Chapter 15
Physical Exercise and the Human Stress Response

It has been suggested (Chavat, Dell, & Folkow, 1964; Kraus & Rabb, 1961; Nesse, Bhatnagar, & Young, 2007) that the "wisdom of the body" dictates that the human stress response should lead to physical exertion or exercise. Indeed, physical exercise appears to be the most effective way of ventilating, or expressing, the stress response in a health-promoting manner, once it has been engendered.

Having reviewed the psychophysiological nature of human stress in Part I, it seems reasonable to conclude that stress represents a psychophysiological process that prepares the body for physical action. The increased blood supply to the heart and skeletal muscles, coupled with increased neuromuscular tension, circulating free fatty acids and glucose, as well as the diminished blood flow to the GI system, all lead to the conclusion that the stress response prepares the organism for action (Benson, 1975; Cannon, 1914, 1929; Chavat, Dell, & Folkow, 1964; Kraus & Rabb, 1961; Smith, 2002).

It also seems feasible to assume that, thousands of years ago, the highly active lifestyle of primitive humans afforded ample opportunity to express physically the arousal that resulted from the frustrations and dangers they encountered on a daily basis. Similarly, there was likely sufficient opportunity for our ancestors to develop many of the positive physical and psychological advantages known to accrue from regular physical exercise. Yet in developing from "physical beings" to "thinking beings," humans have fewer chances to ventilate frustrations, failures, and challenges in healthful physical expression. This need to ventilate and refresh our minds and bodies through exercise is apparently so important that some have suggested (Chavat et al., 1964; Greenberg, Dintiman, & Myers-Oakes, 1998; Kraus & Rabb, 1961; Smith, 2002) that the lack of physically active somatomotor expression may lead to an increased risk of disease and dysfunction. In a narrative review by Warbuton, Nicol and Bredin (2006), they conclude, "there is incontrovertible evidence that regular physical activity contributes to the primary and secondary prevention of several chronic diseases and is associated with a reduced risk of premature death" (p. 807).

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Predicated on information from the World Health Organization (WHO), Chavat et al. (1964) concluded that when the body is aroused for physical action, but that physical expression is suppressed, a condition of strain or psychophysiological overload may be created. They note: "When in civilized man … [stress] reactions are produced, the… [physically motivating] component is usually more or less suppressed.... What is obvious is that often repeated incidents of… [suppressed somatomotor activity] must imply an increased load on heart and blood vessels" (pp. 130–131).

Similarly, Kraus and Raab (1961) proposed that suppressed physical expression has a preeminent role in the etiology of a variety of anxiety- and stress-related diseases, which they referred to as "hypokinetic diseases." This concept is said to have influenced President John F. Kennedy to promote physical fitness as a major national priority during the early 1960s. In 2010, President Barack Obama announced the establishment of an interagency task force on childhood obesity to develop and implement strategies to reduce the childhood obesity rate to 5% by 2030. First Lady Michelle Obama, as part of this ambitious effort, unveiled her nationwide physical activity campaign "Let's Move" to help achieve the goal of having children born today reach adulthood at a healthy weight. These initiatives seem particularly timely and relevant, considering that the WHO (2012) recently noted that globally, around 31% of adults aged 15 years and older were insufficiently active in 2008. Moreover, they suggested that approximately 3.2 million deaths each year are attributable to inadequate physical activity (WHO).

If, indeed, we have accurately interpreted the "wisdom of the body" as intending that the stress response be consummated in some form of physical somatomotor expression, then a rationale quickly emerges for the consideration of physical exercise as a powerful therapeutic tool in prevention, treatment, and rehabilitation programs for stress-related disease and dysfunction.

History of Therapeutic Exercise

It seems reasonable to assume that our ancient ancestors suffered from few stress-related "hypokinetic" diseases because of their physically demanding lifestyles. It also appears that ancient Greeks, at least for a period of time, had an appreciation of the need to create a balance between physical and intellectual ventures. Plato [as cited in Simon and Levisohn (1987, p. 50)] claimed that "physical exercise is not merely necessary to the health and development of the body, but to balance and correct intellectual pursuits as well.... The right education must tune the strings of the body and mind to perfect spiritual harmony." Physical exercise likely gained the potential for therapeutic application when our physically active culture evolved into a more sedentary one.

Perhaps the earliest use of exercise in a therapeutic capacity, according to Ryan (1974), was in the fifth century B.C. It was during this time that the Greek physician Herodicus prescribed gymnastics for various diseases. In the second century B.C., Asclepiades prescribed walking and running in conjunction with diet and massage for disease, as well as for the ills of an "opulent" society.

In 16th-century Europe, Joseph Duchesne is thought to have been the first to use swimming as a therapeutic tool. He is said to have used such physical activity to strengthen the heart and lungs. As a result, exercise gained great popularity in Europe for its therapeutic and preventive applications.

In 1829, the *Journal of Health,* a monthly magazine published in Philadelphia and intended for the general population as well as the medical profession, covered topics such as the health effects of food, drink, atmospheric variables, minerals, hygiene, and exercise. Edward Hitchcock, a professor of chemistry and natural history at Amherst College, and the first professor of physical education in the USA, was a strong supporter of the journal. The publication advocated regular exercise, and Hitchcock considered walking the very best exercise for retaining health (Green, 1986). However, it was not until after the Civil War that exercise and fitness expanded to include all age groups in America.

Following World War I, therapeutic exercise and the study of exercise physiology gained momentum in the USA. According to Miller and Allen (1995), Hans Selye contended that regular exercise would better prepare someone to resist other stressors, and that stressful situations would not be as perilous to a physically fit individual compared with someone who has led a sedentary lifestyle. Physical fitness came into vogue for the lay public with the advent of the President's Council on Physical Fitness in 1956, and the urging of President Kennedy in the 1960s.

As more and more individuals began exercising, more data became available regarding its nature and effects. Physical fitness was promoted in occupational settings with the founding of organizations such as the American Association of Fitness Directors in Business and Industry, which actively and vigorously promoted the "Good health is good business" philosophy to millions at the job site.

Also in the 1960s, America experienced the advent of the urban "health spa." These urban/suburban facilities were centers for the promotion of a health-oriented culture; however, they were typically segregated by gender. The 1970s and the 1980s witnessed two revolutions in the pursuit of exercise that changed the gender separation. The first was the invention of exercise equipment, such as Nautilus, which made weightlifting easier, safer, and more efficient. Moreover, when practiced using the recommended protocol, it actually yielded the potential to facilitate skeletomuscular development while concurrently improving the efficiency of the cardiorespiratory system, thus achieving what exercise enthusiasts at the time considered the best of both worlds. Equipment, such as Cybex®, Hammer Strength®, Precor®, Life Fitness®, and Technogym®, has continued to refine this type of training.

The second revolution involved the image of physical exercise. As noted earlier, there existed two different psychologies of exercise, one for women and one for men. Under the influence of writers such as Kenneth Cooper (*The Aerobics Way: New Data on the World's Most Popular Exercise Program,* 1977) and Jimm Fixx (*The Complete Book of Running,* 1977), as well as the marketing and development of sophisticated exercise facilities that fostered social support, the social barriers to physical exercise fell. For the first time in American history, exercise became a social as well as physical activity that both men and women could pursue and enjoy together.

The 1980s also produced an escalation of scientific research interest in how exercise may be related to mental health (Rejeski & Thompson, 1993). Moreover, the 1980s, with stores such as the General Nutrition Center (GNC), proliferated the current multibillion dollar a year supplement industry that sold products claiming to provide sundry functions such as adding muscle, reducing fat, and accelerating metabolism. The 1980s also spawned the advent of step aerobics, which continues even today in some fitness facilities. The decades of the 1990s and 2000s saw the increase in mind–body therapeutic techniques in fitness facilities, such as yoga, including hot yoga studios, and pilates. Recent trends in the USA such as cycling classes, sports performance training, and muscle confusion and plyometric-style training (e.g., P90X), supercharged workouts and kettle bells (a cast-iron weight resembling a cannonball with a handle) or BOSU® balls (an inflated rubber hemisphere attached to a rigid platform) have demonstrated the cross-training interplay between cardiorespiratory, resistance, and flexibility to create a total body workout. In addition, many facilities are including fitness and nutrition consultations to foster members exercising outside the gym. The introduction of the Nintendo Wii in 2006 changed how video games are played and even how we exercise. The interactivity of the controllers and the ability to track body movements provide a novel approach to exercising, and a host of fitness games like Wii Fit, Wii Fit Plus, EA Sports Active, and EA Sports Active: More Workouts have been created.

Exercise continues to enjoy tremendous popularity in the USA and, as noted earlier, remains a viable area of pursuit for health care professionals. This chapter examines exercise as a therapeutic tool for the treatment of excessive stress.

Mechanisms of Action

Exercise itself represents an intense form of stress response, yet it differs greatly from the stress response implicated in the onset of psychosomatic disease. Why then is the stress of exercise health promoting, in most instances, and the emotionally related stress of living in a competitive urban environment, for example, health eroding? We now examine the mechanisms that may answer this question.

Three therapeutic mechanisms of action serve to explain the clinical effectiveness of exercise in the treatment of excessive stress.

1. Mechanisms active during exercise.
2. Mechanisms active shortly after exercise.
3. Long-term mechanisms.

The therapeutic mechanisms at work during the acute process of exercising are manifest in the propensity for such physical activity healthfully to utilize the potentially harmful constituents of the stress response. The stress-responsive gluconeogenic hormones (primarily cortisol) begin to break down adipose tissue for energy during the stress response. In this process, a form of fat, called *free fatty acid* (FFA), is released into the bloodstream (Ganong, 2005; Laugero et al. 2011). During the stress of physical exercise, FFA levels actually decline, because the FFA is utilized for energy by the active muscles. In contrast, however, during emotionally related stress, FFA is not utilized as rapidly because of the sedentary nature of this type of stress. The FFA persists in the bloodstream and is converted to triglycerides and, ultimately, to low-density lipoproteins (LDLs). LDLs are considered a major source of atherosclerotic plaque associated with premature coronary artery disease (Greco et al., 2010; Olgac et al. 2011; Sarafino & Smith, 2011).

A second factor to consider during the stress response is the significant demand placed on the cardiovascular and cardiorespiratory systems. Cardiac output (heart rate × stroke volume), blood pressure, and resistance to peripheral blood flow all increase. Also, breathing rate increases and bronchial tubes dilate during the stress response. By the use of moderate physical activity, however, these factors are utilized in a healthful form. Although cardiac output must increase, the rhythmic use of the striated muscles actually assists the return of blood to the heart (increase of venous return). Moreover, physical training allows the body to redistribute blood from less active tissues, such as digestive organs and kidneys, to active muscles, and even to the skin for heat dissipation (Sharkey, 1990; Wilmore, Costill, & Kenney, 2008). Blood pressure must increase during exercise as well, but not so dramatically as is seen when one remains inactive when stressed (e.g., as when sitting in a traffic jam). Regarding respiratory and O_2 transport, physical activity and training improve the efficiency of breathing muscles, allowing greater lung capacity. Thus, a moderately active individual uses fewer breaths to move the same amount of air, which improves diffusion of O_2 into the lungs.

Third, during the stress response, the hormones epinephrine and norepinephrine are released. Research (Dimsdale & Moss, 1980; Fibiger & Singer, 1984; Hoch, Werle, & Weicker, 1988; Lundberg, 2005; Wilmore et al., 2008) has shown that during the stress of exercise, norepinephrine is preferentially released, whereas during emotion-related stress, epinephrine is preferentially released. Circulating epinephrine represents the greatest risk to the integrity of the heart muscle, because the ventricles are maximally responsive to epinephrine, not norepinephrine, so in an individual suffering from heart ischemia, high levels of epinephrine could induce a lethal arrhythmia (Krantz, Quiqley, & O'Callahan, 2001; Lovallo, 2005; McCabe & Schneiderman, 1984). Also, during the stress response, the resistance of blood flow to the skin and other peripheral aspects increases. During the stress of exercise, resistance of blood flow in the skin actually decreases, which has implications for cooling the body and lowering blood pressure [(Duncker & Bache, 2008); also see Ganong (2005), for a discussion of cardiovascular dynamics). Overall, exercise seems to fine-tune the body's secretions and response to hormones, leading to a more efficient use of energy sources (Sharkey, 1990; Wilmore et al. 2008).

The preceding examples are indicative of the different ways the body responds to the stress of exercise in contrast to the stress response that we undergo if we remain static or inactive. Clearly, the acute strain on the body is quite different if one undergoes a stress response in an active rather than inactive state. Although physical activity is capable of using the constituents of the stress response in a constructive manner, the therapeutic reactions may persist beyond the acute period of exercise.

The short-term therapeutic mechanisms associated with exercise entail the initiation of a state of relaxation following the physical activity. In most circumstances, plasma catecholamines return to resting levels within minutes of acute exercise (Mastorakos, Pavlatou, Diamanti-Kandarakis, & Chrousos, 2005). Clearly, exercise itself represents a powerful ergotropic response mediated by the SNS; however, according to Balog (1978), on completion of exercise, the organism may undergo psychophysiological recovery by initiating a trophotropic response mediated by the PNS. According to de Vries (1966), gamma motor neural discharge may also be inhibited during recovery from physical activity. The gamma motor system is a complementary connection from the cerebral cortex to the striated musculature. The result of such inhibition is said to be striated muscle relaxation.

The muscle-relaxant qualities of exercise have important implications for short-term declines in diffuse anxiety and ergotropic tone in autonomic as well as striated muscles. It has been demonstrated that striated muscle tension contributes to diffuse anxiety and arousal in striated and autonomic musculature through a complex feedback system (Gellhorn, 1964a, 1967; Jacobson, 1978). This system involves afferent (incoming) proprioceptive stimulation from striated muscles to the limbic emotional centers, the hypothalamus and cerebral cortex. Therefore, reduction in striated muscle tension should lead to a generalized decrease in ergotropic tone throughout the body, as well as a decrease in diffuse anxiety levels. These results have been demonstrated empirically by Gellhorn (1958a), and de Vries (1968, 1981), and the notion that exercise leads to decreased skeletal muscle tension now appears readily accepted (Foss & Keteyian, 1998; McGuigan & Lehrer, 2007).

Several theoretical rationales have been generated to explain the physiological benefits of physical exercise in reducing stress and anxiety. These include the endorphin hypothesis, which suggests that it is the release and binding of morphine-like endogenous opioids, such as beta endorphin, that affect feelings such as euphoria that have been associated with the anecdotal reports of a runner's high (Cox, 2002; Dishman & O'Connor, 2009). Another hypothesis is the monoamine neurotransmitter theory, or norepinephrine hypothesis, which suggests that the affective benefits of exercise may derive from increased levels of norepinephrine. The thermogenic hypothesis contends that the elevation in body temperature that occurs during exercise leads to decreased stress (Tuson & Sinyor, 1993; Craft & Perna, 2004). Although these theories are readily accepted in this field of study, it is worth noting that none has received conclusive empirical support.

The most significant long-term mechanisms of health promotion inherent in exercise appear to emerge when exercise is aerobic and practiced for a minimum of at least 1 month. One of the areas most positively affected is the ability to use O_2 more efficiently. Exercise training of an aerobic nature increases maximum ventilatory O_2 uptake by increasing both maximum cardiac output (the volume of blood ejected by the heart per minute, which determines the amount of blood delivered to the exercising muscles) and the ability of muscles to extract and use O_2 from blood (Banerjee, Mandal, Chanda, & Chakraborti, 2003; Fletcher et al., 1996). In addition to reduced cardiovascular responses to stress, which lead to long-term, reduced risk of clinical manifestations of coronary heart disease (CHD), recent data suggest that physical activity may help in the prevention and treatment of osteoporosis and certain cancers, most notably colon cancer (Courneya et al., 2007; Fletcher et al.; Knols, Aaronson, Uebelhart, Fransen, & Aufdemkampe, 2005; Mutrie et al., 2007; Valenti et al., 2008). There has been a recent study (Bouchard et al., 2012), however, involving 1,687 exercising participants, in which 10% experienced adverse metabolic responses on at least one measure related to heart disease (blood pressure, levels of insulin, HDL cholesterol, or triglycerides) and 7% experienced adverse metabolic responses to at least two measures. Clearly more research is needed in this area.

Researchers have also continued to investigate the effects of exercise on improved psychological functioning in the areas of anxiety, self-esteem, and most notably depression. DiLorenzo and associates (1999) reported that exercise-induced increases in aerobic fitness using a stationary bicycle resulted in improved short- and long-term effects on the psychological variables of anxiety, depression, self-concept, and vigor. Furthermore, Ekeland, Heian, and Hagen (2005) have shown that exercise interventions can improve self-esteem in children and young people.

Blumenthal and associates (2005), in a randomized control trial of 134 patients with stable ischemic heart disease (IHD) and exercises-induced myocardial ischemia, who were assigned to either a stress management group (16 weeks of 1.5 h/week of a cognitive-social learning model) plus usual care (routine medical care), an exercise group (35 min three times/week for 16 weeks of stationary biking, walking and jogging) plus usual care, or just a usual care group, reported that the exercise training group and stress management training group "exhibited greater improvements in psychosocial functioning, including less emotional distress and lower levels of depression compared with usual control groups" (p. 1632). Other studies specifically assessing anxiety sensitivity, or the belief that anxiety-related sensations can have negative consequences (e.g., lead to panic attacks), have demonstrated the efficacy of brief aerobic exercise regimens in lowering anxiety sensitivity scores compared with non-exercisers or waitlist controls (Broman-Fulks & Storey, 2008; Smits et al., 2008; Smits, Tart, Rosenfield, & Zvolensky, 2011). In a recent review of different treatment approaches to pain-related fear associated with chronic musculoskeletal pain, De Peuter and colleagues (2009) suggested that patients might benefit from graded activity (GA), which is an intervention based on learning principles in which selected behaviors or exercises are shaped through positive reinforcement, combined with education about fear avoidance and challenging irrational beliefs (e.g., catastrophizing).

While efficacy studies related to exercise and anxiety are expanding, the preponderance of intervention studies has investigated the relation between exercise and depression. Herman and colleagues (2002) randomly assigned 156 participants aged 50 years and older who were diagnosed with depression into one of three conditions (medication only, exercise only, and combination of exercise and medication). Their results showed that participants who rated themselves as high on state anxiety or low on life satisfaction were more likely to drop out of treatment prematurely, or if they stayed in the treatment condition, they did not experience amelioration of their depressive symptoms. It was additionally noteworthy that these results were observed across all three of the conditions.

A 2009 Cochrane review of 144 potential studies resulting in a sample of 28 randomized controlled trials (25 of which provided suitable data for meta-analysis) evaluated the effect of exercise (aerobic, resistance, or a mixture of the two) compared with no exercise, CBT, pharmacotherapy and light therapy on symptoms of depression (Mead et al., 2009). For the 23 trials (907 participants) that compared exercise to no treatment or a control condition, the pooled analysis found that exercise had a large clinical treatment effect in reducing depression. However, Meade and colleagues noted that most of the studies analyzed had notable methodological weaknesses. Additional subgroup analyses within the same Cochrane Review revealed that resistance exercise and mixed exercise reduced symptoms of depression more than aerobic exercise alone. Moreover, one study ($N=23$) included in the Review noted increased improvement in Beck Depression Inventory scores in patients who exercised 3–5 times a week for 30-min sessions compared with patients who only exercised once a week (Legrand & Heuze, 2007). The notion of higher-dose exercising being more effective in alleviating symptoms of depression than lower-dose exercising was further supported in a recent randomized control study (Trivedi et al., 2011).

Despite the noted methodological uncertainties and limitations addressed in the Cochrane Review, exercise is considered to reduce symptoms of depression as effectively as CBT and pharmacotherapy, and should be considered a viable treatment option for patients with symptoms of mild, as compared to moderate-to-severe, depression (Blumenthal et al., 2007; Blumenthal & Ong, 2009; Dinas, Koutedakis, & Flouris, 2011; Gill, Womack, & Safranek, 2010; Hoffman et al., 2010). Blumenthal and Ong (2009) recommend the future use of well-standardized mulitcenter clinical trials to assess the efficacy of exercise on depression, and a more recent meta-analysis has suggested the inclusion of quality of life (QoL) measures to assess further the impact of exercise on symptoms of depression (Schuch, Vasconcelos-Moreno, & Fleck, 2011).

In a systematic meta-analytic review of intervention studies designed to alleviate concomitant depression in elderly patients with osteoarthritis (OA), Yohannes and Caton (2010) reported that four of the seven exercise program studies reviewed evidenced significantly reduced depressive symptoms. One of the studies by Penninx and colleagues (2002) demonstrated that aerobic exercise had a more beneficial clinical effect on depression than did resistance exercise. Yohannes and Caton concluded that future studies should explore the benefits of community-based exercise programs to increase social support, as well as assessing the sustainable effects of exercise programs on depression in OA patients. More recently, Shahidi and colleagues (2011) in a randomized trial of 60 women aged 60 years or older noted the comparable benefits of exercise and Laughter Yoga, which combines yoga breathing, stretching, and laughter, in alleviating depression.

Collectively, it may well be that the long-term physiological and psychological mechanisms of action that support the use of exercise in the treatment and prevention of stress-related disease represent a higher level of physical and psychological fitness and, therefore, a higher level of stress resistance. This higher level of fitness may then aid the individual, both psychologically and physically, in withstanding the potentially injurious effects of excessive stress. One might consider such a level of fitness as a buffer to excessive stress reactivity (Rejeski & Thompson, 1993). Based upon the work of Sime (1984), Weller and Everly (1985), Sharkey (1990), Seraganian (1993), Weyerer and Kupfer (1994), Haskell (1995), Mokdad et al. (2004), and Vuori (2010), we suggest that the stress-resistant aspects of sustained, chronic exercise include the following:

1. Improved cardiorespiratory efficiency.
2. Improved glucose utilization.
3. Reduced body fat.
4. Reduced resting blood pressure.
5. Reduced resting muscle tension.
6. Decreased ANS reactivity.
7. Increased steroid reserves to counter stress.
8. Reduced trait anxiety.
9. Improved self-concept.
10. Improved sense of self-efficacy, physical self-concept, and self-control.

All of these potential alterations are relevant in that they contribute to the individual's ability to tolerate high levels of stress, and, therefore, decrease the likelihood of developing stress-related pathology.

Research Supporting Therapeutic Exercise for Stress

A review of the following current and past literature on the clinical use of exercise in the treatment of excessive stress and stress-related disease provides ample support and rationale for the application of exercise:

1. Full-time employment for men, even in sedentary occupations, is positively associated with measured physical activity compared with men not working (Van Domelen et al., 2011).
2. Promoting physical activity is a common target of worksite health promotion programs for women (Janer & Kogevinas, 2008).
3. Exercise-based cardiac rehabilitation programs are associated with higher return to work rates and improved job satisfaction (Yonezawa et al., 2009).
4. It is estimated that more than 30% of coronary heart disease worldwide is due to physical inactivity, defined as less than 2.5 h/week of moderate exercise or 1 h/week of vigorous exercise (WHO, 2009).
5. In a review by Blair and colleagues (1996), moderately fit male non-smokers had a 41% lower all-cause death rate than those in the corresponding low fit category. Also, moderately fit female non-smokers had a 55% lower all-cause death rate than those who were low fit. Moreover, high fit men with two or three

other risk-factor predictors had a 15% lower death rate than did low fit men with none of the predictors. High fit women with two or three other risk factors had a 50% lower death rate than did low fit women with none of the predictors.

6. Graded exercise therapy (GET), provided alone or in combination with cognitive behavioral therapy (CBT), has been shown to improve physical and emotional functioning in patients with chronic fatigue syndrome (Castell, Kazantis, & Moss-Morris, 2011; Schreurs, Veehof, Passade, & Vollenbroek-Hutten, 2011).
7. Poor fitness is a diagnostic marker in patients with type 2 diabetes, and a meta-analysis of 266 patients who exercised for at least three times/week for 49 min/session for a minimum of 8 weeks (the mean was 20 weeks of exercise) showed an 11.8% increase in peak oxygen uptake (VO_2max) compared with a 1% decrease in the control group (Boule, Kenny, Haddad, Wells, & Sigal, 2003).
8. In a randomized-control trail of 309 patients with rheumatoid arthritis, a two-year intensive exercise program (consisting of cycling, strength training, and volleyball, basketball, football, or badminton two times/week lasting 75 mins) resulted in improved functional ability, emotional status, and a decreased loss of bone minerals (de Jong et al. 2003, 2004) compared with a usual care group.
9. A meta-analysis of 25 randomized controlled trials yielding a total of 1,404 participants revealed that aerobic exercise (of an estimated average of 120 min/week) resulted in a significant increase in HDL-C level, and that exercise was more effective in patients who exercised for a longer duration, had higher initial total cholesterol levels, and were less obese (BMI < 28) (Kodama et al., 2007).
10. Approximately 15.2% of all deaths in the USA are attributable to poor diet and lack of regular physical activity (Mokdad, Marks, Stroup, & Gerberding, 2005), and in Finland, physical inactivity, smoking, and limited consumption of vegetables were the most important lifestyle behaviors explaining relative educational level differences in cardiovascular and all-cause mortality for men and women (Laaksonen et al., 2008).
11. Engaging in exercise five or more times/week compared with rarely or no exercising was associated with reduced risk of colon cancer among men, whereas sedentary behavior (e.g., watching television) was positively associated with colon cancer (Howard et al., 2008).
12. A cost effectiveness study that assessed physical activity and disease incidence showed that physical activity interventions, compared with no interventions, reduced disease incidence and were cost effective, with dollars per quality-adjusted life year (QALY) gained ratios ranging from $14,000 to $69,000 (Roux et al., 2008).

This section on research may be summarized cogently by the conclusion drawn by Sime (1984) close to 30 years ago: "If stress is defined in the traditional fight-or-flight terminology, then exercise is a classic method of stress management through its active, dynamic release of physiological preparedness" (p. 502).

Exercise Guidelines

Once the decision to exercise has been made, the issue of how much exercise is enough to promote health and better cope with stress needs to be addressed. An acronym often used to account for the ingredients of exercise prescription is FITT, which stands for *F*requency, *I*ntensity, *T*ime (duration), and *T*ype (Foss & Keteyian, 1998). Before beginning an exercise program, it is wise to consider some type of screening or medical evaluation that includes a comprehensive history; a physical exam, including a measure of resting heart rate and blood pressure; blood analysis for fasting blood sugar and cholesterol levels; a measurement of expired gases; a 12-lead resting electrocardiogram (ECG); and an exercise tolerance or stress test with ECG monitoring (American College of Sports Medicine, 2010). Exercise tolerance tests include the Harvard Step Test, the Cooper 12-Minute Test, the Rockport One-Mile Fitness Walking Test, the YMCA protocol, and the Astrand–Ryhming test. These evaluations are useful in determining fitness levels, target heart rates, and maximal aerobic power, and screening for latent abnormalities that may only be evident during physical exertion (Table 15.1).

Returning to the question of how much exercise is enough, the American College of Sports Medicine (ACSM) has been providing minimum guidelines for enhancing cardiorespiratory efficiency since 1975. These recommendations have been based on data on dose–response improvements in performance capacity, especially in maximal aerobic power (maximum O_2 consumption) for otherwise healthy adults of all ages, and apply to adults with chronic diseases or disabilities when evaluated and followed by a health-care professional.

Table 15.1 Estimated Maximum Heart Rates and Exercise Training Heart Rates by Age for Normal Persons

		Percent		
Age	Maximum	70	60	50
21–30	195	159	147	135
31–40	185	152	141	130
41–50	175	145	135	125
51–60	165	138	129	120
61–70	155	131	123	115

Values are listed in beats/minute (bpm), computer using a heart rate of 75 bpm (adapted from Foss & Keteyian, 1998; Topend Sports Network, 2012).

Following these guidelines, Garber and colleagues (2011) from the ACSM, in a special communication in *Medicine & Science in Sports & Exercise,* an official journal of the ACSM, provide the following evidence-based physical exercise recommendations for enhanced cardiorespiratory fitness.

For adults, 150 min of moderate–intensity exercise (65% maximal oxygen uptake; VO_2max) per week that can be met through 30–60 min 5 days/week or 20–60 min of more vigorous-intensity exercise (80% maximal oxygen uptake VO_2max) 3 days/week. Multiple shorter exercise sessions (at least 10 min worth) or one continuous session are both considered adequate to meet the desired amount of daily exercise. Even for those who cannot adhere to these minimum standards, they can still benefit from some form of activity. Increased adherence and decreased injury risk are related to gradual progression of exercise duration, frequency, and intensity.

Exercise sessions for enhancing cardiorespiratory fitness efficiency should be structured using a format that contains a warm-up phase, an exercise phase, and a cool-down phase. Although there is some controversy about whether warming up and cooling down after exercising offers health benefits (Mayo Clinic, 2011), including reducing the number of injuries sustained during physical activity (Fradkin, Gabbe, & Cameron, 2006), since they pose minimal risks, if time allows, it seems worthwhile to implement them. The benefits of the warm-up phase, according to Ribisl (1984), Foss and Keteyian (1998) and Wilmore et al., 2008 include the following:

1. Facilitation of enzymatic activity due to an increase in body and muscle temperature.
2. Increased metabolic activity.
3. Improved blood flow and oxygen delivery.
4. Decreased peripheral resistance.
5. Increased speed of nerve conduction.

Another important component of the warm-up phase is not to begin by immediately stretching a cold muscle. Time should first be taken to do the sport activity at a slow, mild pace for 4–5 min. Foss and Keteyian (1998) suggest that this provides the most physiological benefits and minimizes muscle injuries, such as tears.

The actual aerobic activity itself may include walking, jogging, dance or step aerobics, rollerblading, cycling, and swimming, among others. If these exercise activities are performed according to appropriately prescribed FITT standards, then improved cardiorespiratory efficiency and increased resistance to stress should result. It is important to emphasize that to gauge intensity, standards should be based on heart rate instead of the myth that one must experience pain in order to receive the benefits of training.

The cool-down phase, especially for adults, facilitates venous return. This prevents pooling of blood in the extremities, which reduces the possibility of muscle soreness and cardiovascular strain, and the likelihood of becoming dizzy. The cool-down phase also enhances the removal of lactic acid and other metabolic waste products. This phase, which is the one most likely to be forgotten, is just as important as the two preceding phases for healthful, safe exercising.

Again, these recommendations are for aerobic fitness training, the type of exercise training most often associated with improved cardiovascular health. However, the components of muscular strength, most often associated with anaerobic fitness or resistance training, should also be considered for their potential health benefits. Exercises such as weightlifting, speed skating, and rapid sprinting that require short bursts of "all-out" effort are examples of anaerobic activities. During these types of activities, the body demands more O_2 than can be supplied by the vascular system. Therefore, anaerobic exercises (without O_2), which rely on energy being generated within the muscle by adenosine triphosphate (ATP), creatine phosphate, and the lactic acid (anaerobic glycolysis) system (Greenberg, Dintiman, & Myers-Oakes, 1998), cannot be performed indefinitely.

Although anaerobic activities rely on intensity, frequency, and duration of effort to achieve benefits, intensity (how hard one exercises) is considered the most important factor. Anaerobic performance enhancement typically relies on a process known as interval training, which incorporates the concept of the overload principle. As the name implies, the overload principle requires near maximal intensity in the performance of a series of repeated exercises known as work intervals or sets (e.g., rate, distance, number of repetitions) alternated with periods of relief (e.g., amount of time at rest between intervals, or the performance of some sort of light activity between sets). The number of intervals and periods of relief vary depending on the type of anaerobic activity and the goal of training; however, Garber and colleagues (2011), for general and overall muscular fitness, recommend training each major muscle group (chest, shoulders, back, hips, legs, trunk, and arms) 2 or 3 days each week using a variety of equipment and exercises. Most adults will respond favorably (e.g., hypertrophy and strength gains) to two to four sets of resistance exercises (for each exercise 8–12 repetitions to improve strength and power, 10–15 repetitions to improve strength in middle-aged and older persons just beginning a resistance program, and 15–20 repetitions to improve muscular endurance) per muscle group incorporating 2–3 min rest intervals between each set of exercises. A rest period of 48–72 h between exercise sessions is advisable to promote the cellular/molecular adaptations that foster strength and increased muscle size. Also worth noting is that most aerobic activities can be performed anaerobically by increasing the intensity of effort to approximately 85% or more of the heart rate reserve (Miller & Allen, 1995).

There are many notable benefits to enhancing muscular fitness, including lower risk of all-cause mortality (FitzGerald et al., 2004; Gale, Martyn, Cooper, & Sayer, 2007), improved body composition and image (Greenberg et al., 1998; Sillanpää et al., 2009), improved blood glucose levels (Castaneda, Layne, & Castaneda, 2006; Sigal et al., 2007), improved blood pressure in pre-hypertensive patients (Collier et al., 2008), increased bone density and strength (Kohrt, Bloomfield, Little, Nelson, & Yingling, 2004; Suominen, 2006), and increased energy (Puetz, 2006). These collective benefits serve to enhance an individual's self-concept and increase resistance to stress.

In addition to cardiorespiratory and muscular fitness training recommendations, Garber and her colleagues (2011) provide evidence-based exercise recommendations for the components of flexibility exercise and neuromotor exercise training, and note, as does Wilmore and his colleagues (2008), how all these exercise components can provide valuable health benefits, whether practiced independently or in combination. Even though joint flexibility decreases with age, it is important to incorporate flexibility exercises that have the goal of developing range of motion in the major muscle-tendon groups (shoulder, girdle, chest, neck, trunk, lower back, hips, posterior and anterior legs, and ankles), and to enhance postural stability and balance (particularly when combined with resistance exercises). Garber and colleagues (2011) encourage that flexibility exercises (e.g., static stretching, ballistic or "bouncing" stretching, dynamic stretching or proprioceptive neuromuscular facilitation (PNF)) be done at least 2 or 3 days each week, and should be done when the muscle is warm (either through light aerobic activity or external sources, such as heat packs or taking a hot bath). For static stretching (that may be either active or passive), each stretch should be held for 10–30 s until there is tightness or slight discomfort (there is little benefit from holding for longer durations) and repeated two to four times with the goal of 60s' total time per flexibility exercise.

According to Garber and associates (2011) neuromotor exercise training incorporates motor skills (e.g., balance), coordination, agility, gait, and proprioceptive training, and data show that it has been beneficial in reducing the risk of falls in older adults (Bird, Hill, Ball, Hetherington, & Williams, 2011; Jahnke, Larkey, Rogers, Etnier, & Lin, 2010; Li, Devault, & Van Oteghen, 2007). Examples of neuromuscular training include tai chi, certain forms of yoga, and qigong, which in essence, combine neuromotor exercise, resistance exercise, and flexibility exercise. Studies that have successfully employed neuromotor training incorporated it 2–3 days/week for 20–30 min duration each session. Garber and her colleagues (2011) suggest, however, that more research is needed before making definite recommendations regarding its use.

An additional consideration in developing exercise guidelines concerns adherence issues. Obviously, just providing a fitness program is not enough. The availability of the most modern exercise facilities does not significantly improve exercise adherence. Buckworth and Dishman (2007) have noted some of the major factors affecting exercise adherence:

1. Access to facilities.
2. Perceived availability of time.
3. Social support or reinforcement.
4. Exercise intensity.
5. Self-motivation.
6. History of lack of adherence.

This variety of different factors clearly suggests the multidimensional nature of physical activity determinants in establishing and sustaining exercise adherence.

In their 1995 article, Pate and his colleagues provided a formal and distinctly separate statement regarding *physical activity* and *health.* It is important to note that most exercise regimens have traditionally focused primarily on exercise recommendations and prescriptions for fitness (i.e., cardiorespiratory or muscular). These prescriptive guidelines for improved *general health* were updated in 2007 by the ACSM and the American Heart Association, and Haskell and his colleagues (2007) in this document state that "to promote and maintain health, all healthy adults aged 18–65 years need moderate–intensity aerobic physical activity for a minimum of 30 min on 5 days each week or vigorous-intensity aerobic activity for a minimum of 20 min on 3 days each week. Also, combinations of moderate- and vigorous-intensity activity can be performed to meet this recommendation" (p. 1083). The authors give the example of walking briskly for 30 min two times during the week (moderate intensity) and then jogging for 20 min (vigorous intensity) on two other days of the week as one way to meet the suggested guideline. In addition to these aerobic recommendations, muscle-strengthening activities (lifting weights, weight bearing calisthenics) for a minimum of 2 days each week have been added to the 2007 guidelines. For the estimated 49% of Americans who met neither the aerobic activity nor muscle-strengthening guidelines (National Center for Health Statistics, 2011), it is worth noting that moderate to vigorous routine daily life activities (gardening, carpentry, briskly walking to work) can count toward the recommendations, but they need to occur for at least 10 min.

These guidelines on physical activity for improved health are not meant to detract from the previous exercise recommendations reviewed for fitness. Rather, these current suggestions, based on a comprehensive review of the literature, expand the opportunity for Americans simply to be more active solely for health purposes.

Exercise for Stress Management

It seems that exercise designed for stress management should:

1. Generally be a combination of aerobic and anaerobic training.
2. Exercise should contain rhythmic, coordinated movements rather than random, uncoordinated movements that might place excessive strain on joints or connective tissue.
3. Exercise, from a psychological perspective, should entail a sense of being egoless; that is, it should either avoid competitive paradigms or allow one to win on every occasion. Part of a stress management strategy may include helping the individual define what winning means. Ideally, exercise for stress management should be exercise for the sake of exercise. Its goals should be intrinsic—self-improvement, ventilation, long-range improvement in somatomotor coordination and motoric skill. Whenever exercise and self-evaluation or self-esteem become intertwined, the healthful characteristics of exercise become more equivocal.

Additional Caveats about Physical Exercise

In this chapter, physical exercise has been discussed as a tool in assisting in stress management. The guidelines are offered *not* as an exercise prescription, but as a model to demonstrate to the clinician the therapeutic considerations associated with exercise. Readers interested primarily in exercise prescription should refer to the American College of Sports Medicine (2010), Garber and colleagues (2011), and Haskell et al. (2007). However, we still offer the following considerations.

- Physical exercise is a potent stressor. Intense exercise stresses both the cardiorespiratory and the musculoskeletal systems.
- Physical exercise has the potential to evoke a greater stress response than any imaginable psychosocial stressor. Although physical exertion does appear to divert most of the potential pathogenic qualities associated with psychophysiological arousal, the abrupt quantity of arousal during physical exercise can be overwhelming to the cardiorespiratory system. There are many documented cases of individuals who die from cardiac failure while exercising for their health.
- The musculoskeletal system is also vulnerable to the strain of physical exercise. Numerous joint and connective-tissue problems are related to excessive physical exercise. Therefore, it is recommended that persons use only proper equipment and technique when exercising.
- Exercise is an individualistic, unique activity; what works for some may not be right for others. It is always a reasonable idea to have a family physician assess an individual's physiological readiness to participate in an exercise program and then suggest appropriate guidelines.
- The success of an exercise program depends on its consistent utilization. Therefore, the question of motivation arises. It is important for the participant to find an exercise program that is not aversive. A common mistake is that eager individuals overdo an exercise program. The results are, typically, soreness, injuries, or the realization that the program too lofty a time commitment. Therefore, people should engage in programs that they will continue. Emphasis should be placed on patience and the need to integrate the exercise program into one's lifestyle. It may help to locate an exercise partner, one with whom the person can exercise, not compete.
- The cardiovascular, pulmonary, and weight-reducing aspects of an exercise program will become manifest within several weeks. The therapeutic psychological effects will likely take longer to realize. Therefore, patience is again required.

Summary

In this chapter, the use of physical exercise has been considered for its utility as an instrument in the treatment of excessive stress and its pathological correlates. Let us review the main points:

1. There is ample evidence to suggest that the stress response is nature's way of preparing the human species for muscular exertion. Physical exercise may then represent nature's prescription for how to ventilate healthfully and utilize the initiated stress response.

2. There is also evidence that suppression of the intrinsic need for somatomotor expression that accompanies the stress response may well be pathogenic itself, hence the concept of hypokinetic diseases and related concepts.
3. The idea that exercise can be therapeutic dates back to the fifth century B.C. and the Greek physician Herodicus.
4. In American society, regular exercise is now accepted as a regular part of the lifestyle.
5. Regular exercise appears to be therapeutic by virtue of: for the following reasons:
   - During exercise, constituents of the stress response such as lactic acid, free fatty acid, and epinephrine are utilized in a healthful manner.
   - Upon short-term cessation of exercise, a rebound relaxation effect occurs, which results in feelings of reduced muscle tension and increased feelings of tranquility.
   - Exercise promotes the development of physical and psychological characteristics that appear to facilitate a certain degree of stress resistance, for example, reduced adipose tissue, electrical stabilization of the myocardium, an improved lipoprotein profile, and improved myocardial strength and physical self-concept.
6. Several theoretical rationales have been proposed to explain the physiological benefits of exercise in reducing stress and anxiety, including the endorphin hypothesis, the epinephrine hypothesis, and the thermogenic hypothesis.
7. The major criteria in designing exercise protocols to enhance fitness involve the acronym FITT—Frequency, Intensity, Time, and Type. Generally accepted, minimum exercise guidelines to achieve fitness for normal healthy adults include performing moderate–intensity exercise at a minimum of 65% of maximum heart rate for at least 150 min/week,
8. Actual exercise sessions should contain warm-up, exercise, and cool-down periods. If exercise is not convenient, supported, and perceived as reinforcing, it will most likely not be sustained.
9. Anaerobic activities may also have stress-resistant benefits.
10. The American College of Sports Medicine and the American Heart Association have issued statements suggesting that health benefits can be attained from the accumulation of 30 or more minutes of moderate–intensity exercise 5 days/week or 20 min of vigorous-intensity activity 3 days/week daily, moderate intensity exercise.

In summary, there is ample research evidence to conclude that physical exercise can promote psychological and physical alterations that are antithetical to the pathogenic processes of excessive stress. It may well be that physical exercise activates a form of coping mechanism unlike that of any other stress management intervention—ventilation/utilization of the stress response before it leads to disease, as depicted in the introduction to Part II.

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