REVIEW ARTICLE ▮

THE IMPORTANCE OF EXERCISE AS A THERAPEUTIC AGENT

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Adaptations in the structural and/or functional properties of cells, tissues and organ systems in the human body occurs when exposed to various stimuli. While there is unanimous agreement that regular physical activity is essential for optimal function of the human body, it is evident that extrinsic factors, such as diet, smoking, exercise habits, are reflected in the morbidity and mortality statistics of the population. Ageing is obligatorily associated with reduced maximal aerobic power and reduced muscle strength, i.e. with reduced physical fitness. As a consequence of diminished exercise tolerance, a large and increasing number of the aged population will be living below, at or just above 'threshold' of physical ability, needing only a minor illness to render them completely dependent. Physical training can readily produce a profound improvement of functions essential for physical fitness in old age. Adaptation to regular physical activity causes less disruption of the cells' internal environment and minimises fatigue which enhances performances and the economy of energy output during daily physical activity. Regular physical exercise reduces the risk of premature mortality in general, and of coronary heart disease, hypertension and diabetes mellitus. Physical activity also improves mental health and is important for health and optimal function of muscles, bones and joints. The most recent recommendations advice the people of all ages to include a minimum of 30 minutes of physical activity of moderate intensity, such as brisk walking, on most, if not all, days of the week.

Key words *: Exercise, therapeutic agent, aging, optimal function, exercise training*

Introduction

The reason we need to know the importance of exercise as a therapeutic agent is because exercise provides a unique opportunity to study how different functions are regulated and integrated. In fact, most functions and structures are in one way or another affected by acute and chronic exercises (like a regular training programme). Therefore, physiology of exercise is an integrated science that has the goal of identifying the mechanisms of overall bodily function and its regulation. Let me review some factors of key importance to exercise.

Basic Physiology

For an individual's aerobic performance, the maximal oxygen consumption or uptake is the decisive factor. However, as the exercise prolongs, the availability of substances for the exercising muscles is another factor to consider as well as the economy of movement. During the last century, much research has been done analysing which step in the oxygen cascade from the air to the mitochondria in the skeletal muscle is the limiting factor. Some of these factors include: pulmonary ventilation, pulmonary diffusing capacity, cardiac output, oxygen diffusion from blood to muscle and to mitochondria and oxidising enzymes in the

mitochondria. To date, there is general agreement that the central circulation of the human limits the maximal oxygen uptake during exercise in which large muscle groups are involved (1).

A)   Is maximal oxygen uptake trainable?

A simple answer is yes. A training programme including interval or continuous exercise, for 30-40 minutes three times per week, at 50% for beginners and up to 80% of maximal oxygen uptake or heart rate reserve can effectively increase stroke volume and, therefore, maximal cardiac output by about 15% or more, albeit with large individual variations (2, 3). The percentage improvement in maximal oxygen uptake for the same training programme is the same in young and old adults, in women and men (4).

Recent evidence shows that this cardiorespiratory fitness gains are similar when physical activity occurs in several short sessions (e.g. 10 minutes) as when the same total amount and intensity of activity occurs in one longer session (30 minutes) (5). Although, the health benefits of such intermittent activity have yet to be demonstrated, it is reasonable to expect them to be similar to those of continuous activity. Moreover, for people who are unable to set aside 30 minutes for physical activity, shorter exercise sessions are clearly better than none. This was shown in one study where there was greater adherence to a walking programme among those walking several times per day than among those walking once per day when the total amount of walking time was kept the same (5).

B)   Ageing

From cross-sectional studies, it is concluded that there is a decline in maximal oxygen uptake amounting to 0.5 – 1.0% per year (1, 8). However, as has been reported, the degree of habitual physical activity undertaken and heredity can markedly affect this maximum oxygen uptake.

(C)   Limiting factors for endurance

An untrained person with a maximal oxygen uptake of 2.5 L.min^{-1} may be able to exercise at 90% of the maximum for 20 minutes. If, after a period of training, this maximal oxygen uptake is raised to 3.0 L.min^{-1}, the submaximal rate of oxygen uptake of 2.25 L.min^{-1} will only demand 75% of this new maximum. This trained person can tolerate this metabolic rate for 90 minutes, i.e. there is a 4.5 fold

improvement of endurance that is most probably not limited by the oxygen transport system. It is more likely that the depletion of glycogen stores in the exercising muscles is the limiting factor. With a glycogen-saving, training-induced, and increased utilisation of free fatty acids as a substrate for exercising skeletal muscles, the performance time at 75% of maximal aerobic power will be longer than when a similar relative rate of exercise was maintained before training (7).

Numerous studies have demonstrated a significant increase in mitochondrial density as a consequence of aerobic training with a proportionate increase in mitochondrial enzymes (7, 8). If one expresses skeletal muscle's oxidative capacity for a sedentary individual as one 'unit', then the endurance trained elite athletes will have 3 'units' capacity. In a rabbit muscle, 3-5 week of chronic electrical stimulation with a frequency of 10 Hz can bring the capacity up to 6 'units'. If a leg is subjected to encasement in plaster for some weeks, the activity may drop to 0.7 'unit' (7). From this data, we can conclude that with aerobic training, there is a shift in the trained skeletal muscle to greater muscle reliance on oxidative metabolism to provide energy for Adenosine Triphosphate (ATP) resynthesis.

With training, there is also an increase in capillary density. An increase in capillary density reduces the distance between blood and cell interior, which enhances the exchange rate of gases, substances, and metabolites. The surface area available for this exchange also increases. With more capillaries in a given tissue volume, more blood can flow through the vascular bed per unit of time. The mean transit time in increased, which allows a more complete exchange of substrates. The primary advantage of a high capillary density in highly endurance trained muscle is probably that it allows for an adequate mean transit time at high flow rates, thereby promoting a more complete exchange of materials (9).

The physiological site of action of enzyme lipoprotein lipase (LPL) is in the luminar surfaces of the capillary endothelium. With an increased capillary bed, more binding sites for LPL will be available. This may favour the provision of free fatty acids to the muscle, because the degradation of triglyceride-rich particles depend largely on the activity of LPL. In addition, the activation of LPL also transfers more surface material into high density lipoproteins (HDL). This mechanism may explain the elevated HDL concentration seen in endurance-trained individuals, and may be one of the factors in

the observation that habitual physical activity seems to reduce the risk for coronary heart disease.

(D)   Limitation in strength - effects of training

With age, there is a decrease in muscle strength that seems to parallel the reduction in muscle mass. This age-associated loss of muscle fibres is related to a loss of alpha-motoneurons (12) without affecting the force-generating capacity of the residual contractile material. It is noted that there are normally no signs of degenerated fibres in ageing muscle and the fiber composition is relatively constant, i.e. independent of age. However, the muscle fibres per motor unit have been reported to increase, which is interpreted as a reduction in motoneurons. As such, the increase in muscular strength induced by training is therefore not due to an increase in the number of muscle fibres (13) but due to the facilitation of nerve fibre sprouting (14).

When starting a strength-training programme, a 20-40% increase in strength may occur during the first weeks of training, without a noticeable increase in cross-sectional area of the muscle involved. This suggests a more efficient activation of the muscle. With continued strength training, there is an adaptation hypertrophy exclusively achieved by an increase in fibre size without an increase in the number of muscle fibres (13). It is interesting to note that as little as a 6-seconds isometric contraction repeated five times, three times per week can prevent loss of muscle mass and muscle function during periods of recovery from injury with joint immobilisation (15).

Gains in strength and speed of muscle contraction was observed by Fiatarone *et al*. (16). He studied nine frail, 90 year-old (range 87-96 years) institutionalised volunteers who undertook 8 weeks of resistance training consisting of standard rehabilitation principles of progressive resistance training with concentric (lifting) and eccentric (lowering) activation of knee extensor muscles. The subjects performed three sets of eight repetitions with each leg 6 to 9 seconds per repetition, with a 1 to 2 minute rest period between sets, three times per week. Except for the first week, the load was 80% of one repetition maximum. Strength gain averaged $174 \pm 31\%$ (mean $\pm$ SEM). Midthigh muscle area increased by $9.0 \pm 4.5\%$. Mean tandem gait speed improved by 48% after training. The activation of the muscles involved only lasted some 10 minutes per week. These findings suggest that age does not appear to affect the trainability of skeletal muscle.

(E) Specificity of training

Training adaptations, whether for strength or endurance, in the skeletal muscles are limited to the muscles actually engaged in training. Specificity in training is also obvious with the circulatory response to exercise. Saltin (9) reported that the heart rate was approximately 25 beats, min^{-1} higher at a given oxygen uptake when one leg, which had been inactivated by a cast for 4-6 weeks, was exercised on a cycle ergometer than when the other leg exercised on a cycle ergometer at the same oxygen uptake. Before the cast was put on, no differences in heart rate response was noted.

To maintain or improve both flexibility in joints and dexterity and endurance in technically demanding sports, the specific activities must be practised. It is generally thought that elderly persons cannot execute coordinated, quick, precise finger movements with age. However, it is surprising that many musicians can perform perfectly at an advanced age. For example, Arthur Rubinstein played a very demanding Chopin composition at the age of 88 years and Andres Segovia, at the age of 92 years, gave concerts on the classical guitar. Hours of daily 'training' were behind these achievements. Most likely, their fantastic performances were not only, question of talent but of continuous practice (exercise).

Since there is specificity in training effects, it is advisable that one understands variations in the type of habitual physical activity, i.e. a variety of activities should be practised throughout life.

Is physical inactivity a risk factor for cardiovascular disease?

During the 1987, coronary heart disease (CHD) accounted for 27.5% of the 2.1 million deaths in the United States. In 1998, nearly 30% of the deaths as a result of medical problems in Malaysia is caused by cardiovascular disease and of this, 20% is due to coronary heart disease (17). Well-documented risk factors for CHD are sedentary lifestyles, increases in triglycerides and low density lipoprotein levels in the blood, decreases in the high density lipoproteins level, cigarette smoking, hypertension, diabetes, obesity, post-prandial hyperinsulinemia and carbohydrate intolerance. During the last 10-15 years, there have been several reports showing a significant reduction in morbidity and mortality in CHD in physically active persons compared with sedentary control groups (5, 6, 12,

18-24). In a longitudinal study of approximately 17,000 Harvard alumni, it was found that men who expended more than 2000 kcal per week in walking, stair-climbing and participation in sports were at 39% lower risk of developing coronary heart diseases than less active counterparts (22). This study demonstrated that sedentary adults, who increase physical activity even relatively late in life, can reduce their relative risk of CHD and all-cause mortality to levels similar to those who were always physically active.

In an other study, Blair *et al.*, (18) determined physical fitness by a maximal treadmill exercise test in approximately 10,000 men and 3,000 women in a follow-up study over an average of more than 8 years. The subjects were divided into five fitness levels based on maximal treadmill performance. The death rate in the most-fit group men was 70% less than that in the least-fit group. Similarly, the death rate in most-fit women was 78% lower than that in the least-fit group. The biggest reduction in risk of CHD was associated with going from a low level of cardiovascular fitness to a moderate or average level of fitness for a person's age. A study by Rauramma and Leon (24) concluded that higher level of fitness appear to delay all-cause of mortality primarily due to lowered rates of cardiovascular diseases and cancer. Sternfeld (25) concluded from the review of the literature that there is mounting evidence suggesting that physical activity may be associated with decreased mortality from, and incidence of certain types of cancer.

All these studies indicate a substantial independent risk for CHD for persons with sedentary lifestyles. A high level of habitual physical activity will reduce premature mortality. Physical activity also confers other important health benefits. Habitual physical activity reduces the incidence of, or is otherwise beneficial to, hypertension, hyperlipidemia, obesity, diabetes type II, impaired glucose tolerance, osteoporosis, psychological impairment, colon cancer, and back injury. It induces benefits on the function of metabolic, endocrine, and immune systems (5). The effect on some of these factors may be small and statistically non-significant; however, the sum of these effects may have an important positive impact, influencing health and disease, life and death.

In the United States, life expectancy has increased from 47 years in 1900 to approximately 75 years in 1988. What about the upper limits of human longevity? It has been calculated that eliminating ischemic heart disease would only increase life expectancy at birth by 3 years for females and 3.5 years for males. Eliminating all forms of cancer would also increase life expectancy by 7 years for females and 8.1 years for males (26). In other words, the effects of eliminating major diseases on life expectancy are not dramatic. Advances in medical treatment more than improvements in risk factors may be allowing the elderly who are frail and who suffer from fatal degenerative diseases to survive longer after the onset of the disease than was the case in the past. Current research efforts by the medical community are focused on prolonged life rather than preserving the quality of life. An obvious conclusion, therefore, is that the time has come for a shift towards ameliorating the function for people with non-fatal diseases of ageing (26).

Physical activity and carbohydrate metabolism

Recent study on carbohydrate metabolism, shows that glucose can permanently alter some proteins, which may contribute to age-associated decline in the functioning of cells and tissues (27). An excess glucose concentration in people with uncontrolled diabetes could potentially contribute to diabetic complication. These complications can be described as accelerated ageing, including senile cataracts, joint stiffness and atherosclerosis. These disorders are typical in the ageing person, but in people with hyperglycemia, they develop earlier. Without excess glucose, there may be a slower onset of age-associated dysfunction.

Sedentary people often have reduced response to insulin in their untrained muscles. Elderly individuals may develop a reduced glucose tolerance with elevation of blood glucose concentrations, which may trigger the glucose-protein reaction and by a feedback mechanism also causes hyperinsulinemia, itself a risk factor for CHD.

A regular exercise/training programme, can normalise the glucose tolerance in elderly people and enhance the muscle's sensitivity to insulin (8, 28, 29). It should be emphasised that muscle contraction *per se* will promote the muscle's uptake even with no insulin present (29).

Locomotor organs – osteoporosis

Structural changes in bones, ligaments and tendons are easily demonstrated in connection with decreased rather than increased physical activity (30). Immobilisation will markedly diminish the

number and size of collagen fibres bundles and negatively change the collagen crosslinks. In contrast, trained animals have increased concentration of collagen in ligaments and tendons. Inactivity will not only affect the strength of muscles, bone and joints, but also diminish the forces being transmitted by ligaments and tendons. From these facts, it is therefore suggested that clinicians must constantly reevaluate the necessity and duration of prescribed immobilisation of their patients.

Studies of astronauts and immobilised persons have consistently shown mineral bone loss. Bone involution also poses a serious health risk, especially in ageing women. A progressive decline in bone density starts after maturity and osteoporosis is a serious disease in the elderly. One-third of 65 year old women, will have vertebral fractures and by the age of 81, one-third of women and one-sixth of men will suffer hip fracture, often a catastrophic, if not terminal, event (31).

Bone mass is subject to both local (mechanical) and systemic (hormonal) homeostatic control mechanisms. The local forces acting on bone tissue are due to gravity and muscular contractions. Standing upright is a better stimulus for bone hypertrophy than exercise in the bed, and walking is better than swimming.

Athletes have a greater bone mass than the sedentary population, with the greatest hypertrophy noted in the areas most stressed (e.g. the preferred arm of a tennis player). Exercise interventions also promotes bone hypertrophy and prevents osteoporosis. Both middle-aged and elderly women showed an increase in bone mass or a reduction in the rate of bone tissue loss in response to regular intervention exercise programmes (30, 32 - 36). Rowe and Kahn (31) have suggested that the marked reductions in bone density with 'usual' ageing may in large part be prevented or modifiable by regular exercise, reduced smoking and an adequate intake of calcium.

In summary, prescribed exercises that increase the forces being transmitted to ligaments, tendon, and bones will maintain, and in many cases increase, the strength and functional sturdiness of these structures. In its simplest form, the effect of exercise will depend on the manner in which it is performed: the result displays a specificity. The only structures to respond are those that have been exposed to the forces of exercise. To counteract osteoporosis, the strategies are: adolescents and young adults to increase peak bone mass and adults and the elderly to focus on maintaining and/or slowing down the rate of bone loss (35).

Nutritional aspects of habitual physical activity

The more physically active a person is, the higher the energy intake can be without the worry of obesity. From a nutritional viewpoint, the advantage of such an activity is that higher energy intake will better ensure an adequate intake of essential nutrients (1). From an evolutionary point of view, our energy expenditure and intake of essential nutrients is quite high. It may become critical for the low energy consumer, sedentary person, to be nutritionally well balanced, particularly if exposed to so called "junk" food. At increased age, there is a gradual reduction in the basal metabolic rate, but no proportional reduction of the demand for essential nutrients. For this reason, it is recommended that old people try to stay physically active. In treatment of obese patients, it is essential to combine a recommendation of restriction of energy intake with an increase in energy output by daily physical activity (37). After all, physical activity is the most variable component of energy expenditure. Obesity, particularly visceral adiposity, adversely interacts with physical inactivity to further increase risk of CHD and non-insulin-dependent diabetes mellitus, which itself is an important risk factor for CHD (24).

Effects of habitual physical activity and possibilities to counteract consequences of 'normal' ageing

Between 1985 and the end of the last century, there is an approximately 50% increase in the proportion of the population aged 65 and over in 'developed' countries. With ageing, there is an impairment in bodily functions and structures, leading towards diseases and the endpoint is death. Evans and Meredith (38) reported that in the USA, at age 75 to 84 years, more than 15% have difficulties walking 800m or climbing stairs and more than half cannot lift an object weighing 4.5kg.

It is reported that most research on ageing have emphasized average related losses and neglected the substantial heterogeneity of the older person (31). The effect of ageing process itself has been exaggerated and the modifying effects of diet, exercise, personal habits and psychological factors were underestimated (31). Rowe and Kahn (31) have reported that within the category of normal ageing, a distinction can be made between usual aging, in which extrinsic factors heighten the effects of ageing alone and successful aging, in which extrinsic factors play a neutral or positive role. Therefore research

on the risks associated with usual ageing and strategies to modify them should help elucidate how a transition from usual to successful ageing can be facilitated.

Hence, the key question is to what extent impairment morbidity and mortality are inevitable consequences of the individual's innate genetic composition, i.e. intrinsic factors, and to what extent environment and the individual's lifestyle, i.e. extrinsic factors can modify these processes?

It is has been pointed out that ageing is obligatorily associated with reduced maximal aerobic power and reduced muscle strength, i.e. with reduced physical fitness. Being overweight in addition to these handicaps is additional burden because all these factors make walking, climbing stairs, getting up from bed or chair more difficult and fatiguing and at times impossible. The ability to lift and carry weights becomes reduced. The ageing persons will lose their independence and autonomy. As a consequence of diminished exercise tolerance, a large and increasing number of elderly persons will be living below, at or just above 'threshold" of physical ability needing only a minor intercurrent illness to render them completely dependent.

Physical training can readily produce a profound improvement of functions essential for physical fitness in old age and thus effectively postpone physical deterioration for some 10-25 years (4). However, very little is known about the intrinsic and extrinsic factors behind these achievements. What is known is that the body will quickly adapt to reduced demands on muscle activity, with an accelerated rate of functional impairment and physical fitness as consequences. Many of the beneficial effects of exercise training, from both endurance and resistance activity, diminishes within 2 weeks if physical activity is substantially reduced, and training effects disappear within 2 to 8 months if physical activity is not resumed (5).

Physical activity for patients with cardiovascular disease

The World Health Organisation has attributed a primary role to physical exercise and rehabilitation programmes for patients with heart conditions, calling for the "best possible physical, mental and social conditions for heart patients so that they are able to maintain or resume as far as possible their normal role in society" (18). Oldridge *et al*. (34) reported results from studies in which approximately 2,000 patients who had myocardial infarction were randomly assigned a cardiac rehabilitation programme as compared to 2,000 patients with myocardial infarction and no rehabilitation who served as controls. Rehabilitation began within 8 weeks to as late as 3 years after myocardial infarction. Duration of the programme were as short as 6 weeks to as long as 4 years. Comprehensive rehabilitation resulted in a beneficial effect on mortality but not on nonfatal recurrent myocardial infarction. All cause mortality was reduced by 24% and cardiovascular mortality was reduced by 25% for patients in the rehabilitation programmes as compared with controls (20).

Patients with chronic heart failure can improve muscle function by training small muscle groups at a time.

Prescription for exercise for healthy living

In a recent review, Viru and Smirnova (40) discussed the role of health promotion and exercise training. Haskell (4) argues that quantity and quality of exercise to obtain health-related benefits may be different from what is recommended for physical fitness benefits. He points out that the view taken by advocates of physical activity-health paradigm is that for many people, especially those inclined not to perform more vigorous exercise, and they are in majority, some benefits is better than none. "The greatest health benefits from an increase in physical activity appear to occur when very sedentary persons begin a regular programme of moderate intensity, endurance type activity. Further increase in intensity or amount of activity appear to produce further benefits in some, but not all, biological or clinical parameters. The magnitude of benefits becomes less for similar increases in intensity and/or amount of activity" (41). A similar message is presented in the 1996 report of the Surgeon General in the USA "Physical Activity and Health" (5). In this report it is pointed that during the past few years, American College of Sports Medicine, the Centers for Chronic Disease Control and Prevention and Health Promotions, the American Heart association, the President's Council on Physical Fitness and Sports and the National Institute of Health have all recommended regular, moderate-intensity physical activity as an option for those who get little or no exercise. There are many, more than 60% of Americans adults who are not regularly physically active. In fact, 25% of all adults are not active at all. It also pointed out that many Americans may be

surprised at the extent and strength of the evidence linking physical activity to numerous health improvements. Most significantly, regular physical activity greatly reduces the risk of dying from coronary heart disease, the leading cause of death in most Western industrialised countries. Habitual physical activity also reduces the risk of developing diabetes, hypertension and colon cancer. It fosters healthy muscles, bones and joints. Regular participation in physical activity also appears to reduce depression, improve mood and enhance ability to perform daily tasks throughout the life span. In other words, it helps to maintain function and preserve independence in older adults. This report grew out of an emerging consensus among epidemiologists, experts in exercise science and health professionals that physical activity need not be of vigorous intensity to improve health. Moreover, health benefits appear to be proportional to amount of activity. Thus, every increase in activity adds some benefit. Emphasizing the amount rather than the intensity of physical activity offers more options for people to select from incorporating physical activity into their daily lives. Experts advice previously sedentary people embarking on a physical activity programme to start with short duration of moderate-intensity activity and gradually increase the duration or intensity until the goal is reached.

The most recent recommendations advice people of all ages to include a minimum of 30 min of physical activity of moderate intensity, such as brisk walking, on most, if not all, days of the week. Not necessarily continuously, it could be, 3 X 10 minutes! It is acknowledged that for most people, greater health benefits can be obtained by engaging in physical activity of more vigorous intensity or of longer duration.

Frances (20) pointed out that there is a challenge for physicians and physical therapists to contribute to the promotion of habitual physical activity. All persons, regardless of age, should be encouraged to develop physically active lifestyles because of the low risks and proven disease prevention health maintenance benefits. They should be encouraged to increase physical activity to levels appropriate to their capacity, needs and interests.

Conclusion

It is an important and urgent challenge to teach and promote regular physical activity for target groups from childhood up to old age in order to promote successful ageing and an optimal lifestyle, including advice about diet, smoking, alcohol habits and various newly recognised threats to health. From many points of view, it is a risk factor from quickly changing a lifestyle from the lifestyle of hunter-gatherer to one of an urbanised high tech lifestyle. Insight into our biological heritage may help us to modify our current lifestyle in a positive way. At any rate, adverse effects of non-competitive exercises are very small in comparisons with the health benefits. Health education is a complicated issue: there are case reports of someone with a lifestyle considered to be perfect who may die young from a heart attack. In contrast, a person with a 'catastrophic' lifestyle may have a life span extending to one century. The genetic background is not democratic.

As shown in Table 1, the following recommendations represent an exercise programme for good function and health.

DAILY: At least 30 minutes of physical activity, not necessarily vigorous, not necessarily continuous. During the daily routine of moving, walking, climbing stairs, etc., whether for 1 minutes 30 times a day, 10 minutes three times a day, or any other combination totaling 30 min may demand 150 kcal.

WEEKLY: Exercise, 30-45 minutes three times per week (e.g. brisk walking, jogging, cycling, swimming, aerobic s, racket games etc) are efficient efforts to achieve and maintain good cardiovascular fitness and may consume an additional 750 kcal per week. The extra energy output by these activities may exceed 2000 kcal, an energy output recommended by Paffenberger et a. (22) for better health.

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Table 1 :   *Beneficial effects of habitual physical activity:*

1.   Increase in maximal oxygen uptake and cardiac output

2.   Reduced heart rate at given oxygen uptake

3.   Reduced blood pressure

4.   Reduced heart rate x blood pressure product

5.   Improved efficiency of heart muscle

6.   Favourable trend in incidence of cardiac morbidity and mortality

7.   Increased capillary density in skeletal muscle

8.   Reduced lactate production at given percentage of maximal oxygen uptake

9.   Reduced perceived exertion at given oxygen uptake

10.   Enhanced ability to utilise free fatty acids as substrate during exercise – glycogen sparing

11.   Improved endurance during exercise

12.   Increases metabolism – advantageous from a nutritional point of view

13.   Counteracts obesity

14.   Increases HDL concentrations in blood

15.   Improved structure and function of ligaments, tendons and joints

16.   Increased muscular strength

17.   Increased production of endorphines

18.   Enhanced nerve fibre sprouting to reinnervate muscle fibre

19.   Enhance tolerance to hot environment-increased sweat production

20.   Reduced platelet aggregation

21.   Counteracts osteoporosis

22.   Can normalise glucose tolerance

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