consumption of simple sugars; increased intakes of fruit, vegetables and whole grains.

Genest *et al.*[35] developed guidelines for diagnosis and treatment of dyslipidaemia and CVD prevention in Canadian adults citing the importance of obesity and the metabolic syndrome as important factors to consider. They suggested that the guiding principles for treatment of the metabolic syndrome are to target adults for screening unless there are compelling reasons against that; to determine cardiovascular risk since CVD is a predominant finding; to institute lifestyle changes; and to treat further according to level of risk.

Treatment of obesity; lifestyle change approach

As alluded to previously, lifestyle change is most important for the treatment of obesity and it is particularly here that one size does not fit all since people are different in their response to many factors, not the least of which is the dietary regimen of choice. Lifestyle change proved more effective than metformin based on the results of the Diabetes Prevention Program[36]. In fact, 53% of the participants in the Diabetes Prevention Program had metabolic syndrome at baseline; of these 1711 individuals, a reduction of 41% was noted in the lifestyle group compared with only 17% in the metformin group[37]. Reducing energy intake to reduce weight is necessary, regardless of your choice of dietary composition. The Look AHEAD study has also provided important insights into dietary responses to lifestyle. First, not all people achieve weight loss with an intensive lifestyle intervention. Although the average weight loss at one year was 8·6%, nearly 25% of the participants failed to lose 5 kg and should have their treatment reconsidered[38]. Second, the success at one year was related to the initial rate of weight loss. Those who lost most rapidly were more successful in maintaining weight loss at one year[39]. Previous research focused on the Dietary Approaches to Stop Hypertension Diet[40–44] and other macronutrient altered diets, such as the POUNDS LOST study conducted at Pennington Biomedical Research Center and Harvard[45], maintain that energy control is most effective regardless of the type of diet. Many of these and other lifestyle programmes include increasing physical activity[36–44].

The usefulness of strategies for long-term weight loss maintenance has been reported by individuals who comprise the National Weight Control Registry[46]. Individuals in the National Weight Control Registry are primarily female (80%) who have lost an average of 66 lbs and kept the weight off for more than 5 years. While the averages are impressive, so is the diversity of these individuals. Some have lost as much as 300 lbs; some boast of an impressive number of years maintaining weight loss; and there are differences in the rates of weight loss that are reported. Almost half of the individuals lost weight on their own and others relied on weight loss programmes, indicating that people who were motivated could actually do it on their own. There were a number of other interesting factors identified by studying the individuals in the National Weight Control Registry [42]:

1. The majority modified food intake to lose weight with most maintaining low energy, low fat diets.
2. Overwhelmingly, almost all increased physical activity, with walking being the most frequently reported choice for this increase.
3. In addition, 78% ate breakfast every day, 75% weighed themselves at least once a week, 62% watched fewer than 10 h of television a week, and 90% exercised about 1 h/d on average.

Treatment of obesity; diet alone

Treating obesity through diet alone has posed problems. Minich and Bland[47] reported that uniform consensus is lacking as to which dietary approach is most effective. They reported that reduction of simple carbohydrates are agreed upon by most since these promote inflammation and may up-regulate genes that cause stress-like states[47]. Minich and Bland further reported that many studies promoting dietary patterns which contain high levels of whole, unprocessed plant foods with an abundance of phytochemicals are beneficial in the treatment of metabolic syndrome[47]. Laaksonen *et al.*[48] reported that carbohydrates with a low glycaemic index compared with high glycaemic index foods enhanced insulin secretion in persons with metabolic syndrome, perhaps lowering the risk of deteriorating glucose tolerance and developing type 2 diabetes. One must, however, keep energy intake at levels to promote weight loss and weight maintenance regardless of macronutrient composition, as suggested by Sacks *et al.*[45].

The Mediterranean diet is popular in some circles. Use of this approach has been shown to favourably impact metabolic syndrome[47], although energies need to be the primary focus since this is a higher fat diet which may be less effective in weight loss without an energy focus. The benefits have been ascribed to the abundance of fish providing *n*-3 fatty acids, the presence of antioxidants contained in the consumption of red wine and the promotion of olive oil which contains monounsaturated fat and has been shown to improve insulin sensitivity[47].

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Other dietary factors to consider in the treatment of metabolic syndrome include diets based strictly on plant foods such as those contained in the Portfolio Diet recommended by Jenkins *et al.*[49]. These diets are rich in soyabean containing foods and have a high content of fibre and phytosterols, beneficial in treatment of metabolic syndrome. Soyabean foods are increasingly recognised due to the fact that they may help to fight inflammation by inhibiting inflammatory cytokines and other processes that affect inflammation[47].

Specific foods have been reported to have beneficial effects on several components of the metabolic syndrome. Damsgaard *et al.*[50] reported that fish oils are important for cardiovascular health since they reportedly lower blood TAG and LDL-cholesterol (LDL-C) levels; however, they caution that high doses of fish oil can actually increase LDL-C levels. Consumption of nuts has been reported to reduce the risk of developing diabetes and CVD due to their nutritional profile of high mono- and polyunsaturated fats along with more fibre, vitamins and minerals; glycaemic control may improve although additional studies are needed[51]. Fibre has been shown to modulate and assist in weight regulation, to have a positive effect on insulin sensitivity and diabetes and perhaps reduce the risk of CVD[52]. Minich and Bland[47] reported that phytochemicals that may improve insulin signalling are associated with cinnamon, green tea, bitter melon, berberine, ginseng, hops, quercetin and resveratrol.

Benefits of treating obesity

Orchard *et al.*[37] associated weight loss in the Diabetes Prevention Program with reversal of the metabolic syndrome; they reported that there was a significant reversal of the metabolic syndrome that was lowest in the placebo group at 18% and rose to a 38% reduction in the lifestyle group who initially lost 7% of their body weight and maintained an average weight loss of 5·5%.

However, it is also clear that weight loss is difficult to achieve and sustain and is often deemed inadequate. The question thus arises as to whether it might not be better to treat the components of the metabolic syndrome rather than trying to induce significant loss of weight and loss of visceral fat. As previously described, successful weight loss will improve insulin resistance, blood pressure and blood cholesterol levels. Since a variety of other components are included in the diagnosis of metabolic syndrome, an important course of action is to treat these individual components by altering diet as a first course, but realising that other treatment will often be needed. Regardless, the aim is to push each component into the 'normal' range as much as possible, e.g. blood pressure, lipids and glucose status. In summarising the approaches associated with the individual components treatable by diet, each is considered separately later.

Treating hypertriglyceridaemia

Hypertriglyceridaemia often calls for a reduction in carbohydrate intake. Increasing monounsaturated fats using a Mediterranean diet approach has been successful in reduction of serum TAG. Consumption of foods with a low glycaemic index may be beneficial to some individuals. Increasing *n*-3 fatty acid intake may also improve hypertriglyceridaemia. Not all of these strategies may be appropriate for all individuals, but these should be considered as viable options in what is often termed a 'tool box' approach.

Treating dyslipidaemia

The target in treatment of dyslipidaemia is reduction in LDL-C levels and improvement in HDL-cholesterol levels. Often, the decrease in the overall fat content of the diet will improve LDL-C levels, but may have a negative impact on HDL-cholesterol. Higher intakes of monounsaturated fat, such as the Mediterranean diet approach, benefits HDL-cholesterol in that levels are not lowered and may in fact rise somewhat. Treatment of dyslipidaemia with fish oils, nuts, avocados and soyabean products also has advantages; in particular fish oils, nuts and avocados contain fats that are consistent with a Mediterranean diet approach and soyabean products have beneficial effects on serum lipids and inflammatory cytokines and significantly decrease total cholesterol, LDL-C and TAG[47].

Treating high glucose levels

As discussed previously, to improve blood glucose levels carbohydrate intake should be modified to include more whole grains. This will improve insulin secretion, not necessarily improving glucose tolerance. One approach is to replace some of the carbohydrate intake with monounsaturated fats, keeping total energy intake in check. Increasing fibre will increase satiety and has the added advantage of decreasing risk of CVD. Use of soyabean, cinnamon, green tea, bittermelon, berberine, ginseng, hops, quercetin and resveratrol will improve insulin secretion. Lifestyle intervention among participants from the Diabetes Prevention Program Outcomes Study who achieved normal glucose regulation, even if transient, was associated with a significantly reduced risk of future diabetes development, as reported by Perreault *et al.*[53]; diabetes risk during the Diabetes Prevention Program Outcomes Study was 56% lower for participants returning to normal glucose regulation *v.* those who were consistently diagnosed as prediabetic.

Treating hypertension

Limiting Na/salt intakes is an important approach in the treatment of hypertension. As reported in the studies of hypertension, focusing on increases in low-fat dairy products, fruit, vegetables and whole grains reduced both systolic and diastolic blood pressure; this dietary approach is called the Dietary Approaches to Stop Hypertension Diet. Individuals should also lower their alcohol intake. Saturated fat in the diet needs to be decreased. Although not diet related, physical activity is important and should be increased and achieving a desirable weight needs to be the primary goal.

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Conclusions

When treating the metabolic syndrome with diet, it is important to the dietary plan to individual goals and patient likes and dislikes. Access to appropriate foods, which may be an issue for the African community, is critical when dietary modifications are recommended. One should attempt as much as possible to prevent conflicts when coming up with a plan of action; for example, increasing carbohydrates with insulin secretion *v*. decreasing carbohydrates with dyslipidaemia. Although not a dietary approach, stress the importance of increasing physical activity as much as possible since dietary changes are often enhanced by adopting an exercise regimen. Lifestyle changes are an alternative to pharmaceutical therapy and need to be the first course of action. When the plan is drafted, follow up with the patient is needed to determine rate of success and, if necessary, to revise the treatment plan to ensure success.

Practice points for the nutrition professional

Strategies for dealing with the metabolic syndrome patient are presented to assist the nutrition/dietetic professional[54]:

1. More than ever, the personal history of the patient should be a critical focus area for the clinical dietitian or nutritionist who deals with patients diagnosed with metabolic syndrome[55]. In particular, assessment of past dietary habits using valid FFQ or other instruments is warranted. The current diet of the patient can help to highlight target areas; collecting a food record for as many days as the patient is willing to keep it will be instrumental in future counselling efforts.
2. Encourage the patient to provide as much dietary information as possible. This will make a measurable difference in the accuracy of the dietary data for evaluation purposes, an area of concern in the validity of self-reported dietary intake information[56]. Remember to stress that no judgments will be formed; only areas of diet for targeting change.
3. Assess physical activity patterns to design an effective and comprehensive lifestyle programme. The dietitian may choose to collect a physical activity questionnaire from the patient and, in addition, provide the patient with an activity monitor, such as a pedometer, to assess actual physical activity steps for a more accurate appraisal of daily activity levels.
4. For greater success, the dietary treatment needs to be highly individualised. It may be helpful to include a variety of weight loss strategies, such as meal replacements (for quicker initial weight loss), slightly higher protein diets, low-fat diets and, perhaps, even a Mediterranean diet approach. It is important to remember that what works for one patient may not necessarily be ideal for another. Consider options available in various African communities.
5. Work with the patient's physician to provide the ideal combination of diet, physical activity suggestions, behaviour changes and drug (if prescribed by the physician), which are key components to the patient's success. Frequently, this is the most effective procedure, especially for dyslipidaemic patients[57–59].
6. Finally, follow-up evaluations to monitor progress are important factors in weight management, both on the part of the physician and the nutrition professional as a part of the treatment team.

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