# Testing the Master Athlete

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Many sporting organisations define a Master athlete as an individual older than 35 years of age, who either trains for, or takes part in athletic competitions often specifically designed for older participants. Many of these athletes are experienced competitors who continue their athletic pursuits after their sports careers have ended, often transferring from another sport. Others include individuals who return to sport after extended periods of inactivity or simply participate and train sporadically for enjoyment and health benefits (Tayrose *et al.*, 2015). At the elite level these athletes, both men and women, show remarkably well-maintained performance into their mid-50's for all sports (Balmer *et al.*, 2005; Baker and Tang, 2010).

Trends for sport participation in younger age groups are generally in decline and activity of older age groups of the general population are either flat or are at best increasing very slightly. However, over the last 50 years, the size of competitive age-group competitions has grown significantly, with elite masters level competition flourishing (van Uffelen *et al.*, 2015). For example, the Sydney 2009 World Masters Games attracted a record 28,676 competitors. This is more than double the number of competitors that took part in the Sydney 2000 Olympic Games. Other indicators of increased participation include an increase in the proportion of over 40-year-old male finishers in the 'Ironman Switzerland' from 23% to 48% in the period 1995-2010 (Stiefel, Knechtle and Lepers, 2014). Participation rates in the marathon show that master athletes now make up ~55% (Lepers and Cattagni, 2012) of the total field growing to ~70% of the field in ultra-marathons (Knechtle *et al.*, 2012).

Possibly stemming from increased participation, age-categorised record performances have improved significantly over the last 50 years. For example, Ed Whitlock set a number of running world records in his later life, the most recent being the oldest person to complete the marathon in under 4 hours (age 85, 3 hours 56 minutes 34 seconds) and was estimated to have a $VO_2max$ close to 50 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ in his 80's (Lepers and Stapley, 2016). Remarkably, Robert Marchand set new world records for one hour track cycling of 26.927 km at age of 102 and then at 105 years of age set a record of 22.547 km. Examples from other sports demonstrate significant improvements in master athletes' times, much greater than comparative improvements for younger counterparts (Akkari, Machin and Tanaka, 2015).

Therefore, the likelihood of conducting physiological assessments on an older (master) athlete is high and possibly increasing. The aim of this chapter is to highlight and address additional considerations required when conducting standard tests described elsewhere in this book.

These considerations fall into two key areas:

1. Additional safety considerations related to the increased probability of underlying medical conditions with age; and
2. Adaptations to protocols and methodology to accommodate the age-related declines in physiological function with age.

**Safety and risks of exercise for the older athlete** (see also chapter 3.1)

The risk of sudden cardiac death (SCD) or acute myocardial infarction (AMI) is much higher in older exercisers, particularly recreational athletes, and this declines significantly with increasing levels of exercise frequency (Mittleman and Mostofsky, 2011) duration and intensity. The relative risk of SCD within 30 minutes of vigorous exercise for highly athletic populations is about 10.9 with the relative risk of AMI of 5.9 (Chugh and Weiss, 2015). One must consider this risk in light of the prevalence of SCD and AMI in the general sedentary population, which is about 50 times higher than those who are regular exercisers. In addition, the burden of SCD during sport across all age groups represents a small proportion (5% to 6%) of sudden deaths in the general population (Chugh and Weiss, 2015).

Data from the UK suggest that myocardial disease typically accounts for 40% of SCD in all athletes, being more prevalent in older athletes. The predominant causes were idiopathic left ventricular hypertrophy (LVH) and/or fibrosis and arrhythmogenic right ventricular cardiomyopathy (ARVC) (Finocchiaro *et al.*, 2016). The majority of athletes died during exertion (61%) and only a minority of subjects (8%) had a family history of sudden death. Unfortunately, we do not know the relationship between age and circumstances of death, but many of fatalities at rest are related to sudden arrhythmic death syndrome (SADS), which is more common in the younger athlete. The older athlete is more likely to die during exercise with Coronary Artery Disease (CAD) as the predominant cause of SCD (Chugh and Weiss, 2015; Finocchiaro *et al.*, 2016)). The significantly lower prevalence of arrhythmias in the older population suggests that pre-participation ECG screening may be of limited use. Although data from Jensen-Urstad *et al.*, (1998) suggests that abnormal arrhythmias are highly prevalent in elderly (>70 years of age) lifelong strenuous exercisers. Indeed, the European Society of Cardiology updated their ECG screening criteria in 2010 to distinguish training-related and training-unrelated changes (Corrado *et al.*, 2010). Morrison *et al.*, (2016)suggested that, while cardiac screening protocols do exist around the world, they have yet to be systematically and extensively evaluated particularly for their suitability for master athletes.

Below are a number of considerations and safeguards that the exercise physiologist should consider prior to conducting any physiological testing of master athletes. The purpose of this list is to guide the exercise physiologist in the development of appropriate protocols for their laboratory and thus there is not an expectation that everything item is included for every athlete, a pragmatic risk stratified approach is required.

1. Age

   The older the athlete, regardless of current activity level, the higher risk of a potential complication resulting from physiological testing.

2. Exercise history

   If an athlete is already exercising and/or training, one should pose pertinent questions about frequency and overall weekly duration of exercising/training; *i.e.*, is training ≥3h per week? Further, does an athlete's habitual exercise/training include high-intensity efforts (*i.e.*, intervals performed in the severe domain) and is the athlete competing on a regular basis?

3. Health history

> Employ the PAR-Q+ questionnaire and consider quantifying relative risk according to the European Society of Cardiology Systemic Coronary Risk Evaluation (SCORE). Since most deaths in the older athlete are from coronary artery disease, there needs to be consideration of the known risk factors and symptoms (e.g., presence of angina, syncope, or pre-syncope during or after exertion, or unusual fatigue, dyspnoea and/or palpitations). The use of the online SCORE assessment is an additional diagnostic resource, which can help detect CAD in master athletes.

4. Consider pre-screening ECG

> The European Society of Cardiology (ESC) 2005 criteria for resting ECG is effective at specifically detecting high risk cardiac conditions in master athletes (Panhuyzen-Goedkoop *et al.*, 2020). To prevent a high false positive rate with physiologically normal training-related changes, an experienced sport cardiologist will be best suited for the assessment of high-risk athletes. However, resting ECG screening is likely to result in a considerable number of false-negatives, thus should not be routine, nor accepted as a single source of information to assess risk.

5. Ensure that normal safety measures are in place *i.e*., suitably trained test administrators with knowledge of emergency first aid and effective use of an AED

> Unfortunately, in a high proportion (~2/3) of sports-related SCD, no cardio-pulmonary resuscitation (CPR) was administered (Marijon *et al.*, 2011), which undoubtedly contributed to the final (fatal) outcome. Therefore, it is important that appropriately trained staff with knowledge of AED use are present for all testing.

Even with master athletes there is a low risk of SCD or AMI with exercise and, with the appropriate pre-checks, continuous monitoring and emergency procedures in place, overall risk of significant cardiac events and fatalities during physiological exercise testing are extremely low and thankfully rare. Thus, we would direct institutional ethics committees to, with appropriate safeguards in place, accept that the routine testing of master athletes can be conducted with minimal risk to the participant.

**Recommendations for Exercise testing adaptations**

With an athlete's increasing age, the main adaptation linked to exercise testing will be to adjust an exercise test protocol to accommodate reductions in physical capacity. All physiological functions decline with age within the master category and this rate of decline is highly individualistic and modified by activity levels (Pollock *et al*. 2015).

Existing research confirms that all physiological systems decline with age. Each of these systems will decline at subtly different rates, influenced by the activity/training an individual habitually undertakes. Therefore, an observable change in performance of any individual sport will be influenced both by the predominance of a specific physiological system(s) and the typical/habitual training of that system(s).

A number of research studies have quantified the impact of age on the rate of decline in function and performance across a variety of sports. However, few studies have specifically considered the impact of ageing on the design and implementation of a testing protocol. This raises the question of the suitability of an otherwise standard testing protocol as one ages.

On average, for variables like $VO_2$max (Pollock *et al.*, 2015) and peak aerobic power (Balmer *et al.*, 2005), the decline for master athletes is in the range of 8-15% per decade. Elite athletes in many sports appear able to maintain relatively high levels of performance well into their 50s. However, despite debate about the nature of decline, it is likely that a reduction in physiological performance will exhibit an exponential fall from about the age of 35 years, a pattern that is evident in the performances for most sports. Further, events that require strength and/or anaerobic power experience the greatest rates of declines with age (Baker and Tang, 2010).

With this in mind, a starting exercise intensity, along with adjustments to the rate of subsequent ramp or step increments to ensure that these do not have a dramatic effect on the duration of a test. This will ensure the rate of change of measured physiological variable responses will be equitable between athletes, reducing the likely (negative) impact on the validity of specific test measures.

**Measurement of $VO_2$ max**

Absolute $VO_2$max declines with age and, even in lifelong exercisers, while a rate of functional decline may be slowed, it cannot be completely halted (Degens *et al.*, 2013; Valenzuela *et al.*, 2020). Interestingly, and counter-intuitively, for some components that contribute to measurable $VO_2$max, observed rates of decline are similar between highly active and sedentary individuals. This is particularly noticeable for ventilatory function (Degens *et al.*, 2013) where an age-related rate of decline is similar for most individuals. Such adverse changes will impact on function/performance and, therefore, should be considered in the context of the safe and effective design and implementation of testing methodologies. Due to these age-related functional reductions, older men and women are likely to perceive higher levels of exertional breathlessness.

Virtually all cardiopulmonary exercise testing (CPET) systems increase ventilatory dead space, which adds to the increasing physiological dead space related to increasing age. This may result in a disproportionate impact with older athletes. Further, many CPET systems will slightly increase the resistance to flow during inspiration and expiration. While this is meant to be negligible and imperceptible, a recent study has demonstrated variability between different systems (Beltrami *et al.*, 2021), which could potentially impact more on the exercise tolerance of older athlete who naturally possess a reduced respiratory muscle strength and performance. Commonly a masters athlete may identify that a CPET system facemask or mouthpiece causes acute dyspnoea and it is likely that this effect may become increasingly evident at higher relative or maximal exercise intensities. Indeed, it was recently demonstrated that increasing the mechanical (ventilatory) constraint during moderate, constant load exercise in older adults did not increase the sensation of breathlessness (Molgat-Seon *et al.*, 2019).

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