THE METABOLIC SYNDROME:

The Crucial Role of Exercise Prescription and Diet

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LEARNING OBJECTIVES

- To provide health and fitness professionals with an understanding of the beneficial effects that regular physical activity and fitness have on metabolic syndrome.
- To provide safe, effective guidelines for the health and fitness professionals charged with developing exercise prescriptions for those diagnosed with metabolic syndrome.

Key words:
Hypokinetic Disease, Physical Activity, MET·hour per week, MET·minute per week, Resistance Training

The metabolic syndrome is the clustering of five cardiovascular (CV) risk factors that include impaired fasting glucose (IFG) or overt Type 2 diabetes (T2D), overweight/obesity (particularly abdominal obesity), hypertriglyceridemia (high triglycerides), low high-density lipoprotein cholesterol (HDL-C), and hypertension (HTN). An individual that possesses three or more of these CV risk factors would be diagnosed with the metabolic syndrome (Table 1). The underlying causes of metabolic syndrome are numerous and complex; however, research suggests the two driving forces behind the development of the metabolic syndrome are abdominal obesity and insulin resistance (14). Recent studies estimate that every three adults living in the United States are overweight or obese (22), and one third of the U.S. adult population have T2D or IFG (high blood sugar) (7), both core components of a metabolic syndrome diagnosis. In addition, physical inactivity and low levels of cardiorespiratory fitness (CRF) are linked with the metabolic syndrome, and some researchers state that these two factors could be considered components of the syndrome (21).

An estimated 70% of the U.S. population have hypokinetic disease (physical inactivity) (13,20). This, coupled with poor nutrition habits, is the driving force behind the increasing number of people who have or will develop the metabolic syndrome. The national health objectives for the United States (Healthy People 2010) recognize the metabolic syndrome as a prominent health problem primarily due to the increased risk of CV disease (CVD)

TABLE 1: **Diagnostic Criteria for Metabolic Syndrome**

Any 3 of 5 Criteria Constitute Diagnosis of Metabolic Syndrome	Categorical Cut Points
Elevated waist circumference	≥102 cm in men
	≥88 cm in women
Elevated triglycerides	≥150 mg/dL (1.7 mM) or medication for hypertriglyceridemia
Reduced HDL-C	<40 mg/dL (0.9 mM) in men
	<50 mg/dL (1.1 mM) in women or medication for low HDL-C
Elevated blood pressure	≥130 mm Hg systolic BP or >85 mm Hg diastolic BP or medication for elevated blood pressure
Elevated fasting glucose	≥100 mg/dL or medication for elevated glucose

Adapted from Grundy et al. (14).

that accompanies a metabolic syndrome diagnosis. Health and fitness professionals (*e.g.*, physicians, exercise physiologists, dietitians) are now charged with helping people make positive lifestyle changes that will delay or reduce the risk of developing the metabolic syndrome and many other related chronic conditions.

This article presents the benefits that regular physical activity (PA) and fitness have on the metabolic syndrome and provides a guide for health and fitness professionals to develop safe, effective exercise prescriptions for this growing at-risk population.

IMPACT OF THE PROBLEM

Current data from the most recent National Health and Nutrition Examination Survey suggest that one in three U.S. adults (6), and approximately 3.5% of U.S. adolescents 12 to 19 years of age (23) have the metabolic syndrome. The metabolic syndrome has been shown to contribute to premature morbidity (sickness) and mortality (death) resulting from CVD and T2D, two of the leading causes of death worldwide (17). With this in mind, the U.S. medical community recognized the importance of diagnosing the metabolic syndrome by creating the International Classification of Disease Code 277.7 for the dysmetabolic syndrome (9). Despite recognition from the medical community, metabolic syndrome prevalence in the United States continues to increase (12).

PA, FITNESS, AND ENERGY EXPENDITURE

The health benefits of regular PA are well recognized (24). Recent studies have examined the effects of leisure-time PA (LTPA) and CRF on the metabolic syndrome. Increased levels of both LTPA and CRF have been shown to reduce the risk of metabolic syndrome among whites and ethnically diverse people (5, 16, 26). Increased levels of muscular strength resulting from resistance training (RT) also seem to provide protection from the development of the metabolic syndrome (18, 19). Furthermore, a recent study reported that engaging in enough PA and or exercise to expend 400 Kcal per day (brisk walking for 1 hour) may help prevent the development of the metabolic syndrome (10).

THE ROLE OF THE HEALTH AND FITNESS PROFESSIONAL

With the number of people presenting with multiple risk factors (*e.g.*, central obesity, T2D, HTN) for CVD continuing to increase, the prevalence of the metabolic syndrome also has continued to rise (12). This places a greater demand on the primary care physician for treating multiple chronic disorders and on the individual for making healthy lifestyle changes. Previous research has shown that physicians do not typically discuss exercise or PA with their patients (27). However, a recent study (8) provided encouraging news regarding physician counseling on increasing PA in people with T2D. The results of this study suggest that people with other chronic conditions (*e.g.,* central obesity, hypertension) or a clustering of risk factors as found with the metabolic syndrome may be more likely to receive counseling on increasing PA from their physician or other health care professional (*e.g.*, exercise physiologist, dietitian).

EXERCISE PRESCRIPTION FOR PEOPLE WITH METABOLIC SYNDROME

Qualified fitness professionals should have a good understanding of how to develop a safe, effective exercise prescription. However, when working with people with the metabolic syndrome, exercise prescriptions demand a high level

TABLE 2: **Partial List of Compendium of Physical Activities**

Compcode	METs	Heading	Description
01009	8.5	bicycling	bicycling, BMX, or mountain
01010	4.0	bicycling	bicycling, <10 mph, leisure, to work, or for pleasure bicycling
01015	8.0	bicycling	bicycling, general
01020	6.0	bicycling	bicycling, 10–11.9 mph, leisure, slow, light effort
01030	8.0	bicycling	bicycling, 12–13.9 mph, leisure, moderate effort
01040	10.0	bicycling	bicycling, 14–15.9 mph, racing or leisure, fast, vigorous effort
01050	12.0	bicycling	bicycling, 16–19 mph, racing/not drafting or >19 mph drafting, very fast, racing general
01060	16.0	bicycling	bicycling, >20 mph, racing, not drafting
01070	5.0	bicycling	unicycling
02010	7.0	conditioning exercise	bicycling, stationary, general
02011	3.0	conditioning exercise	bicycling, stationary, 50 W, very light effort
02012	5.5	conditioning exercise	bicycling, stationary, 100 W, light effort
02013	7.0	conditioning exercise	bicycling, stationary, 150 W, moderate effort
02014	10.5	conditioning exercise	bicycling, stationary, 200 W, vigorous effort
02015	12.5	conditioning exercise	bicycling, stationary, 250 W, very vigorous effort
02020	8.0	conditioning exercise	calisthenics (*e.g.*, pushups, sit-ups, pull-ups, jumping jacks), heavy, vigorous effort
02030	3.5	conditioning exercise	calisthenics, home exercise, light or moderate effort, general (example: back exercises), going up & down from floor
02040	8.0	conditioning exercise	circuit training, including some aerobic movement with minimal rest, general
02050	6.0	conditioning exercise	weight lifting (free weight, nautilus, or universal-type), power lifting or body building, vigorous effort
02060	5.5	conditioning exercise	health club exercise, general
02065	9.0	conditioning exercise	stair-treadmill ergometer, general
02070	7.0	conditioning exercise	rowing, stationary ergometer, general
02071	3.5	conditioning exercise	rowing, stationary, 50 W, light effort
02072	7.0	conditioning exercise	rowing, stationary, 100 W, moderate effort
02073	8.5	conditioning exercise	rowing, stationary, 150 W, vigorous effort
02074	12.0	conditioning exercise	rowing, stationary, 200 W, very vigorous effort
02080	7.0	conditioning exercise	ski machine, general
02090	6.0	conditioning exercise	slimnastics, jazzercise
02100	2.5	conditioning exercise	stretching, hatha yoga
02101	2.5	conditioning exercise	mild stretching
02110	6.0	conditioning exercise	teaching aerobic exercise class
02120	4.0	conditioning exercise	water aerobics, water calisthenics
02130	3.0	conditioning exercise	weight lifting (free, nautilus, or universal-type), light or moderate effort, light workout, general
02135	1.0	conditioning exercise	whirlpool, sitting

TABLE 2: **(continued)**

Adapted from Ainsworth et al. 2000 (1).

of specificity. With this in mind, fitness professionals should possess a certain level of knowledge, experience, and comfort if they choose to work with this at-risk population. The most recent PA recommendations issued by the American College of Sports Medicine (ACSM) and the American Heart Association (AHA) for adults 18 to 65 years of age (15) provide a sound base for developing an exercise prescription in healthy adults. A combination of moderate- and vigorous-intensity PA in the range of 450 to 750 MET·minutes·per week is the minimal amount necessary to realize significant health benefits. In addition, at least 2 days per week of RT is recommended (15). The current recommended level of PA for the management of the metabolic syndrome is 30 to 60 minutes per day of moderate-intensity PA supplemented by 2 days per week of RT (14). This recommendation is very similar to the ACSM/AHA except vigorous PA is not

TABLE 3: Calculating Lower and Upper Targets for Individuals With Metabolic Syndrome Using %HRR* (Karvonen Method)

220 age = APMHR† (known maximal heart rate from a graded exercise test can be substituted)
Lower target HR‡ range = (0.50) (APMHR† - RHR¶) + RHR¶
Upper target HR‡ range = (0.75) (APMHR† - RHR¶) + RHR¶

* *%HRR indicates percentage heart rate reserve.*
† *APMHR, age-predicted maximal heart rate.*
‡ *HR, heart rate.*
¶ *RHR, resting heart rate.*

encouraged in those with metabolic syndrome due to the increased CV risk.

Exercise professionals now have many tools (*e.g.,* accelerometers, heart rate monitors) that allow them to develop more precise exercise prescriptions in both healthy and at-risk populations. One particular tool that is invaluable is the Compendium of PA (1). The Compendium of PA can be used to assign a specific MET level (absolute intensity level) to each type of activity making up the exercise prescription. Metabolic equivalents are obtained by dividing the relative oxygen consumption (milliliters per kilogram per minute) by 3.5 $ml \cdot kg^{-1}$·per minute. Using a specific MET level gives more precise information regarding how much energy the person is expending (Table 2), thus allowing the fitness professional to easily translate the current level of PA recommended for the management of the metabolic syndrome into MET·minutes per week or MET·hours per week. This is becoming a more accepted way of expressing exercise volume and determining energy expenditure; thus, fitness professionals need to become more familiar with this concept. Metabolic equivalent·minutes per·week are calculated by taking the number of times per week an individual engages in an activity (frequency [*F*]), the MET level (intensity [*I*]) of the activity, and the duration in minutes (time [*T*]) of the activity and putting them in the following formula:

$$F \times I \times T = MET_{7 \text{ minutes per } 7 \text{ weeks}}$$

$MET_{7 \text{ hours per } 7 \text{ weeks}}$ are calculated by dividing $MET_{7 \text{ minutes per } 7 \text{ weeks}}$ by 60 minutes:

$$MET_{7 \text{ min per } 7 \text{ weeks}/60 \text{ minutes}} = MET_{7 \text{ hours per } 7 \text{ weeks}}$$

For example, if a person is working at 3 METs for 30 minutes per day, 5 times per week, the person would be accumulating 450 MET·minutes per week of activity, or divided by 60 minutes per hour, the person would be accumulating 7.5 MET·hours per week. If a physician, exercise professional, or other health care professional recommends an individual engage in a specific amount of activity at a precise MET level, the aforementioned calculations can be done in reverse. For example, if a person was prescribed 750 MET·minutes per week at an intensity of 5 METs, the person would need to accumulate 150 minutes (750/5 = 150) over the course of the week at that intensity.

Considering their sedentary nature and the level of overweight/obesity found in those with metabolic syndrome, fitness professionals must address relative intensity when selecting the appropriate absolute intensity for starting these individuals on an exercise program. Fitness professionals need

TABLE 4: Calculating Lower and Upper Ranges for MET·Minutes per Week, MET·Hours per Week, and Total Weekly Energy Expenditure

Lower Range					
Frequency	**Intensity**	**Time**	**MET·minutes per week**	**MET·hours per week**	**BW = Energy Expenditure, Kcal**
Aerobic-/Endurance-Type Activity					
3×/week*	3 METs*	30 minutes = 270	MET·minutes per week/60 minutes = 4.5	MET·hours per week*	80 kg = 360 Kcals
RT-Type Activity					
2×/week*	6 METs*	15 minutes = 180	MET·minutes per week/60 minutes = 3.0	MET·hours per week*	80 kg = 240 Kcals
Weekly total = 450 MET·minutes per week/60 minutes = 7.5 MET·hours per week* 80 kg = 600 Kcals					
Upper Range					
Frequency	**Intensity**	**Time**	**MET·minutes per week**	**MET·hours per week**	**BW = Energy Expenditure, Kcal**
Aerobic-/Endurance-Type Activity					
5×/week*	6 METs*	30 minutes = 900	MET·minutes per week/60 minutes = 15	MET·hours per week*	80 kg = 1,200 Kcals
RT-Type Activity					
2×/week*	6 METs*	20 minutes = 240	MET·minutes per week/60 minutes = 4.0	MET·hours per week*	80 kg = 320 Kcals
Weekly total = 1,140 MET·minutes per week/60 minutes = 19 MET·hours per week* 80 kg = 1,520 Kcals					

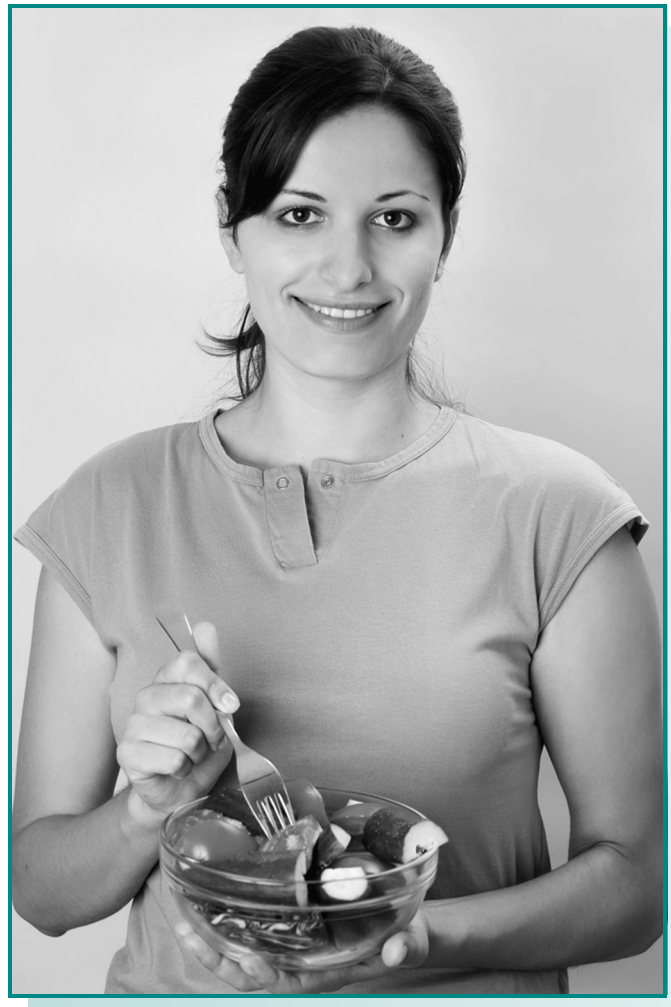
1 Kcal is expended for every 1 MET·hour per kg of BW.
BW indicates body weight in kilograms (2.2 pounds = 1 kg); Kcals, energy expenditure.

to consider the PA history and current fitness level for each of their clients. However, as is the case in many fitness settings, $\dot{V}O_{2max}$ or $\dot{V}O_{2peak}$ may not be known, and fitness professionals must rely on heart rate when developing exercise prescriptions. When this is the case, using percentage of heart rate reserve (%HRR), also known as the Karvonen method, for prescribing exercise intensity would be appropriate. David Swain, Ph.D., FACSM, and Brian Leutholtz, Ph.D. (25) nicely illustrated that independent of age, fitness level, or resting heart rate, the %HRR is equivalent to $\dot{V}O_{2R}$ (the percentage of the difference between resting and maximal $\dot{V}O_2$). Table 3 illustrates how fitness professionals can calculate the lower (50%) and upper (75%) targets for %HRR. This represents the range of exercise intensities that has been recommended by ACSM for individuals with metabolic syndrome (2).

In management of the metabolic syndrome, a primary concern is reducing caloric intake by 500 to 1,000 calories per day. Gradual increases in regular PA can contribute to the overall caloric deficit (14). An individual expends approximately 1 Kcal/kg of body weight for every 1 MET hour of activity (1 Kcal kg^{-1} per hour). For example, a person weighing 100 kg (220 pounds) who is exercising at an intensity of 6 METs for 60 minutes will have a gross caloric expenditure of 600 Kcals. Knowing this allows exercise professionals to use energy expenditure (calories) in developing exercise prescriptions. Table 4 presents an example, which illustrates lower and upper ranges for both aerobic-/endurance-type activities and RT-type activities using MET·minutes per·week, MET·hours per week, and total weekly energy expenditure. In addition to aerobic-/endurance-type exercise, regular RT has been shown to have favorable effects on all components of the metabolic syndrome (3). Therefore, including 8 to 10 RT exercises performed for 8 to 12 repetitions 2 days per week should be considered based on other risk factors for adults, including those with the metabolic syndrome. For individuals with high CV risk (*i.e.*, metabolic syndrome), RT exercises should be terminated when the concentric phase becomes difficult. This typically corresponds with a rating of perceived exertion of 15 to 16 (2).

In addition to the previously mentioned relative intensity of PA, the absolute intensity of PA can be described in METs. Activities requiring a MET level less than 3.0 are considered ''light,'' 3.0 to 6.0 METs are classified as ''moderate,'' and any activities requiring greater than 6.0 METs are ''vigorous.'' In developing an exercise prescription for a healthy individual, a combination of moderate and vigorous activities can safely be used. However, when prescribing exercise for someone with metabolic syndrome, fitness professionals are encouraged to recommend 30 to 60 minutes of daily moderate-intensity aerobic-/endurance-type PA and at least 2 days per week of RT (14). Light activities and activities of daily living should not contribute to the PA recommendation in apparently health adults (15); however, due to their sedentary nature and risk profiles of those with metabolic syndrome, these activities can be a beneficial part of an active lifestyle. Tables 3 and 4 are important because they illustrate a starting point and a range of gradual progression for safe, effective exercise programs in those with metabolic syndrome.

The AHA/ACSM states that healthy adults should accumulate a minimum of 450 to 750 MET·minutes per week or 7.5 to 12.5 MET·hours per week through a combination of moderate and vigorous PA (15). The 30 to 60 minutes of daily moderate-intensity aerobic PA recommended by the AHA/National Heart, Lung, and Blood Institute (NHLBI) for individuals with the metabolic syndrome (14) can easily be converted to 450 MET·minutes per week, which mirrors the lower end of the range for the PA recommendation for healthy adults. Individuals with the metabolic syndrome need this level of PA (or more) primarily to promote weight loss and reduce insulin resistance, the two core components of the syndrome.



WHAT ABOUT DIET?

Preference is given to a caloric deficit of 500 to 1,000 calories per week by the AHA/NHLBI for the management of the metabolic syndrome (14). Given the relatively small role exercise plays in inducing weight loss when compared with decreasing caloric intake, the clinical dietitian plays a vital role in metabolic syndrome management. Assessing an individual's PA pattern via questionnaire, providing individualized dietary interventions, working with physicians on counseling for behavioral change, and performing follow-up evaluations for dietary adherence and weight management are key roles that can be filled by the dietitian (4). Despite the small contribution exercise makes toward weight loss, increases in daily PA can lead to improvements in CRF. Recent data from the Aerobics Center Longitudinal Study examining the association between CRF, macronutrient intake, and the metabolic syndrome illustrate a similar prevalence of the metabolic syndrome among men and women with similar macronutrient (carbohydrate, protein, fat) intakes (11). However, when they looked at CRF, individuals in the highest fitness categories had the lowest prevalence of the metabolic syndrome independent of their diet. This does not devalue the importance of diet among individuals with the metabolic syndrome; however, it does reinforce the importance of regular PA in promoting and maintaining a greater level of CRF for those with or at risk of the metabolic syndrome.

FINAL THOUGHTS

In dealing with both healthy adults and at-risk populations, the exercise professional must stay within his or her scope of practice (*e.g.,* exercise prescription, motivation). Engaging in the practice of writing dietary recommendations and suggesting specific supplement usage beyond common knowledge information (*e.g.,* staying hydrated) could be considered both unethical and a breach of the law. This should be left to a registered dietitian or licensed nutritionist. A competent exercise professional should develop professional relationships with both their medical and nutrition communities for referral services. Exercise professionals working with at-risk populations must require that individuals receive a complete medical evaluation and obtain a physician clearance before beginning an exercise program. This will provide important information for establishing a risk factor profile and providing critical baseline information (*e.g.*, blood pressure, lipid profile) for developing an initial exercise prescription that is safe and effective.

SUMMARY

With two thirds of the U.S. adult population being classified as overweight or obese and one third having IFG or T2D, it is not surprising that the metabolic syndrome prevalence continues to increase. We know that both increased levels of LTPA and CRF reduce the risk of developing the metabolic syndrome. Health and fitness professionals have been charged with combating this highly prevalent syndrome. Increased physician counseling about exercise and PA can have a great impact on the health of those diagnosed with the metabolic syndrome. Just as important, the exercise professionals working with those with the metabolic syndrome should use the Compendium of PA and take into consideration individualized risk factors for each client.

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CONDENSED VERSION AND BOTTOM LINE

The metabolic syndrome is a cluster of CV risk factors that has become highly prevalent in the U.S. adult population. The health and fitness professional plays a crucial role in helping these individuals make positive lifestyle changes. Encouragement from the primary care physician may increase PA participation in those diagnosed with the metabolic syndrome and many other chronic conditions. Knowing that a minimum of 30 minutes of moderate-intensity PA is preferred for managing the metabolic syndrome, the exercise professional can now develop very precise exercise prescriptions using the Compendium of PA.