Exercise Considerations for the Masters Female Athlete

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ABSTRACT

Female participation in sport as a masters athlete has grown considerably in recent years. Functional losses and physiological changes in the cardiovascular, musculoskeletal, and endocrine systems that occur with female aging require recognition and thoughtful exercise prescription. In working with this population, the strength and conditioning professional should be able to recognize the biology of aging, factors affecting recovery and performance, and application of appropriate training parameters to keep the female athlete in their sport while mitigating the effects of aging and maximizing performance. This special populations article outlines key age-related changes in the female athlete and presents comprehensive, practical training guidelines for this growing population.

INTRODUCTION

The number of aging athletes in the United States has grown considerably in recent years. Older athletes are capable of training and competing in sport while adapting to changes related to natural aging. These athletes are typically referred to as masters athletes. They are described as individuals beyond peak performance age who systematically train for and compete in organized forms of team and individual sports specifically designed for older adults (5,43). Masters athletes are defined by each sport's governing body, with most being designated at age 35 years and older (36). In particular, the masters designation begins at 25 years of age for swimming, at 35 years of age for weightlifting and track and field, and at 50 years of age for golf (5,16). The U.S. Census Bureau reports the median age in the United States to be 38.5 ± 0.1, with 48.2 percent aged 35 years and older (46). Hence, nearly half of the U.S. population is eligible for participation in exercise and sport under the masters classification.

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Moreover, more than half of this subset is female. These athletes range from beginners who have never trained or competed to experienced competitors who continue their athletic endeavors. Some may return to sport after prolonged inactivity or merely train and participate occasionally.

Numerous benefits to participation in masters athletics have been identified. It has been suggested that masters athletes exemplify successful aging because of remarkable physical functioning and higher psychological, cognitive, and social functioning (14). Physical exercise and healthy lifestyle habits are known for their ability to prevent and manage conditions such as diabetes, obesity, and hypertension. The active lifestyles of masters athletes further contribute to overall improved life satisfaction and reduced sleep impairment commonly encountered in older age. Beneficial effects of habitual exercise on physiological reserve and quality of life seem to be the foundation of healthy aging (47).

As masters athletes enlist in structured training programs to improve performance and/or exercise capacity, they face natural physiological changes that come with age. Notable cardiovascular and musculoskeletal changes may require a closer look at exercise prescription to address target areas. Female athletes may require additional considerations related to hormonal changes and menopause. The strength and conditioning professional should recognize the cardiovascular and musculoskeletal changes combined with hormonal influences in female masters athletes, so they can implement programs that mitigate these changes and maximize athletic performance in this population.

PHYSIOLOGICAL CHANGES WITH AGE

CARDIOVASCULAR SYSTEM

Several physiological changes to the cardiovascular system occur with aging that may impact athletic performance in the masters athlete. Pertinent cardiovascular changes include a decrease in maximum heart rate (HRmax) and a decrease in maximal oxygen consumption ($\dot{V}O_2max$) (34). It is estimated that

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the age-adjusted HRmax decreases one beat per year after age 10 years; however, training can slow down the typical decline in HRmax (34). Nonetheless, progressive declines in cardiovascular function, including decreasing HRmax, reduced compliance with diastolic filling, incomplete emptying during systole, and declines in stroke volume, ejection fraction, and cardiac output may affect activity tolerance in masters athletes. Hence, masters athletes should anticipate the need to adjust their training intensities accordingly. For example, a runner who engages in high-intensity interval training sessions may need to monitor heart rate and relative perceived exertion more closely than their younger counterparts. Although maintenance of a rigorous training program cannot increase HRmax in masters athletes, it can attenuate the expected age-related decline in HRmax from 10 beats/min to 4 to 7 beats/min per decade (34).

Aging also results in a progressive decrease in maximal oxygen consumption. The decrease in $\dot{V}O_2$max is estimated at 10% per decade, or 1% per year, after age 25 years (12). $\dot{V}O_2$max is dependent on cardiac output (heart rate × stroke volume) and the exchange of oxygen between the arterial and venous systems. The decline in $\dot{V}O_2$max reflects reduced efficiency of the pumping heart, stiffness in the vascular system, and declining lung capacity (24). A lesser amount of blood pumped out by the heart results in less blood available for exercising muscles. Aging may have a lesser impact on aerobic versus anaerobic power in trained masters athletes. Nonetheless, high levels of ongoing exercise can decrease the age-related decline in $\dot{V}O_2$max by nearly 50% (34). Masters athletes can maximize $\dot{V}O_2$max through a combination of total volume and total intensity of training.

Masters athletes routinely exceed the recommended 150 minutes of moderate or 75 minutes of strenuous exercise per week (13). Long-term and high levels of endurance exercise, in particular, may be associated with adverse cardiovascular outcomes in masters athletes, including increased incidence of atrial fibrillation, myocardial fibrosis, coronary artery disease, and aortic dilation (4,45). This topic has faced ongoing debate in recent years, and findings seem to suggest these conditions are more common in male athletes. Female athletes have a lower incidence of sudden cardiac arrest or death than male athletes in the masters athlete years (35). In addition, female athletes are less likely to have coronary disease and atrial fibrillation than male athletes (35). Although an association between intense exercise and cardiovascular disease has been found in male endurance athletes, the same association has not been identified in the female endurance athlete population (35). It is unclear why these sex-based variances exist; hence, future research investigating the underlying mechanisms of cardiac adaptation in female athletes is warranted (35). It is recommended that masters athletes be screened for cardiovascular risk factors and family history of coronary artery disease and other concerning symptoms to evaluate the need for additional testing such as an echocardiogram and/or exercise stress test (28). Nonetheless, no conclusive data support advising against high-level exercise for healthy individuals without cardiac risk (45). Stratification of cardiovascular risk based on current guidelines and shared decision-making continues to be suitable for masters athletes with established cardiovascular risk and/or disease (45).

Training implications. Masters female athletes will benefit from a combination of high-intensity and high-volume cardiovascular training to decrease age-related declines in HRmax and maximal oxygen consumption. Utilization of a warm-up period focusing on increasing metabolism and blood flow is recommended to prepare the body for exertion (24).

MUSCULOSKELETAL SYSTEM

Age-related changes in the musculoskeletal system include declines in lean muscle mass, type II fast-twitch muscle fibers, overall muscle power, and bone mass, strength, and quality. Resistance exercise has the potential to mitigate these age-related changes (34). The loss of lean muscle mass, known as sarcopenia, begins around age 30 years and accelerates to 10–15% per decade between age 50 and 70 years (44). This decline in muscle mass contributes to the age-related decrease in $\dot{V}O_2$max and endurance performance in masters athletes (36).

Muscular atrophy accompanying aging is due to a decrease in size and number of muscle fibers, particularly type II muscle fibers. The loss of these fast-twitch anaerobic fibers and their decrease in cross-sectional area results in slowed reaction time and decreased muscular power. The power loss in women is estimated to be 40–50% in those older than 50 years (44). Although type II muscle fibers decrease in size and number, a maintenance or increase in size of type I slow-twitch muscle fibers has been observed in masters athletes. This may increase reliance on type I fibers and further reduce power output and performance velocity. However, evidence suggests the potential for reversal of disuse atrophy of type II muscle fibers through high-intensity strength and power training (34).

It is important to note that the decline in muscle mass with age may not be attributed to age alone. Strength measured relative to muscle volume reveals that the loss of strength with aging is almost eliminated (34). This suggests that training routine rather than age may explain the difference in muscle fiber distribution and lean body mass. Hence, an appropriate training program can return muscle fiber distribution to levels like that of younger athletes (34).

The musculoskeletal system also sees age-related declines in bone mineral density (BMD). After age 40 years, bone density loss is estimated at 0.5% per year, regardless of sex or age (34). This loss in BMD is of particular concern to the masters female athlete.

Menopause, the cessation of the menstrual cycle, can accelerate bone loss to more than 3% in the 2 to 3 years before and 10 years after (22). Ultimately, a woman may experience a 15–25% decrease in bone density in the 5 years after menopause (34). Loss of BMD and lean mass presents greater risk of osteopenia, sarcopenia, and eventually osteoporosis. Masters female athletes participating in long-distance running may be at increased risk of stress fracture because of increased loading rates combined with decreased bone mineral density (24). Evidence suggests that resistance training with higher loading forces has a positive effect on bone health in older women by maintaining or increasing BMD (42). Relatedly, female masters runners may be susceptible to the female athlete triad or relative energy deficiency in sports, reflecting spectrums of energy availability (EA), menstrual function, and BMD. Signs of low EA and menstrual dysfunction, 2 components of the triad, have been identified in masters distance runners. Menstrual dysfunction may have occurred because of low EA or perimenopausal state. Screening for menstrual status and nutritional intake may be warranted in the masters female runner (38).

Musculoskeletal connective tissues, including tendons, ligaments, and fascia, become less tolerant to physical stress with age (24). Lower metabolic rate, higher cross-linkage of collagen fibers, progressively decreasing elasticity, and lower tensile strength have been observed in aged tissue (23). These changes lead to increased stiffness, reduced flexibility, and less workload tolerance in masters athletes. Estimates suggest a 6% decline in flexibility every decade after age 50 years (11). Tendon stiffness may limit joint range of motion and negatively affect sports performance (12). Decreased tendon elasticity combined with decreased tensile strength can increase the risk of tendinopathy. Degenerative changes can also lead to tendon rupture, rotator cuff injury, and meniscal tear (5).

The combination of decreased muscle mass decreased bone mass, and loss of flexibility increases the risk of musculoskeletal injury in masters athletes. Estimates suggest nearly 89% of masters athletes sustain a sport-related injury after age 50 years, with 68% of them because of overuse (2,48). Hence, it is imperative to maximize tissue strength and resilience in the masters athlete through training programs containing a warm-up/cool-down, strength training, flexibility exercises, and adequate recovery.

Relatedly, age-related changes to the neuromuscular system, including slowed nerve conduction velocity and reduced reaction times, can lead to impaired balance and slower response rates (5). Both aerobic exercise and strength training can mitigate declines in neuromuscular function. The addition of power strength training has been found to improve the ability of older adults to generate force, which leads to improved reaction times and the ability to respond to perturbation and balance challenges (5).

Pelvic floor muscle dysfunction (PFMD) is a musculoskeletal consideration in the masters female athlete. PFMD often results from pregnancy and delivery and can result in urinary incontinence (UI), fecal incontinence, pelvic organ prolapse, pelvic pain, and sexual dysfunction (37). Women with a history of cesarean childbirth, hysterectomy, and other abdominopelvic surgical history may also present with pelvic-related dysfunction (37). Participation in high-impact sports is a risk factor for PFMD because of the increased intra-abdominal pressure that occurs with running, jumping, or landing, which can overload the pelvic floor muscles. Evidence shows that higher impact sports have a greater prevalence of UI than lower impact sports (58.10 and 12.48%, respectively) (26). Even female swimmers have been found to have a 15% prevalence of incontinence, despite lack of ground impact (26). Training age, defined by years of sports practice, training frequency, and training intensity, have been identified as risk factors for incontinence while exercising (37). Although most research has examined UI in young female athletes, the masters female athlete may present with the additional risk factors for PFMD related to childbearing and training age. Should masters athletes present with urinary and/or fecal incontinence, heaviness, pressure in the pelvic area, or musculoskeletal lumbopelvic pain with exercise, a referral to a pelvic health rehabilitation specialist is warranted. The best prevention and treatment for UI is pelvic floor muscle training, which should begin as soon as women start exercising (7,26).

Training implications. Masters female athletes will benefit from a variety of training to maximize musculoskeletal health and performance. Specifically, high-intensity resistance training using heavy loads can mitigate age-related declines in muscle mass, muscular strength and power, and bone health. Inclusion of eccentric exercises, including plyometrics, can further enhance gains in muscular power. As joint range of motion and muscular flexibility decline with age, performing flexibility exercises at least twice per week can maximize connective tissue mobility and minimize risk of injury. Inclusion of balance and proprioceptive exercises can minimize declines in neuromotor function. Furthermore, screening masters female athletes for possible pelvic floor muscle dysfunction that may impact participation in sport is recommended to ensure referral for treatment as needed.

ENDOCRINE SYSTEM

Metabolic function generally declines with age because of physiological and hormonal changes. Resting metabolic rate (RMR), which entails 60–75% of an individual's total daily energy expenditure, typically declines 2–5% per decade of life (33). Because muscle is very active tissue, muscle loss that occurs with aging is accompanied by a reduction in RMR. Research indicates that RMR can be kept elevated in masters athletes through resistance and endurance training (33). Greater beneficial effects on RMR are seen with higher intensity resistance and endurance training in women (3). However, poor eating habits and caloric restriction can result in negative energy availability and subsequent catabolism of already declining lean body mass in the masters female athlete. Hence, maintenance of ideal metabolism and energy balance through focused training and meal-planning is recommended for masters female athletes.

Hormonal changes occurring with age have particular implications for masters female athletes. Menopause is often categorized into premenopause, perimenopause, and postmenopausal stages and typically occurs between 42 and 58 years of age (40). Perimenopause is the period preceding menopause, during which women experience physiologic changes resulting in the onset of menstrual irregularities and other symptoms, including hot flashes, vaginal or sexual symptoms, sleep and mood changes, and bleeding (6). The average length of perimenopause is 4 years, but for some women, this stage may last only a few months or continue for 10 years. Earlier symptom development often predicts increased time in the perimenopause period. Perimenopause ends when women have gone 12 months without having a period (40).

During perimenopause, women often gain weight, specifically subcutaneous fat mass, and visceral adipose tissue, which are tied to decreasing estrogen levels. The reduction in estrogen is also correlated with decreased muscle mass, muscle quality, and reduced strength during and after the menopause transition, which may magnify the expected declines that occur with aging (31,32). Furthermore, estrogen reduction often leads to vasomotor symptoms (i.e., hot flashes), which may negatively affect sleep and recovery. Weight gain combined with declining muscular strength and performance is often a concern of the masters female athlete, which may lead to decreased caloric consumption, ultimately leading to low energy availability. Dietary consumption of foods with estrogen-like properties (i.e., soybeans, legumes, and flaxseeds) and hormone replacement therapy may aid in mitigating the effects of perimenopause and menopause to maximize aerobic power and performance in the masters female athlete (15).

Training implications. Masters female athletes should recognize the effects of perimenopause and menopause on aging, training, and performance. Menopausal status and related hormonal fluctuations should be considered by the strength and conditioning professional when training masters female athletes because they may contribute to sleep disturbance, weight gain, and impaired recovery. Referral to a health care professional specializing in female health (i.e., gynecologist) may be beneficial for further assessment.

NUTRITION CONSIDERATIONS

Masters athletes must consider the physiological changes that occur with aging and volume of exercise when making dietary selections. An important challenge faced by masters athletes is the maintenance of energy balance and consumption of enough dietary protein. As muscle mass declines with aging, the masters athlete must consume adequate energy and protein intake to avoid a protein-energy deficit. This shortage can rapidly lead to further loss of muscle mass, strength, and function combined with a temporarily diminished immune response that can ultimately compromise exercise performance. It is recommended that masters female athletes eat enough food to maintain a sufficient EA of greater than 30 kcal/kg of lean body mass per day (41).

Consuming protein intakes greater than the recommended daily allowance may be necessary for masters female athletes to support muscle mass and function (41). Relatedly, masters athletes have a greater need for particular vitamins (i.e., vitamin D) and minerals to support aerobic capacity and muscle strength, power, and function when compared with their younger counterparts (41). Energy intake must match the intensity and volume of training for the masters athlete to be successful. Proper nutrition of the masters athlete will support health and performance, prevent low bone and muscle mass, and may reduce inflammatory load in masters athletes (41). Referral to a registered dietitian for nutritional assessment and intervention may be warranted.

Training implications. Key nutrition-related concerns of the masters female athlete include the need for sufficient energy and protein intake for preventing low bone and muscle mass and a higher demand for specific nutrients. Nutritional assessment and intervention may benefit masters female athletes to ensure appropriate energy balance and protein intake to maximize training and performance.

When addressing the needs of the female masters athlete as a strength and conditioning professional, it is imperative to recognize the physiological changes, the resulting effects, and strategies to address these changes presented in Table 1. Ultimately, the professional must meet the athlete based on current training needs and goals. From the novice athlete looking to begin masters competition to the seasoned competitor who is healthy and free from injury, the strength and conditioning professional should address the physiological changes with female aging in an effective training program. The recommendations outlined in this article are most appropriate for the experienced, uninjured masters athlete looking to improve performance and maximize training capacity. Nonetheless, these recommendations could be adapted for new masters athletes and those returning from injury.

TRAINING RECOMMENDATIONS FOR THE MASTERS FEMALE ATHLETE

SCREENING

It is generally recommended that masters athletes undergo a complete

Physiological change	Resulting effects	Mitigating interventions
Decrease in $\dot{V}O_2max$	Decline in performance	Aerobic training with high-intensity intervals
Decrease in muscle mass	Decreased strength Decreased power	Resistance exercise 2–×3 wk, heavy load, less repetitions Eccentric exercise
Decrease in bone mass	Risk of injury Osteoporosis	Weight-bearing, impact exercise Proper energy balance Calcium intake ~2000 mg/d Vitamin D intake 800–1500 IU/day
Decrease in tissue elasticity	Stiffness, flexibility loss Risk of overuse injury	Flexibility exercises 2–×3/wk Dynamic and static stretching
Decrease in metabolism	Increased fat mass Decline in performance	Maximize lean body mass through training Achieve energy balance Eat small, frequent meals
Pelvic floor muscle weakness	Urinary incontinence	Screening for pelvic floor dysfunction Referral to pelvic health rehabilitation specialist
Menopause	Decreased $\dot{V}O_2max$, loss of muscle/bone mass, increased fat mass, and sleep disturbance	Nutritional management Hormone replacement therapy Sleep education

Table 1
The effects of aging on the masters female athlete

musculoskeletal examination before beginning an exercise program to identify areas of limitations such as range of motion, strength imbalances, altered muscle firing patterns, or other biomechanical deficits that may warrant targeted rehabilitation. Screening for cardiovascular risk factors is also recommended before progressing aerobic exercise. A general assessment of current sleep quality and quantity, menopause status, urinary continence, nutritional intake, and training patterns should be assessed initially because they may require modifications tailored to the aging female athlete.

TRAINING TECHNIQUE

Masters female athletes often participate in endurance sports, such as running, cycling, swimming, and triathlon. Because of the repetitive nature of these endurance sports, it is important to ensure proper training form and training volume. The risk of injury increases with age because of declining bone mass, muscle mass, and flexibility, along with increased fatigue with exercise. It is estimated that 89% of masters athletes experience one sports-related injury after age 50 years, with 68% of these injuries related to overuse (2,48).

Participation in masters weightlifting has dramatically increased in recent years, with the proportion of women competitors at the U.S. National Masters Weightlifting Championships increasing from 14% in 2009–59% in 2019 (16). The popularity of CrossFit has likely contributed to the increased participation in masters weightlifting. Athletes who participate in Olympic-style weightlifting may be at increased risk of knee and shoulder injuries; older athletes, in particular, are also susceptible to tendon rupture (20). Hence, the masters female athlete needs to learn proper lifting form and technique to minimize risk of injury.

Proper training techniques combined with strength training, flexibility exercises, and adequate warm-up and cool-down are recommended for injury prevention for masters female athletes regardless of sport participation. The strength and conditioning professional should evaluate training form and ensure technique when delivering exercise interventions accordingly.

AEROBIC TRAINING

A combination of high-intensity and high-volume cardiovascular training can decrease age-related declines in HRmax and maximal oxygen consumption (34). Utilization of a warm-up period before intense aerobic exercise is recommended to prepare the body for exertion. A 10-minute, dynamic, low-intensity warm-up can increase metabolism and blood flow and improve tissue elasticity before exercise. Aerobic exercise intensity should range from moderate to vigorous; the American College of Sports Medicine (ACSM) recommends at least 30 minutes of moderate-intensity exercise 5 days per week, at least 20 minutes of vigorous aerobic exercise 3 days per week, or a combination of moderate and vigorous exercises at least 3 days per week (13). Depending on the sport demands and athlete goals, variable time spent on cardiovascular exercise can be individually prescribed. Exercise intensity can be assessed through a variety of methods, including percentage of HRmax, $\dot{V}O_2$max, or heart rate reserve (HRR), and relative perceived exertion. Table 2 outlines common intensity ranges used for aerobic exercise prescription. High-intensity training that incorporates intervals may be beneficial for masters athletes in reaching vigorous intensities for shorter periods. For runners, vigorous intensity can be attained through hill training and tempo workouts. Aerobic training should be followed with a 5- to 10-minute cool-down period to allow heart rate levels to gradually drop and prepare for recovery.

STRENGTH TRAINING

With known declines in muscle mass and strength, masters female athletes must engage in resistance training. Training programs should include power training and eccentric exercise to maximize strength and decrease risk of injury. The ACSM recommends resistance training for major muscle groups 2 to 3 times per week. Exercise intensity should begin at 60–70% of the 1 repetition maximum (1RM), or moderate to hard intensity, for novice to intermediate exercisers and progress to >80% of the 1RM (hard to very hard intensity) for athletes experienced with strength training (13). Resistance training at least twice per week for strength and power should generally use 2 to 4 sets of 8 to 12 repetitions at intensities between 60 and 80% 1RM with 2- to 3-minute rest between sets (13). As the female masters athlete is prone to decreased bone mineral density and increased risk of a stress fracture, resistance training can maximize bone health and muscular strength to attenuate forces that accumulate with endurance training loads (24).

Eccentric exercise, in particular, will benefit the masters athlete in maximizing connective tissue function that is known to decline with age (39). Aging tendons lose their ability to transmit forces and are prone to injury, and aging muscles show greater fatigue with eccentric contraction (39). Focusing on slowly controlling the lowering of a weight emphasizes eccentric muscle contraction. For example, during a squat, the athlete may lower into the squat position over 3–5 seconds, then quickly return to an upright position in a count of 1 second.

Plyometric exercises can also be beneficial in maximizing tendon elasticity and antifatigue capacity, reducing injury risk of tendons and tendon-bone interface and improving their ability to transmit and absorb forces (24). Plyometric training for the masters athlete may consist of alternating between high- and low-intensity upper and lower extremity exercises on alternate days to allow for sufficient recovery. Upper extremity activities may include chest passes and vertical ball tosses, whereas lower-body activities involve hopping, jumping, and skipping drills. This training may lead to muscle soreness, so a gradual increase from 80 contacts per session is recommended (43). Caution for plyometrics is warranted in masters athletes who have moderate to severe arthritis, severe osteoporosis, and impaired proprioceptive ability. Resistance training suggestions to improve muscular strength and power and suggested exercises for masters female athletes are presented in Tables 3 and 4.

Table 2
Aerobic exercise intensity guidelines for masters female athletes

Intensity	Relative intensity		
	% HRR	% HRmax	Perceived exertion (rated on 6–20 RPE scale)
Light	30–39	57–63	Very light to fairly light (RPE 9–11)
Moderate	40–59	64–76	Fairly light to somewhat hard (RPE 12–13)
Vigorous	60–89	77–95	Somewhat hard to very hard (RPE 14–17)

Table adapted from the American College of Sports Medicine (2).

%HRR = percent of heart rate reserve; %HRmax = percent of maximal heart rate; RPE = relative perceived exertion.

FLEXIBILITY

Flexibility training is recommended daily for the masters female athlete to improve joint range of motion and aid in injury prevention (24). The ACSM recommends flexibility exercises 2 to 3 times per week for improving joint range of motion, with the greatest gains occurring when the muscles are warmed through exercise (13). Dynamic stretching is recommended to mobilize the joints of the masters athlete before exercise. Dynamic stretches are active movements enabling joints and muscles to go through a full range of motion. Examples may include hip circles, trunk rotations, arm swings, leg swings, skipping, side shuffles, and lunges. Adding dynamic stretching to a training program has been shown to increase muscle power, agility, and sprint performance (9,10,27). Static stretching, on the other hand, is recommended after exercise to maximize muscle length. Stretching for 60–90 seconds per major muscle group is ideal after exercise.

RECOVERY, SLEEP, AND NUTRITION

As the body ages, sufficient recovery from training and racing is essential. In fact, recovery may be the most important part of the masters athlete's training plan. Muscular fatigue levels are similar in masters and younger athletes; however, muscles typically are slower to recover in the aging athlete (8). Athletes are most vulnerable to injury and illness in the period immediately after high-intensity training or racing (24). Hence, recovery is an essential part of the overall training program. Recovery can be built into a program by taking off days, getting extra sleep, and consuming ample recovery nutrition. Muscles rebuild,

Table 3 Resistance training recommendations for masters female athletes			
Phase	**Initial**	**Progression**	**Maintenance**
Goal	Neuromuscular adaptation and muscular strength	Accumulate muscular strength and power	Maintain muscular strength and power
Strength (2–3 d per wk)	4-6 sets × 6–10 reps 70–80% 1RM 2-min rest intervals	2-4 sets × 3–6 reps 85% 1RM 2- to 3-min rest intervals	3-4 sets × 4–8 reps 70–85% 1RM 2- to 3-min rest intervals
Power (1–2 d per wk)	Up to 6 exercises Total of 80–100 contacts per session Begin with lower-level skills	3-4 exercises 100-140 contacts per session Add in higher-level skills	3-4 exercises 50-100 contacts per session Mix of lower/higher-level skills

and connective tissues recover from training stress on these off days. It has been suggested that 1 hour of racing requires 3–5 days of recovery (24). Masters athletes should be encouraged to take time for recovery after demanding workouts and races.

The ultimate recovery, however, is sleep. The addition of 1 to 2 hours of extra sleep after an intense workout or race is recommended (24). However, getting the recommended 7 to 9 hours of sleep per night is often a challenge for older adults because of physiological changes in the brain and endocrine systems (21). After a regular sleep schedule, exercising at least 3 hours before bedtime, and unplugging from electronics before bed are advised to maximize nighttime sleep. A daytime nap between 20 and 90 minutes between 13:00 and 16:00 hours has been found to benefit athletes in physical and cognitive performance, perceptual measures, psychological state, and night-time sleep (18). Should the athlete have an intense workout planned but does not yet feel recovered or had a poor night of sleep, they should either take a complete rest day or perform easy exercise that creates less stress on the body (i.e., walking, yoga, or normal activities at lower intensity). Additional difficulties with sleep may present as the masters female athlete experiences menopause. Decreasing estrogen levels linked to increased levels of inflammatory cytokines along with declines in melatonin production contribute sleep disturbance in menopause (19). Nutritional management strategies may minimize sleep disturbance in masters female athletes through menopause. Consumption of adequate protein, phytoestrogens, fish rich in omega-3, low glycemic index foods, and foods rich in fiber is recommended to support sleep during menopause (19).

Table 4 Exercise suggestions for masters female athletes		
Exercise		
Upper-body strength	Seated row Bent-over row Lat pull-down Chest press Push-ups Shoulder press Biceps curls Bent-over triceps Shoulder internal/external rotation	
Lower-body strength	Back squat Front squat Goblet squat Leg press Calf raise Deadlift Lunge Split squat Step-ups Single-leg press Single-leg calf raise Single-leg deadlift	
Power—plyometrics[a]	Lower level: Jumping in place Small hops front to back Small hops side-to-side Skipping Bounding	Higher level: Squat jumps Split squat jumps Zigzag jumps Jump up to box Tuck jumps

[a]Progress to single-leg as desired.

Key nutrition-related concerns for the masters athlete include the need for adequate energy and protein intake for mitigating muscle and bone loss that occur with aging. Deficits in protein and energy levels can lead to a loss of muscle mass, strength, and function, resulting in compromised immune function and exercise performance (41). Within 30–60 minutes after workout, it is recommended to consume fuel at a ratio of 3:1 or 4:1 carbohydrate to protein (24). To promote postexercise muscle glycogen resynthesis, masters athletes should consume carbohydrates in the amount of 8.0-g/kg body mass/day for daily fuel needs and high training days (1,25). An additional 30- to 70-g carbohydrates per hour of exercise, depending on exercise intensity and duration, will further support immune system recovery after intense exercise sessions (30). A high-carbohydrate diet combined with 1–2 days of rest can replenish glycogen stores within 24 hours, which is especially beneficial for the masters athlete (24). Masters athletes should prioritize protein intake at all times (25). Masters athletes should consume 35–40 g/meal to meet a daily goal of ~1.5- to 1.6-g/kg body mass/day to optimize lean mass gains during resistance training (29).

Micronutrient intake is equally important in masters athletes, particularly for the following vitamins: vitamin A, vitamin D, vitamin E, vitamin C, vitamin B6, folate, thiamin, riboflavin, niacin, and vitamin B12 (41). Nutrient deficiencies may negatively affect aerobic capacity, muscle strength, muscle power, and endurance. Specifically, calcium and vitamin D supplementation may be warranted because vitamin D deficiency is common in athletes (41). Vitamin D can mitigate decreasing bone mass, aid in preventing bone stress injury, reduce inflammatory markers, enhance sleep, and improve sarcopenia in masters athletes (41). Recommended supplementation for calcium is 2000 mg/d and vitamin D 800–1500 IU/day to maximize bone health and reduce risk of stress fracture (17,41). Ultimately, masters female athletes should consume a diet rich in macronutrients, carbohydrates, proteins, and fats, focusing on increasing protein intake compared with younger athletes. A daily multivitamin can supplement vitamin and mineral needs. Further consultation with a registered dietician can identify energy intake needs and appropriate dietary recommendations accordingly. Table 5 presents nutritional guidelines for masters female athletes.

Relatedly, physiological changes in total body water, thirst sensation, and diminished kidney function occur with aging. Total body water declines from 80% in infancy to 60–70% in older adults (25). This, combined with a decrease in thirst sensation and a subsequent decrease in renal blood flow may lead to dehydration in masters athletes (25). Therefore, masters athletes must obtain adequate hydration to meet fluid needs of exercise. Consuming 2–3 L of fluid per day is recommended for masters female athletes (25).

CONCLUSION

Masters female athletes experience physiological changes with age that can affect training and performance. Cardiovascular changes include a reduction in maximal heart rate and maximal oxygen consumption. These changes are directly related to declines in lean body mass and loss of type II muscle fibers, which ultimately contribute to reduced overall muscle power and strength. Aging also leads to decreased joint range of motion and muscular flexibility. Hormonal changes related to menopause lead to increases in fat mass and decreases in bone mineral density, along with changing sleep patterns and dietary needs. Hence, considerations for exercise programming for the female masters athlete must be maximized to counteract the physiological losses that come with age while supporting nutrition, sleep, and recovery simultaneously.

Table 5
Nutritional needs for masters female athletes

	Carbohydrates	Protein	Fats	Calcium	Vitamin D
Recommended daily intake	≥ 8.0 g/kg (high-intensity training d) <2.5 g/kg (low-intensity training d)	≥ 1.2–1.6 g/kg	1–1.5 g/kg	2000 mg	800–1500 IU
Intake strategies	Before, during, and after high-intensity training sessions	> 30 g every 3–4 h	Moderate intake	Food sources preferred	Food sources preferred
Food sources	Whole grain foods (brown rice, cereals, and breads) Foods high in fiber Fruits and vegetables	Milk Eggs Yogurt Fish Lean meats Plant-based sources	Omega-3 rich-foods (nuts, avocado, and salmon)	Milk Eggs Cheese Yogurt	Milk Eggs Cheese Yogurt

Compiled from Desbrow et al. 2019 (1), Louis et al., 2020 (3), and Strasser et al., 2021 (4).

The strength and conditioning professional should recognize the cardiovascular, musculoskeletal, endocrine, and physiological changes that come with female aging. Initial screening for cardiovascular risk, musculoskeletal function, and lifestyle factors can assist in determining specific areas of focus for the masters female athlete. High-intensity, high-volume aerobic training is appropriate for masters female athletes without cardiovascular risk. Musculoskeletal training should include high-resistance exercises, eccentric activities, and stretching to maximize the loss in muscle mass and bone mineral density. Sleep, recovery, and nutrition should be prioritized to meet the needs of the masters female athlete to maximize their participation and performance in sport throughout the lifespan.

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