

Resistance Training for Health*

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*Since publication of this issue of the *Research Digest* on “Resistant Training for Health,” the American College of Sports Medicine has accepted for publication in their journal *Medicine and Science in Sports and Exercise* the publication of a symposium issue on Resistance Training for Health and Disease edited by Michael Pollock, Ph.D., and William Evans, Ph.D. This issue will highlight the effect of resistance on bone density, body composition, and function of the elderly, low-back pain and disability, acute responses to resistance training and safety, and finally, a prescription of resistance training for health and disease. These timely papers will supplement this *Research Digest* topic.

HIGHLIGHT

“Adding strength training to a program of regular physical activity will help to decrease the risk of ‘chronic diseases’ while improving quality of life and functionality, allowing people of all ages to improve and maintain their health and independent lifestyle.”

INTRODUCTION

Increasing physical activity and participation in an aerobic endurance exercise program have been shown to decrease the risk of chronic diseases (e.g., coronary heart disease [CHD], stroke, osteoporosis, diabetes, obesity/weight control), which have become the leading causes of morbidity and mortality in the United States. The American Heart Association (AHA) has identified physical inactivity as a primary risk factor for the development of CHD along with cigarette smoking, high blood pressure, and elevated levels of cholesterol. As an intervention, the American College of Sports Medicine (ACSM), the AHA, and the Surgeon General’s Report on Physical Activity and Health all have established guidelines for aerobic exercise programs designed to positively affect health status. These recommendations are based on a preponderance of evidence establishing the effect of exercise on disease prevention (see Figure 14.1).

The effects of resistive type exercise (strength training) on health status have been largely overlooked. Traditionally, strength training has been seen as a means of improving muscular strength and endurance (muscle mass) and power, but not as a means for improving health. There is increasing evidence that strength training plays a significant role in many health factors (see Figure 14.1). The ACSM (1990, 1995), AHA (1995), and the Surgeon General's Report on Physical Activity and Health (1996) all have recognized the importance of strength training as an important component of health. These organizations have recommended performing 1 set of 8–12 repetitions of 8–10 exercises 2–3 times per week for persons under 50 years of age and the same regimen using 10–15 repetitions for persons over 50 years of age. The research and rationale for this exercise prescription have been reviewed (ACSM, 1990; Pollock et al., 1994; Feigenbaum & Pollock, 1997). Although greater intensity (fewer repetitions and greater weight) with multiple sets can elicit greater improvements in strength and power, it may not be appropriate for older nonathletic participants. A regimen of 8–12 or 10–15 repetitions appears to be an adequate balance for developing both muscular strength and endurance. The research suggests that 80–90% of the strength gains can be elicited using this regimen compared to the high volume types of programs. Thus, because time is an important factor for program compliance, the above recommended guidelines seem appropriate. Although more research is necessary to confirm the best combination of intensity (repetitions, weight, sets) for older or more fragile participants, it appears that the 10–15 repetition guideline may create less joint stress and injury than the 8–12 repetition program.

FIGURE 14.1

Comparison of the effects of aerobic endurance training to strength training on health and fitness variables.

Exercise	Aerobic	Resistance	Variable	Exercise
Bone mineral density	↑↑	↑↑		
Body composition				
%fat	↓↓	↓		
LBM	↔	↑↑		
Strength	↔	↑↑↑		
Glucose metabolism				
Insulin response to	↓↓	↓↓	glucose challenge	
Basal insulin levels	↓	↓		
Insulin sensitivity	↑↑	↑↑		
Serum lipids				
HDL	↑↑	↑↔		
LDL	↓↓	↓↔		
Resting heart rate	↓↓	↔		
Stroke volume	↑↑	↔		
Blood pressure at rest				
Systolic	↓↓	↔		
Diastolic	↓↓	↓↔		
VO ₂ max	↑↑↑	↑		
Endurance time	↑↑↑	↑↑		

Physical function	↑↑	↑↑↑
Basal metabolism	↑	↑↑

Improving muscular strength has been traditionally viewed as important for athletes, competitive weightlifters, and bodybuilders, but not for improving health status. Recent evidence indicates that this conception is no longer true. In this paper we will provide information concerning how strength training can influence health and disease prevention.

IMPROVEMENTS IN STRENGTH AND FUNCTION

Aging has been associated with a decrease in muscle mass and strength (Larsson et al., 1979). This decrease in strength is linked to decreased mobility, decreased functionality, and increased risk of falling in older people (Bendall et al., 1989; Fiatarone & Evans, 1990). Falls have been identified as the most frequent cause of injury-related mortality in the elderly (Fife et al., 1984). According to Greenspan et al. (1994), 90% of all hip fractures in the elderly occur as a result of a fall. The authors also suggested that to help prevent the risk of falling, interventions should include exercise designed to improve quadriceps strength, neuromuscular function, and gait. Nevitt et al. (1991) conducted a prospective study to determine the risk factors that lead to injurious falls in the elderly. They reported that the fallers' ability to protect him- or herself during the fall affected the risk of injury. Upper and lower extremity strength, reaction time, and time to complete a cognitive test were associated with risk of falling and injury. The authors recommended that interventions intended to reduce the risk of falling and injury should include strength training and exercise. Fiatarone et al. (1994) examined the effect of 10 weeks of resistance exercise for the legs only on muscle strength and function in elderly adults (mean age, 87± 0.6 yr). Resistance exercise increased muscle strength (113%), gait velocity (12%), stair climbing power (28%). Fiatarone et al. (1990) reported that eight weeks of resistance exercise for the legs improved strength and function in nonagenarians (mean age 90±1 yr). Quadriceps strength improved 174% and tandem gait speed increased 48% following resistance training.

The Surgeon General's Report on Physical Activity and Health stated that developing muscular strength can improve one's ability to perform tasks and reduce the risk of injury. The report goes on to say that "resistance training may contribute to better balance, coordination, and agility that may help prevent falls in the elderly."

LOW BACK PAIN AND STRENGTH

Low back pain and spinal disorders are the predominant reason for disability in the workforce. It is estimated that chronic low back pain accounts for nearly 80% of the annual cost of low back disorders even though this classification represents only 10% of all spinal disorders (Spengler et al., 1986). Lack of lumbar strength has been associated with the development of low back pain and dysfunction.

Russell et al. (1990) reported increased lumbar strength and decreased low back pain following eight weeks of isolated lumbar extension exercise in subjects with chronic low back pain. Risch et al. (1993) examined the effect of 10 weeks of lumbar extension exercise on patients with chronic low back and reported decreased low back pain, physical and psychosocial dysfunction. The results also showed a significant improvement in lumbar extension strength. Nelson et al. (1995) examined the effect of isolated lumbar extension exercise on 895 chronic low back pain patients who had failed an average of six other treatment modalities prior to enrolling in the study. The patients performed lumbar extension and torso rotation exercise for 10 weeks. The results showed that most of the patients increased low back strength, decreased low back and leg pain, and improved their ability to perform daily activities. Seventy-two percent were able to return to work.

Some evidence is also available suggesting that improving low back strength is effective in reducing the incidence of low back dysfunction in the work place. Mooney et al. (1995) reported that the prevalence of low back injuries was reduced at a coal mine following a program of 20 weeks of lumbar extension exercise.

BONE MINERAL DENSITY

Osteoporosis is a degenerative disease that is characterized by a decrease in bone mineral density (BMD). This loss makes the bones more susceptible to fractures. These fractures can lead to decreased physical activity and possibly increased susceptibility to further health problems and mortality. Research has indicated that bone formation can be stimulated by placing a strain on the bone as is seen during resistive and aerobic exercise (Rubin & Lanyon, 1984). Although both forms of exercise can increase BMD, the increase is site-specific to the joints exercised. Hamdy et al. (1994) reported higher BMD in the upper arm in persons who weight trained compared to runners, but that there was no difference for lower body BMD between the two groups. Karlsson et al. (1993) reported that active and retired weightlifters had higher BMD for the spine, hip, tibia, and forearm when compared to controls. In a comparison of BMD between female weightlifters, cyclists, cross-country skiers, and orienteers, Heinonen et al. (1993) reported that the weightlifters had the highest weight adjusted BMD in the distal radius, lumbar spine, distal femur, and patella. Snow-Harter et al. (1992) showed that eight months of either resistance exercise or jogging improved lumbar BMD when compared to controls, but no difference was seen between the exercise groups. Braith et al. (1996) examined the effects of six months of resistance exercise on BMD following heart transplant surgery. Typically, BMD decreases during the post-operative period as a consequence of glucocorticoid therapy. The group that performed strength training for six months was able to return their lumbar, total body, and femoral neck BMD to near baseline levels while the non-strength-training groups' BMD remained depressed. Pollock et al. (1992) showed that six months of isolated lumbar training improved lumbar BMD compared to controls in men and women 60 to 79 years of age. Menkes et al. (1993) reported a significant increase in femoral neck BMD in middle-aged to older men following 16 weeks of strength training. These data indicate that resistance and aerobic exercise can both positively affect BMD, but that this influence is site-specific to the mode of exercise.

AEROBIC CAPACITY

Exercise programs that emphasize endurance exercise usually elicit a 15–30% increase in maximum oxygen uptake (VO_2max). Available evidence indicates that traditional weight training (greater than 1–2 minutes rest between exercises) does not increase VO_2max (Pollock & Wilmore, 1990). However, it has been shown that performing circuit training regimens can increase VO_2max 5–8%. These regimens consist of a circuit of approximately 10 exercises. A weight is chosen that can be lifted for 15 repetitions for each exercise with a short (15–30 second) rest period between exercises. Thus, circuit weight training has only a modest effect on VO_2max and should not be used for that sole purpose. Although weight training has only a modest effect on VO_2max , it has a dramatic effect on strength, endurance, and physical function. For example, Hickson et al. (1980) found that strength training the legs for 10 weeks improved performance time on both a treadmill (12%) and a stationary cycle (47%), while VO_2max only increased 4%. Ades et al. (1996) reported that 12 weeks of strength training improved submaximal treadmill walking time by 38% while no change was reported for controls.

BODY COMPOSITION

Obesity is a risk factor for several health problems including diabetes mellitus, arthritis, cardiovascular disease (CVD), and kidney dysfunction (Stone et al., 1991). Also, due to excess nonmetabolically active weight, an obese person has to expend more energy for movement placing increased stress on the cardiovascular system. Aerobic exercise has been widely prescribed and utilized as a means of weight control and fat loss. There is also evidence indicating that strength exercise is an effective means of influencing body composition. Gettman and Pollock (1981) summarized the effects of five weight training and six circuit weight training studies on changes in body composition. The studies showed a mean decrease in body weight of 0.12kg, increase in lean body mass of 1.5kg, and a decrease in fat mass of 1.7kg.

The added benefit of strength training to an aerobic exercise program (caloric expenditure) is its effect on developing and maintaining muscle mass and metabolic rate. Metabolic rate decreases with age and a primary factor influencing this decrease is reduced fat-free mass. Campbell et al. (1995) reported that resting metabolic rate and energy intake required to maintain body weight significantly increased in older adults following 12 weeks of strength training. These data are in agreement with Pratley et al. (1994). Thus it appears that resistance exercise should be a part of a well-rounded program including aerobic endurance exercise for weight loss and controlling weight with age.

EFFECT ON CARDIOVASCULAR RISK FACTORS

There is growing evidence to indicate that strength training may also be important to risk factor intervention. Strength training exercise has been shown to increase insulin sensitivity, decrease glucose intolerance, and has a modest effect on decreasing diastolic blood pressure and may alter serum lipids.

Miller et al. (1984) reported that 10 weeks of strength training significantly reduced basal insulin levels and area under the insulin response curve following glucose ingestion. The decrease in insulin was significantly correlated with increase in lean body mass. Hurley et al. (1987) reported that insulin response to an oral glucose tolerance test was significantly lower following 16 weeks of resistance training. Smutok et al. (1993) compared the effect of endurance and strength training on responses to a glucose tolerance test. Both modalities decreased the total area under the curve for glucose levels and insulin response, and there was no difference between the two types of exercise.

Aerobic endurance exercise has been well established as a means for favorably altering high density lipoprotein cholesterol (HDL-C). The research concerning the effect of strength training is not as clear and recent studies have produced conflicting results. Studies that do show a positive result, typically involve higher volumes emphasizing multisegment exercises. Hurley et al. (1987) reported a 13% increase in HDL cholesterol following 16 weeks of heavy strength training. Wallace et al. (1989), and Johnson et al. (1982) both reported positive changes in lipid profiles, but only during the highest volumes of training. Goldberg et al. (1984) showed that a program emphasizing high volume with short rest periods increased HDL while decreasing LDL and serum triglycerides. Conversely, Kokkinos et al. (1987, 1991), Kohl et al. (1992), and Smutok et al. (1993) all reported that strength training did not significantly alter serum lipid profiles. Thus, the available evidence seems to indicate that the type of exercise performed by average strength trainers may not be sufficient to impact serum lipids.

SAFETY AND PRACTICAL APPLICATION

Data regarding the safety of strength training and testing show that it is safe if proper guidelines are followed. Gordon et al. (1995) reported no adverse cardiovascular events following maximal strength testing in 6,653 healthy men and women. Other studies have shown no excess incidence of cardiovascular events using resistance training compared to aerobic endurance training in varied populations. Muscle soreness is common in beginning exercisers but significant musculoskeletal injuries are rare. Persons with previous joint injuries are at higher risk for sustaining an injury from strength training.

An important reason why strength training is beneficial in daily life and may cause less risk in doing various lifting tasks is related to the training effect. For example, McCartney et al. (1993) showed that following 12 weeks of leg press training, maximal strength increased 24%, and that blood pressure measured during submaximal lifting decreased following the training period. Thus, strength training can decrease the stress placed on the heart during lifting tasks such as carrying groceries, snow shoveling, and lifting moderate to heavy boxes, which have been implicated as a cause of heart attacks.

CONCLUSION

The effects of resistance/strength training on muscular strength and endurance (muscle mass) and rehabilitation from musculoskeletal injury is well known. As a result, most of the major health organizations have included it as an important component of a well-rounded exercise program along with aerobic endurance and flexibility exercise. More recently, strength training has been shown to be beneficial in improving many factors associated with good health. These factors include increased function and prevention of falls, decreased pain in chronic low back pain patients, improved glucose tolerance and insulin sensitivity, increased BMD, increased basal metabolic rate (weight control), and improved quality of life. Added long-term epidemiological studies are necessary to confirm these findings. It appears that most of the above findings can be attained in strength training programs that include 8–10 exercises that are performed 2–3 days per week, using 1 set of 8–15 repetitions to fatigue.

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