Masters Athletes: A Model for Healthy Aging

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Keywords: masters athletes, aging, age-related decline, health, exercise

While some suggest that the increased level of injuries diagnosed within the aging population is due to simply "outliving our warranties," a look into the masters athlete sub-culture reveals a number of individuals who are outperforming society's age-defined expectations. Athletes in the media spotlight such as Brett Favre, Lance Armstrong and Dara Torres are redefining how we think about aging. However, these feats of enduring performance are not limited to elite level athletes, as recreational athletes, including those who are abandoning the couch in pursuit of a more active lifestyle, have demonstrated some remarkable accomplishments of their own. Despite the fact that waiting rooms at doctor's offices across the country are filled with these "weekend warriors," sports medicine has largely ignored this group, preferring to focus on the child, collegiate or professional athlete. The purpose of this article is to illuminate the factors effecting performance and injury prevention in the aging athlete and summarize the benefits of active aging in order to ameliorate the perception that age is the sole factor contributing to an individual's activity level.

In order to maintain an active lifestyle as we age, it is important to understand the biology behind the aging process. At the cellular level, rapid cell division provides the human body with a remarkable regeneration capacity. It enables us to recover from injury rapidly throughout childhood and early adult years. As we continue to age, our bodies become less efficient at these regeneration activities, resulting in stiffer tissues and a decline in overall performance [1]. These changes occur, not only at the macro-level of muscles and joints, but at the micro-level of DNA. The way our genes are expressed also changes with age and activity level. The consensus among the general population is that this lapse in athletic prowess is an inevitable and irreversible part of the aging process. This consensus, however, is less grounded in science than anecdote. Many studies are revealing the true capacity of our musculoskeletal system with aging and show that aging is not necessarily an irreversible decline from vitality to frailty.

We know from recent research efforts that "old" cells can be reprogrammed at the cellular level to behave like "young" cells by simply using exercise as medicine. In general, much more investigation into this decline and how much can be attributed to physical inactivity is needed. The high level of physical activity maintained by masters athletes throughout their lifespan make them a model subject for investigating healthy aging. By studying this population, we are able to eliminate the variable of physical inactivity or other health conditions when investigating the aging process.

THE LONGEVITY OF THE MASTERS ATHLETE

Masters athletes everywhere continue to debunk the common myth that turning 40 means slowing down. In a survey conducted by the Arthritis Foundation, 64 % of masters athletes reported feeling an average of 11 years younger than their actual age, while 40 % reported living a more healthy and physically fit lifestyle than in their 20's. Moreover, 33 % of them boasted that they can beat their children in at least one sport. It is important to note that these people are not the exception, but the standard. All individuals have the chance to maintain this high quality of life and functional capacity throughout their lifespan if they chose to avoid a sedentary lifestyle. Studies of performance decline in masters athletes indicate that the slowing phenomenon of the aging process does not have a significant impact until the 7^{th} decade of life.

In a study of track athletes aged 50 to 85 who participated in the 2001 National Summer Senior Games, running times across all distances declined with age. While this trend was expected, the surprising find was the small degree of performance decline that occurred with age. Until the age of 75, the observed decline was slow and linear, with decreases of less than 2 % per year. This decline was not found to be statistically significant. At age 75, however, the rate of decline jumped to approximately 8 %. This trend of performance decline with age is shown in Senior Olympians competing at all distances, from the 100 meter dash to the 10,000 meter run. These results suggest that if disuse and disease are eliminated, individuals should be able to maintain high levels of functional independence until the age of 75 [2]. Therefore, the loss of independence before the age of 75 must be attributed to lifestyle habits, disease or genetic predisposition.

Similar rates of maintained performance are also observed when investigating the scores of masters athletes on tests of aerobic capacity, such as the VO2 max and lactate threshold test. An analysis of the VO2 max scores of masters athletes over the age of 35 proposes that a 0.5 % decline per year may be an intrinsic biomarker of the aging process [3]. Women have displayed a slightly faster rate of decline than men in this area [1]. These rates are much less than would be expected, considering a low VO2 max is believed to be one of the fundamental reasons behind decreases in functional capacity in the aging population. Research investigating declines in endurance performance with aging attributed poor performance to a reduced VO2 max and lactate threshold. In a study comparing healthy young adults, older sedentary individuals and older endurance athletes, approximately 50 % of the age-related differences witnessed in VO2 max score were found to be the result of a smaller stroke volume. The remaining differences were attributed to a lower maximal heart rate and reduced oxygen extraction. However, as shown within the masters athlete group, these trends can be greatly diminished through high-levels of habitual exercise [2]. This suggests that any exaggerated rates of decline are the result of lower energy levels, decreased training intensity and less time spent training. Only modest portions of these declines in performance are age related.

These moderate rates of performance decline also depend on factors such as gender and type of physical activity. Investigation of track and field records to examine the rate of performance decline show that strength deteriorates before stamina. This is best seen in sprinters, as their declines in running speed are paralleled with a decrease in stride length. This is believed to be the result of a decrease in muscle strength, which requires athletes to take a greater number of strides to cover the same distance. However, when examining the times of Senior Olympian record holders, the rates of decline were most prominent among the endurance athletes. In swimmers, the sex differences were largest in the sprint events and smallest in the distance events. The data examining the rates of performance decline among type of swimming event also yields conflicting results, as some studies reported a larger decline in sprint races while others found a larger decline in endurance races. Parallel to the runner’s decrease in stride length, swimmers demonstrate a decreased stroke length, which results in an increase in stroke frequency [2]. It is believed that the mechanisms of decline are different for each sport depending on the demands of the activity, yet altogether remain gradual.

INJURIES IN MASTERS ATHLETES

The magnitude of evidence in favor of active aging raises an important question, if masters athletes are so healthy, why are they getting hurt? According to the U.S. Consumer Products Safety Commision, a 33 % increase in injuries were witnessed within the masters athlete population from 1991-1998. Injuries are the number one reason for a stoppage of physical activity in this group, and occur highest in sports such as cycling, basketball, baseball, and running. Investigation of the mechanism of these injuries reveals that 69 % of masters athletes attempt to work through their pain in order to remain active. This is most likely why 60 % of the injuries reported are the result of overuse, and only 23 % are the result of falls. Research has suggested a number of reasons for the increased incidence of injury witnessed within this group, the most notable of which is inappropriate training methods. Unpublished data from a study conducted by Wright and colleagues reveals that, in a sample of masters athletes surveyed, 50 % of the athletes devoted 5 % or less of their total training time to stretching exercises. Of that group, 31.5 % devoted only 0-2 % of their time to stretching activities. This is without question an insubstantial amount of time. In order to avoid injury, masters athletes must train smarter than they did in their younger years. This includes proper nutrition, not overextending oneself when training and adequate amounts of daily stretching, especially before intense bouts of exercise.

Muscle

Acute muscle strains account for a predominant portion of the injuries witnessed within the aging population. This is attributed to the loss of flexibility, as well as weak or fatigued muscles. The predisposition of masters athletes to these injuries is thought to be the result of their frequent participation in endurance sports. Investigation of the mechanism of these injuries reveals that the athletes often report changes in their training activities when recounting the onset of the injury. This supports the belief that older athletes do not transition from sport to sport as quickly as they did in their younger years, and require a more extensive warm-up before commencing rigorous physical activity. Further, all individuals have a responsibility to exercise no matter what age, in order to maintain stronger, resilient muscles that are more resistant to injury.

Tendon

Tendinosis in masters athletes commonly occurs as the result of overtraining. This subjects the tendon to repetitive microtrauma, which in turn causes it to stiffen. Other factors which can contribute to this age-related stiffening of connective tissues are decreases in water content, increases in elastin fibril thickness, and hormonal abnormalities, such as diabetes mellitus or an excess of corticosteroids [4]. Three of the most prevalent types of tendinosis in masters athletes are rotator cuff tendinopathy, Achilles tendonitis or Tennis elbow [1]. All of this suggests that the gradual stiffening of tendons must be paralleled by changes in the masters athlete’s training regimen if they are to avoid these injuries. Daily stretching exercises are paramount in eluding tendon stiffening and the subsequent tendinosis.

Knee

In recent years, the consensus that exercise provides protective benefits to joints by reducing the incidence of degenerative diseases, such as osteoarthritis, has been a controversial issue. Traditionally, the prescribed therapy for knee pain has been modification of training activities, a technique not well received by many masters athletes. This makes the management of knee osteoarthritis one of the most challenging issues in sports medicine today, since those affected by this disorder typically wish to maintain a high-level of physical activity. Investigations of this disorder reveal that athletes symptomatic for knee osteoarthritis all demonstrated quadriceps weakness, reduced proprioception and increased postural sway. Altered proprioception due to muscle fatigue may weaken the neuromuscular response and decrease the efficiency of protective muscular reflexes [5]. This contradicts the paradigm that the aging athlete should not participate in activities which subject the knees to high levels of impact, such as running, as knee injuries can be avoided by maintaining quadriceps, core and hip strength, as well as restraining from high-intensity workouts when fatigued.

Shoulder

Shoulder injuries, such as subacromial impingement and rotator cuff tears, are commonly associated with repetitive shoulder motion. Initially, the goal of shoulder surgery was to alleviate pain symptoms. Currently, the goal is to achieve a return to physical activities, which is becoming increasingly more common. Patients over 65 years old demonstrate great success recovering from subacromial decompression and rotator cuff repair, with a 94% satisfaction rate. The majority of these patients report a reduction in pain symptoms, independent living and a return to sports. Research investigating return to sports suggested 80% of patients return to sports at their previous level of competition following surgery to their dominant shoulder [4]. However, this becomes increasingly more difficult as patients pursue higher-intensity, higher-impact sports. Despite the success rates of these surgical procedures, these injuries are best treated through preventative efforts. Many athletes focus on building the “cosmetic” muscles, such as the biceps, triceps and deltoids, while ignoring the exercises which work the smaller muscles, which are paramount for joint stability and avoiding injury.

Hip

Studies of women with lower extremity osteoarthritis revealed that fatigue was strongly associated with physical activity while pain was more weakly associated with physical activity and in the direction opposite to what was expected. This stresses the importance of fatigue management in helping masters athletes with osteoarthritis maintain high levels of physical activity. Hip arthroscopy is a method commonly used to treat labral tears and the early stages of osteoarthritis. It has yielded reproducible results in the diagnosis and treatment of intra-articular hip disorders in elite athletes [4]. Hip arthroscopy could be a promising treatment for the aging population as many elite masters athletes refuse to modify their activities and do not have the degenerative changes to warrant joint replacement. Regardless of activity levels, the senior population will exhibit a redistribution of joint torques from plantar flexion to hip joint extension over time. However, active elderly display a more pronounced increase of hip extension torque, which enables them to perpetuate the support torque at the level of young subjects. This age-related redistribution of joint torques is of pivotal importance since the active elderly use it a means to compensate for diminishing muscle function [6]. By maintaining flexibility, core and gluteal strength, masters athletes may avoid hip injuries and continue to enjoy high levels of functional capacity.

CHANGES THAT OCCUR AS WE AGE

Natural Aging: The Cardiovascular System

In the aging process, upkeep of cardiovascular function is imperative: 40 % of deaths in people age 65 to 74 are the result of heart disease; for individuals over the age of 80, this number jumps to 60 %. This is because many age-related physiological changes are witnessed in the cardiovascular system. For example, a 70-year old heart has 30 % fewer cells than the heart of a 20 year-old. The cardiac output of a 20-year old is 3.5 to 4 times that of their resting capacity, while an 80-year old can output only twice their resting capacity. During exertion, the maximum heart rate for a 20-year old is between 180 and 200 beats per minute (bpm), while only 145 bpm for an 80-year old [1]. To some extent, these changes are part of the natural maturation of the heart. As part of the aging process, the maximum heart rate, the stoke volume and the contractility of the heart will decrease. In the arteries, a decreased elasticity occurs, which results in a narrower space for blood to flow from the heart. This produces a rise in blood pressure and forces the heart to pump harder, which eventually leads to a thicker left ventricle. All of these changes disrupt the heart's delivery of oxygen to the tissues, which affects performance, metabolism and energy levels. Although these physiological changes may appear alarming, chronic high-level exercise and a healthy diet have long been associated with healthy cardiovascular function and a slowing of these changes.

Masters Athletes: The Cardiovascular System

Through endurance conditioning, one is capable of modifying maximum oxygen consumption, diastolic filling, relaxation and arterial stiffness [7]. In a prospective study of masters athletes across 20 years, less than 14 % evidenced risk factors for coronary heart disease at the 20-year evaluation point [8]. In addition, a study of the effects of vigorous endurance training reflected a low prevalence of hypertension in masters athletes when compared to controls, with the masters athlete group being 27.8 % less likely to have used medication for hypertension at any time. While lower body mass and decreased body weight may explicate this effect, researchers believe other mechanisms exist whereby exercise may induce a decreased rate of hypertension [9].

Natural Aging: The Muscular System

Sarcopenia, or the loss of lean muscle mass, is one of the major contributors to the loss of independence in the aging population. This is because large decrements in muscle mass will lead to an increased risk of injury. Similar to the heart, skeletal muscles will lose cells as they age, as well as exhibit increased stiffness and a reduced size of the muscle fibers, beginning around the age of 50. These changes result in a decrease in muscle mass, which in turn produces an equal or greater decline in muscle strength and power [2, 10]. In the sedentary population, this loss of lean muscle mass is approximately 15 % per decade between the ages of 50 and 70. After 70, this loss reaches approximately 30 % per decade. The clinical impression is that these changes are the result of compositional changes of the muscle, as research has shown an increased fat infiltration in the muscle of the aging sedentary population. However, recent studies of masters athletes have discovered this is not the case.

Masters Athletes: The Muscular System

A study of masters weightlifters revealed a muscle deterioration rate of 1.0 – 1.5 % per year. Additional studies determined that an 85 year old weightlifter is as powerful as an inactive 65 year old. This indicates that competitive performance throughout later life stages is still feasible, and that maintaining an increased level of physical activity in late life is imperative for healthy aging. Further, analysis of anaerobic muscle performance indicated that age-related rates of decline in women exceed those of men but only in events requiring explosive power. It is in these events that we witness the largest rates of decline for both sexes [2]. To contest the paradigm that muscle undergoes many age-related composition changes, Wright and colleagues are currently conducting a study which investigates the role of chronic high-level exercise in preventing the loss of lean muscle mass and strength. Preliminary findings support the observation that fat infiltration did not increase with age, and that total muscle area and quadriceps strength did not decline with age. This offers further support that by maintaining muscle mass and strength, masters athletes are able to stave off falls, functional decline, osteoporosis or other factors that lead to the loss of functional independence.

Natural Aging: The Skeletal System

The loss of Bone Mineral Density (BMD) associated with aging is another major contributor to the loss of independence in the senior population. Decreases in BMD can lead to osteoporosis, subjecting the individual to an increased risk of fracture. Risk factors for osteoporosis include decreased calcium intake, low levels of active exercise, smoking, and low levels of testosterone in men [1-2]. The loss of bone mass is a major problem for both men and women over the age of 40. Women lose bone mass twice as fast as men, at a rate of 1.5-2 percent per year. This rate reaches 3 % per year post-menopause [4].

Masters Athletes: The Skeletal System

When comparing whole-body BMD values of masters athletes and sedentary adults, the athlete group exhibited significantly larger values of BMD. In a study of masters athletes participating in the 2005 National Senior Games, the majority of the women had more normal bone density than weak bone density, even those who were over 80 years old. The incidence of osteoporosis among this group of female masters athletes was less than that of the general population at any age [2]. In other studies, a 0.8 % increase in hip BMD was associated with each hour per week difference of high-level exercise in women. These increases were most prominent among premenopausal women [11]. A study of femoral neck, spine and whole body BMD in men over 65 years of age determined that bioavailable testosterone, physical activity level, and BMI all contributed to variance of BMD values at the femoral neck. Independent analysis of these three variables revealed that bioavailable testosterone accounted for 20.7%, physical activity for 9.0 % and BMI for 6.5 % of this variance. Bouts of high-intensity resistance training demonstrated sharp increases in testosterone levels in middle-aged and older men, which may further alleviate decreases in BMD [4]. All of this demonstrates that BMD may be maintained in the aging population through high-levels of chronic exercise.

Natural Aging: Cartilage and Tendon

Both cartilage and tendon can deteriorate through atrophy or overuse. Maintaining these tissues is of primary concern for the aging population. Tendonitis is a painful inflammation of the tendon that is quite common in athletes over 40. This condition develops as the tendon experiences repetitive microtears through excessive movements or inadequate stretching prior to physical activity. The lack of stretching causes the fibers of the tendon to gradually become shorter. Tendonitis is most commonly seen in the elbow, wrist, biceps, shoulder, leg, knee and Achilles [1]. Ultimately, it occurs in the areas of the body that the individual uses most. Healthy cartilage can deteriorate by softening or fissuring. High-impact activities have been shown exacerbate this wear on deteriorated cartilage. Fortunately, this is not always the case.

Masters Athletes: Cartilage and Tendon

These conditions can be easily avoided with smart training methods, such as a proper warm-up and stretching prior to strenuous physical activity. The best way to protect cartilage and tendon is to adequately address issues such as pain and fatigue as they arise. Ignoring symptoms such as pain or weakness will only subject cartilage and tendon to further abuse. Rest and moderation of training activities are imperative in order to protect the health of your cartilage. If masters athletes adopt the right training methods, they will yield the most favorable results. For example, a study of health middle-aged women athletes revealed that participation in exercise that produced an increased pulse rate for a minimum of 20 minutes was positively associated with the volume of medial tibial cartilage. None of the women in this study exhibited knee cartilage deficits as a result of this activity [12].

ADDITIONAL BENEFITS OF ACTIVE AGING

While chronic exercise is a known preventer and antidote to many of the problems that plague sedentary agers, there exist additional benefits that exercise brings to the aging population that are not often discussed in the literature.

Cancer

Recent research suggests that exercise can not only prevent cancer, but can significantly reduce the risk of cancer-specific mortality in individuals who increase their levels of exercise post-diagnosis, specifically breast and colorectal cancer. Adjusting for age of diagnosis, stage of the disease, state of residence, interval between diagnosis and physical activity assessment, BMI, menopausal status, hormone therapy, energy intake, education, family history and treatment modality, researchers discovered that women who regularly participated in high-levels of physical activity had a significantly greater chance of surviving breast cancer [13]. Reduced mortality rates were also witnessed in women with stage I to III colorectal cancer who participated in at least 18 metabolic equivalent task hours of physical activity per week [14]. Further research is necessary to evaluate this trend as related to other cancers as well as the precise amount of exercise necessary to obtain these benefits.

Cognitive Function

While many studies have investigated the benefits of active exercise on one's physical health, the benefits specific to cognitive function have received little recognition by comparison. This is staggering since declines in cognitive function have become one of the major contributors to the loss of independence in the aging population. Recent studies indicate that regular exercise can reduce reaction time and increase serum levels of testosterone and growth hormone in elderly males. These hormones are believed to exhibit a protective effect on the risk of dementia and Alzheimer's disease [15]. Associations between these diseases and low levels of physical activity were more distinct among carriers of particular genotypes. However, chronic exercise at midlife and beyond suggests the ability to delay the onset of dementia and Alzheimer's disease despite genetic susceptibility [16]. At present, Wright and colleagues are investigating the effects of chronic high-intensity exercise on specific areas of thought processing ability: working memory, sustained and selective attention time, response variability, non-verbal problem solving and reaction time.

Depression

Depression is a common condition in later life stages. Studies have shown that depression is most likely to emerge when an individual transitions from an active to a sedentary lifestyle. It is consorted with the largest decrease in minutes of physical activity [17]. When mobility status was assessed, individuals who were able to maintain high levels of mobility throughout the aging process exhibited fewer depressive symptoms despite their decline in overall physical activity [18].

Diabetes

In recent years, type 2 diabetes has emerged as one of the most rapidly growing public health concerns worldwide. It is well known that obesity, diet and levels of physical activity combine with genetic factors to increase the risk of developing type 2 diabetes. While all of these factors contribute independently, obesity has shown to be the largest contributor to the onset of the disease [19]. Those with diabetes or at highest risk for developing the disease engage in rates of physical activity that are significantly below the national average, as determined by a nationally representative survey of the U.S. population conducted by the Medical Expenditure Panel Survey. Although genetics are an important contributing factor, it is important to note that they are only part of the problem, and must usually be coupled with unhealthy lifestyle choices in order to develop the disorder.

Stroke

Studies on the preventative benefits of physical activity on stroke revealed that increased activity levels paired with a reduction in stroke mortality. Test subjects were assessed by self-reports of occupational and leisure activities. In addition, moderate levels of exercise exhibited benefits among individuals already diagnosed with heart conditions, such as left ventricular hypertrophy [20].

It is of paramount importance for the senior population to maintain increased levels of physical activity if they wish to remain functionally independent throughout midlife and beyond. While there exist many age-related changes that we cannot avoid, exercise is a known preventer and antidote to the ravages of age-related disease. People everywhere are starting to realize these benefits, as the number of individuals over 50 participating in high level sports continues to increase. Records of the New York City Marathon from 1983-1999 reveal that the number of runners over the age of 50 are increasing rapidly than any other age group. In addition, the race times of the masters athlete group are demonstrating significantly greater improvement than the younger runners.

While injuries do occur within this masters athletes group, this is primarily because the athletes do not change their training regimens to accommodate for the physiologic changes their bodies are experiencing. In order to avoid these changes and still participate in chronic high-level exercise, these athletes must F.A.C.E. their future. F.A.C.E. is an acronym for the four components of fitness after 40 that are essential to maximizing performance and training effectively:

F – Flexibility
A – Aerobic Exercise
C – "Carry a load," or resistance training
E – Equilibrium and balance

Creating a balanced workout that touches on these cornerstones of physical fitness is a smart way to achieve your fitness goals. F.A.C.E. applies not only to competitive athletes, but people of all ages and activity levels. Those who adopt an exercise regimen that embodies all of these components will be able to reduce the slowing phenomenon that is so often thought to accompany life after 40.

Future efforts should focus on raising awareness about the benefits of active aging and preserving the longevity of masters athletes. This way, more individuals will be able to enjoy functional independence and the benefits of a healthy lifestyle into their later years. This is becoming increasingly more important each day, as the baby-boomer generation is now in their 60s and is starting to transition to the age of senior citizens. Therefore, time is running out for physicians to intervene and encourage the sedentary individuals within this group to start exercising before they reach the age of reduced functional capacity.

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