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Musculoskeletal Fitness, Health Outcomes and Quality of Life

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Abstract

The health benefits and quality-of-life outcomes of a fit musculoskeletal system (musculoskeletal fitness) are reviewed in this article. The World Health Organization suggests health is a state of complete physical, mental or social well-being and not merely the absence of disease or infirmity. Physical health includes such characteristics as body size and shape, sensory acuity, susceptibility to disease and disorders, body functioning, recuperative ability and the ability to perform certain tasks.

One aspect of physical health is the musculoskeletal system, which consists of 3 components; muscular strength, endurance and flexibility. Muscular strength (dynamic) is defined as the maximum force a muscle or muscle group can generate at a specific velocity. Muscular endurance is the ability of a muscle or muscle group to perform repeated contractions against a load for an extended period of time. Flexibility has 2 components, dynamic or static, where dynamic flexibility is the opposition or resistance of a joint to motion, that is, the forces opposing movement rather than the range of movement itself. Static flexibility is the range of motion about a joint, typically measured as the degree of arc at the end of joint movement. If strength, endurance and flexibility are not maintained, musculoskeletal fitness is then compromised which can significantly impact physical health and well-being.

Many health benefits are associated with musculoskeletal fitness, such as reduced coronary risk factors, increased bone mineral density (reduced risk of osteoporosis), increased flexibility, improved glucose tolerance, and greater success in completion of activities of daily living (ADL). With aging, the performance of daily tasks can become a challenge. Additionally, falls, bone fractures and the need for institutional care indicate a musculoskeletal weakness as we age. The earlier in life an individual becomes physically active the greater the increase in positive health benefits; however, becoming physically active at any age will benefit overall health.

Improved musculoskeletal fitness (for example, through resistance training combined with stretching) is associated with an enhanced health status. Thus, maintaining musculoskeletal fitness can increase overall quality of life.

1. Musculoskeletal Fitness

At present, the health outcomes associated with a fit musculoskeletal system are somewhat unclear. This section will draw together research in an attempt to clarify the health benefits associated with musculoskeletal fitness. Increasing muscular strength, muscular endurance and flexibility (improving musculoskeletal fitness) is believed to have a positive effect on the cardiovascular system and musculoskeletal metabolism. It is important to consider that as we age, a decline in musculoskeletal fitness takes place and this is accelerated if we are sedentary. A sedentary lifestyle is associated with many negative health effects (e.g. coronary heart disease (CHD), diabetes mellitus, obesity), thus, maintaining an active lifestyle is beneficial to overall health status.[1,2]

There are numerous activities that can impact the musculoskeletal system, such as jogging, biking, swimming, gymnastics and aerobics to name a few. However, the mode of training focused on in this review is resistance training. Resistance training programmes have been associated with improved musculoskeletal fitness and some aspects of cardiovascular functioning.[3,4] The specifics of the resistance training programmes, i.e. the number of sets and repetitions employed, vary in the papers reviewed for this article, and the superior programme is currently unclear. It is not within the scope of this article to make recommendations as to the best programme available, but to provide evidence that long term resistance training, as a whole, is capable of producing positive health changes. In 1998, a review article by Carpinelli and Otto[5] suggested that single set workouts may be as effective in producing certain results as multiple set workouts. Additionally, it is necessary to recognise that the positive cardiovascular and musculoskeletal changes referred to in this section can be made at all ages.[3,6-9] The purpose of the following section is to examine the cardiovascular and metabolic health benefits of developing or maintaining musculoskeletal fitness throughout life.

1.1 Heart Rate, Stroke Volume and Cardiac Output

Research suggests that in developing musculoskeletal fitness the cardiovascular system and myocardium undergo change. Resistance training has been associated with modifications to the myocardium that result in positive changes in heat rate, stroke volume (SV) and cardiac output, but not to the same magnitude as those found with long term endurance training.

There is an increase in heart rate during an acute resistance training session;[10-13] this increase is associated with an increased sympathetic stimulation, a rise in circulating plasma catecholamine levels and decreased parasympathetic stimulation at the start of exercise.[10,14,15] Moderate intensities [40 to 60% of 1 repetition maximum (1RM)] of resistance training exhibit the largest increases in heart rate response, while at higher intensities of 1RM the heart rate response is increased but not to the same extent.[13] The effect of long term resistance training is less clear, as studies demonstrate either no change[3,16-18] or a significant reduction in resting heart rate.[3,12,16,19] The reduced resting heart rate may be associated with increased parasympathetic stimulation, and/or reduced sympathetic stimulation.[20] Additionally, the reduced resting heart rate may also be caused by morphological changes to the myocardium; an increased left ventricular wall mass, which increases myocardial contractility and SV.[20,21]

SV during the lifting phase of a resistance exercise remains largely unaffected at light intensities,[22] while at heavier intensities SV appears to decrease.[23] The decrease in SV during the lift phase of higher intensity lifts is likely the result of a decreased preload and an increased afterload on the myocardium.[24] Increases in blood pressure, preload, afterload, systemic vascular resistance and heart rate all increase myocardial stress, which is associated with cardiovascular adaptations leading to an improvement in pumping force and thus increased SV at rest.[16,25-27] Research also indicates a small to moderate increase in cardiac output from rest to exercise during short term dynamic resistance training,[28-30] but not to the level associated with endurance exercise.

1.2 Blood Pressure

During short term isometric and dynamic resistance training both systolic and diastolic blood pressures increase.[16,22,23,29,31-34] The amplitude of the increase is dependent on the intensity of muscular contraction, the amount of muscle mass recruited, and the duration of contraction,[35] but not on the velocity of movement[22] or the mode of contraction (static or dynamic).[31] Thus, during an acute resistance exercise bout blood pressure generally increases; however, the adaptations to long term resistance training involve a reduced resting blood pressure.[6,15,36,37] The exact mechanism associated with the decreased blood pressure is unknown, but is likely to be related to a concomitant decrease in cardiac output and/or total peripheral resistance.[38] A decline in blood pressure is also considered a positive step in reducing the risk of CHD and reducing hypertension.[39]

1.3 Lipids

Lipid profiles are used as indicators of potential cardiovascular health problems. Resistance training literature indicates that it is possible to significantly improve blood lipid profiles,[9,40-43] although the results are not conclusive. A cross-sectional study contrasting body builders and sedentary bodyweight-matched and non-bodyweight-matched controls indicated that body builders had lower resting plasma total cholesterol, low density lipoprotein (LDL)-cholesterol and very low density lipoprotein-cholesterol levels.[44] Whether this was due to the training programme or the type of low fat diet normally consumed by bodybuilders cannot be discerned in this latter study. Hurley et al.[9] suggested that resistance training can increase high density lipoprotein (HDL), increase HDL_2, reduce LDL, and decrease the cholesterol/HDL ratio. However, no significant difference was found in HDL-cholesterol, or its subfractions (HDL_2 and HDL_3), or lipoprotein lipase activity in muscle or adipose tissue,[44] suggesting that the positive adaptations in lipid profiles with resistance training are not conclusive. Significantly, improvements in blood lipid profiles are associated with a reduced incidence of CHD, especially if the training programme is maintained over most of the individual's life.[43]

1.4 Diabetes Mellitus, Glucose Tolerance and Insulin Response

Diabetes mellitus is characterised by a relative lack of insulin or sensitivity to insulin. Two types of diabetes mellitus exist, type 1 (insulin dependent diabetes mellitus, IDDM) and type 2 (noninsulin dependent diabetes mellitus, NIDDM). Treatment of patients with type 1 diabetes mellitus by insulin injection aids in the transport of glucose into the cells.[45] In comparison, type 2 diabetes mellitus is marked by a cellular resistance to insulin. A potential rationale for the inability to transport glucose into the cell is a disruption in the translocation of the GLUT-4 receptor in the muscle cell to the muscle cell surface.[45] Exercise and a controlled diet are often the most effective treatments for patients with type 2 diabetes mellitus.

Currently, attempts to normalise resting blood glucose levels are made through the implementation of long term aerobic exercise training (walking, running or cycling). However, recently resistance training has been put forward as a possible mode of exercise to help manage patients with type 2 diabetes mellitus. Short term studies indicate that significant improvements in glucose uptake are possible through long term resistance training exercise.[44,46-48]

Ishii et al.[48] demonstrated significant improvements in resting glucose uptake in both type 1 and type 2 diabetes mellitus following 4 to 6 weeks of resistance training. It is suggested that the improvements in resting glucose levels are linked to improved insulin sensitivity. Two other studies using nondiabetic participants revealed analogous results. Similar findings suggest that resistance training can diminish the plasma insulin response to a resting glucose tolerance load without diminishing glucose tolerance, suggesting an increase in insulin sensitivity.[9,49]

Yki-Jarvinen et al.[44] suggest that the response of the body to oral glucose ingestion may be improved by having increased muscle mass. Using an oral glucose tolerance test, body builders were compared with bodyweight-matched controls. Results indicated that body builders had both a lower blood glucose and plasma insulin response.[44] These findings are most likely associated with the 50% greater relative muscle mass and 50% smaller relative body fat content of the body builders.

Thus, long term resistance training may positively influence glucose tolerance and insulin response and sensitivity by altering the amount of lean body mass (LBM) and quality of muscle. Miller et al.[50] and Yki-Jarvinen et al.,[44] suggest that an increase in LBM may be linked to an improved glucose uptake and insulin response; however, it cannot be ruled out that the improved insulin response may be associated with improved insulin sensitivity and not necessarily an increase in LBM.[50]

2. Health Implications of Musculoskeletal Fitness

The development of musculoskeletal fitness via long term resistance training is associated with enhanced cardiovascular function and musculoskeletal metabolism. The health benefits associated with an intervention programme (resistance training) to develop musculoskeletal fitness are as follows: a reduced resting heart rate;[3,12,16,19] increased SV at rest and exercise;[20,21] maintenance of cardiac output at rest;[3,51] a decline in resting systolic and diastolic blood pressures;[9,15,36,37] improved resting lipid levels; and improved glucose sensitivity, insulin response and sensitivity.[44]

Improvements in heart rate, SV and cardiac output can reduce myocardial stress during submaximal work and rest. With reduced heart rate and increased SV at rest and submaximal work there is diminished stress on the myocardium at the same relative work rate. Myocardial performance is more economical, supplying more blood per beat to the working skeletal musculature. Long term resistance training may also improve systolic and diastolic blood pressure and blood lipid profiles, which can reduce the risk of CHD.

Current research provides reasonable evidence that improving musculoskeletal fitness via resistance training can reduce many of the risk factors associated with CHD.[52] The overall effect of resistance training on the coronary risk factors may not always be statistically significant, but the sum of all of the effects may have a positive influence in reducing morbidity and mortality from CHD.[39] Consequently, by improving musculoskeletal fitness one can improve overall health status and reduce the risk of cardiovascular disease.

3. Aging

Aging is associated with a decline in musculoskeletal strength and mass, which has been linked to a decline in function, impaired mobility and physical frailty. A functional decrease is evident when an individual shows reduced mobility, muscular strength and co-ordination with aging. This diminished functional ability is often measured as a reduced ability to carry out activities of daily living (ADL).[53,54]

Reduced functional ability can be traced to human biological changes associated with aging and reduced physical activity. The primary musculoskeletal changes that take place as we age include: a decrease in muscle mass, caused by a reduced number of contractile elements;[55,56] a decrease in the number and size of type II muscle fibres; a decrease in motor unit numbers;[57] an abnormal grouping of type I fibres;[58] and a decrease in bone mineral density (osteoporosis).[59] These structural changes are associated with a diminished ability to perform ADL. Research suggests that the use of concurrent resistance (single or multiple sets) training and stretching can have a positive effect on musculoskeletal function and maintain or enhance numerous aspects of independent living.[6,60]

3.1 Body Composition and Muscle Fibre

Body composition is related to the relative proportion of LBM and percentage body fat.[61,62] Change in body composition is often determined by a combination of factors such as genetics, physical activity and caloric intake.[62,63] Increased fat mass is associated with increased obesity, blood pressure, risk of diabetes mellitus, a poorer blood lipid profile and reduced musculoskeletal strength and flexibility.[45,62-64] The aging process is linked with a change in body composition, marked by a decline in LBM and an increase in fat mass.[65-69]

The decrease in muscle mass (LBM) and increase in fat mass associated with aging may account for the reduced muscle fibre volume, with less of a decrease in muscle cross-sectional area (CSA). The loss of muscle fibre contractile proteins and the increase in fat mass may explain why the force per unit CSA is significantly reduced with aging.[70] Muscle mass begins to decrease at ≈30 years of age,[59] while fat mass begins to increase. The reduced muscle mass may be due to: (i) a reduction in total muscle fibre number; (ii) a reduction in muscle fibre volume; (iii) an increase in type I fibre number and concomitant decrease in type II fibre number; or (iv) a combination of both i and ii.[71]

Lexall et al.[72] found that older men (aged 30 to 74 years) had 25% fewer muscle fibres in the vastus lateralis muscle than younger men. Type I muscle fibres appear to be less affected by aging,[58] when compared with type II muscle fibres.[71] Tsuneko et al.[73] studied the pectoral muscles of women (n = 200) and proposed that there was a decrease in the number of type II and type I muscle fibres after the age of 40 and 60 years, respectively. The decrease in type II fibre volume is accompanied by a change in the percentage of myosin heavy chain (MHC) between elderly and younger individuals. A cross-sectional study found that elderly individuals (n = 26, mean = 69 years) had a 27% greater MHC type I content, and a correspondingly lesser MHC type IIa and IIb content than younger controls.[57]

McComas[74] suggested that the reduced strength observed in aging is not only the result of changes in muscle fibre number and volume, but is also due to a reduced nerve innervation. There may be a disruption in neural input to muscle as we age;[70] electromyographic (EMG) analysis and motoneuron counting demonstrated an age-related decline in active motor units.[74] However, because the decrease in motor unit number may be gradual as we age, it cannot be equivocally concluded that denervation is associated with reduced maximal voluntary contraction (MVC).[74] Terminal sprouting and/or collateral reinnervation may delay, but not stop the decline in motor unit number, as indicated by the significantly larger mean amplitude of the motor unit potentials associated with elderly individuals.[67] The collateral reinnervation may also explain the increased percentage of type I fibres in the elderly and the decrease in type II fibres, as terminal sprouts from type I motor units reinnervate destitute type

II muscle fibres, thus changing the trophic influence to the muscle fibre.

The cumulative effect of the gradual decrease in total muscle fibre number[71-73,75] and reduced fibre volume[76] results in a decrease in force generating capability with aging.[71] The maximum force a muscle can generate increases with increasing CSA of the muscle,[71] therefore, as muscle mass declines with age the ability to produce force (MVC) has been shown to decrease.[77] A study of healthy women (mean = 70 years) demonstrated that the MVC of the quadriceps muscle was 35% less than that of healthy women in their 20s.[56] A reduced muscle CSA may explain the discrepancy in MVC between these 2 groups, as a significant positive correlation between isometric strength and mid-thigh CSA was evident (r = 0.66 and 0.53, respectively).[56]

Research suggests that in both young and old, long term resistance training is associated with increases in total muscle area,[78] CSA,[79,80] muscle fibre hypertrophy,[65] muscle volume[81] and total fat-free mass,[82] and it is these changes that lead to improvements in body composition, delaying the effect of aging.[65,69,81-84] Thus, improvements in body composition can be made regardless of age.[81-84]

3.2 Independent Living

3.2.1 Basic and Instrumental Activities of Daily Living

Independent living requires the ability to complete most daily tasks, which are termed ADL. ADL can be divided into 2 categories: basic ADL, items such as eating, bathing, dressing, transferring from bed to chair and walking across a small room; and instrumental ADL, items such as house keeping, food preparation, grocery shopping and transportation.[85,86] If a person can fulfil most of the basic and instrumental ADL he or she will presumably succeed in living an independent life.

In older adults, musculoskeletal impairment of hand function (motor coordination and strength) is associated with a decline in basic ADL[86] and an increased incidence of disability.[87] Jette et al.[86] suggested that musculoskeletal impairment of hand function is the greatest cause of decline in basic ADL, and that this is most likely caused by impairment of fine motor control. Activities such as eating and dressing are negatively impacted by reduced fine motor control and hand strength.[87] Handgrip strength is also associated with disability in nondisabled older adults.[87] A study of 422 men (aged 71 to 91 years): 58 disabled in ADL, 179 disabled in mobility, and 185 not disabled, demonstrated that the incidence of disability and death increases with decreasing handgrip strength.[87] Following the fourth decade in life, grip strength begins to decline and the rate of decline becomes more rapid in the fifth decade.[88] The rate of decline is inversely related to the initial baseline strength value. However, other factors may impact grip strength such as chronic disease, osteoarthritis, decreased physical activity, decreased motivation and changes in the aging muscle itself,[88] as well as, cognitive impairment and diabetic neuropathy in some cases.[87]

Instrumental ADL predominantly rely on lower extremity musculature for locomotion in activities such as house keeping and grocery shopping.[86] Young and Skelton[89] suggested that there is a loss in strength of ≈1.5% per year and a loss in power of ≈3.5% per year, between the ages of 65 and 84 years. Reductions in strength and power such as these may have a negative influence on walking velocity, stair climbing ability and rising from a seated position.[89] Walking velocity is associated with leg extensor power and may influence instrumental ADL.[90,91] An investigation of 230 women (mean = 75 years) revealed that absolute muscular strength of the leg, as determined by MVC of the right leg, was significantly linked to walking velocity;[91] however, relative leg strength may be more important during many weight-bearing activities. Walking times over 30m were slower for heavier women than lighter women, and heavier women took more steps to complete the distance.[91] Furthermore, men tend to have greater leg extensor power than women. A study of residents in a long term care hospital (mean age = 88.5 ± 6 years; 13 women, 13 men) demonstrated that women had significantly less leg extensor power than men (best leg, men: 67.0 ± 8.3W; women: 34.8 ± 5.1W).[90] Leg extensor power was significantly related to chair rising speed (r = 0.65), stair climbing speed (r = 0.81), walking speed (r = 0.80) and stair climbing power (r = 0.88).[90] Similar results were found (n = 50 men, 50 women; aged 65 to 89 years) with rising from a chair, stepping unaided onto boxes of different heights, isometric knee extensions, isometric elbow flexion, leg extensor power and handgrip strength, as men were significantly stronger than women in all muscular strength tests.[92]

Laukkanen et al.[93] examined muscular strength and mobility as predictors of survival in 75- to 84-year-old individuals, with no significant difference in 10m walking speed found between gender or age groups. However, leg extensor and handgrip strength was significantly related to walking time over 10m, and a 48-month follow-up revealed that of the fastest quartile, 9 out of the 10 participants were still alive, while in the slowest quartile 1 in 4 individuals had died.[93] Moreover, it may be sound to use leg extensor power to predict success in completing instrumental ADL,[90] as well as strength and mobility tests to indicate the probability of survival in the aged.[93]

The implementation of a resistance training programme is associated with increased musculoskeletal fitness, as indicated by increased muscular strength and muscular endurance.[53,65,78,80,94,95] Dupler and Cortes[96] implemented a whole body resistance training programme using elderly male (mean = 69.4 years) and female (mean = 62.8 years) participants. Results demonstrated a significant increase in 1RM for all resistance-trained individuals, with no significant increase in muscle fibre hypertrophy. Similar findings were observed in a study of untrained healthy men (mean = 66 years). The men resistance trained for 12 weeks (80% 1RM) and increases in the following were demonstrated: muscle strength (12%), total thigh area (4.7%), total muscle area (11.4%), quadriceps area (9.3%), type I muscle fibre (33.5%) and type II muscle fibre (27.6%).[78] Improving musculoskeletal fitness in the elderly (60 to 75 years of age) via resistance training can significantly increase muscular strength, muscular endurance and, in many cases, muscle CSA.[65,78,80,95] If significant increases in musculoskeletal fitness are possible for the elderly, the impact on both basic and instrumental ADL can be positive, and translate into an improved opportunity for independent living.

3.2.2 Osteoporosis

Aging is associated with osteoporosis, the loss of bone mineral density resulting in reduced bone tensile strength due to diminished mineral and collagen matrices.[8,64] Osteoporosis increases the risk of bone fractures, which are linked to an increased risk of mortality. The mortality rate following a hip fracture in the elderly is ≈50%. The loss of bone mass is not fully understood, but it is thought to be associated with inactivity, diet, skeletal blood flow and/or endocrine function.[39,45]

During growth and development the load placed on the weight bearing bones from bodyweight alone is sufficient to cause bone modelling.[97] In adulthood however, bodyweight plateaus, and the load placed on the bone from running and walking is not sufficient to maintain bone remodelling.[97] Through resistance training greater loads can be transferred onto the bone, thus stimulating increased bone mineral absorption and bone remodelling.[39,97] Cross-sectional studies have indicated that resistance training may be associated with elevated bone mineral density.[98-103] Results from a study of elite Olympic weightlifters (n = 25; mean = 17.4 ± 1.4 years) and age-matched controls, found that bone mineral density at the lumbar spine and the proximal femur were significantly correlated with strength measures of related musculature.[100] The weightlifters had significantly greater bone mineral densities for all anatomical sites measured. Thus, resistance training can increase bone mineral density in adulthood by increasing the force transmitted to the muscle, tendon, ligament and bone.[99,102,104,105]

3.2.3 Flexibility

Flexibility is defined as the range of motion (ROM) about a joint,[106] and research suggests that flexibility decreases with age (≈20 to 30% between 30 to 70 years of age).[107] Factors associated with an increased rate of decline in ROM are immobilisation and inactivity (disuse). Immobilisation leads to an increased rate of collagen turnover, a shortening of skeletal muscle fibre, and decreased muscle mass, which are all associated with reduced ROM.[108] Similarly, inactivity is associated with reduced ROM caused by degeneration of collagen fibres, cross-linkage formation between adjacent fibrils of collagen, fibrous synovial membranes, joint surface deterioration and decreased viscosity of synovial fluid.[64] The decrease in ROM common with aging is associated with an increased difficulty in completing ADL.

Flexibility (ROM) is necessary for good mobility, coordination and the completion of ADL. One study indicated that simply squatting and tying one's shoe required the largest ROM of all ADL.[109] A study by Murray et al.[110] compared the walking gait of healthy older and younger men (20 to 87 years) and found that men 60 to 65 years of age walked at a slower cadence, had a lower swing to stance ratio, shorter strides, decreased hip flexion, decreased hip extension and decreased ankle flexibility. The result was a slower walking speed and altered gait in the older male participants. The previous and current level of physical activity has been hypothesised to have considerable impact on sustaining or improving flexibility.[54,111]

Concurrent resistance training and stretching exercise is thought to increase flexibility,[112] as resistance training should emphasise a full ROM and must be functionally similar to the natural movement pattern of the joint.[28] Raab et al.[112] compared a 25-week light resistance training and stretching programme with exercise without external resistance. The study used a strength and flexibility programme (25 to 30 min/day: n = 46 women, 65 to 89 years) to examine weighted wrist and ankle exercises with an initial resistance of 0.5kg following the preliminary 4 weeks of training, increasing to 0.75kg following 6 weeks of training, and again every 4 weeks. Both exercise groups significantly increased ROM in ankle plantar flexion, shoulder flexion, shoulder abduction and left neck rotation, compared with controls. A cross-sectional study of elderly women (n = 50, 71.5 ± 4.2 years) indicated that habitually physically active elderly women tend to have a lower bodyweight, better body mass index, greater flexibility in the hip and spine, and greater walking endurance than inactive women.[111] The most physically active participants obtained the highest test scores, while the least physically active had the lowest test scores. Consequently, it is feasible to increase flexibility without added external resistance, but concurrent resistance training and stretching will also improve muscular strength and endurance.

4. Musculoskeletal Fitness, Health Status and Aging

The overall health benefits associated with the development or maintenance of musculoskeletal fitness through resistance training are positive when viewed from an aging perspective. An improvement in body composition is believed to be feasible regardless of age or gender.[81] In both young and old, resistance training has been associated with increases in one or all of the following: total muscle area, CSA, muscle fibre hypertrophy, muscle volume, total fat-free mass, body composition, bone mineral density and flexibility.[65,78-82] Musculoskeletal fitness is associated with a higher level of muscular strength and muscular endurance, which can positively benefit both basic and instrumental ADL and translate into a greater opportunity for independent living. Of note, support for most of the findings reported in this review article has been provided by Warburton et al.[113]

A positive relationship between musculoskeletal fitness and health status exists throughout adulthood and this relationship is consistent with the findings that older people complete ADL better with higher levels of muscular strength, muscular endurance and flexibility.[114] If the elderly are able to maintain basic and instrumental ADL it is then possible to maintain an independent lifestyle for a longer period of time.

5. Conclusions and Clinical Implications

Enhancing musculoskeletal fitness (muscular strength, muscular endurance and flexibility) improves both basic and instrumental ADL. High levels of muscular strength and muscular endurance are associated with reduced injury, disability and mortality, increased ability to perform ADL, increased walking velocity, improved stair climbing ability, improved functional capacity, a reduced incidence of falling, and independent living. High levels of flexibility are associated with improved ability to complete ADL, increased functional independence and increased mobility. Moreover, long term concurrent resistance training and stretching will enhance musculoskeletal fitness regardless of age or gender, and increase overall quality of life.

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