© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

CHAPTER

14

Cardiovascular Risk of Injury or Death from Physical Activity

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

The purpose of this chapter is to foster a deeper understanding of the potential injury inherent in physical activity or structured exercise programs. This is important if doctors are to encourage large populations to become more physically active. Such an understanding also will help the scientists to tailor exercise programs that minimize risk and maximize health benefits.

Injury during or as a result of exercise is not a new phenomenon. The first death mentioned as a result of physical exertion is recorded by the Greeks.

Legend has it that Phidippides, a messenger, ran from the battlefield of Marathon to Athens (approximately 26 miles) to carry the news to the Athenians that they were victorious against the invading Persians. He reached Athens in perhaps 3 hours, delivered his message, and died shortly thereafter from exhaustion.

Was it the 26-mile run that killed Phidippides? Not likely! Less known are the facts that, only days prior to the battle at Marathon, Phidippides had been sent to Sparta to ask for help. He ran the rugged, mountainous 140-mile course in about 36 hours to deliver the message. Afterwards, Phidippides ran that same 140-mile trail back to Athens with the disappointing news that the Spartans refused to send warriors to help. A few days later he was in the battle of Marathon where, in all likelihood, Phidippides had been carrying messages back and forth to the different generals on the field during the day's battle. It was at the end of that last day when he was charged with running to Athens to deliver the victorious news.

Although we cannot know exactly what killed Phidippides, the story has prompted some to proclaim that the human body is not designed to withstand the punishing 26-mile run and inspired others to test the possibility that we are designed to run this and more. The numerous modern marathon and ultra-marathon races run by millions of runners annually are proof that humans are capable of such a task when trained properly. On the other hand, the occasional death of a runner reminds us of our vulnerabilities.

Over the years we have come to realize that there is an inherent risk for injury when the body is exposed to the stress that is concomitant with physical activity or exercise. That is, the likelihood of injury increases by the simple fact that the body is exposed to greater physical stresses. We also have realized that the human body possesses an inherent capacity to adapt to these stresses. By doing so, it becomes more resilient to the stress as well as to the potential injury carried by the stress.

This can be illustrated by using an analogy with the sun. Exposure to the sun stimulates certain skin cells (melanocytes) to produce melanin, a biological substance that gives the skin its natural color and also acts as a sunscreen, protecting the skin from ultraviolet light. As more melanin is produced, the skin becomes darker and more resilient to sunburn and other harmful effects of ultraviolet light.

Similarly, proper exercise allows the body to adapt to the physical stress, so that as the duration, intensity, and frequency (volume) of exercise progressively increase, the body becomes more resilient to the potential risk of injury inherent to the exercise. In fact, the risk of injury during physical activity is much higher in those not accustomed to that activity (sedentary) compared to those who maintain a physically active lifestyle. In short, exercise or

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

physical exertion can be considered as a two-edged sword: it can increase the short-term risk of sudden death and also protect against it when proper exercise is performed regularly.

Because exercise can protect against injury, the goal of any exercise program should be to lower the risk to an absolute minimum while maximizing the exercise-related benefits. When the risk increases, exercise needs to be re-evaluated and adjusted. The probability, severity, and type of injury are dictated by a number of factors discussed in this chapter. The reader is encouraged to become very familiar with the risk of injury and even death associated with exercise or physical activity, especially in individuals with cardiovascular and other chronic diseases.

ETIOLOGY OF CARDIOVASCULAR RISKS

The acute cardiovascular changes that occur during physical exertion foster the likelihood of a cardiovascular event when the cardiovascular system is compromised. For example, during physical activity or exercise, the heart rate and systolic blood pressure (SBP) increase (see Chapter 12). This in turn causes the oxygen demand of the myocardium to rise. In the case of significant coronary artery disease that limits coronary blood flow, ischemia may ensue, which may lead to malignant arrhythmias and even death.

Another possibility is plaque rupture within the coronary arteries, first proposed by Black and coworkers.[1] The investigators reported acute plaque rupture in 13 individuals who died or suffered a myocardial infarction (MI) during vigorous exertion. The reasons for plaque rupture during strenuous physical activity are not well understood. Black postulated that during physical work, the myocardial contractions in the blood vessels become more vigorous. This places a greater excursion of blood through the coronary arteries because of the increase in end-diastolic volume and reduction in end-systolic volume. This along with the increased "twisting and bending" of the coronary arteries with each contraction during vigorous exercise might contribute to plaque rupture (coined *Blacks' crack in the plaque*), resulting in myocardial infarction and sudden cardiac death.

MYOCARDIAL INFARCTION AND SUDDEN CARDIAC DEATH

Almost all exercise-related deaths in previously asymptomatic adults without prior history of coronary heart disease have been the result of atherosclerotic plaque rupture in one of the coronary arteries that led to an acute coronary thrombosis.[2] These events have been substantiated by coronary angiography in athletes within hours following exercise[3] and also in those shoveling snow[4] or engaging in other physically demanding activities.[5]

Because the most common cause of cardiac complications is atherosclerotic coronary artery disease, the risk of exercise varies according to the population. In older populations where the prevalence of coronary atherosclerotic disease is high, the risk of death during exercise or physical exertion will be correspondingly high.[6]

Despite this risk, the exercise-related cardiac event is relatively rare even in such populations. One widely known study on the incidence of exercise-related deaths is the Rhode Island study.[7] Thompson and colleagues collected data on all deaths in joggers during a 5-year period from 1975 to 1980. There was one death per year for every 7,620 male joggers between the ages of 30 and 65 years. When those with known coronary heart disease were

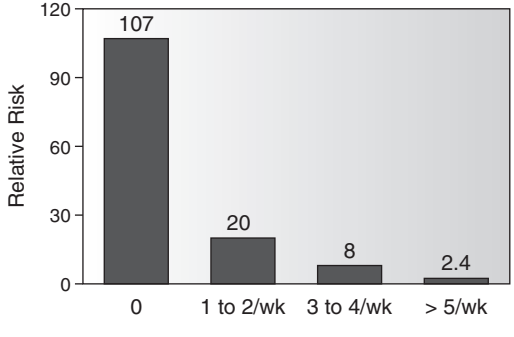
© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

excluded, the death rate was one death per year for every 15,240 male joggers. In general, the estimated rate of sudden cardiac death is very low. Others estimated the rate of sudden death during exercise to be between 0 and 2 per 100,000 hours of exercise in the general population and 0.13 to 0.61 per 100,000 hours in cardiac rehabilitation programs.[8,9]

Fitness of the Individual and Risk of Sudden Cardiac Death

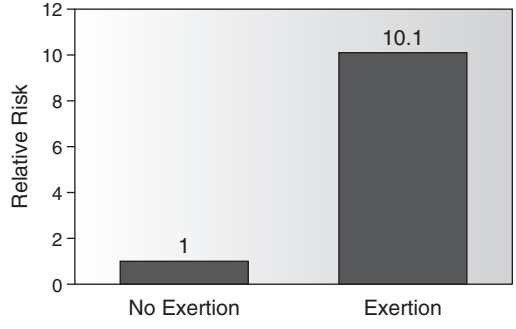
Study findings support that physically active individuals are less likely to suffer a sudden cardiac event during physical exertion (**Figures 14.1** and **14.2**). The risk for a myocardial infarction attributed to exercise and the role of the fitness status of the individual also were assessed by several studies in the United States[10–12] and Europe.[13] Mittleman and colleagues[10] examined the relative risk of those who survived a myocardial infarction during or within 1 hour after exercise. The investigators concluded the following:

Figure 14.1 The relative risk of myocardial infarction within 1 hour of exercise according to physical activity.



Source: Mittleman MA, et al. Triggering of acute myocardial infarction by heavy physical exertion. Protection against triggering by regular exertion. *N Engl J Med* 1993;329(23):1677–1683.

Figure 14.2 The relative risk of exercise-related myocardial infarction according to physical activity status



Source: Giri S, et al. Clinical and angiographic characteristics of exertion-related acute myocardial infarction. *JAMA* 1999;282(18):1731–1736.

- The relative risk for a myocardial infarction was 5.6-fold higher during vigorous compared to less vigorous exercise. Activities included jogging (30%), yard work (52%) consisting of chopping wood or gardening, and lifting and pushing (18%).
- Diabetics had an 18.9 times higher risk of a myocardial infarction during exercise than at rest.
- In sedentary individuals, the relative risk of a myocardial infarction was 107-fold higher during exercise than at rest.
- The relative risk of myocardial infarction in individuals who engaged in physical activity five or more times per week was 2.4-fold higher during exercise compared to rest.
- However, when compared to the exercise-related mortality risk of the inactive individuals in this study, the relative risk of those who engaged in physical activity five or more times per week was approximately 45 times higher (Figure 14.1).

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

Giri and colleagues[11] also examined the risk for an MI in active and sedentary individuals who underwent angioplasty as a treatment for their myocardial infarction. These investigators reported the following:

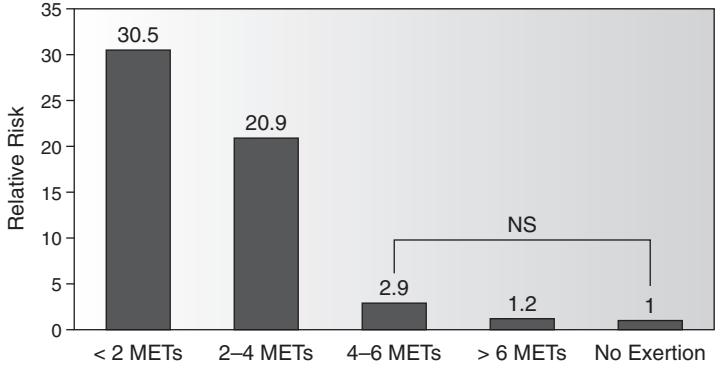
- The overall risk of a myocardial infarction during physical exertion was 10 times higher compared to rest (Figure 14.2).
- The risk was among the sedentary individuals was 30.5 times higher.
- The risk in the physically active individuals was not raised significantly (**Figure 14.3**).

In the German population, the findings were similar. The relative risk of an MI during physical exertion was 2.1-fold higher compared to resting individuals.[13] However, the risk in physically inactive individuals was over five times higher when compared to the physically active (**Figure 14.4**).

The Physicians' Health Study,[12] examined male physicians (N = 21,481) who were initially free of cardiovascular disease and who provided baseline information on their habitual level of exercise. Investigators compared the risk of sudden death during and up to 30 minutes after an episode of vigorous exertion with the risk incurred during periods of either no or light exertion. In addition, they evaluated whether the risk of sudden death associated with vigorous exertion was attenuated by habitual vigorous exercise. The follow-up period was 12 years. Albert and colleagues reported a significant transient increase in the relative risk of sudden death during and up to 30 minutes after vigorous exertion. However, the absolute risk of sudden death was extremely low during any particular episode of vigorous exertion was one sudden death per 1.51 million episodes of exertion. They concluded that habitual vigorous exercise diminishes the risk of sudden death during vigorous exertion.

Collectively, findings of these studies strongly support that the risk of cardiac events

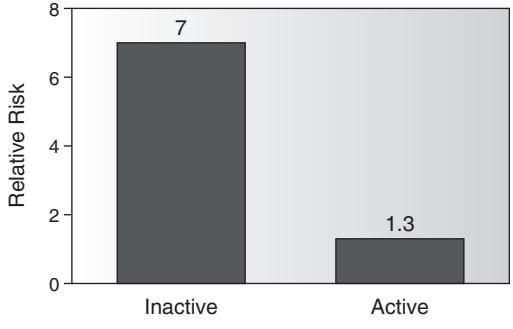
Figure 14.3 The relative risk of exercise-related myocardial infarction according to physical activity status. Note that the increase in exercise-related risk occurs in the two least active groups whereas the risk is diminished and even eliminated in individuals engaging in moderate levels of physical activity.



Source: Giri S, et al. Clinical and angiographic characteristics of exertion-related acute myocardial infarction. *JAMA* 1999;282(18):1731–1736.

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

Figure 14.4 The relative risk of exercise-related myocardial infarction according to physical activity status. Again, the risk is substantially lower in physically active compared to inactive individuals.



Source: Willich SN, et al. Physical exertion as a trigger of acute myocardial infarction. Triggers and Mechanisms of Myocardial Infarction Study Group. *N Engl J Med* 1993;329(23):1684–1690.

increases as a result of physical exertion or exercise. However, the risk is substantially diminishes and (in some studies) is eliminated if the individual is physically active.

Exercise is associated with a transient increase in the risk of a cardiac event. For example, for men with coronary artery disease, the risk of sudden death during exercise increases about sixfold. However, the risk for overall mortality for exercisers is half that of sedentary individuals. Therefore, the long-term benefits of exercise outweigh the risk of being sedentary.

The estimated rate of sudden death during exercise ranges from 0 to 2 per 100,000 hours of exercise in the general population and 0.13 to 0.61 per 100,000 hours in cardiac rehabilitation programs.

Exercise-Related Cardiac Events in Young Athletes

Exercise-related cardiac events as a result of coronary heart disease is rare in young people. When it occurs, it is the result of genetic abnormalities in low density lipoprotein (LDL).[14] The major cause of death in this age group is congenital cardiac abnormalities (**Table 14.1**). Of those, hypertrophic cardiomyopathy accounts for 56% of the cases.[15]

The potential cardiovascular complications of exercise can be summarized as follows: Exercise or habitual physical activity reduces coronary heart disease events, but vigorous activity can acutely and transiently increase the risk of sudden cardiac death and acute MI in susceptible persons. Exercise-associated acute cardiac events generally occur in individuals with structural cardiac disease. Hereditary or congenital cardiovascular abnormalities are predominantly responsible for cardiac events among young individuals, whereas atherosclerotic disease is primarily responsible for these events in adults. The absolute rate of exercise-related sudden

Table 14.1 Common Cardiac Causes of Death in High School and College Athletes

Cardiac Causes of Death	Percent
Hypertrophic cardiomyopathy	56
Coronary artery abnormalities	11
Myocarditis	7
Aortic stenosis	6
Cardiomyopathy	6
Atherosclerotic coronary disease	2
Aortic rupture	2

Source: Van Camp SP, Bloor CM, Mueller FO, et al. Nontraumatic sports death in high school and college athletes. *Med Sci Sports Exerc* 1995;27(5):641–647.

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

cardiac death varies with the prevalence of disease in the study population. The incidence of both acute myocardial infarction and sudden death is greatest in the habitually least physically active individuals. Maintaining physical fitness through regular physical activity may help to reduce events because a disproportionately higher number of events occur in the least physically active subjects who perform unaccustomed physical activity.[16]

MINIMIZING THE RISK

The risk of exercise-related injuries only can be minimized. They cannot be eliminated. The goal of any exercise program should be to lower the risk of exercise to an absolute minimum and maximize the benefits. When the risk increases, exercise needs to be re-evaluated and adjusted.

It is important to mention that no strategies have been adequately studied that evaluate their ability to reduce exercise-related acute cardiovascular events.[16] However, the risk can be attenuated by systematically controlling all factors that potentially increase the risk of injury. For example, maintaining physical fitness through regular physical activity may help to reduce events because a disproportionate number of events occur in the least physically active subjects performing unaccustomed physical activity. Other strategies, such as screening patients before participation in exercise, excluding high-risk patients from certain activities, promptly evaluating possible prodromal symptoms, training fitness personnel how to cope with emergencies, and encouraging patients to avoid high-risk activities, appear prudent but have not been systematically evaluated.[16]

Despite the lack of strong evidence on exercise-related risk prevention, the limited data available and certain intuitive approaches to reduce the risk are presented.

Type of Exercise Performed

For certain populations, particular types of exercise can cause more injury than others. For example, jogging may not be the recommended type of exercise for an obese person. A more appropriate form of exercise may be walking or swimming, starting slowly and building up speed and distance over a period of weeks to months. More information about the types of exercise for different populations and those with a specific disease is discussed later in this chapter.

Intensity of Exercise

Very little information is available on the intensity and risk of injury relationship, so no clear conclusion can be made. As a general rule, studies have found that the more intense the exercise, the higher the risk for injury. One study found that a runner's best time on a 10-mile run was associated with a higher risk of injury. However, when adjusted for the total distance, the association was no longer statistically significant.[17]

It is important to keep in mind that exercise need not be intense for health benefits to occur. In fact, the proportional increase of health benefits is substantially higher at lower rather than higher intensities, regardless of the risk for injury.

Duration of Exercise

There is also a lack of information about the relationship between exercise duration and injury. The findings of one study suggest that the injury incidence rate appears to be higher when running for more than 45 minutes per session.[18]

An important point to make is that optimum exercise benefits are realized at durations between 20 and 40 minutes per session. In fact,

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

benefits begin to plateau with exercise lasting over 40 minutes, with little to no benefits beyond 60 minutes.

Frequency of Exercise

Exercising once a week is not enough to induce any health benefits and may even increase the risk for injury. At least one study found twice the risk of injury in those attending aerobics class once a week compared to those attending class four times per week.[17] One reason may be that the stimulation for the body to adapt to changes is not adequate. This can lead to the false sense that the participant can tolerate more exercise than he or she actually can endure. This becomes very evident when exercising in hot environments. The "weekend athlete" is usually more prone to heat-related injuries than the seasoned athlete. More on heat-related injury and exercise is presented later in this chapter.

There is also some evidence to support that the risk is similar when running two, three, or four sessions per week.[18] It is my personal opinion that exercising more than six times per week maybe counterproductive for most people. This is based on the notion that the body is not allowed enough time to recover and make the necessary adaptations. As a result, muscle strains, pulls, and even bone fractures are more likely.

The number of exercise sessions per week is also influenced by the individual's weekly schedule, sleep, age, diet, level of fitness, and a number of other factors. It is also a good practice to stop exercising for 1 week of every 12 weeks of consistent exercise.

Engaging in physical activity once a week is not enough and perhaps injurious and every day is too much. It appears that a prudent approach for most people is to engage in exercise at least two to five times a week.

Cumulative Distance Run

There is consistent evidence to support that the amount of distance run per week is associated with increased risk of injury.[19,20] The risk increases after about 20 miles per week and remains significant even after adjusting for other factors related to running.[17,21] Based on this observation, one can extrapolate that progressively running four to five times per week at a distance of 4 to 5 miles per session appears to be within a relatively safe domain.

The Presence of Disease

The presence of a disease can diminish the body's capacity to do work and therefore increases the risk of injury during physical work. Particular attention should be given to those with chronic illness who wish to become more physically active.

The good news is that, if challenged properly, the body will respond by becoming more resilient to injury. The final outcome is that the exercise may not "cure" the disease, but it makes the body more capable of coping with the disease.

It is important to keep in mind that physical activity or exercise represents stress for the body. Increased stress (any stress) has the inherent potential to cause harm. However, keep in mind that the risk of death during exercise is extremely low and the benefits are high. One can think of exercise as the armor worn by the ancient and modern warriors. The armor does not guarantee full immunity from injury or death during the battle. It only increases protection, and by doing so decreases the risk of injury. Given the choice, no warrior of sound mind would go to a battle without it. Similarly, exercise does not guarantee immortality, only protection against premature mortality.

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

EXERCISE IN HOT ENVIRONMENTS AND RELATED HEALTH RISKS

Heat-related illnesses are likely to occur in hot, humid environments. They are the result of the inability of the body to dissipate heat rapidly.[22] Heat is eliminated by the difference in temperature between the body and the environment. This is accomplished by sweating and evaporation of moisture on the skin that results in cooling. Generally, an increase in the ambient temperature results in a proportional increase in the rate of sweating.

Heat produced by working muscles and other interior tissues is transferred to the skin via blood circulation. When the ambient temperature is less than body temperature, heat dissipates to the surrounding environment thereby cooling the blood, which cools the internal organs.

When the ambient temperature is higher than body temperature, the body actually gains heat. In this case, sweating and evaporation becomes the only means for heat dissipation. However in humid conditions, evaporation diminishes. This causes more sweating and a greater loss of water without the cooling effect.

Under such environmental conditions, especially when exercising or working and without adequate hydration, excessive water loss can occur that results in dehydration and overheating. This is more common among those who are in poor physical condition or in individuals who are not acclimated to the hot environment. Excessive water loss of about 6% to 10% of body weight regardless of the reason, will lead to the following heat-related illnesses:

1. Muscle cramping, resulting from excessive sodium (salt) loss.
2. Heat exhaustion, due to a large volume of water loss. Symptoms include: paleness, heavy sweating, dizziness, fainting, nausea, and vomiting.
3. Heat stroke (the most serious of the three) is a life-threatening form of hyperthermia caused by dehydration and an inability of the body to dissipate heat. Onset of symptoms may be sudden. Symptoms can mimic a heart attack, but include nausea, vomiting, weakness, dizziness, headache, aches, and muscle cramping. There is no sweating and the skin may be flushed red and dry despite high body temperatures. The individual may have difficulty breathing, a rapid pulse, appear disoriented and confused, and have a seizure or even go into a coma.

Dehydration and Arrhythmias

In addition to the heat-related illnesses mentioned, dehydration can present an even greater risk for individuals with cardiovascular disease (CVD) for two reasons. First, the workload of the heart increases as the demand for blood to maintain a constant core temperature increases. Second, the loss of water can lead to electrolyte imbalance. Consequently, the propensity for arrhythmias increases. Both conditions increase the risk for a serious cardiac event.

Additional Risk Factors

It is important to remember that the strain on the body imposed by a hot environment not only depends on the environmental temperature but in a number of other factors. The following have been identified as likely to increase the risk of heat-related illness.

- Age
- Overweight
- Dehydration
- Lack of acclimatization

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

- Poor fitness
- Exercise intensity (the higher the intensity, the higher the risk)
- Alcohol consumption
- Certain medications that promote that promote excessive discharge of urine (diuretics)
- Caffeine consumption or other supplements that promote excessive discharge of urine
- Tight-fitting, dark clothing

Clothing worn during exercise should be of a light-color, cotton (or other moisture-wicking) material, and loose. It should not restrict movement. Clothing that interferes with sweat evaporation must not be worn. Suits made of plastic or other non-natural fibers (e.g., polyester) that hinder sweat evaporation must be avoided.

To minimize the risk of heat-related injuries, the following should be considered:

1. Exercising in the heat should be avoided (**Table 14.2**). Note that moisture in the air increases the body's heat stress. When humidity is high (over 80%), even temperatures carrying a moderate risk can be dangerous.
2. If exercising or working in hot environments cannot be avoided, proper hydration must be practiced. Plenty of fluids should be consumed before exercise and afterwards.
3. Avoid exercising in the middle of the day (11:00 AM to 2:00 PM), because the temperature during that period is generally the highest in the day.
4. Proper clothing (light-colored, cotton or other moisture-wicking fabric) should be worn.

The Heat-Stress Index

Another way to look at the strain of heat on the body is to consider temperature plus humidity. The risk of heat-related injuries increases when the temperature plus humidity add to 90° or above (**Table 14.3**).

Water Replacement

How much water does one need when exercising in hot environments? There is no straightforward answer to this question. Normally, adults drink about 1.2 liters of water each day (or approximately 41 oz, which is 5 to 6 cups. However, in hot and humid environments, the need and desire for water increases significantly. This is particularly true when one exercises in a hot and humid environment. As stated earlier in this chapter, cooling of the body is accomplished to a major degree by the evaporation of sweat. In a hot environment, the sweat rate increases dramatically. If the environment is also high in humidity, then the sweat rate is even higher. As one sweats, the volume of

Table 14.2 Exercise Guidelines for Hot Environments

Temperature (°F)	Risk of Heat Injury and Recommendations
Below 65°	Low risk.
65° to 73°	Moderate risk. Avoid strenuous exercise, especially if not acclimated.
73° to 82°	High risk. Avoid all outdoor physical activity.
Above 82°	Very high risk. Avoid all outdoor physical activity.

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

Table 14.3 Heat-Stress Index

Temperature (°F) + Humidity (%)	Risk of Heat Injury
90–105	Possibility of heat cramps
105–130	Heat cramps or heat exhaustion likely; heat stroke possible
130 or more	Heat stroke a definite risk

water in the body decreases. This has serious consequences in physical performance and overall health. A loss of 4% to 5% of body weight in water diminishes the body's capacity to do hard work by 20% to 30%. A loss of 10% to 20% of body weight in water leads to heat stroke, and possibly death.

When exercising in a hot environment, one needs to keep in mind that thirst is not a sufficient or reliable indicator to the need for water. Plenty water must be taken before the event and during an exercise session or athletic event to prevent dehydration. Although this is now common knowledge among athletes, too often the information is not applied correctly.

Exercise, Sweating, and Weight Loss

There was (and perhaps still is) a widespread misconception that weight loss can be expedited through excessive sweating during exercise. This notion was supported by the fact that the actual scale weight is lower immediately after exercise. But this phenomenon is not a mystery. The loss of water through sweat during exercise translates into a lower reading on the scale.

However, this is not a *true* weight loss—the loss of weight is not due to loss of body fat. It is only due to the loss of water, which is replenished within a few minutes after drinking water.

Not only is there no actual weight loss from excessive sweating, but the health problems mentioned previously (muscle cramping, heat exhaustion, heat stroke) are very likely to occur, especially when a rubber suit or similar nonbreathable fabric clothing is worn that does not allow the sweat to evaporate. Clothing that don't allow sweat to evaporate must never be worn when exercising or doing physical work.

Proper Clothing for Exercise

The environment should be a strong factor in choosing proper clothing for exercise. In hot weather, clothing should be made of cotton or other types of breathable fabric to maximize air circulation and sweat evaporation. In cold weather, layers of clothing are more effective in keeping you warm than a single heavy garment. Wearing a turtleneck sweater and a hat will keep your neck and head warm, and is recommended because we lose considerable heat from the neck and head areas. A windbreaker jacket is an excellent choice to protect you from the wind and even a light rain. For the legs, clothing should not be too heavy because exercise keeps the legs relatively warm.

Recently, synthetic materials have been developed for use in exercise clothing. The

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

concept is to wick moisture away from the body and therefore keep you cooler and more comfortable when exercising in hot environments. The feel and look of such exercise garments is a personal choice. So long as such exercise garments improve heat dissipation in hot environments and reduce heat losses in cold environments, such garments are recommended.

A good pair of walking or jogging shoes is a must. Good shoes will protect against leg and foot injuries. Almost all shoe manufacturers provide adequate shoes for exercise. However, some shoes are softer than others, some are wider, and others provide more support for different parts of the foot. It is a good idea to try different types of shoes before deciding on the one that will be the best fit for the particular type of exercise or sport.

OVERTRAINING

There was time when the "fitness gurus" preached that exercise had to be vigorous or there was no reason to exercise. "No pain, no gain" was their motto. This attitude drove a number of ambitious people into overtraining and all of the pitfalls that went with it.

Overtraining occurs when either the frequency, intensity, duration of exercise, or all are violated. Overtraining is a serious problem. Not only does it decrease performance, but it also increases the chance for injury and may even lead to serious illness. Overtraining is worse than not exercising at all.

Warning Signs and Symptoms of Overtraining

There are signs and symptoms that are likely to develop with overtraining. Although these symptoms may vary from one person to another, a general understanding of these symptoms can be helpful for every athlete to know. If any of these symptoms are present following several weeks of hard training and no rest, the athlete should stop training immediately for at least 3 days. If no improvement is evident at the end of a week, a physician should be consulted. Symptoms of overtraining include:

1. Stiffness and soreness in the muscles, tendons, or joints that lasts for several days longer than usual.
2. Decrease in performance.
3. Persistent fatigue and sluggishness over several days.
4. An elevation in the resting heart rate by 6 to 12 bpm.
5. Excessive irritability, anxiety, nervousness.
6. Frequent sore throats and colds.
7. Loss of appetite.
8. Diarrhea or constipation.
9. Loss of interest in the sport or activity.
10. Uneasy sleep and nightmares.
11. Elevated white blood cell count.

Best Time to Exercise

The time of the day to initiate exercise is usually a matter of preference for most people. Others may have limited choices because of job and/or or family responsibilities. There are positive and negative aspects for exercising at different times in the day. These are discussed briefly.

Because exercise increases alertness and induces a natural emotional "high" for approximately 4 hours afterwards, some people believe that the best time to exercise is in the afternoon hours. They feel like the afternoon exercise period rejuvenates them from the

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

morning's work and allows them to stay alert late into the day.

This is generally true. However, avoid exercising in the middle of the day (11:00 AM to 2:00 PM) when the weather is hot. Air pollution is the highest during that time, especially during hot, humid weather. If you must exercise during the midday hours, it would be preferable to exercise in indoors in a temperature-regulated (cooled) environment, perhaps a gym.

Sleep and Exercise

Just as exercise affects alertness and mood, it also affects sleep. It is interesting that although exercise will keep you alert for hours, it will also help you to fall asleep quickly. Usually the sleep is deep and restful. Keep in mind that unlike sleeping pills, there are no side effects with exercise, so one does not have nightmares. With regular exercise (providing that you don't exercise too late at night), you can look forward into a good night's sleep and being rested and alert the next day.

A Final Note

It is important to keep in mind that physical activity or exercise represents "stress" for the body. Increased stress (any stress) has the inherent potential to cause harm. However, let us keep in mind that the risk of death during exercise is extremely low, while the benefits are high. One can think of exercise as the armor worn by the ancient and modern warriors. The armor does not guarantee full immunity from injury or death during the battle. It only increases protection and by doing so, decreases the risk of injury. Given the choice, no warrior of sound mind would go to the battle without it. Similarly, exercise does not guarantee immortality, only protection against premature mortality.

SUMMARY

- There is an inherent risk of injury when the body is exposed to physical stress (physical activity or exercise). There is also an inherent capacity possessed by the body to adapt to the stress exposed and become more resilient. The goal of any exercise program thus should be to lower the risk imposed by exercise to absolute minimum and maximize the exercise-related benefits.
- Exercise is associated with a small and transient increase in risk for a cardiac event. However, the risk is substantially diminished and in some studies eliminated if the individual is physically active.
- In general, practicing moderation is the best approach to reduce the risk of an exercise-related cardiac event.
- Exercise-related cardiac events as a result of coronary heart disease are rare in young subjects. When it occurs, it is the result of genetic abnormalities.
- The most important factors that contribute to the risk of musculoskeletal injuries include the intensity of the activity and the cumulative weekly mileage or total exposure to the activity.
- Heat-related illnesses are likely to occur in hot and humid environments. They are the result of the inability of the body to dissipate heat. In addition to the obvious (i.e., avoid exercising in extremely hot temperatures), proper hydration, and wearing light-colored cotton or other moisture-wicking clothing is recommended for reducing the risk of heat-related illness.
- Individuals with CVD are at a relatively higher risk when exercising in the heat.
- Overtraining is a serious problem. It is likely to occur when either the frequency,

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

intensity, duration of exercise, or all three factors are violated. Not only will it decrease performance, but it also increases the chance for injury and even serious illness. Overtraining is worse than not exercising at all.

- The time of day to exercise varies among individuals and there is no best time. However, exercise increases alertness for several hours afterwards. For this reason, it is not advisable to exercise late in the evening because it may interfere with falling asleep. On the other hand, exercise helps you to fall asleep quickly and the quality of sleep is deep and restful.

REFERENCES

1. Black A, Black MM, Gensini G. Exertion and acute coronary artery injury. *Angiology* 1975;26(11):759–783.
2. Davies MJ, Thomas AC. Plaque fissuring: the cause of acute myocardial infarction, sudden ischaemic death, and crescendo angina. *Br Heart J* 1985;53(4):363–373.
3. Ciampricotti R, Deckers JW, Travane R, et al. Characteristics of conditioned and sedentary men with acute coronary syndromes. *Am J Cardiol* 1994;73(4):219–222.
4. Hammoudeh AJ, Haft JI. Coronary-plaque rupture in acute coronary syndromes triggered by snow shoveling. *N Engl J Med* 1996; 335(26):2001.
5. Burke AP, Farb A, Malcolm GT, et al. Plaque rupture and sudden death related to exertion in men with coronary artery disease. *JAMA* 1999;281(10):921–926.
6. Thompson P. The cardiovascular risks of exercise. In: *Exercise & Sports Cardiology.* New York: McGraw-Hill; 2001:127–145.
7. Thompson PD, et al. Incidence of death during jogging in Rhode Island from 1975 through 1980. *JAMA* 1982;247(18):2535–2538.
8. Haskell WL. Cardiovascular complications during exercise training of cardiac patients. *Circulation* 1978;57(5):920–924.
9. Van Camp SP, Peterson RA. Cardiovascular complications of outpatient cardiac rehabilitation programs. *JAMA* 1986;256(9): 1160–1163.
10. Mittleman MA, Maclure M, Tofler GH, et al. Triggering of acute myocardial infarction by heavy physical exertion. Protection against triggering by regular exertion. Determinants of Myocardial Infarction Onset Study Investigators. *N Engl J Med* 1993;329(23):1677–1683. (see comments)
11. Giri S, Thompson PD, Kiernan JF, et al. Clinical and angiographic characteristics of exertion-related acute myocardial infarction. *JAMA* 1999;282(18):1731–1736.
12. Albert CM, Mittleman MA, Chae CU, et al. Triggering of sudden death from cardiac causes by vigorous exertion. *N Engl J Med* 2000;343(19):1355–1361. (see comments).
13. Willich SN, et al. Physical exertion as a trigger of acute myocardial infarction. Triggers and Mechanisms of Myocardial Infarction Study Group. *N Engl J Med* 1993;329(23):1684–1690.
14. Maron BJ, Roberts WC, McAllister HA, et al. Sudden death in young athletes. *Circulation* 1980;62(2):218–229.
15. Van Camp SP, Bloor CM, Mueller FO, et al. Nontraumatic sports death in high school and college athletes. *Med Sci Sports Exerc* 1995;27(5):641–647.
16. Thompson PD, Franklin BA, Balady GJ, et al. Exercise and acute cardiovascular events placing the risks into perspective: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism and the Council on Clinical Cardiology. *Circulation* 2007;115(17): 2358–2368.
17. Marti B, Vader JP, Minder CE, Abelin T. On the epidemiology of running injuries. The 1984 Bern Grand-Prix study. *Am J Sports Med* 1988;16(3):285–294.
18. Pollock ML, Gettman LR, Milesis CA, et al. Effects of frequency and duration of training

© Jones and Bartlett Publishers, LLC. NOT FOR SALE OR DISTRIBUTION

on attrition and incidence of injury. *Med Sci Sports* 1977;9(1):31–36.
19. Jones BH, Cowan DN, Knapik JJ. Exercise, training and injuries. *Sports Med* 1994;18(3): 202–214.
20. Koplan JP, Rothenberg RB, Jones EL. The natural history of exercise: a 10-year follow-up of a cohort of runners. *Med Sci Sports Exerc* 1995;27(8):1180–1184.
21. Lysholm J, Wiklander J. Injuries in runners. *Am J Sports Med* 1987;15(2):168–171.
22. Selected issues in injury and illness prevention and the team physician: a consensus statement. *Med Sci Sports Exerc* 2007;39(11): 2058–2068.