

The Summer Meeting of the Nutrition Society was held at the University of Nottingham on 30 June–3 July 2008

Conference on ‘Multidisciplinary approaches to nutritional problems’ Symposium on ‘Performance, exercise and health’

Exercise in improving health v. performance

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Regular and goal-appropriate exercise is critical to improving and maintaining both health and performance. However, the frequency, intensity, duration and type of activities needed to optimise health or achieve successful sports performance will differ considerably depending on an individual’s goals and capabilities. Although sport is one of many forms of exercise that can be counted towards daily physical activity, participation in sport is not necessary to meet current physical activity recommendations. The current consensus is that the minimum amount of physical activity needed to improve and maintain good health is 30 min moderate-intensity activity/d on ≥ 5 d/week. The evidence supporting this consensus is based on predominantly observational evidence that performing regular aerobic (endurance)-type physical activity is associated with reduced morbidity and premature mortality from CVD, CHD, stroke and colorectal cancer. The exact dose needed to improve health and the slope of the dose–response gradient between physical activity and mortality for various diseases are not known, and one major limitation of the existing evidence is the lack of objective measurement of physical activity. Limited evidence indicates that a much higher dose of activity (45–90 min each day on ≥ 5 d/week) may be needed to prevent overweight and obesity and to avoid weight regain in previously overweight and obese individuals. The role of resistance training and heavy domestic work in reducing morbidity and premature mortality for various diseases is unclear. As most adults do not meet current recommendations there is a critical need for innovative approaches to increase physical activity across large-scale populations.

Exercise: Health-related physical activity: Obesity reduction: Chronic disease risk

Regular and goal-appropriate exercise is critical to improving and maintaining both health and sport performance. However, the frequency, intensity, time (or duration) and type of activities needed to optimise health or achieve successful sports performance will differ considerably depending on an individual’s goals and capabilities. In fact, the activity needed to improve health and reduce premature mortality is substantially different from the exercise needed to optimise sport-specific performance. Thus, the purposes of the present article are to: (1) distinguish between activity patterns linked to health v. those that are targeted to athletes in competitive situations; (2) compare and contrast the current physical activity recommendations from various organisations around the world; (3) provide an evaluation of the evidence base for these guidelines and explore whether current physical activity guidelines are

sufficient to optimise health and reduce an individual’s risk for obesity and consequent chronic diseases. Within these discussions will include an exploration of the role of physical activity, exercise and sport and their potential to improve and maintain good health within the larger context of an individual’s overall lifestyle.

Basic definitions

To better understand the differences between physical activity and exercise and to allow for a more thorough discussion of the evidence supporting current physical activity recommendations for health, it is necessary first to be familiar with the terms used to define physical activity, exercise and the various categories of physical fitness. This

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Table 1. Components of physical fitness and examples of activities to achieve fitness within each component

Component	Definition	Activities to achieve fitness
Cardio-respiratory fitness	Ability of the heart, lungs and circulatory system to adequately supply O ₂ and nutrients to working muscles	Aerobic-type activity such as jogging, hiking, brisk walking, bicycling, aerobic dance
Musculoskeletal fitness:	Fitness of skeletal muscle and bones	Resistance training, weight lifting
Muscular endurance	Ability of muscle to maintain submaximal force levels for an extended period of time	Weight lifting using lighter weights with a higher number of repetitions
Muscular strength	Ability of muscle to produce its maximal force	Weight lifting using heavier weights with a lower number of repetitions
Muscular power	Ability of muscle to produce a large amount of force quickly	Plyometrics, bounding
Flexibility	Ability of a joint to move fluidly through its complete range of motion	Yoga, stretching exercises

information is provided in a recent thorough overview of the terminology related to activity, exercise and fitness⁽¹⁾. In brief, physical activity is any bodily movement produced by skeletal muscles that increases energy expenditure above resting levels. There are two categories of physical activity: leisure-time physical activity, which describes the activities that are participated in during time outside occupational work; occupational physical activity, or the activity associated with the performance of a job usually within an 8 h workday. Examples of leisure-time physical activity include jogging, hiking, dancing, swimming, bicycling and sport.

Exercise, or exercise training, is a subcategory of leisure-time physical activity. Exercise is defined as planned, structured and repetitive bodily movements that are performed to improve or maintain one or more components of physical fitness (Table 1). Physical fitness is defined as the ability to carry out daily tasks with alertness, vigour and sufficient energy to enjoy leisure-time activities without undue fatigue⁽²⁾. The components of physical fitness include cardio-respiratory fitness, musculoskeletal fitness (including endurance, strength and power) and flexibility⁽³⁾. Each of these terms is defined in Table 1 and examples of activities that can be done to achieve fitness in each component are also listed.

The intensity at which physical activity or exercise is performed influences the level of physical fitness achieved and the resultant health benefits that will result. Both moderate-intensity and vigorous-intensity activities are known to increase fitness and improve health, while low-intensity activities are not associated with these benefits. Moderate-intensity activities are those that cause a moderate increase in heart rate, breathing and sweat rate; examples include brisk walking, heavy cleaning, golfing (walking while pulling clubs) and swimming at a leisurely pace. Vigorous-intensity activities are those that cause marked increases in heart rate, breathing and sweat rate; examples include jogging and running, hiking, carrying heavy loads, moderate to hard swimming and playing singles tennis.

Successful sport performance is dependent on achieving optimal fitness in the components most closely linked with each sport-specific outcome. For instance, marathon runners participate in training activities that will maximise cardio-respiratory fitness, and will also include an emphasis on muscular endurance and reducing body fat to relatively low

levels. Power lifters, alternatively, will train to maximise muscular strength, power and body mass. Achieving health-related fitness may also involve participating in one or more activities associated with each of the components of physical fitness, but the intensity and duration needed to gain the associated health benefits is substantially lower than that needed to succeed in competitive sports.

What defines an athlete? There is not necessarily a clear distinction between an athlete (one who participates regularly in a sport) and one who participates in sport as a means to achieve health-related fitness. Elite athletes are individuals who compete at the highest levels of their sport, and may be considered professional because they are paid to compete and have achieved an official designation as an elite performer within their sport. Recreational or amateur athletes are individuals who may regularly train for and compete in sports for enjoyment, fitness and health but are either not performing at the top levels and/or do not receive payment (or only receive restricted payment) for competing in sports. However, an individual does not need to compete in sports to gain the health benefits of physical activity, and many individuals participating in sports are not necessarily achieving optimal fitness within each component of physical fitness. Thus, increasing opportunities for participation in sport may increase overall physical activity levels of those who enjoy sport-related activities, but will not benefit those who do not enjoy sport or for whom sports participation is not considered culturally acceptable.

Physical activity recommendations for health

Over the past 15 years a series of reports have been published providing health-related physical activity recommendations for adults based on currently-available evidence⁽⁴⁻¹²⁾ (Table 2). The general consensus is that a minimum of 30 min moderate- to vigorous-intensity physical activity/d at least five times per week is necessary to promote and maintain health. These recommendations are endorsed by various international governmental agencies and health-related associations such as the American College of Sports Medicine, Centers for Disease Control and Prevention, the National Institutes of Health, the American Heart Association, the Department of Health, the International Association for the Study of Obesity, the

Table 2. A comparison of various physical activity recommendations to improve and maintain health

Health category	Recommendation	Reference
General health	Accumulation of ≥ 30 min moderate-intensity physical activity on most, preferably all, days of the week	Pate <i>et al.</i> ⁽⁴⁾ , National Institutes of Health Consensus Development Panel on Physical Activity and Cardiovascular Health ⁽⁵⁾
	A total of ≥ 30 min at least moderate-intensity physical activity/d on ≥ 5 d/week	Department of Health ⁽⁶⁾
	Healthy adults 18–65 years of age need moderate-intensity aerobic (endurance) physical activity for a minimum of 30 min on 5 d/week or vigorous-intensity aerobic physical activity for a minimum of 20 min on 3 d/week; combinations of moderate- and vigorous intensity activity can be performed to meet the recommendation; to maintain good health and physical independence, adults should perform exercises that maintain or increase muscular strength and endurance for ≥ 2 d/week	Haskell <i>et al.</i> ⁽⁷⁾
Cancer prevention	Be moderately physically active, equivalent to brisk walking, for ≥ 30 min/d; and as fitness improves, aim for ≥ 60 min moderate, or for ≥ 30 min vigorous, physical activity every day (evidence indicates convincing decreased risk for colo-rectal cancer, probable decreased risk for post-menopausal breast cancer and endometrial cancer and limited–suggestive decreased risk for cancers of the lung, pancreas and breast (premenopausal))	World Cancer Research Fund/American Institute for Cancer Research ⁽⁸⁾
Weight loss and prevention of weight regain	Marked health gains can be achieved with participation in a minimum of 150 min/week and overweight and obese individuals should gradually increase to this initial goal; there may be advantages to progressively increasing exercise to 200–300 min (approximately 45 min/d)/week to facilitate long-term maintenance of weight loss	Jakicic <i>et al.</i> ⁽¹⁰⁾
	60 min moderate-intensity physical activity/d should be performed to prevent weight gain and confer additional health benefits	Institute of Medicine, Food and Nutrition Board ⁽¹¹⁾
	45–60 min moderate-intensity physical activity/d is needed to prevent overweight and obesity; prevention of weight regain may require 60–90 min moderate-intensity activity or lesser amounts of vigorous-intensity physical activity/d	Saris <i>et al.</i> ⁽¹²⁾
Bone health	To preserve bone health adults should perform weight-bearing aerobic (endurance) activities, activities that involve jumping and resistance exercise; bone loading forces should be moderate to high in intensity; weight-bearing activities should be done three to five times per week and resistance training should be done two to three times per week; a combination of weight-bearing endurance activities, activities that involve jumping and resistance exercise that targets all major muscle groups for 30–60 min/d	Kohrt <i>et al.</i> ⁽⁹⁾

World Cancer Research Fund and the American Institute for Cancer Research. The more recent publications have refined earlier recommendations⁽⁷⁾ or focused on addressing specific disease outcomes such as various forms of cancer⁽⁸⁾, bone health⁽⁹⁾ and weight loss and prevention of weight regain^(10–12).

The recommendations for overall health were generated primarily from reviews of the evidence for all-cause mortality and morbidity from CHD, stroke, CVD and various forms of cancer. The Department of Health report additionally has reviewed the evidence of benefits of regular physical activity for reducing risks for type 2 diabetes and improving musculoskeletal health, psychological well-being and mental health⁽⁶⁾. While there is clear and consistent evidence from randomised controlled trials and observational studies that meeting current physical activity guidelines will improve overall health and reduce premature

mortality, the exact dose of activity needed to improve specific health outcomes is not presently known. A review of the evidence from observational cohort and case–control studies has found a consistent inverse dose–response gradient for both level of self-reported physical activity and cardio-respiratory fitness for fatal and non-fatal health outcomes, particularly for CHD, CVD, stroke and colon cancer⁽¹³⁾. The authors of the review conclude that while there is a clear benefit of increasing levels of physical activity and cardio-respiratory fitness above the lowest levels, the data currently available are not sufficient to determine whether the slope of the gradient is different for different health outcomes, nor is it clear whether the shape of the dose–response curve is curvilinear or linear. A more recent review has indicated that there is sufficient evidence from both randomised trials and non-randomised studies to support the recommendation of a minimum of 30 min

moderate-intensity aerobic physical activity/d on 5 d each week or vigorous-intensity aerobic activity for a minimum of 20 min/d on 3 d each week, and that performing combinations of moderate- and vigorous-intensity activities will meet this recommendation⁽⁷⁾. Additionally, based on the dose–response relationship between physical activity and health, the authors of the review recommend that by exceeding the minimum recommendations individuals can gain greater health and fitness benefits.

The evidence for the amount of physical activity needed for weight loss, to prevent weight regain and to maintain an overall healthy body weight indicates that the current minimum recommendation is probably not sufficient to achieve these goals. While overweight and obese individuals will still derive important health benefits from meeting the minimum physical activity recommendations, there is a relatively limited body of evidence from randomised controlled trials, non-randomised studies and doubly-labelled-water data indicating that 45–90 min moderate-intensity physical activity/d on ≥ 5 d/week is needed to achieve and maintain a healthy body weight^(10–12,14,15). The publication of the Institute of Medicine⁽¹¹⁾ recommendation that ≥ 60 min moderate-intensity activity/d is needed to avoid unhealthy weight gain has created considerable controversy; many health and fitness organisations have suggested that this recommendation is inconsistent with current public health guidelines and would confuse the general public. There is also substantial concern that this message would be too daunting and would deter inactive individuals from taking up regular activity, as most individuals do not currently meet the minimum recommendations. There is no evidence supporting or refuting the validity of these concerns. Although there has been initial resistance to this higher recommendation, it is now accepted as consistent with the activity recommendations for general health, as the current guidelines indicate a minimum of activity needed to improve health outcomes. Experts agree that definitive data are lacking in relation to exactly how much physical activity is needed for the primary prevention of weight gain^(12,15). However, based on the existing evidence related to weight loss and maintenance of healthy weight, it appears that the amount of activity needed to reduce risks for certain conditions (such as obesity) may be different than for other diseases (such as CHD, CVD and some cancers).

Existing gaps in the literature

Although there is a growing body of evidence supporting the health benefits of meeting at least the current minimum recommendation for physical activity, there are still many questions that need to be answered. In relation to dose response, more studies need to be conducted to determine the precise dose of physical activity needed to improve health. As the current guidelines are based on self-reported physical activity levels that have poor accuracy and reliability, there is a critical need to measure physical activity using objective measures (e.g. accelerometers) to guide this line of research. As many individuals cannot or will not participate in the minimum recommended amount of physical activity, it would be extremely valuable to determine

whether performing <15 min physical activity each day confers substantial health benefits. The results from two small intervention studies suggest that accumulated stair climbing among young women, performed for a total of <12 min/d on 5 d/week over 8 weeks can result in marked improvements in cardio-respiratory fitness and beneficial changes in HDL-cholesterol and LDL-cholesterol^(16,17). There is also a need for more studies to determine whether additional health benefits are derived from performing higher-than-recommended amounts of physical activity (e.g. ≥ 60 min/d). In addition, very little is known about the dose of physical activity needed to reduce the risk of morbidity and premature mortality for diseases such as type 2 diabetes, various cancers (such as breast, pancreatic and lung), cognitive function and mental health disorders (such as depression and anxiety).

More research also needs to be conducted to determine how activities other than aerobic (or endurance) types of activities contribute to reduced morbidity and premature mortality. For instance, although resistance exercise training is known to be beneficial to improving muscular strength and bone health, little is known about whether resistance exercise can decrease risks for chronic diseases such as CVD, CHD and type 2 diabetes. There is also controversy surrounding the theorised health benefits of performing heavy domestic work. Heavy domestic work (e.g. heavy cleaning, sweeping and vacuuming) is currently classified as a moderate-intensity activity that can be used to meet physical activity recommendations. However, recent evidence indicates that while including heavy domestic work in estimates of daily physical activity markedly increases the percentage of adults meeting current physical activity recommendations, these activities are not associated with reductions in CVD risk factors or obesity^(18–20). Thus, more research is needed to determine whether heavy housework and other forms of heavy domestic activity actually contribute to improved health.

The biggest challenge facing researchers and healthcare professionals is how to get the majority of the population to meet or exceed current physical activity recommendations. Results from studies prescribing (and in many cases providing) exercise training to motivated research volunteers indicate increases in physical activity and fitness levels and improvements in cardiovascular and metabolic health profiles. However, there is currently no evidence indicating how to increase the physical activity levels of the general population, either acutely or longitudinally. There is a multitude of activities that can be performed to meet current physical activity recommendations and receive the consequent health benefits; these activities include a wide variety of moderate-intensity and or vigorous-intensity activities that do not have to be planned and structured, and may or may not involve participation in sport. Presently, researchers around the world are conducting studies to gain a better understanding of the complex interactions between the environmental, social, cultural, genetic and personal factors that influence participation in physical activity, to assess which of these factors has the greatest impact on changing physical activity behaviours and to explore innovative approaches to increasing the activity levels of large-scale populations.

Conclusions

There is currently consensus across various international organisations that the minimum amount of physical activity needed to improve and maintain good health is 30 min moderate-intensity activity each day on ≥ 5 d/week. This consensus has been reached based on predominantly observational evidence that performing regular aerobic (endurance)-type physical activity is associated with reduced morbidity and premature mortality from CVD, CHD, stroke and colo-rectal cancer. The exact dose needed to improve health and the slope of the dose–response gradient between physical activity and mortality for various diseases are not known. One major limitation of the existing evidence is the lack of objective measurement of physical activity. The impact of performing regular physical activity that is lower or higher than the current recommendation is also not clear. Limited evidence indicates that a much higher dose of activity (45–90 min each day on ≥ 5 d/week) may be needed to prevent overweight and obesity, to promote weight loss and to avoid weight regain in previously overweight and obese individuals. Studies are needed to determine whether resistance training reduces morbidity and premature mortality and, if so, which disease risks are positively impacted by resistance training. There is evidence suggesting that heavy domestic work (e.g. heavy housework) may not be associated with lower BMI or reductions in CVD risk factors, challenging the current recommendation that heavy domestic activities can be counted towards the amount of moderate-intensity physical activity done each day. Although current recommendations appear achievable, most adults do not meet them. Thus, there is a critical need for innovative approaches that can be applied to large-scale populations to increase physical activity levels and in turn reduce morbidity and premature mortality resulting from the various chronic diseases that affect human health across the lifespan.

Acknowledgement

The author declares no conflict of interest.

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