

Training Strategies to Optimize Cardiovascular Durability and Life Expectancy

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Physical fitness is the single best predictor of life expectancy and healthspan. Try to achieve and maintain a high level of physical fitness throughout life.



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Abstract

The optimal dose of physical activity and best types of exercise for improving cardiovascular (CV) durability and optimizing longevity are unknown. The purpose of this article is to review the recent literature on the effects of duration and intensity of exercise, physical fitness, and specific types of training/sports on long-term CV health and life expectancy.

A systematic review of recent studies (2011 to 2022) was conducted using PubMed. Studies were included if they addressed the topic of fitness and/or exercise dose/type and CV health and/or life expectancy. Epidemiological studies show that cardiorespiratory fitness (is inversely related to risk of all-cause mortality, with no increased mortality risk in the most fit cohort. Being unfit is among most potent risk factors for all-cause mortality. Moderate PA (MPA) and vigorous PA (VPA) were associated with reduced CV and all-cause mortality in a recent definitive study. Paradoxically, high doses of MPA reduced both CV and all-cause mortality better than did high doses of VPA. A large meta-analysis showed that strength training was

independently associated with lower rates of all-cause mortality and CV disease, though the best outcomes were associated with a cumulative dose of about 60 minutes/week. Physical interactive play is strongly associated with improved life expectancy. Physical fitness is a key determinant of CV health and life expectancy. Moderate to vigorous exercise, strength training and interactive sports are associated with improved life expectancy. Very large volumes of strenuous exercise and/or weightlifting may not be the ideal for optimizing longevity.

Introduction

Physical activity is one of the key factors for achieving and maintaining cardiovascular (CV) health and improving both life expectancy and healthspan—the period of one's life spent in good health free from disabilities of aging.¹ However, the ideal duration and intensity of PA, and types of exercise for optimizing lifelong CV health, longevity, and healthspan are unknown. To address this question, we conducted a systematic review of studies from 2011 to 2022 using the PubMed database. Search terms included: exercise, physical activity, CV fitness, sports, outdoor activity,

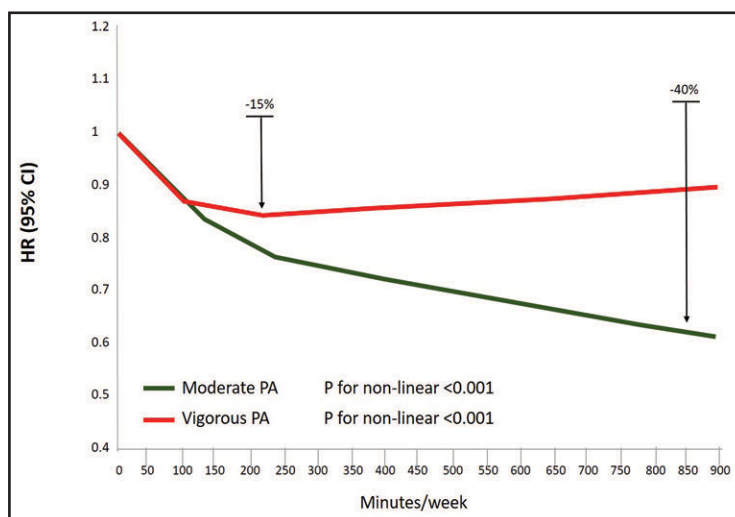
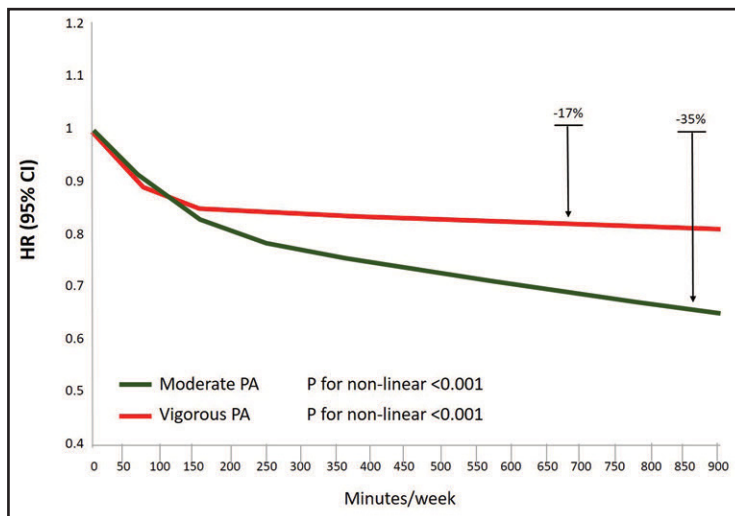
gardening, dogs, life expectancy, longevity, healthspan, CV events, and CV mortality. The most current meta-analyses and large, long-term prospective studies were selected preferentially.

Dose and Intensity of Exercise and Mortality Reduction

A landmark, long-term, prospective, cohort study evaluated the links between leisure-time physical activity duration and intensity with all-cause mortality and cause-specific mortality.² They concluded: “Higher levels of long-term leisure-time vigorous and moderate physical activity achieve the maximum benefit of mortality reduction.”² Although this is arguably the best long-term prospective epidemiological study addressing the topic of exercise dose and mortality reduction, their conclusions were somewhat misleading due to over-generalization.

The relationships between dose of exercise and risk of death during follow up were distinctly different for vigorous physical activity (VPA) than for moderate physical activity (MPA). First and foremost, very high levels of MPA reduced risk of cardiovascular disease (CVD) mortality and all-cause mortality substantially better than very high levels of VPA (Figure 1A and 1 B). Secondly, the reductions in CVD mortality and all-cause mortality were maximized at ~150 minutes/week of VPA; doses >150 minutes/week of VPA were associated with a plateau in all-cause mortality, and a modest but progressive loss of CVD mortality reduction (slight reverse-J curve) at higher doses. In contrast, MPA reduced CVD mortality and all-cause mortality in dose-dependent, inverse relationships—the higher the dose of MPA the lower the number of deaths during the study.

This Harvard School of Public Health study that included 116,221 individuals assessed 15 times during 30 years of follow up suggests that if one’s goal is optimizing long-term CV health and overall longevity, more is better for moderate-intensity exercise. However, the same cannot be said for vigorous exercise, where optimal benefits are achieved at approximately



Figures 1a, 1b. Hazard ratios (HR) for all-cause mortality (1a) and CV disease (CVD) mortality (1b) as a function of dose of VPA and MPA.² Used with permission.

150 minutes/week. MPA typically includes activities like walking, hiking, gardening, housework, dancing, shopping, golf, pickle ball, doubles tennis, volleyball, and leisurely bike riding. In contrast, VPA typically involves strenuous bicycling, running, or swimming, or high-intensity interval training (HIIT), singles tennis, basketball, or other activities that cause heart-pounding, sweat-producing, breathlessness.

This fits well with the hypothesis of extreme exercise cardiotoxicity/cardiac overuse injury, which is particularly relevant for middle-aged and older individuals.³⁻⁵ A large amount of vigorous exercise, though required for attaining peak physical

performance, may not be necessary for maximizing life expectancy and cardiac durability. Very strenuous exercise acutely increases the risk of CVD events (myocardial infarction, sudden cardiac arrest) particularly for individuals who are in mid-life and beyond.^{5,6} Admittedly, these catastrophic CVD events are very rare, but more common issues such as orthopedic injuries and over-training issues may force individuals to curtail or abandon excessively strenuous exercise regimens.

For an individual whose goal is to decrease the risk of CVD and boost life expectancy, a routine of MPA appears to be adequate.

Although chronically performing very high doses of VPA may attenuate some of the benefits bestowed by less extreme efforts, this is relevant for only about 2.5% of the United States (U.S.) adult population.⁷ This is not to say that VPA is harmful; it substantially reduces all-cause mortality and CVD mortality compared to a sedentary lifestyle. Yet, the magnitude of the mortality and CVD risk reductions with high doses of VPA do not appear to be as substantial as for high doses of MPA.^{3,4} In the Lee study, chronically doing very high doses of moderate exercise reduced risks of all-cause mortality and CVD mortality at least two-fold better compared to chronically performing very high doses of vigorous exercise.²

At the other extreme, a sedentary lifestyle—which affects about half of the U.S. adult population—is associated with worse health outcomes and diminished life expectancy.^{7,8} After sitting more than 60 minutes, the levels of blood glucose, triglycerides and inflammatory markers begin to rise.⁹ Even light or moderate activity mitigates these adverse effects of sedentary behavior without unduly increasing orthopedic injuries or cardiac risks.

Throughout the last three million years of hominin evolution, our ancestors' existence necessitated a very physically active lifestyle. Adults would usually accumulate 14,000 to 16,000 steps/day, mostly in the form of walking three to eight miles, often while carrying objects such as wood, food, water, and children.^{10,11} Hunter-gatherer humans' daily subsistence required large amounts MPA with smaller

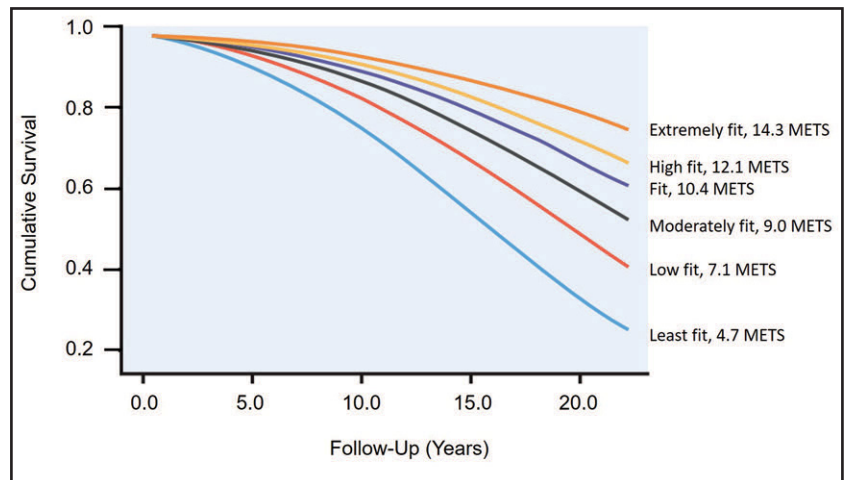


Figure 2. Survival Curves According to Cardiorespiratory Fitness Categories as measured by time achieved on a Bruce protocol treadmill exercise test.¹³ Used with permission.

doses of interspersed VPA—this is the activity pattern for which we remain genetically adapted.^{7,12} This evolutionary template would seem to be a logical guide to structuring an ideal activity pattern for promoting optimum health and longevity.

The Survival of the Fittest

A recent Veterans Affairs (VA) study in the *Journal of the American College of Cardiology* that followed 750,302 U.S. veterans up to 20 years reported that cardiorespiratory fitness (CRF) as measured by performance in treadmill testing was strongly related to survival in a graded continuous manner.¹³ The best survival rates among both men and women were noted in those who attained peak exercise level of 14 metabolic equivalents (METs). No increased risk of premature mortality was noted in the most fit cohort (Figure 2).^{13,14} Importantly, being in the least fit cohort carried a greater mortality risk and any other traditional risk factor including age, diabetes, smoking, chronic kidney disease, hypertension, atrial fibrillation, obesity, prior CVD, and cancer.

A very recently updated meta-analysis of 37 studies with nearly 2.3 million participants with nearly 110,000 deaths supported the prognostic importance of CRF, as every one MET increase was associated with an 11% reduction in mortality.¹⁵ Compared with the lowest tertile of CRF, those in the highest tertile of CRF had a 45% lower mortality, highlighting the fact that fitness is one of the strongest predictors of survival.¹⁴⁻¹⁶

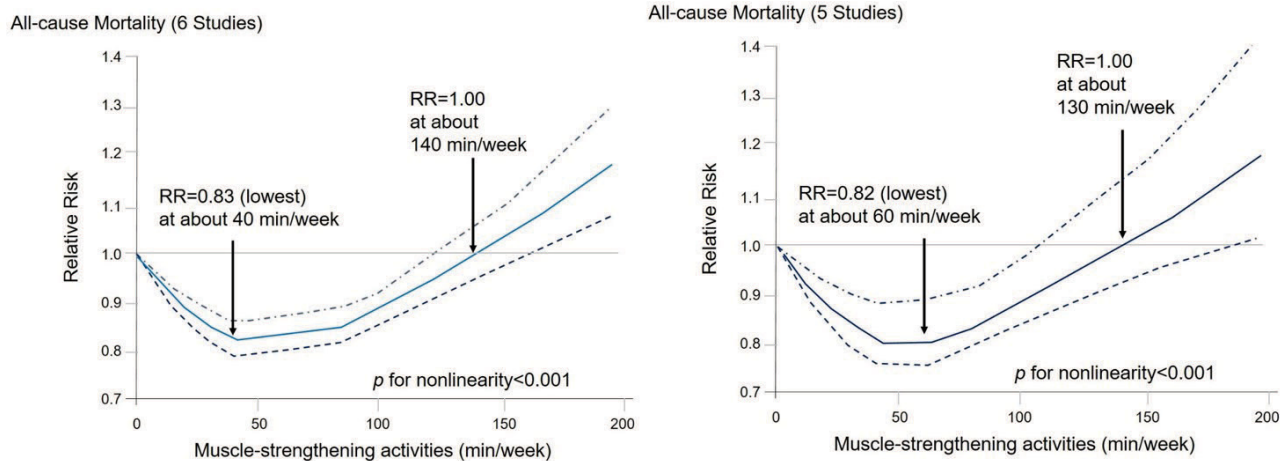


Figure 3. J-shaped dose–response curves for weekly dose of muscle-strengthening activities and all-cause mortality.¹⁹ Used with permission.

The hypothesis that life expectancy is best among individuals demonstrating the highest levels of fitness seems to be at odds with the recent Lee study² showing that large amounts of moderate exercise are better than large amounts of vigorous exercise for reducing mortality and CVD risks. Presumably, vigorous exercise produces higher levels of fitness than moderate exercise. Still, there are many factors that determine one's fitness, including general health, genetics, nutrition, and body composition, not just the amount and types of exercise performed. In the VA study, CVD risk factors like obesity, smoking, diabetes, hypertension, chronic kidney disease and overall disease burden were progressively more unfavorable going from the most fit to the least fit categories.¹³ This is a bidirectional causal relationship, with arrows going both ways: a normal-weight, non-smoking person with favorable genes, who is eating well and following a generally healthy lifestyle will have an easier time maintaining high fitness even if they are not performing large volumes of vigorous exercise. On the other hand, an excellent exercise regimen will improve multiple CVD risk factors such as body composition, blood pressure, blood glucose, chronic inflammation, and bone health—and these benefits are conferred by both MPA and VPA.

High Intensity Interval Training (HIIT)

One alternative for maintaining high CRF without doing large volumes of VPA is HIIT, which is an efficient exercise regimen characterized by short, repeated bouts of intense exercise.¹⁷ HIIT protocols lead to better improvements in maximum oxygen

uptake than protracted sessions of continuous moderate or strenuous exercise, with better adherence and lower risk.¹⁷ Once or twice weekly HIIT sessions might be better for achieving high levels of fitness without having to do exhaustive and prolonged bouts of strenuous exercise.^{17, 18} This would maintain very high fitness levels but avoid the longevity benefit plateau that appears to be present with very high doses of VPA.

Clearly, aerobic fitness as measured by treadmill performance is a powerful predictor of life expectancy, but other dimensions of physical fitness including strength, balance, flexibility, and body composition have also been shown to be important for optimal functioning and wellbeing. These non-aerobic fitness parameters also exert significant independent effects on life expectancy and healthspan.

J-Shaped Risk Reduction from Strength Training

A recent comprehensive meta-analysis reported that about 30 to 60 minutes/week of strength training (also referred to as resistance training) produced significant risk reductions of 17% for all-cause mortality, 18% for CVD events, and 9% for all cancer.¹⁹ Joint analysis between strength training and aerobic activities revealed that a greater benefit was obtained for all-cause mortality, CVD mortality and total cancer mortality when these two types of exercise were combined. This important finding about the synergism of

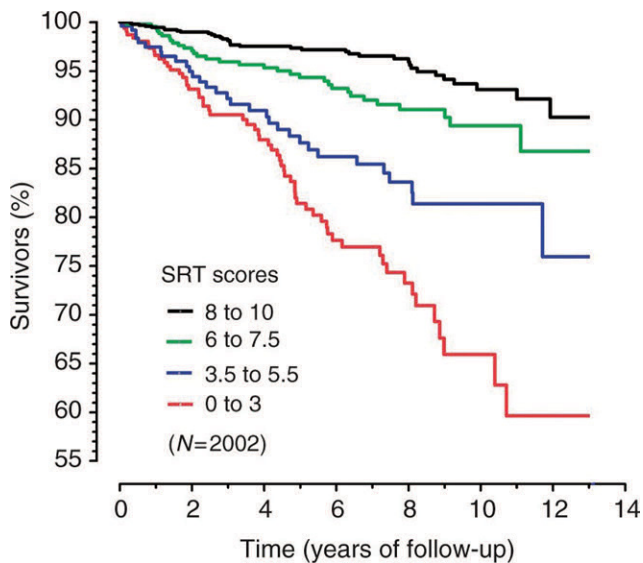


Figure 4. Kaplan-Meier survival curves based on SRT scores.³¹ Used with permission.

aerobic conditioning and resistance training has been confirmed by previous meta-analyses, and strongly suggests that adding muscle-strengthening activities to routine of cardio activities may provide additional benefits for preventing disease and improving life expectancy.^{19, 20}

However, in this recent comprehensive meta-analysis by Momma et al., the survival curves were J-shaped—benefits were completely lost at strength training durations of ~130 to 140 minutes/week, with possible harm at progressively higher doses (Figure 3).¹⁹ Another meta-analysis showed that doing resistance-training sessions one or two times/week was associated with reduced risk of all-cause mortality, although increasing the frequency to three or more sessions/week was not.²⁰ In contrast, aerobic exercise tends to follow a reverse-J curve whereby some of the conferred benefits for CV health and life expectancy may be lost at the highest levels of strenuous exercise, but even very high doses of VPA do not increase risk of premature mortality or CVD compared to a sedentary lifestyle.^{4, 21}

Adults who are inactive lose 3% to 8% of total muscle mass/decade, which is accompanied by increased fat accumulation and decreased resting metabolic rate.²² Strength training can reverse these abnormalities by increasing muscle mass and resting metabolic rate, with a

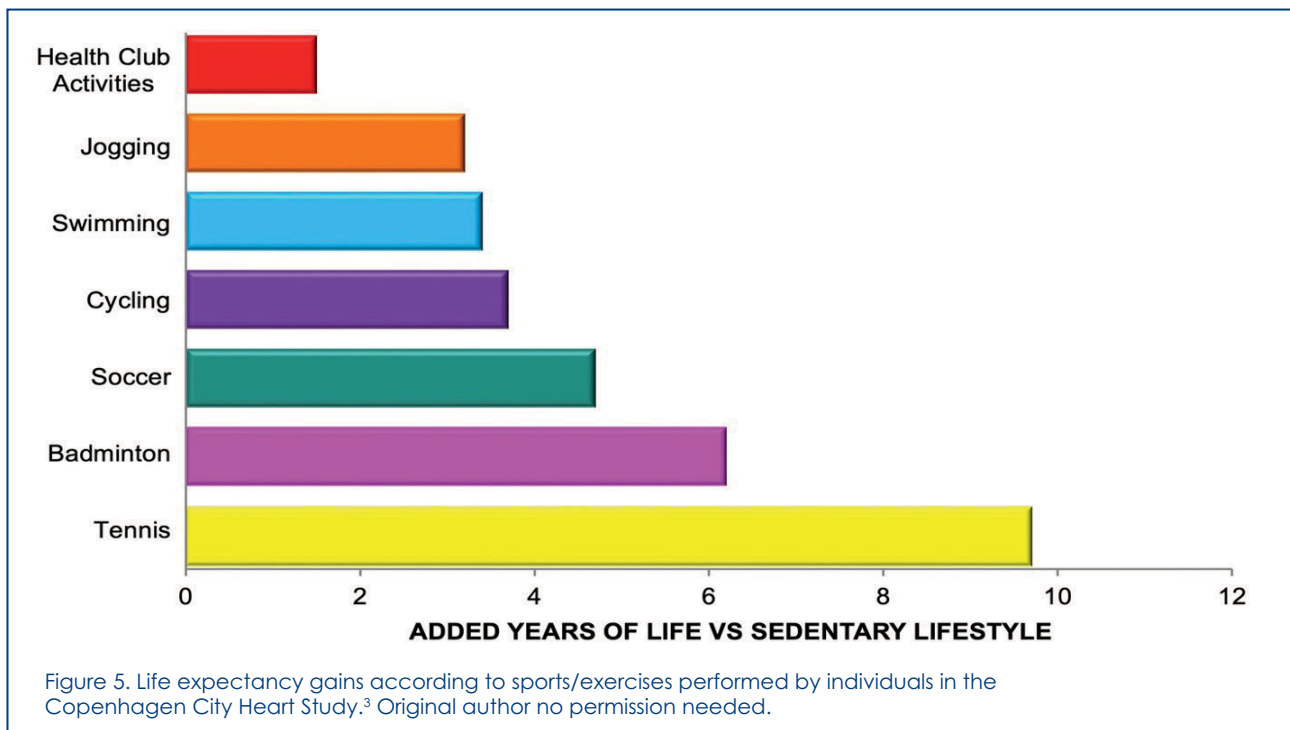
reduction in visceral fat.²² Resistance training also improves physical performance, cognitive function/mood, blood pressure, insulin sensitivity, glucose metabolism, and lipid levels.^{22, 23} Additionally, strength training augments bone mineral density and functional independence, and supports CV health.^{22, 23} The World Health Organization (WHO) recommends that muscle-strengthening activities be performed at least twice a week.²⁴

Grip strength has been proposed to be useful biomarker of aging.²³ Strong observational evidence suggests that grip strength is an accurate way to assess current and future strength, physical functionality, bone mineral density, risk for fractures, and vulnerability to hospitalization.^{25, 26} Grip strength is also highly predictive for multiple health outcomes including all-cause and disease-specific mortality, and surprisingly, even cognitive function.^{25, 26} Weightlifting, gardening, and competitive sports are all practical strategies for maintaining or improving robust grip strength.

Other Fitness Dimensions: Balance, Flexibility, Body Composition

Balance is an aspect of fitness that has been shown to decline steeply starting about 50 years of age. The ability to balance one's body can be assessed by simply standing on one leg. In a prospective study of 1,702 individuals followed for seven years, the ability to successfully complete the 10-second one-legged standing test was independently associated with all-cause mortality.²⁷ In a multivariable adjusted model incorporating age, sex, body mass index and other comorbidities, the hazard ratio for all-cause mortality was higher 84% higher ($P < 0.001$) for the cohort who could not stand on one leg for 10 seconds without losing their balance and having to put the other foot on the floor.²⁷ Furthermore, the ability to stand on one leg for 10 seconds provided incremental prognostic information beyond age, sex and other relevant fitness and clinical variables.²⁸ Balance is highly trainable. Yoga and tai chi are forms of MPA done in social settings that improve balance and flexibility.²⁹

Arising from the floor is a basic task required for autonomous functioning. The sitting-rising test (SRT) is a simple and quick assessment based on the ability to sit on the floor and then rise.³⁰ A score ranging from zero to five is achieved for each the sitting and the rising phase, with one point being subtracted from



five for each support used (hand, forearm, and knee); the two scores are added together for a maximum score of 10. The SRT simultaneously evaluates the fundamental non-aerobic components of physical fitness—flexibility, balance, muscle strength, and body composition—which turn out to be important for optimal functioning and survival.

A prospective study of 2,002 subjects with ages ranging from 51–80 years showed that low SRT scores were associated with a higher all-cause mortality risk during follow up.³¹ A low score on the SRT was associated with >six-fold higher all-cause mortality; the vast majority of deaths in this study occurred in participants with low SRT scores (Figure 4).³¹ In contrast, only two subjects with a perfect SRT score of 10 (ability to sit and stand without placing a hand or knee on the floor) died during a follow-up time of 6.3 years. The predictive power of this simple test that requires no aerobic effort is similar to that seen with cardiorespiratory fitness as measured on treadmill testing.

The Power of Play

The best types of exercise for improving life expectancy and mental health appear to be social sports such as tennis, golf, badminton, pickleball,

soccer, basketball, volleyball, softball, touch football, baseball, and group exercise. The activities that involve interactive physical play not only improve fitness, but also promote interpersonal bonding and reduce stress.

In the Copenhagen City Heart Study, adults who reported frequently participating in tennis or other racquet sports or team sports such as soccer lived significantly longer than individuals who were sedentary.³ After statistical adjustment for multiple potential confounders, the people who play social sports also had longer life expectancies than those who regularly did other types of exercise, some of which are strenuous but are typically done by oneself, such as running, swimming, and cycling (Figure 5).³ This finding that interactive social sports have a halo effect on health, well-being, and longevity has been corroborated in other large prospective registry studies.^{32,33} In the U.S., about three of four people play some form of sports when they are in school and in young adulthood, but unfortunately after age 25 years, only one in four still plays a sport regularly.³⁴

Social support independent of exercise exerts potent positive effects on health, wellbeing and life expectancy.³⁵ Engaging in team sports or group exercise not only confers the physical health benefits of exercise, but also fosters interpersonal connection and tends to

brighten mood and reduce anxiety.³² Thus, playing a sport that requires a partner or a team or doing group exercise may result in distinctive psychological and physiological effects that amplify the benefits of the exercise.³ Moreover, because interactive physical play is usually perceived as fun, participants tend to do it more often than a joyless workout.

Nature Therapy

Growing evidence suggests a positive association between time spent in natural environments and good mental and physical health.³⁶ A recent study assessed the dose-response relationship of “nature therapy” by focusing on the amount of time spent by 19,806 adults during a typical week outdoors in green spaces like parks, woodlands and countryside or by blue spaces such as lakes and beaches.³⁷ Those who spent ≥ 120 minutes/week in nature were 59% more likely to report good health and 23% more likely to report wellbeing compared with those who reported spending no time in nature. The authors concluded that spending at least two hours/week of outdoor recreation time may be a threshold for achieving the nature dividend for health and wellbeing.

Notably, nature exposure can improve health and mood even if the person is not exercising while in the natural setting.³⁷ Shinrin-yoku (forest-bathing), is a popular therapy in Japan that has been shown to have psychological and CV benefits (reduced blood pressure and pulse, lower levels of cortisol and inflammatory markers) when individuals are being active or passive while in natural settings such as woodlands, mountains, lakes, streams, etc., rather than urban settings.³⁸

Even so, exercise performed in nature appears to be more psychologically beneficial than physical activity in other locations.³⁹ Gardening is popular worldwide and is practical form of leisure-time activity that involves immersion in nature, relaxation, multi-faceted movements, exposure to potentially beneficial microbes and sunlight. Gardening is consistently linked to physical and mental health benefits as well as longevity.⁴⁰

Exercise with a dog is virtually always done outside. Individuals who adopt a dog into their home compared to non-dog owners are approximately 14 times more likely ($P < 0.001$) than to be recreational walkers and four times more likely to meet current exercise guidelines of 150 minutes/week ($P < 0.001$).⁴¹ Furthermore, a prospective register-based nationwide

study from Sweden that included 3,432,153 individuals with 12 years of follow-up found that dog ownership for people who were otherwise living alone was associated with significant all-cause mortality reduction of 33%, HR 0.67 (95% CI, 0.65–0.69), and CVD mortality reduction of 36%, HR 0.64 (0.59–0.70).⁴² People living in multiple-person households also benefited from dog ownership with less impressive but still highly significant reductions in risks of all-cause mortality and CVD mortality (11% and 15% reductions, respectively).

Summary

- Physical fitness is the single best predictor of life expectancy and healthspan. Try to achieve and maintain a high level of physical fitness throughout life.
- More is better for moderate-intensity exercise with respect to CV health and life expectancy. Vigorous exercise is also beneficial for optimizing life expectancy and healthspan, but maximal benefits are achieved at 150 minutes/week.
- HIIT is a time-efficient strategy for attaining and maintaining high-level CRF. Regular participation in team sports or other forms of physical interactive play is associated with good mental health and longevity.
- Shoot for at least two hours/week spent outdoors in natural settings (green spaces or blue spaces). Gardening and adopting a dog are practical strategies for accomplishing this goal.
- Aim for two sessions/week of strength training for a cumulative time of about 40 to 60 mins/week, ideally not exceeding 150 mins/wk.
- Incorporate flexibility and balance training sessions like yoga or tai chi.
- Allow ample time for rest, relaxation, recovery, and sleep after strenuous exertion.

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Disclosure

None reported.

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