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FIMS Position Statement

Resistance exercise for health

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by

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INTRODUCTION

Though aerobic activities have been an integral part of preventive medicine for more than 30 years, there is still a rather reserved attitude of medical community to resistance exercise. It has been taken for granted that strength exercise elicits a substantial increase in blood pressure and thus imposes, especially in elderly subjects, a risk of potentially fatal cardiovascular complications. In addition, a lack of maximal oxygen uptake increase due to typical resistance training has been considered as an equivalent of no health promoting value of this type of physical activity. This is why, with the exemption of rehabilitation, resistance exercise has been largely restricted to general population and used namely by elite athletes with the aim to improve sports performance. However, data on cardiorespiratory response to resistance exercise and its health related effects accumulated over the last two decades provides evidence that such an overcautious attitude is not justified.

BLOOD PRESSURE RESPONSE TO RESISTANCE EXERCISE

Though it remains a valid fact that blood pressure may reach extremely high values at certain types of resistance exercise, this cannot be considered as a general rule. Actual blood pressure response to strength exercise depends on following factors:

1. **Exercise intensity (load or resistance used**)
   There is a rather simple rule that blood pressure rises rather proportionally to the force exerted (Sale et al., 1993). The highest values are reached while applying maximal strength.
2. **Muscle mass activated**
   Though resistance exercise involving a small muscle group leads to a rather moderate response, activation large muscle groups while performing exercises like squat, leg press or dead lift is usually associated with more pronounced increase in blood pressure values (Benn et al., 1996).
3. **Number of repetitions in a set at a given submaximal load,** e.g. weightlifted, there is a steady increase in blood pressure with each subsequent repetition in a set (Sale et al., 1993). Its changes are usually closely related to the level of perceived exertion.
4. **Type of exercise**
   Blood pressure response tends to be higher during isometric as compared to dynamic forms of strength exercise (Mc Dougal et al., 1992). Lifting the weights elicits higher blood pressure than isokinetic exercise with the comparable force production (Kleinert et al. 1996, Sale et al., 1993).
5. **Involvement of Valsalva maneuver**
   Closing the glottis while contracting the expiratory chest and abdominal muscles in order to stabilize torso (necessary to provide support for the limb muscles especially during heavy lifts) substantially increases systemic blood pressure. Its increase is a prerequisite for moving the blood from heart to aorta and systemic arteries. Under such circumstances values exceeding 300 torr have been measured by invasive method in athletes performing heavy lifts (e.g. squat) with weights close to subject’s maximum. The same weight lifted without Valsalva maneuver elicited values by at least 100 torr lower (Narloch and Brandstetter, 1992). However, it should be noted that Valsalva maneuver activates also mechanisms, which can, at least in part, compensate potentially dangerous increase of blood pressure. It has been shown, the higher intra-thoracic pressure is transmitted through spinal nerve foramina into the cerebrospinal fluid in medullar space and cerebral chambers and further on also to cerebral tissues (Dickerman et al., 2000). Resulting force on external wall of arteries reduces mechanical stress due to increased intra-arterial blood pressure. However, though such compensation may be considered as a positive at lower intensities, extremely high values of intracranial and also intraocular pressure accompanying maximum strength effort remain a source of concern and should be avoided. If applied only for a short period of time, so that no serious impairment of venous blood return occurs, higher intra-thoracic pressure evoked by Valsalva maneuver exerts concordant “outside” force to

ventricular walls, which in fact may enhance systolic contraction (Hughes et al., 1989).

Taking in account factors influencing blood pressure response, it is possible to design resistance exercise program - without seriously compromising its efficiency -which will keep systemic pressure response within acceptable and reasonably safe limits.

This applies for the exercise with weight or resistance not exceeding 75 % of one repetition maximum (1RM) allowing to perform between 10 to 15 in a set. Under such conditions blood pressure response remains rather moderate, corresponding with the one recorded during common forms of aerobic exercise. However, there is one practice relevant difference. Aerobic activities elicit an increase only of systolic pressure with diastolic values staying unaffected or even decreasing slightly. On the other hand resistance exercise rises both systolic and diastolic pressure. This difference is of a substantial practical importance. As a blood flow to coronary arteries occurs only in diastole, resistance exercise has a potential to enhance blood perfusion of myocardium and hence to decrease the risk of ischemia, especially in persons with sclerotic narrowing of coronary arteries.

EFFECTS OF RESISTANCE TRAINING

Usually only the most evident effect of resistance training, i.e. an increase in strength and power of exercising muscles is taken in account. However, there is whole complex of additional adaptation changes, many of them having a substantial impact on health.

Even improvement of muscle force and power, may be considered as health related benefit, despite of the fact, that this may not be readily apparent in young or middle aged subjects. However, in elderly, especially after the age of 60, when force and power substantially deteriorate (annually 1 and 3.5% respectively, Dutta and Hadley, 1995), amelioration of capability to produce force and power may substantially improve quality of life. In fact, it is not uncommon, that lack of strength plays more important role in disability than impairment of cardiorespiratory functions. Muscles with higher strength reserve may also contribute to alleviation of osteoarthritis related problems (Nelson et al. 1994). Stronger muscles obviously take a part of mechanical stress away from by osteoarthritis affected cartilage, thus relieving related irritation and pain.

Improvement of insulin sensitivity, traditionally attributed solely to aerobic activities, represents another health benefit of resistance exercise (Ettinger et al. 1994). In addition, it seems that mechanisms responsible for this effect are different for aerobic and resistance exercise respectively. This assumption is based on the fact that incorporating resistance exercise to aerobic program leads to further improvement of insulin sensitivity (Cuff et al., 2003). It seems obvious that appropriate forms of resistance exercise may be a valuable tool in prevention as well as in treatment of diabetic patients (Craig et al., 1989). It can also be assumed that such a better diabetes control might decrease the incidence of late diabetic complications and improve quality of life.

Not to neglect is also the effect on proprioceptive functions and related feedback control of movement with subsequent enhancement of coordination and balance. Such changes may substantially decrease the risk of falling and resulting complications affecting namely elderly population.

Resistance exercise has also a potential to improve bone density, in both, women and men. This effect, though not dramatic (in some longitudinal studies not enhancement, but stopping of deterioration has been reported), is substantially more pronounced than in typical aerobic exercises including weight bearing activities as running and walking (Bravo et al., 1996, McDonagh and Davies, 1984).

It has been shown, that an average energy consumption during common forms of resistance exercise session is rather moderate, reaching a level corresponding with easy walking. However, there is a slight elevation of energy consumption for several hours after exertion (Elliot et al., 1992), which contribute to the increment of absolute caloric use. Resting metabolic rate is also enhanced by increase of muscle mass (Skelton at al., 1995) occurring after several months of resistance training. (Treuth et al. 1995). Taking in account such a influence on the energy balance, resistance training may be considered as an important factor in weight reduction and maintaining more favorable body composition (Pratey et al. 1994).

Strength training program has been shown to accelerate whole bowel transit time (Koffler, 1992), an effect which might reduce intestinal disorder such as constipation, diverticulosis and colon cancer.

Contrary to traditional beliefs resistance training not only has no negative effect on baseline blood pressure, but as shown in recent meta-analytic study (Kelley, 2000) there is a slight, however, significant tendency to resting blood pressure reduction. In addition, as training progresses, the same absolute load, which becomes a smaller load relative to peak capacity, elicits lower blood-pressure response (Connonie et al., 1993). Thus, resistance training may help to lower blood-pressure response to ordinary activities that involve lifting or carrying objects (Mc Cartney et al., 1993).

Recent studies have also demonstrated positive effects of resistance training on impaired function in peripheral vascular disease (McGuigan, 2000), state anxiety profile (Focht and Coltyn, 1999) and blood lipoprotein spectrum (Wallace et al., 1991). Health benefits of strength exercise can be used no only in prevention, but also as a therapeutic means in following pathologies (Evans 1996, Pollock et al., 1989, Pollock et al., 1993):

- diabetes (non insulin dependent type)
- obesity
- osteoartritis
- osteoporosis
- low back pain
- coronary heart disease
- certain types of cancer
- functional disability in elderly persons
- peripheral vascular disease

RISK OF RESISTANCE EXERCISE

A number of studies have demonstrated that, if carried out properly, resistance training can be a reasonably safe physical activity comparable with variety of aerobic exercise. However, as with any physical activity, resistance exercise involves the some risk, namely musculoskeletal injuries and cardiovascular events.

Frequency of musculoskeletal injuries, both acute and overuse, in properly administrated resistance exercise programs is, even in groups of elderly people, relatively low. In one study (Pollock et al., 1991) of men and women 68-85 years of age including persons with different pathologies, e.g. osteoarthritis, diabetes, ischemic heart disease, etc., only 2.2 minor musculoskeletal injuries per 1000 exercise hours were reported. Most of injuries recorded were not serious, most of the subjects were able to resume the program after skipping few training sessions.

There are several studies involving hundreds of older volunteers in supervised research settings not reporting any occurrence of stroke or myocardial infarction. It appears that excluding high-risk patients (in similar way as in aerobic exercise programs) and sticking on recommendations to avoid potentially risky blood pressure response, resistance exercise can be employed as a reasonably safe form of physical activity (Smutok et al., 1993).

IMPLEMENTATION OF A RESISTANCE EXERCISE PROGRAM

It has been shown that in order to achieve the health benefit of resistance exercise one does not need to follow the quite demanding training patterns of body builders. Between two and three strength training sessions a week are recommended. Each one should include 1 set per major muscle groups, i.e. flexors and extensors of legs, arms, shoulders, back, hips. It has been shown that increasing the number of set to 2 or 3 leads only to a small additional improvement of strength, which is not worth of further increase of injury risk and decrease of adherence to training program.

Concerning training intensity a common recommendation is to keep load between 60 and 80 % of subject's maximum. A practical guideline is to set such a weight, which allows between 12 and 15 reps in a set. However, as the maximum capacity will gradually increase, the amount of weight or resistance should be increased accordingly. Usually after several months of training, it is difficult to increase strength any further, and the goal should be to maintain the strength. This can be usually achieved with one to two sessions per week at the maximum intensity attained during the training phase.

It is important to emphasize that the program is effective only if it becomes an integral part of the subject's life. A few missed sessions result in little loss of strength or other beneficial effect, so brief interruption of the program should not be discouraging. Equally important is complex approach, i.e. that resistance exercise should be complemented by regular aerobic activities.

Though health oriented resistance training will neither provide bodybuilder´s musculature to young or middle aged men, nor give a 70-year-old person the physique of a 25-year-old one. However, incorporating resistance activities will increase muscle strength, enhance the health benefits of aerobic exercise program and improve quality of life.

REFERENCES

1. Benn SJ, McCartney N, McKelvie RS. Circulatory responses to weight lifting walking, and stair climbing in older males. J Am Geriatr Soc, 44(2):121-125, 1996.
2. Bravo G, Gauthier P, Roy PM, et al. Impact of a 12-month exercise program on the physical and psychological health of osteopenic women. J Am Geriatr Soc, 44(7):756-762, 1996.
3. Cononie CC, Graves, JE, Pollock ML, et al. Effect of exercise training on blood pressure in 70-to 79-yr-old men and women. Med Sci Sports Exerc, 23(4):505-511, 1991.
4. Craig BW, Everhart J, Brown R. The influence of high-resistance training on glucose tolerance in young and elderly subjects. Mech Ageing Dev,49:147-157, 1989.
5. Dickerman RD; McConathy WJ; Smith GH, et al. Middle cerebral artery blood flow velocity in elite power athletes during maximal weight-lifting. Neurol Res, 22 (4): 337-40, 2000.
6. Dutta C, Hadley EC. The significance of sarcopenia in old age. J Gerontol; 50A (Special Issue):1-4, 1995.
7. Elliot DL, Goldberg L, Kuehl KS. Effect of resistance training on excess post-exercise oxygen consumption. J Appl Sport Science Research; 6(2), June/July, 77-81, 1992
8. Ettinger WH, Burns R, Messier SP. A randomized trial comparing aerobic exercise and resistance exercise with a health education program in older adults with osteoarthritis. JAMA, 277(1):25-31, 1997.
9. Evans WJ. Reversing sarcopenia: How weight training can build strength and vitality. Geriatrics, 51(5):46-53, 1996..
10. Cuff DJ; Meneilley GS; Martin A, et al. Effective exercise modality to reduce insulin resistance in women with type 2 diabetes. Diabetes Care, 26: 2977-2982, 2003.
11. Focht BC; Koltyn KF Influence of resistance exercise of different intensities on state anxiety and blood pressure Med Sci Sports Exerc; 31 (3): 456-63, 1999.
12. Hughes LO, Heber ME, Lahiri A, et al. Haemodynamic advantage of the Valsalva manoeuvre during heavy resistance training. Eur Heart J, 10 (10): 896-902, 1989.
13. Kelley G. Dynamic resistance exercise and resting blood pressure in adults: A meta-analysis. J Appl Physiol, 82(5): 1559-1565, 1997
14. Kleiner DM, Blessing DL, Davis WR, et al. Acute cardiovascular responses to various forms of resistance exercise. J Strength and Conditioning Research, 10(1): 56-61, 1996.
15. Koffler KH, Menkes A, Redmond RA, et al. Strength training accelerates gastrointestinal transit in middle-aged and older men. Med Sci Sports Exerc, 24 (4) 415-419, 1992.
16. McCartney N, Hicks AL, Martin J, et al. Long-term resistance training in the elderly: Effects on dynamic strength, exercise capacity muscle, and bone. J Gerontol, 50A(2): 97-104, 1995.
17. McCartney N, McKelvie RS, Martin J, at al. Weight-training-induced attenuation of the

circulatory response of older males to weight lifting. J Appl Physiol, 74(3):1056-1060, 1993.
18. McDonagh MJ, Davies CT. Adaptive response of mammalian skeletal muscle to exercise with high loads. Eur J Appl Physiol, 52(2):139-155, 1984.
19. McGuigan MR. Resistance training for patients with peripheral arterial disease with special reference to effects on skeletal muscle. Doctoral Thesis. Southern Cross University, School of Exercise Science and Sport Management, Lismore, 2000.
20. MacDougall JD, McKelvie RS, Moroz DE, et al. Factors affecting blood pressure during heavy weight lifting and static contractions J Appl Physiol, 73 (4): 1590-7, 1992.
21. Narloch JA, Brandstater ME. Influence of breathing technique on arterial blood pressure during heavy weight lifting. Arch Phys Med Rehabil, 76(5): 457-462, 1995.
22. Miller JP, Pratley RE, Goldberg AP, et al. Strength training increases insulin action in healthy 50- to 65-yr-old men. J Appl Physiol, 77(3):1122-1127, 1994.
23. Nelson ME, Fiatarone MA, Morganti CM, et al. Effects of high-intensity strength training on multiple risk factors for osteoporotic fractures. JAMA, 272(24):1909-1914, 1994.
24. Pollock ML, Leggett SH, Graves JE, et al. Effect of resistance training on lumbar extension strength. Am J Sports Med 1989, 17 (5) :624-629.
25. Pollock ML, Carroll JF, Graves JE et al. Injuries and adherence to walk/jog and resistance training programs in the elderly. Med Sci Sports Exerc 1991,23(10):1194-1200.
26. Pollock ML, Graves JE, Bamman MM, et al. Frequency and volume of resistance training: effect of cervical extension strength. Arch Phys Med Rehabil 1993, 74(10):1080-1086.
27. Pratley R, Nicklas B, Rubin M, et al. Strength training increases resting metabolic rate and norepinephrine levels in healthy 50-to 65-yr-old men. J Appl Physiol 1994, 76(1):133-137.
28. Pruitt LA, Jackson RD, Bartels RL, Lenhard HJ. Weight-training effects on bone mineral density in early postmenopausal women. J Bone Miner Res 1992,7(2):179-185.
29. Sale DG, Moroz DE, McKelvie RS, et al. Comparison of blood pressure response to isokinetic and weight-lifting exercise. Eur J Appl Physiol Occup Physiol; 67(2): 115-120, 1993.
30. Skelton DA, Young A, Greig CA, et al. Effects of resistance training on strength, power and selected functional abilities of women aged 75 and older. J Am Geriatr Soc, 43(10):1081-1087, 1995.
31. Smutok MA, Reece C, Kokkinos PF, et al. Aerobic versus strength training for risk factor intervention in middle-aged men at high risk for coronary hearth disease. Metabolism, 42(2):177-184, 1993.
32. Treuth MS, Hunter GR, Weinsier RL, et al. Energy expenditure and substrate utilization on older women after strength training: 24-h calorimeter results. J Appl Physiol, 78(6): 2140-2146, 1995.
33. Wallace MB, Moffatt RJ, Haymes EM, et al. Acute effects of resistance exercise on parameters of lipoprotein metabolism. Med Sci Sports Exerc, 23(2): 199-204, 1991.