The metabolic syndrome is a critical target for intervention. Several different definitions for the metabolic syndrome have been proposed over the years. Recently, the National Heart Lung and Blood Institute (NHLBI), International Diabetes Federation, American Heart Association (AHA), and others proposed a harmonized definition for metabolic syndrome as the presence of abnormalities of at least 3 of the following 5 cardiometabolic risk factors: fasting plasma glucose, high-density lipoprotein (HDL) cholesterol, triglycerides, waist circumference, and blood pressure.1

The relationship between metabolic syndrome and increased risk of developing cardiovascular disease (CVD) (risk ratio [RR], 1.78; 95% confidence interval [CI], 1.58 to 2.0) is supported by meta-analyses of prospective studies.2 CVD risk was found to vary based on the metabolic syndrome biomarkers present. The combination of abdominal obesity, elevated blood pressure, and hyperglycemia had the greatest risk for CVD (hazard ratio [HR], 2.36; 95% CI, 1.5 to 3.61), and mortality (HR, 3.09; 95% CI, 1.93 to 4.94) in the Framingham Offspring Study.3

The adverse health outcomes and thus economic consequences of metabolic syndrome are substantial. The total cost and the indirect mortality cost estimates for CVD remain higher than for any other major diagnostic group.4 Between 2010 and 2030, direct health care costs of CVD are projected to triple, from $272.5 billion to $818.1 billion.5 Further, health care costs increase by approximately 24% for each additional metabolic syndrome component present.6 Metabolic syndrome is associated with multiple comorbidities, including atrial fibrillation,7 heart failure,8 ischemic stroke,9 sleep apnea, nonalcoholic fatty liver disease, gallbladder disease, musculoskeletal disorders, and reproductive abnormalities,10 further contributing to the personal health and financial burdens.

PREVALENCE

The prevalence of metabolic syndrome is high and increasing among adults parallel with lifestyle risk factors and changes in population demographics. Based on estimates from the Centers for Disease Control and Prevention, 57 million adults were classified as having metabolic syndrome in 2008, and this number climbed to 79 million in 2011.11 In fact, approximately 1 in 4 adults older than 20 years has this condition.12

The prevalence of metabolic syndrome varies by age, race/ethnicity, and gender. In the general population, the prevalence of metabolic syndrome is highly age-dependent, ranging from 7% for ages 20 to 29 to more than 40% for those older than 70.12 Among the various ethnicities, Mexican Americans have the highest age-adjusted prevalence at 32%.13 Although in the general...
population the prevalence of metabolic syndrome is similar in men and women, Mexican American and African American women have a higher prevalence than their male counterparts. In addition, metabolic syndrome was found to increase markedly in women, independent of other risk factors as hormonal changes occurred during the transition to menopause. More studies are needed in women during perimenopause to elucidate these findings.

**PHYSICAL ACTIVITY**

Physical activity is the single most effective therapeutic strategy to reduce cardiometabolic risk. According to the NHLBI National Cholesterol Education Program (NCEP), Adult Treatment Panel (ATP) III guidelines, any patient at high risk or moderately high risk for metabolic syndrome who has lifestyle-related risk factors (abdominal adiposity, physical inactivity, elevated triglycerides, or low HDL cholesterol) is a candidate for therapeutic lifestyle changes, such as physical activity, as first-line therapy.

Physical activity is defined as any activity involving movements that prompt muscle contractions and a rise in resting metabolic rate, whereas exercise is generally a structured, planned activity. The current evidence for the positive effects of physical activity on the biomarkers of the harmonized definition of the metabolic syndrome will be discussed.

**Effects of Physical Activity on Metabolic Syndrome Biomarkers**

Large randomized, controlled trials, reviews, and meta-analyses found that physical activity was an effective and efficient method to improve metabolic syndrome. Physical activity of approximately 120 minutes per week at moderate (75% maximum oxygen uptake) or greater intensity decreased fasting triglyceride levels and increased HDL cholesterol concentrations. High HDL cholesterol levels provide protective cardiovascular effects; however, the benefits of HDL cholesterol are reduced in the metabolic syndrome population with low HDL levels. Physical activity is thought to increase the positive effects of HDL cholesterol by mediating cholesterol efflux from the vasculature, thereby reducing inflammation and thrombosis.

Elevated plasma triglycerides have atherogenic and thrombogenic effects, causing endothelial cell dysfunction in the arterial wall. Triglyceride concentrations are also believed to play a role in concentrating the more atherogenic low-density lipoprotein (LDL) cholesterol particles present in metabolic syndrome. Elevated triglycerides were found to improve with physical activity of relatively low intensity. The cumulative effects of lifestyle activity conducted every hour throughout the day produced reductions in triglycerides that were greater over time than episodic sessions of moderate exercise.

When triglycerides are elevated (≥ 200 mg/dL), non-HDL cholesterol can be used to determine the proportion of atherogenic and protective lipoproteins. Non-HDL cholesterol is equivalent to the amount of small, dense LDL cholesterol as measured by the LDL subfraction profile. Non-HDL cholesterol is calculated based on the fasting lipid profile as the difference between total cholesterol and HDL cholesterol. Physical activity reduces triglycerides and increases HDL cholesterol, which results in reduced non-HDL cholesterol levels. Non-HDL was as good as or better than the lipid subfraction profile in predicting cardiovascular events. The non-HDL cholesterol goal is determined by adding 30 points to the LDL cholesterol goal derived from the Framingham Risk Score.

Physical activity was also found to reduce waist circumference. Central or intra-abdominal obesity is characteristic of metabolic syndrome and is defined in the harmonized definition by increased waist circumference. In susceptible individuals, physical inactivity leads to an accumulation of abdominal adipose tissue associated with insulin resistance. Some US adults of non-Asian origin with marginally increased waist circumference (eg, 94-102 cm [37-39 inches] in men and 80-88 cm [31-35 inches] in women) may have strong genetic contribution to insulin resistance. According to several studies, regular physical activity preferentially targets abdominal fat and reduces waist circumference, even when minimal weight is lost. Weight reduction can be promoted by increasing moderate or greater intensity physical activity to 60 minutes, continuously or intermittently on 5 if not all days of the week.

Lowered blood pressure is another benefit of physical activity. Hypertension is considered a major independent risk factor for CVD and is commonly associated with insulin resistance and metabolic syndrome. Patients with the highest rates of hypertension are more likely to be middle-age or older, overweight or obese, physically inactive, and have other cardiometabolic risk factors.
Modest blood pressure reduction was found in individuals engaging in regular physical activity, although those with stage 1 or 2 hypertension benefit more than those who are normotensive.\textsuperscript{34} The beneficial effects of physical activity on lowering blood pressure in the presence of metabolic syndrome may be attributed primarily to weight loss; however, regular expansion and contraction of arteries during physical activity appear to keep the blood vessels resilient and maintain endothelial function, despite the effects of aging.\textsuperscript{16} Physical activity may also provide protective effects by limiting the production of LDL cholesterol and other substances that may cause damage to the endothelium.\textsuperscript{23}

Physical activity was found to lower fasting plasma glucose or prevent the increase associated with a sedentary lifestyle.\textsuperscript{35,36} Habitual physical activity was shown to increase citrate synthase and cellular GLUT-4 protein expression, each of which increases the uptake of glucose into the skeletal muscle.\textsuperscript{37,38} This process effectively reduces plasma glucose. Conversely, sitting for long periods leads to changes in cellular regulation of skeletal muscle and lipoprotein lipase activity, a protein important in controlling plasma triglyceride catabolism, HDL cholesterol, and other metabolic risk factors.\textsuperscript{22}

Physical activity not only lowers serum glucose levels but also increases insulin sensitivity, so less insulin is needed to transport glucose into cells.\textsuperscript{39} As a result, physical activity reduces microvascular and macrovascular complications. The Diabetes Prevention Project, a large, randomized, clinical trial, found that participants who did not meet weight-loss targets but did meet the goal of 150 minutes of physical activity per week were 44% less likely to develop diabetes.\textsuperscript{40} Further, some studies have shown that exercise training improves metabolic syndrome overall.\textsuperscript{41-43}

High sensitivity C-reactive protein (hsCRP) is a biomarker of the chronic inflammatory process associated with CVD risk.\textsuperscript{34-46} Recent clinical trials found that individuals diagnosed with metabolic syndrome had an approximate 2-fold higher level of hsCRP.\textsuperscript{15} This emerging biomarker of cardiometabolic risk appears to be one of the most reliable inflammatory markers under investigation at this time. HsCRP is synthesized in the liver in response to the release of cytokines, such as interleukin-1 (IL-1), interleukin-6 (IL-6), and tumor necrosis factor.\textsuperscript{15} The high sensitivity assay detects the small but significant CRP concentrations that are necessary to assess cardiometabolic-related risk. Physical activity appears to block inflammatory processes marked by hsCRP and prevents the formation of blood clots in individuals with increased cardiometabolic risk.\textsuperscript{23}

The research on physical activity in the presence of the metabolic syndrome has generally focused on episodes of moderate or greater intensity physical activity or structured, planned exercise throughout the week. Low intensity “lifestyle” physical activity frequently throughout the day appears to be equally as important as episodic exercise sessions. Over time, low intensity activity may impart greater benefits for cardiometabolic-risk reduction.

It is important to note that low intensity activity is advantageous in terms of accessibility, tolerance, and cost and is associated with fewer activity-related injuries.\textsuperscript{47} For these reasons, low intensity physical activity may lead to improved adherence and maintenance over time. Research is underway in this area.

**ADHERENCE AND LONG-TERM MAINTENANCE OF PHYSICAL ACTIVITY**

Despite the benefits of physical activity to reduce cardiometabolic risk, it is well documented that adherence and long-term maintenance are not only difficult to achieve but also decrease over time as the prevalence of metabolic syndrome increases. Between NHANES III (1988–1994) and NHANES 2001–2006, the proportion of adults who engaged in physical activity more than 12 times per month declined from 57% to 43% in men and from 49% to 43% in women.\textsuperscript{48} In addition, the proportion of adults reporting levels of physical activity consistent with the Healthy People 2010 objectives of at least 150 minutes per week of moderate intensity physical activity or 75 minutes per week of vigorous physical activity (or equivalent combination) remained low and decreased with age.\textsuperscript{49}

Some of the strategies recommended by the NHLBI to promote adherence with physical activity recommendations include setting goals, tracking progress, and providing feedback.\textsuperscript{23} Specific, achievable goals are recommended for successful change. Goals that involve behaviors (“I will walk for 30 minutes on most days of the week”) tend to be more effective than physiological goals (“I will improve my fitness level”). Tracking
progress may help with all the things patients have to remember each day and helps patients to know whether they are meeting their daily physical activity goals.

Providers must also be aware that patients’ subjective perceptions of their level of activity are not always accurate. Among men, self-reported physical activity was 44% greater than actual (objectively measured) values, and among women, self-reported activity was 138% greater than actual measured physical activity. Involving the patient in monitoring activity is a strategy that may be effective for some. Information and communication technology makes it possible to provide objective evidence and real-time monitoring of physical-activity levels to improve patient awareness and motivation. Real-time monitoring using an armband device was found to be an effective motivator for health behavior changes in a weight-loss trial.

Maintenance of physical activity translates to improved cardiometabolic outcomes but is a challenge to achieve long term. A meta-analysis of 79 intervention studies to increase physical activity involving 11,877 participants found that more contact between interventionists and participants was more effective for physical activity adherence. Research is needed to characterize the mechanisms underlying adherence and long-term maintenance of physical activity and to identify effective interventions that can be translated to clinical practice.

ROLE OF THE NURSE PRACTITIONER

Nurse practitioners (NPs) are in an ideal position to promote adherence and maintenance of physical activity to reduce cardiometabolic risk. Cognitive and behavioral strategies are typically used to promote physical activity, although often with equivocal results over the long term. When making recommendations to initiate or increase physical activity, providers must be aware that approximately one third of respondents in a study examining awareness of current US physical activity guidelines had direct knowledge of the recommended “dose” of physical activity (ie, frequency and duration).

The consensus of the current national guidelines is physical activity of moderate or greater intensity for at least 30 minutes, continuously or intermittently, on 5 if not all days of the week for a total of at least 150 minutes per week is needed. Further, when implementing and monitoring a plan for physical activity, the NP must be aware that the public’s recognition of cardiometabolic risk involved may be limited. It is important for providers to note that extensive research has found provider advice may be necessary but is rarely sufficient to result in the desired health behavior changes. Simply educating patients about cardiometabolic risk and informing them of the current physical activity guideline recommendations is not likely to change their behavior in the long term.

A strategy that may be more effective in promoting physical activity or other health behavior change is creating a 2-way conversation between patient and provider. Evidence-based practice requires that clinical decisions be consistent with the best available evidence in accordance with the values and preferences of the informed patient.

An innovative tool called a decision aid can be developed and implemented in the clinic setting to achieve these goals. Information about disease risk and treatment choices on a set of plastic or laminated cards and can be used for patients and their providers to visualize the best available evidence in an understandable format. The premise behind decision aids is that taking into account the patient’s context, values, and preferences, as well as the burden of other health care recommendations, will improve choices and increase adherence. Providers may have difficulty communicating the degree of cardiovascular risk in the setting of metabolic syndrome in a way patients can understand, and they cannot predict patient preferences for treatments. This tool also allows providers to present unbiased information about the advantages and disadvantages of treatment choices, and thus, increase health care quality and reduce costs.

Decision aids have been developed to help patients and their providers discuss options and associated outcomes and to make informed decisions about diabetes mellitus medications, statin medications, antihypertensive medications, and the short-term risk of acute coronary syndrome for patients with chest pain in the emergency department. Decision aids can be also developed to help create a conversation about physical activity and other health behaviors.

CONCLUSION

Health care providers must be prepared to assist patients with metabolic syndrome to achieve physical activity goals over the long term. The positive impact of physical activity on metabolic syndrome biomarkers cannot be underestimated. The individual benefits of physical activ-
ity are maximized by adherence; however, no approach to date has been successful in achieving maintenance long term in most patients. The current guidelines promote episodes of moderate or greater intensity physical activity each week; however, low intensity physical activity throughout the year is gaining support as a strategy necessary for reducing cardiometabolic risk.

Research is ongoing in this area to address the complex issue of adherence and maintenance of physical activity and other health behaviors. Approaches that focus on the process of change, supplemented by technology capable of providing real-time monitoring and feedback, hold promise for achieving physical activity goals. Including the patient in a 2-way conversation about values and preferences appears to contribute to adherence. This process can be supported by the development and use of innovative decision aids. Providers must be aware of the current evidence supporting various approaches for adherence and maintenance of health behaviors, such as physical activity, to achieve the best outcomes in view of the escalating prevalence of metabolic syndrome and cardiometabolic risk.

References


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