Does Strength Training Improve Health Status?

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BACKGROUND: "WEIGHT TRAINING may be fine for increasing muscular strength and muscle tone, but it doesn't offer any health benefits," said an exercise physiology professor during a lecture in a graduate course at Florida State University in 1976. A student in that class by the name of Michael Stone (now Dr. Stone) immediately challenged this conclusion, and a lengthy and emotionally charged discussion ensued.

I was also a student in that class and, intrigued by the arguments on both sides, decided to investigate this issue further. After examining all the exercise physiology textbooks and research papers I could find at that time, I came to the same conclusion as the professor. Although I was unable to find any research studies that directly addressed the question, the prevailing belief among exercise physiologists at that time was that strength training (ST) did not offer any physiological health benefits. Even after looking through recent editions of exercise physiology textbooks, I was unable to find much on the potential of ST to produce health benefits.

Since this episode, Dr. Stone and I have both spent a big part of our research careers trying to answer the question, Does strength training improve health status? While this may seem like a simple question with an obvious answer, until now there has been very little evidence upon which to base an answer. Therefore this article examines the current body of knowledge dealing with the effects of ST on physiological factors that have an impact on health status.

For the purpose of this review, I will define an improvement in health status in a very narrow sense—as a reduction in risk factors for disease—even though the term health actually refers to a general state of well-being which includes many other physical, mental, and social factors. I will focus primarily on those risk factors associated with age related diseases such as coronary heart disease (CHD), diabetes, osteoporosis, and colon cancer.

Blood Lipids

It is well established that the level of blood cholesterol and triglycerides (lipids) and their transporters, known as lipoproteins, are important risk factors for CHD. In the past, researchers had concluded that strength trained athletes are at higher risk for CHD than sedentary individuals, because of their less favorable blood lipid profile (3).

However, it is not possible to isolate the effects of training using this kind of a research design (cross-sectional) in which one group is compared to another. Other factors such as genetics, diet, and the use of anabolic/androgenic steroids could have explained the differences between the groups. For this reason there was a need to determine the separate effects of ST by studying untrained subjects before and after undergoing a training program (longitudinal research design).

Dr. Stone and his colleagues were the first to investigate the effects of ST on blood lipid profiles using the appropriate longitudinal design (30, 58). They found an improvement in blood lipid profiles when using an ST regime that incorporated weight-bearing, large muscle mass, multisegment exercises.

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These were the first published reports I'm aware of that provided evidence of physiological health benefits from ST. Hence it was quite a surprise to many researchers in the field of exercise physiology who had previously maintained that only aerobic exercise training could produce health benefits. More important, these studies led the way to a series of longitudinal studies addressing this issue further.

Our group (26) and others (9) later reported similar findings using non-weight-bearing, single segment ST regimes. We also reported a worsening of blood lipid profiles from using anabolic/androgenic steroids (29). Together these studies showed for the first time the separate effects of ST and anabolic/androgenic steroids and questioned whether previous cross-sectional investigations may have been influenced by the use of anabolic/androgenic steroids among some of the strength trained athletes being compared.

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Recent reviews of the ST literature revealed significant improvements in blood lipid profiles from several independent laboratories (25, 59). The magnitude of these improvements are comparable to those that have been reported from aerobic exercise training. However, many of these studies, both aerobic and strength training, had design flaws or methodology problems that may have affected their results (25, 57).

Even the most recently published study which showed improved lipid profiles with ST did not control for normal variations of blood lipids, and used subjects who were not at risk for heart disease (9). Although there are probably more ST studies that show improvements in subjects with normal initial blood lipid profiles than those that show no effects, there is no evidence that improving blood lipid profiles in people with normal initial values represents an improvement in health status.

Unfortunately, when we tried to control for some of the factors that affect blood lipid profiles and used subjects at high risk for CHD, we were unable to replicate the favorable blood lipid findings from our own earlier study (26) or from others (9, 30). Dr. Stone has argued that this may be due to using non-weight-bearing, single segment, small muscle mass exercises (57).

He maintains that weight-bearing, multisegment, large muscle mass exercises are required because they lead to a higher training volume and therefore to greater changes in body composition, an important factor for altering blood lipid profiles (59). Dr. Stone further states that large muscle mass exercise may be important independent of training volume. While it is possible that this could explain the difference between our finding of no improvements (36) and his group's finding of improved blood lipid profiles (30), it is not likely to explain the disparity in findings among other studies, in my opinion.

There does not appear to be a trend for a higher training volume among other studies that show improvements in blood lipids (9, 26) compared to those that show no improvements (36–39, 55). For example, we reported an improvement in blood lipids in only one study (26) and found no improvements in three studies (36, 37, 55), yet the one study showing improvements (26) had the lowest training volume. In contrast, Dr. Stone's group has reported that the greatest changes in blood lipid profiles occur during the greatest volume of training (4, 30, 58, 59).

Thus, the factors that explain why some ST studies show favorable changes in blood lipids whereas other studies show no improvements remain controversial. Nevertheless, I am not aware of any studies that show favorable changes in blood lipid profiles with ST, which had adequate control for factors that influence blood lipid profiles and which have used subjects who were at high risk for CHD.

However, studies that have compared aerobic exercise training to ST have not found any differences in the effectiveness of these two training modalities to alter blood lipid profiles (4, 30, 55). For a more comprehensive review of studies on the effects of ST on blood lipids, see reviews by Hurley (25) and by Stone et al. (59).

Blood Pressure
It is well recognized that both systolic and diastolic blood pressure (BP) can rise substantially during heavy resistance exercise (20). Recent evidence indicates that this response is more related to the level of voluntary effort than to the mode of resistance or the type of muscular exertion: concentric, eccentric, or isometric (50).

The effect of ST on resting BP is less clear. Decreases (23, 24, 26, 60) and no significant changes beyond control levels (7, 21, 33) have been reported. However, only three of these studies used hypertensive or borderline hyper-
tensive subjects (7, 23, 24). Only one study used a relatively large sample size with random assignment to treatment and control groups, and adequately controlled for BP variability (7). That study showed reductions in both systolic and diastolic pressures following an ST and flexibility program, but these changes were not significantly different from those in an inactive control group.

Because there are so few well controlled studies, it is difficult to make any definitive conclusions about the effectiveness of ST for reducing the risk of hypertension. Nevertheless, it does seem clear that the large acute elevations in BP observed during heavy resistive exercise does not lead to elevations in resting BP levels following an ST program.

Many exercise physiologists, as well as people in the medical community, have assumed that aerobic exercise training reduces BP and that ST either has no effect or increases BP. However, to my knowledge, there are only two studies that have compared ST to aerobic exercise training using a population who were at risk for CHD (7, 55). Both studies found no differences between these two training modalities in their effectiveness for lowering BP (7, 55).

Glucose Metabolism

High blood glucose levels in response to glucose ingestion (glucose intolerance) and high insulin levels (hyperinsulinemia) are not only indicative of diabetes but are considered important risk factors for CHD independent of other risk factors (2, 61). They are also associated with a worsening of other risk factors such as abnormal blood lipids (63) and hypertension (45). Glucose intolerance increases with age due to hyperinsulinemia (49).

Improvements in glucose metabolism resulting from exercise training were thought to be dependent on changes in body fat (44) and increases in VO2 max (35). Strength training does not result in substantial increases in VO2 max (28). Thus it was believed that only aerobic-type exercise would provide the proper stimulus for eliciting improvements in glucose metabolism (15).

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Recent evidence does not support this belief. We demonstrated improvements in glucose metabolism with ST independent of changes in body fat or aerobic capacity in subjects with normal (26, 55) as well as in those with abnormal glucose metabolism (56). Furthermore, all subjects with impaired glucose tolerance (prediabetic condition) became normalized following an ST program without significant losses of body fat or increases in aerobic capacity (56).

Other investigators have also observed improvements in glucose metabolism with ST (16, 18, 42), but until recently these improvements were restricted to a blunted blood insulin response to an oral glucose tolerance test. We have since demonstrated an improved glucose tolerance (55, 56) as well as an increase in glucose uptake (41). Four months of ST increased glucose uptake by an average of 23% (41). This is on the high end of the average improvements that occur in response to aerobic exercise training (31).

Smutok et al. (55) have recently compared these two training modalities and found that ST was just as effective as aerobic exercise training for improving glucose metabolism. We have found that an improved glucose metabolism is one of the most reproducible findings from both training modalities.

Age and Body Composition

Aging is associated with the loss of fat free mass and an increase in body fat (11). The age related decline in muscle mass may be related to changes in glucose metabolism (6), which may increase the risk for diabetes and CHD (61). It is also related to reductions in basal metabolic rate (62), which can lead to obesity.

Early reports indicated that older individuals did not increase their muscle mass in response to ST (43). Strength gains were thought to be due entirely to neurological factors (43). Recently, investigators from independent labs have observed substantial increases in muscle tissue with ST in older individuals (19, 27) all the way up to the age of 96 (19).

Whether this increase in muscle mass leads to improved health status among the elderly is a question of major importance that remains unanswered. However, it has now been demonstrated that ST-induced increases in muscle mass in middle-aged and older men are accompanied by an improvement in glucose metabolism (16, 41, 55, 56), an increase in resting metabolic rate (46), a reduction in regional fat tissue (54), and an increase in bone mineral density (40, 53).

Aging is associated with the preferential deposition of body fat in the trunk region (8). This factor is independently associated with
an increased risk of CHD (17). We recently observed reductions in fat tissue in the trunk region as well as in the legs and arms following an ST program in older men (54). This finding could have important implications for the risk of heart disease and diabetes. Even when limb circumference is unchanged, we found increases in limb muscle tissue and decreases in limb fat tissue.

Bone Mineral Density

Osteoporosis is characterized by a marked loss of both the mineral and collagen matrices of bone, making bone more susceptible to fracture (47). Several cross-sectional studies show that ST is associated with a high bone mineral density (BMD) (5, 12, 13, 32) and that BMD is related to the strength of the anatomically related muscles (13, 51). The few published reports of longitudinal investigations on the effects of ST on BMD have yielded conflicting results (22, 48, 52).

Recent advances in the development of bone densitometers have permitted more precise measurement of BMD with less exposure to radiation than was used in past studies. An example of such technology is dual energy X-ray absorptiometry (DEXA). We have used this technique to assess the effects of ST on BMD. In two separate and independent studies, we have observed significant increases in femoral neck BMD (a common fracture site in elderly osteoporotic individuals), after only 4 months of heavy resistance ST (40, 53).

Although more research is needed to assess the effects of longer training programs, these preliminary reports suggest that ST may help prevent or delay bone fractures in the elderly.

Gastrointestinal Transit Time

A prolonged gastrointestinal transit time and physical inactivity are associated with an increased prevalence of colon cancer (1, 10). The incidence of this disorder increases with age (1). Cordain et al. (14) demonstrated an accelerated gastrointestinal transit time (GITT) as a result of a running program. They attributed this effect to the mechanical stresses placed on the GI tract during running.

We hypothesized that the mechanical stresses from an ST program that includes exercises for the abdominal musculature might produce similar effects on the GITT. After only 13 weeks of ST, we observed an average acceleration of 56% in GITT (34). Most of this change appeared to be in the large intestines.

...strength training [may] reduce some risk factors for heart disease, diabetes, osteoporosis, and colon cancer.

The mechanism for how ST might accelerate GITT is unknown. Nevertheless, these results provide preliminary indications that ST might serve as an effective intervention for reducing risk factors for age related gastrointestinal motility disorders such as colon cancer.

Summary and Practical Implications

Until recently there was very little evidence of physiological changes that would have direct health benefits from strength training. There is now evidence that strength training can reduce some risk factors for heart disease, diabetes, osteoporosis, and colon cancer. Although some studies found improvements in blood lipid profiles and reductions in blood pressure with strength training, it is unclear whether individuals who are at high risk for coronary heart disease or hypertension can actually reduce their risk status as a result of strength training.

There is more consistent support for strength training’s ability to improve glucose metabolism in a way that lowers the risk for both heart disease and diabetes mellitus (type II). There is even preliminary evidence that prediabetics may become normalized with strength training.

Until now, most studies that have shown improvements in indices of health status often studied young, lean individuals who were not at risk for health problems and had normal strength and muscle mass. Thus, decreases in risk factors or increases in muscle mass may not necessarily represent an improved health status, since they didn’t really have a health or functional limitation to begin with.

However, recent studies have shown that older individuals may have health and functional limitations due to a reduction in muscular strength and muscle mass as well as from elevated risk factors. For this reason, people who start a strength training program at an older age may actually see greater improvements in health status than will younger people.

In conclusion, it appears that there is new strong support for the arguments made by Dr. Stone as a graduate student in 1976, that strength training can indeed improve health status. Although many components of health status have yet to be investigated, there is evidence that risk factors for many age related diseases are
reduced after a strength training program. These include heart disease, diabetes, osteoporosis, and possibly colon cancer. ▲

References


Ben Hurley is Associate Professor of Kinesiology at the University of Maryland. He holds a PhD from Florida State University and began a post-doctoral fellowship in 1981 under the direction of Dr. John Holloszy at Washington U. School of Medicine in St. Louis. He has published numerous articles in refereed journals on the health aspects of strength training.

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