Chapter 12
Physical Activity and Chronic Disease Prevention

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Introduction

It is clear that there are many benefits of sports participation for the young female athlete, including increased self-esteem, higher academic performance, decreased risk of depression, and lower rates of drug use [1–3]. In addition, there are also significant long-term health benefits that come with regular physical activity.

Approximately 12 % of all mortality in the USA is related to the lack of regular physical activity, and generally recommended levels of physical activity provide a 20 % reduction in all-cause mortality [4, 5] (Fig. 12.1). Studies have consistently shown that physical activity reduces the risk of major chronic diseases in a dose-dependent relationship (Table 12.1). The strongest evidence exists for diabetes, cardiovascular disease, colon cancer, breast cancer, and osteoporosis. There is also emerging evidence of the protective effect of physical activity on dementia. In the following sections, we briefly review the evidence for each of these conditions.

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Despite demonstrated and robust health benefits, less than half (47 %) of adult women in the USA engage in recommended levels of aerobic physical activity [6, 7]. In girls aged 12–15 years old, only 23 % meet the recommended guidelines for youth of 60 min of moderate to vigorous-intensity activity every day [8]. Just under 9 % of girls get zero moderate or vigorous-intensity activity in the course of a week.

Increasing physical activity levels is a major goal of Healthy People 2020, which aims to set achievable targets for improving the nation's health [9].

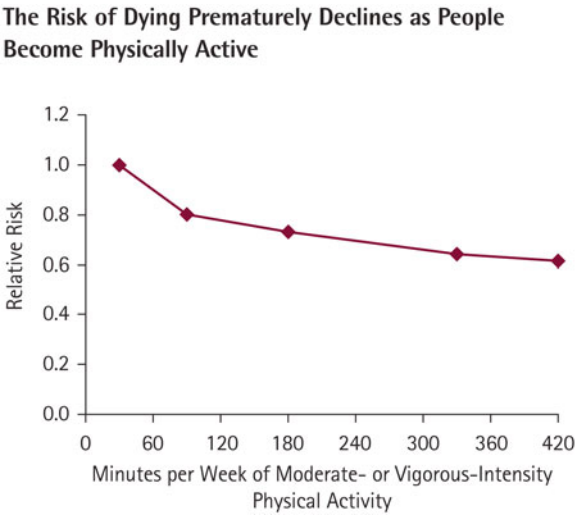

Fig. 12.1 Risk reduction of premature death with increasing physical activity. Reproduced from: Physical Activity Guidelines for Americans. US Department of Heath and Human Services. Available at: http://www.health.gov/paguidelines/pdf/paguide.pdf

Table 12.1 Health benefits associated with regular physical activity

Children and adolescents
Strong evidence
• Improved cardiorespiratory and muscular fitness
• Improved bone health
• Improved cardiovascular and metabolic health biomarkers
• Favorable body composition
Moderate evidence
• Reduced symptoms of depression
Adults and older adults
Strong evidence
• Lower risk of early death
• Lower risk of coronary heart disease
• Lower risk of stroke
• Lower risk of high blood pressure

(continued)

Table 12.1 (continued)

• Lower risk of adverse blood lipid profile
• Lower risk of type 2 diabetes
• Lower risk of metabolic syndrome
• Lower risk of colon cancer
• Lower risk of breast cancer
• Prevention of weight gain
• Weight loss, particularly when combined with reduced calorie intake
• Improved cardiorespiratory and muscular fitness
• Prevention of falls
• Reduced depression
• Better cognitive function (for older adults)
Moderate to strong evidence
• Better functional health (for older adults)
• Reduced abdominal obesity
Moderate evidence
• Lower risk of hip fracture
• Lower risk of lung cancer
• Lower risk of endometrial cancer
• Weight maintenance after weight loss
• Increased bone density
• Improved sleep quality

Reproduced from: US Department of Health & Human Services. 2008 Physical Activity Guidelines for Americans

Definitions

Physical activity: bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above the basal level [10].

Exercise: a form of physical activity that is planned, structured, repetitive, and purposeful with a main objective of improvement or maintenance of one or more components of physical fitness [11].

Type 2 Diabetes

Diabetes affects over 11 % of females in the USA, with the vast majority of cases being preventable type 2 diabetes [12]. Once very rare in childhood, type 2 diabetes is now seen with increasing frequency in obese youth under age 20 [13]. All told, the economic cost of diabetes is approximately $245 billion each year in the USA alone [14].

Strong evidence supports physical activity as a key intervention for preventing type 2 diabetes (DM2). One analysis of ten prospective cohort studies reported a 30 % reduction in the risk of developing DM2 with moderate physical activity, such as brisk walking, compared with being sedentary [15]. Regular exercise has also been shown to reduce hemoglobin A1c (HbA1c), which is an indicator of average blood glucose levels over the previous 60–90 days [16–19].

In DM2, genetics play a substantial role in insulin resistance and impaired insulin secretion. Moderate physical activity on a long-term basis increases the translocation of insulin-responsive glucose transporter (GLUT4) from intracellular stores to cell surface. GLUT4 promotes glucose uptake, which probably explains the overall increase in insulin sensitivity [20]. In addition, favorable changes also occur in skeletal muscles including increased mitochondrial enzyme activity, thereby improving muscle energetics, and muscle capillary recruitment. However, there is little or no increase in muscle capillaries in patients with microvascular complications [21]. Although exercise can transiently increase urinary protein excretion, there is no evidence of increased progression of chronic kidney disease [22].

The American Diabetes Association recommends at least 150 min of moderate-intensity aerobic activity per week for prevention of DM2, along with strength-training multiple days per week. Efforts to lose weight or maintain weight loss may require greater levels of aerobic activity. Regular activity is also a key part of managing DM2 as well as helping to reverse it [22–24].

Cardiovascular Disease

Cardiovascular disease is a major health burden in the USA. More than a third of adult women have some type of cardiovascular disease, which includes heart disease, stroke, and related conditions [25]. Cardiovascular disease kills approximately 400,000 women each year—more than all cancers combined [25].

Despite their high prevalence, heart disease and stroke are largely preventable through a mix of healthy lifestyle choices and therapeutic interventions to control risk factors like diabetes, unhealthy blood lipids, and hypertension [26]. Though heart disease and stroke usually do not present until older age, risk factors can begin to accrue early in life. A 2012 analysis by May et al. found that 14 % of US adolescents 12–19 years old had hypertension or prehypertension; 22 % had high or borderline high low-density lipoprotein (LDL) cholesterol; and 15 % had diabetes or prediabetes. Fully 37 % of normal weight adolescents had at least one cardiovascular disease risk factor, while 43 % of obese adolescents did [27].

Regular physical activity has been demonstrated to lower the risk of cardiovascular disease, with the American Heart Association classifying activity as a “useful and effective” Class I lifestyle intervention [26]. Separate analyses of the Women’s

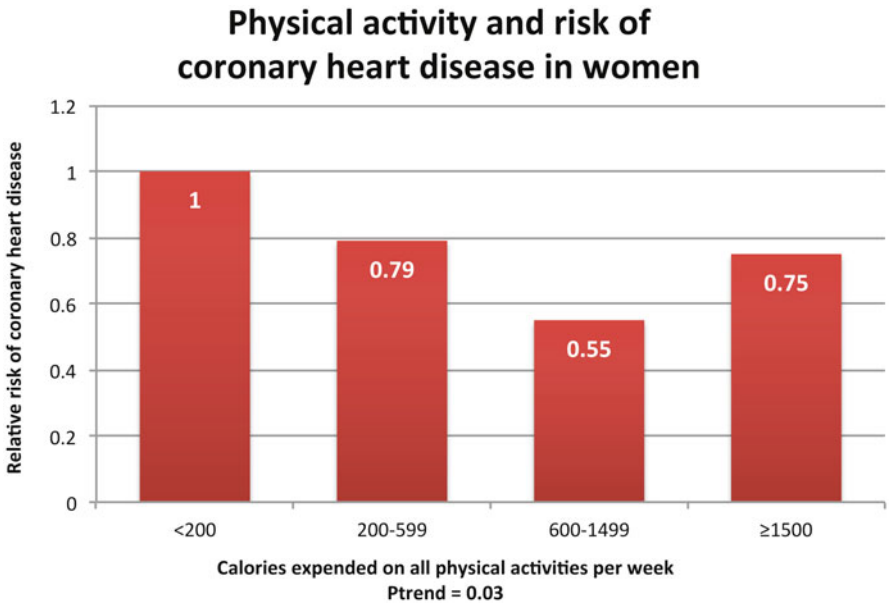

Fig. 12.2 Risk reduction of coronary heart disease with physical activity. Data source: Lee et al., 2001

Health Study and Nurses' Health Study found significant benefits from regular walking, with 1 h or more a week lowering risk by 30–50 % compared to those who did not walk regularly (Fig. 12.2) [28, 29]. Results from the Nurses' Health Study also showed a lower risk of total stroke and, especially, ischemic stroke with increasing amounts of regular physical activity and walking [30].

Regular activity reduces serum triglyceride and increases high-density lipoprotein cholesterol (HDL) with variable effect on LDL. Within 4 weeks of beginning an exercise program, blood pressure can lower as much as 5–15 mmHg in patients with primary hypertension. There is also increasing evidence that regular exercise reduces serum C-reactive protein, which plays an important role in atherosclerosis [31–33].

For adults, the American Heart Association strongly recommends 30 min of moderate-intensity aerobic activity at least 5 days per week for a total of 150 min, or 25 min of vigorous aerobic activity at least 3 days per week for a total of 75 min, or a combination of the two. A weaker recommendation is given for moderate to high intensity muscle strengthening activity at least 2 or more days per week for additional health benefits [34].

Cardiac events during exercise are uncommon, with the highest risk in those who are untrained and take part in vigorous-intensity activity [10]. The overall benefits of physical activity far outweigh the possible associated risks in the majority of individuals [10].

Sudden cardiac death in youth and young adult athletes is a rare, but often high profile, event, affecting fewer than 100 athletes each year [35]. Hypertrophic cardiomyopathy and coronary artery abnormalities have been identified as primary causes, among others [35, 36]. Multiple professional medical and athletic organizations endorse pre-participation cardiovascular screening for young competitive athletes to identify those at high risk of cardiac events [36]. The American Heart Association currently recommends that such screening involve a targeted personal history, family history, and physical examination [37, 38]. For more information on cardiac conditions and risks, see Chapter 11.

Cancer

Cancer is rare in youth and young adults, and becomes increasingly common with age. Over three quarters of all cancers are diagnosed at age 55 years or older [39]. Early life, however, is an important period for establishing lifelong healthy habits that can reduce adult cancer risk. Regular physical activity lowers the risk of numerous cancers, including colon cancer, breast cancer, endometrial cancer, and possibly lung cancer.

Colon and rectal cancer: Cancer of the colon and rectum is the third most common cancer among American women, after lung and breast cancers [39]. The benefit of physical activity on colon cancer risk has been extensively studied, with consistent reports of 30–40 % reduction in colon cancer risk in adults who increase their physical activity [40]. A meta-analysis by Wolin et al., of 52 observational studies, found that, compared to the least active women, the most physically active women experienced a 21 % lower risk of colon cancer (Fig. 12.3) [41]. However, no association has been found for rectal cancer [42, 43]. It is estimated that 30–60 min of moderate to vigorous physical activity per day is needed to protect against colon cancer [40].

Breast cancer: Breast cancer is the most common cancer among women both in the USA and worldwide [39, 44]. In the USA and other high-income countries, approximately 22 % of cases are diagnosed in women under 50 years old, and about 8 % in those under age 40. Early interest in the effect of physical activity on breast cancer resulted from the association of activity with weight and hormone metabolism. However, physical activity is now recognized as an independent risk factor. Numerous studies have reported that moderate to vigorous physical activity is associated with a decreased breast cancer risk of 20–30 % among both premenopausal and postmenopausal women [45, 46]. A study by Bernstein et al. linked lifetime regular exercise habits from the age of 10 years with reduced adult breast cancer risk (Fig. 12.4) [47]. Women who increase their physical activity after menopause may also experience a reduced risk [48, 49]. In addition, research also suggests that regular activity in early life, between the ages of 12–22 years, may be particularly beneficial when it comes to later life breast cancer risk [50]. Most studies suggest

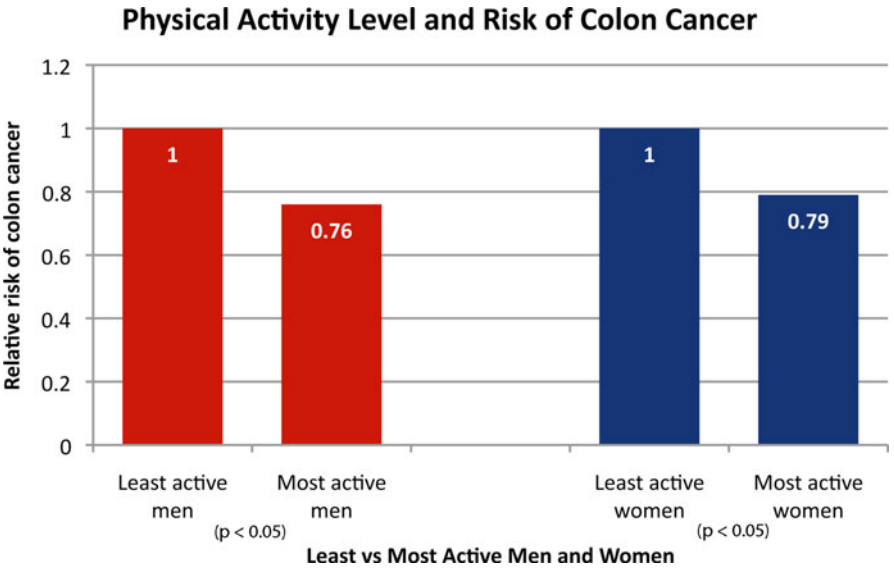

Fig. 12.3 Risk reduction of colon cancer with physical activity. Data source: Wolin et al., 2009

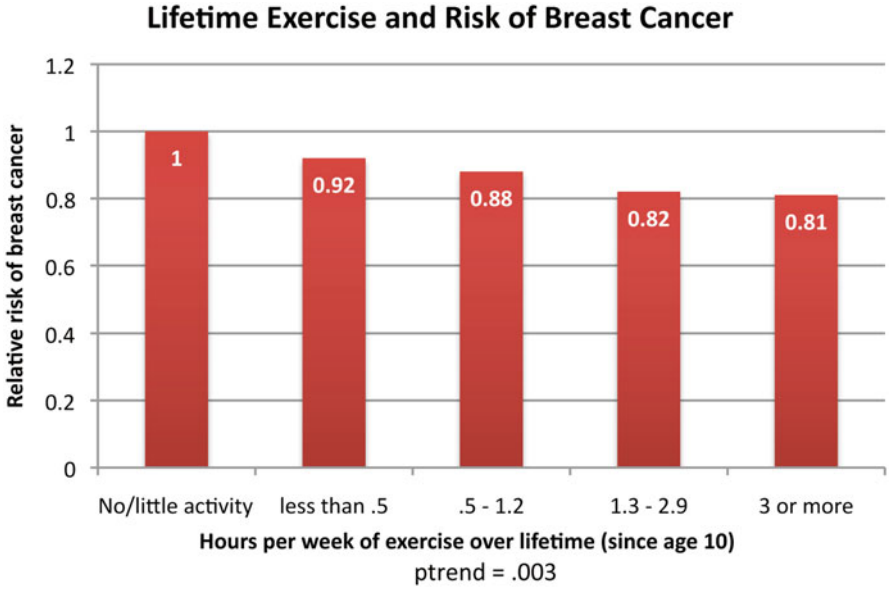

Fig. 12.4 Risk reduction of breast cancer with lifetime exercise. Data source: Bernstein et al., 2005

that 30–60 min per day of moderate- to high-intensity physical activity is associated with a reduction in breast cancer risk [40, 51].

Endometrial cancer: Epidemiologic studies consistently report an inverse association between physical activity and endometrial cancer. These studies suggest that women who are physically active have a 20–40 % reduced risk of endometrial cancer in a dose-dependent relationship [40].

Lung cancer: Lung cancer is the leading cause of cancer death in both women and men in the US, with more than 85 % of deaths caused by tobacco smoking [52, 53]. Overall, studies suggest a 20 % risk reduction in lung cancer with physical activity [40, 51]. However, smoking is an important risk factor, and tobacco use is associated with lack of activity and unhealthy dietary habits. Therefore, it is difficult to isolate effects of these factors in relation to the risk of developing lung cancer. For example, one study found that higher levels of physical activity among current and former smokers were associated with a lower risk of lung cancer, but no association was found in nonsmokers. The authors suggested these discrepancies may be due to a residual confounding effect of smoking [54].

Physical activity may lower cancer risk through a number of potential causal mechanisms, including improved immune function and the regulation of selected hormones [55, 56]. Although the optimal intensity, duration, and frequency of physical activity to prevent cancer are unknown, standard recommendations of 150–300 min or more of moderate intensity physical activity each week should provide benefits.

Osteoporosis

Osteoporosis is a major health burden in the US. Sixteen percent of women age 50 or older suffer from osteoporosis of the femoral neck or lumbar spine, while over 75 % exhibit some level of compromised bone strength [57].

Marked by a significant fracture risk due to poor bone strength, osteoporosis is a condition most often of later life. Yet modifiable lifestyle factors in youth and young adulthood can have an important impact on later adult risk. Physical activity is a particularly important factor in both achieving optimal bone mineral density (BMD) and maintaining bone mass throughout adulthood.

Approximately 90 % of a woman's peak bone mass (PBM) develops by the time she reaches age 18, with most of this occurring in the adolescent years [58]. The remainder accumulates between the ages of 20–30 [58]. Bone mass is slowly and inevitably lost after this. Optimizing PBM in early life offers one of the most important opportunities to avoid or delay osteoporosis in later adulthood [58].

Studies of identical twins attribute 60–70 % of variability in the magnitude of peak bone mass to genetics, while 30–40 % of variability is thought to be related to environmental factors such as diet, exercise, diseases, and medications [59].

Lack of physical activity in adolescence has been shown to be an independent risk factor of low bone mass in healthy premenopausal women [60]. Results from studies in children consistently report that weight-bearing physical activity increases

both bone size and BMD during pre-puberty and early adolescence [61]. Additionally, in a 20-year longitudinal study, Foley et al. found a positive correlation between measures of childhood fitness and later adult bone health [62].

While regular activity in adolescence and the young adult years have undeniable benefits, the young female athlete also needs to be cautious about the Female Athlete Triad (Triad), which is a medical condition that involves at least one of three components of low energy availability, menstrual dysfunction, and poor bone health [58, 63]. Though any female may be affected, athletes in sports that stress leanness (such as gymnastics, long-distance running, and Nordic skiing) are more prone to the condition, which, if untreated, can advance to disordered eating, amenorrhea, and osteoporosis, with both short-term and lasting effects [64]. The initial focus of treating Triad conditions is to improve an athlete's energy availability, with increased calorie intake, lower energy output, or a combination of both [63, 64]. On a population level, coaches, trainers, parents, and others directly involved with athletes need to be educated on the health risks related to the Triad and approaches to help avoid them [64]. For additional information on the Triad, see Chapter 5.

In adulthood, bone loss begins to occur around age 40. Rates of loss vary from woman to woman but are on the order of 0.5 % per year, with a higher rate of loss in the years surrounding menopause [65]. Regular physical activity can help limit bone loss and reduce the risk of fractures. A 2010 Cochrane Collaboration meta-analysis of 43 randomized controlled trials by Howe et al. found that regular exercise in postmenopausal women had a "relatively small statistically significant, but possibly important, effect [on bone density]" [66]. Women in the exercise group had 0.85 % less bone loss at the spine and 1.03 % less bone loss at the trochanter compared with controls. A meta-analysis by Moayyeri of 13 prospective cohort studies found that regular exercise lowered the risk of osteoporotic hip fracture by 38 % compared to those who did not exercise regularly [67]. The role of regular activity in the prevention of falls in the elderly remains unclear.

Evidence is lacking on the exact exercise program that will optimize bone health and lower the risk of osteoporosis [66]. Generally recommended levels and types of physical activity that promote overall health and chronic disease prevention are likely to also have bone health benefits. Within the 60 min of daily activity recommended for youth in the *Physical Activity Guidelines for Americans*, it is recommended to include bone-strengthening activities, such as jumping jacks, running, and weight-lifting, at least 3 days of the week [68]. A 2004 position stand by the American College of Sports Medicine (ACSM) highlights approaches that may help optimize bone health in youth and adults. The ACSM recommends that, to maximize peak bone mass, children and adolescents need to perform high intensity impact activities, such as plyometrics, gymnastics, and jumping, and moderate intensity strength training 3 or more days per week for 10–20 min [69]. Running, soccer, and basketball are likely beneficial as well. The Canadian Academy of Sports and Exercise Medicine recommends that youth perform at least 60 min of weight-bearing activity per day, mostly at moderate to high intensity, and including 15 min sessions of jumping three times per week [70].

Adult activity is aimed at limiting bone loss. ACSM recommendations focus on weight-bearing endurance activities and activities that include jumping, such as running, walking with periods of jogging, and playing basketball, tennis, and volleyball, 3–5 times per week, in addition to strength training 2–3 times per week, for a total of 30–60 min per day [69]. A moderate or high intensity level is recommended for bone-loading forces [69].

Alzheimer's Disease and Dementia

With the aging of the US population, cognitive decline will become an increasing burden on the nation's health system. In 2000, Alzheimer's Disease (AD) had a prevalence of 4.5 million. By 2050, this is expected to balloon to 13.2 million [71]. Identifying effective approaches to lowering the risk or delaying the onset of AD and dementia is essential, and growing evidence supports the benefits of healthy behaviors in preventing cognitive decline [72, 73].

Though there is some variance in study results, the overall body of evidence points to regular physical activity playing an important role in helping maintain cognition and in preventing both AD and dementia [74–76]. A 2003 meta-analysis of 18 intervention studies found that fitness training improved performance on cognitive tasks by 0.5 standard deviations compared to 0.16 standard deviations in controls [76]. Other reviews have demonstrated reductions in AD and dementia risk with physical activity, but some studies have found no risk reduction from physical activity [74, 75].

Regular activity likely works to reduce cognitive decline though multiple mechanisms, such as the mitigation of coronary heart disease, stroke, and diabetes risk factors, as well as improved blood perfusion and brain volume [75].

Though results of studies to date do not point to clear guidelines for the type and duration of activity that has the greatest cognitive benefits, practical guidelines for the prevention of AD were discussed at the International Conference on Nutrition and the Brain in Washington, DC in July 2013 and subsequently published in 2014 [72]. The recommendations for physical activity included 40 min of brisk walking (or other moderate-intensity aerobic activity) three times per week.

Amounts of Physical Activity for Disease Prevention and Overall Health

Young athletes, by definition, are physically active and many exceed recommended activity guidelines for health and wellness. However, with variances between athletes, sports, and sports programs, it is important to detail current activity guidelines for both adults and youth. Though there are immediate benefits from physical activity, the majority of prevention and health benefits accrue when it is practiced throughout life—in addition to, and often well after, participation in organized

Table 12.2 Examples of moderate-intensity and vigorous-intensity physical activity

Moderate-intensity physical activity (approximately 3–6 METs)	Vigorous-intensity physical activity (approximately >6 METs)
Requires a moderate amount of effort and noticeably accelerates the heart rate.	Requires a large amount of effort and causes rapid breathing and a substantial increase in heart rate.
Examples of moderate-intensity exercise include:	Examples of vigorous-intensity exercise include:
• Brisk walking	• Running
• Dancing	• Walking/climbing briskly up a hill
• Gardening	• Fast cycling
• Housework and domestic chores	• Aerobics
• Traditional hunting and gathering	• Fast swimming
• Active involvement in games and sports with children/walking domestic animals	• Competitive sports and games (e.g., traditional games, football, volleyball, hockey, basketball)
• General building tasks (e.g., roofing, thatching, painting)	• Heavy shovelling or digging ditches
• Carrying/moving moderate loads (<20 kg)	• Carrying/moving heavy loads (>20 kg)

Metabolic Equivalents (METs) are commonly used to express the intensity of physical activities. MET is the ratio of a person's working metabolic rate relative to their resting metabolic rate. One MET is defined as the energy cost of sitting quietly and is equivalent to a caloric consumption of 1 kcal/kg/h. It is estimated that compared with sitting quietly, a person's caloric consumption is three to six times higher when being moderately active (3–6 METs) and more than six times higher when being vigorously active (>6 METs)

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athletics. Certain activities such as tennis, swimming, and cycling can be part of an active lifestyle throughout all stages of life.

Youth should get at least 60 min of moderate intensity or vigorous activity each day, largely from aerobic activities such as brisk walking, running, cycling, and active sports (see Table 12.2). Muscle-strengthening and bone-strengthening activities three or more times per week are an important part of the physical activity routine [10]. It is important to guard against the health risks of the Triad by promoting healthy levels of athletic training combined with a healthy diet that includes adequate calories. Overtraining should also be avoided, and adequate time for healing and tissue repair must be allotted.

Adults should avoid inactivity and work to be regularly active, getting at least 150 min of moderate intensity activity each week. Getting 300 min or more per week has added health benefits and may be necessary for weight control and sustained weight loss. Even greater amounts have further health benefits [10]. Exercise programs should also include strength-training two or more times per week.

Counseling Patients

Though many young athletes will reach or exceed recommended levels of physical activity, many will not, and it is important to counsel them on healthy levels and types of physical activity. The focus should be on choosing enjoyable activities that provide health benefits but also lay a solid foundation for lifelong physical activity. Some young female athletes will also require counseling related to the Triad.

Patient counseling on physical activity can be done in less than 5 min and should be directed at healthy patients as well as those with chronic disease or related conditions. The 5A's brief intervention model, which has been used successfully for smoking cessation, can be modified for physical activity counseling (Table 12.3). It can be helpful to understand the stages of change through which individuals can move forward or back (Trans-theoretical model). Even if patients are not ready to change, providers may help patients move forward from one stage to the next toward the goal of increasing physical activity or taking a healthier approach to physical activity.

General Messages for Patients

Youth

- Aim for 60 min a day of moderate or vigorous activities, such as running, brisk walking, and playing basketball, and get three or more muscle-strengthening and bone-strengthening sessions each week.
- Choose activities you enjoy—whatever gets the body moving.
- Avoid long periods of sitting—even on days that include a lot of physical activity.
- Keep screen time (TV, computer, phone) to under 2 h a day. Less is even better.
- Being on a sports team may not provide all the activity you need to be healthy. Be active on top of sports if need be.
- If you are very active in sports (especially sports that place a priority on being thin), be sure to get enough calories to keep your weight healthy and your bones healthy.

Adults

- Any level of activity is better than none, and it is important to avoid inactivity.
- Try to get at least 150 min of moderate intensity physical activity per week, like brisk walking. More is even better and can help with losing weight or keeping it off.

Table 12.3 5A's for adult physical activity counseling

Ask all patients about their current level of activity.
• Ask about the type, frequency, and duration of exercise, including occupational, household, and leisure-time activities.
• Determine whether their activity level is below, at, or above the minimum recommended levels of 150 min per week of moderate-intensity aerobic activity, with two or more strength-training session per week.
• Document this information in the patient's chart.
Advise all patients to be physically active.
• Deliver a clear, strong, and personalized message advising the patient to get at least 30 min of exercise per day.
Assess the patient's attitudes toward physical activity.
• Understanding the patient's readiness to change can help both the provider and the patient set realistic physical activity goals.
• If the patient is unwilling to consider becoming more active, provide information, and stress the benefits of increased physical activity.
• If the patient is interested in increasing activity, provide motivational support and assistance as described below.
• For patients who are currently active, provide encouragement and assistance, and note that increasing the duration or intensity of activity can yield additional health benefits.
Assist patients who want to become more active.
• Identify potential barriers, and help patients come up with solutions that will work for them.
• For patients who have been inactive for a while, counsel them to initiate activity slowly and then gradually increase.
• Discuss exercise safety and help tailor the mode, intensity, duration, and frequency of activity to meet the needs of individual patients.
Arrange follow-up.
• Follow up is necessary to support successful behavior change, to reinforce messages, and to examine barriers that persist or arise.
• Offer positive feedback and congratulate patients on their successes. Provide additional encouragement and practical advice.
• Reinforcement is important for helping patients maintain their activity levels. Studies suggest that the number, type, and duration of reinforcements are central to the success of behavioral interventions.
• Help patients reassess their goals and obstacles.

- Try to add three or more muscle-strengthening sessions per week.
- Avoid long periods of sitting—even on days that include a lot of physical activity.
- Keep screen time (TV, computer, phone) to under 2 h a day. Less is even better.
- If starting a new exercise program, start slowly and build from there.
- Choose activities you enjoy—whatever gets the body moving.

Conclusion

Regular activity is one of the most important contributors to wellness, quality of life, and disease prevention (Table 12.1). Relatively modest amounts of activity can lower the risk of heart disease, stroke, diabetes, osteoporosis, dementia, and numerous cancers. Though there are immediate benefits from physical activity, the majority of prevention and health benefits accrue when it is practiced lifelong—in addition to, and often well after, participation in organized athletics.

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