Anthropometric, physical function and general health markers of Masters athletes: a cross-sectional study (#17871)

First submission

Please read the **Important notes** below, the **Review guidance** on page 2 and our **Standout reviewing tips** on page 3. When ready **submit online**. The manuscript starts on page 4.

Important notes

Editor and deadline

Scotty Butcher / 2 Jun 2017

Files	3 Figure file(s) 3 Table file(s) 3 Raw data file(s) 1 Other file(s) Please visit the overview page to **download and review** the files not included in this review PDF.
Declarations	**Involves the study of human participants/human tissue.**

Review guidelines

Please read in full before you begin

How to review

When ready **submit your review online**. The review form is divided into 5 sections. Please consider these when composing your review:

1. **BASIC REPORTING**
2. **EXPERIMENTAL DESIGN**
3. **VALIDITY OF THE FINDINGS**
4. General comments
5. Confidential notes to the editor

You can also annotate this PDF and upload it as part of your review

To finish, enter your editorial recommendation (accept, revise or reject) and submit.

BASIC REPORTING

- Clear, unambiguous, professional English language used throughout.
- Intro & background to show context. Literature well referenced & relevant.
- Structure conforms to **PeerJ standards**, discipline norm, or improved for clarity.
- Figures are relevant, high quality, well labelled & described.
- Raw data supplied (see **PeerJ policy**).

EXPERIMENTAL DESIGN

- Original primary research within **Scope of the journal**.
- Research question well defined, relevant & meaningful. It is stated how the research fills an identified knowledge gap.
- Rigorous investigation performed to a high technical & ethical standard.
- Methods described with sufficient detail & information to replicate.

VALIDITY OF THE FINDINGS

- Impact and novelty not assessed. Negative/inconclusive results accepted. *Meaningful* replication encouraged where rationale & benefit to literature is clearly stated.
- Data is robust, statistically sound, & controlled.
- Conclusions are well stated, linked to original research question & limited to supporting results.
- Speculation is welcome, but should be identified as such.

The above is the editorial criteria summary. To view in full visit **https://peerj.com/about/editorial-criteria/**

7 Standout reviewing tips

The best reviewers use these techniques

Tip	***Example***
Support criticisms with evidence from the text or from other sources	*Smith et al (J of Methodology, 2005, V3, pp 123) have shown that the analysis you use in Lines 241-250 is not the most appropriate for this situation. Please explain why you used this method.*
Give specific suggestions on how to improve the manuscript	*Your introduction needs more detail. I suggest that you improve the description at lines 57- 86 to provide more justification for your study (specifically, you should expand upon the knowledge gap being filled).*
Comment on language and grammar issues	*The English language should be improved to ensure that your international audience can clearly understand your text. I suggest that you have a native English speaking colleague review your manuscript. Some examples where the language could be improved include lines 23, 77, 121, 128 – the current phrasing makes comprehension difficult.*
Organize by importance of the issues, and number your points	*1. Your most important issue* *2. The next most important item* *3. …* *4. The least important points*
Give specific suggestions on how to improve the manuscript	*Line 56: Note that experimental data on sprawling animals needs to be updated. Line 66: Please consider exchanging “modern” with “cursorial”.*
Please provide constructive criticism, and avoid personal opinions	*I thank you for providing the raw data, however your supplemental files need more descriptive metadata identifiers to be useful to future readers. Although your results are compelling, the data analysis should be improved in the following ways: AA, BB, CC*
Comment on strengths (as well as weaknesses) of the manuscript	*I commend the authors for their extensive data set, compiled over many years of detailed fieldwork. In addition, the manuscript is clearly written in professional, unambiguous language. If there is a weakness, it is in the statistical analysis (as I have noted above) which should be improved upon before Acceptance.*

Anthropometric, physical function and general health markers of Masters athletes: a cross-sectional study

Samantha Fien Corresp., [1] , **Mike Climstein** Corresp., [2, 3] , **Clodagh Quilter** Corresp., [1, 4] , **Georgina Buckley** Corresp., [1, 4] , **Timothy Henwood** Corresp., [1, 5, 6] , **Josie Grigg** Corresp., [1] , **Justin W. L. Keogh** Corresp. [1, 7, 8]

[1] Health Science and Medicine, Bond University, Robina, Queensland, Australia
[2] Water Based Research Unit, Faculty of Health Sciences, Bond University, Robina, Queensland, Australia
[3] Exercise Health & Performance Faculty Research Group, The University of Sydney, Lidcombe, New South Wales, Australia
[4] Physical Education and Sport Sciences, University of Limerick, Dublin, Ireland
[5] School of Human Movement and Nutritional Science, University of Queensland, Brisbane, Queensland, Australia
[6] Community Wellness and Lifestyle, Southern Cross Care (SA & NT) Inc., Adelaide, South Australia, Australia
[7] Human Potential Centre, Auckland University of Technology, Auckland, New Zealand
[8] Cluster for Health Improvement, Faculty of Science, Health, Education and Engineering, University of the Sunshine Coast, Sunshine Coast, Queensland, Australia

Corresponding Authors: Samantha Fien, Mike Climstein, Clodagh Quilter, Georgina Buckley, Timothy Henwood, Josie Grigg, Justin W. L. Keogh
Email address: samantha.fien@student.bond.edu.au, mike.climstein@sydney.edu.au, 14154889@studentmail.ul.ie, 14154749@studentmail.ul.ie, tim.henwood@southerncrosscare.com.au, jgrigg@bond.edu.au, jkeogh@bond.edu.au

Once the general decline in muscle mass, muscle strength and physical performance falls below specific thresholds, the middle or older adult will be diagnosed as having sarcopenia (a loss of skeletal muscle mass and strength). Sarcopenia contributes to a range of adverse events in older age including disability, hospitalisation, institutionalisation and falls. The European Working Group on Sarcopenia for Older People (EWGSOP) framework is commonly used to better understand factors contributing to sarcopenia and interventions which may minimise its negative effects. One potentially relevant but understudied population for sarcopenia researchers would be Masters athletes. Masters sport is becoming more common as it allows athletes (typically 40 years and older) the opportunity to participate in individual and/or team sports against individuals of similar age. This study examined a variety of measures of anthropometric, physical function and general health markers in the male and female Masters athletes who competed at the 2014 Pan Pacific Masters Games held on the Gold Coast, Australia. Bioelectric impedance analysis (BIA) was used to collect body fat percentage, fat mass and fat-free mass; with body mass, height, body mass index (BMI) and sarcopenic status also recorded. Physical function was quantified by handgrip strength and habitual walking speed; with general health described by the number of chronic diseases and prescribed medications. Between group analyses utilised ANOVA and Tukey's post-hoc tests to examine the effect of age group (40-49, 50-59, 60-69 and > 70 years old) on the outcome measures for the entire sample as well as the male and female sub-groups. A total of 156 athletes (78 male, 78 female; mean age

55.[illegible] years) provided informed consent to participate in this study. These athletes possessed substantially better anthropometric, physical function and general health characteristics than the literature for their less physically active age-matched peers. No Masters athletes were categorised as being sarcopenic, although one participant had below normal physical performance and six participants had below normal muscle strength. In contrast, significant age-related reductions in handgrip strength and increases in the number of chronic diseases and prescribed medications were observed for the overall cohort as well as the male and female sub-groups. Nevertheless, even those aged over 70 years only averaged one chronic disease and one prescribed medication. These results further support the view that participation in Masters sport helps to maintain anthropometry, physical function and general health in middle-aged and older adults. Future research should utilise longitudinal research designs that compare the age-related changes experienced by Masters athletes and age-matched non-Masters athletes to better quantify the benefits of Masters sport participation.

Anthropometric, physical function and general health markers of Masters athletes: a cross-sectional study

Samantha Fien [1], Mike Climstein [2,3], Clodagh Quilter [1,4], Georgina Buckley [1,4], Tim Henwood [5,6,1], Josie Grigg [1], Justin WL Keogh[1,6,7]

[1] Faculty of Health Sciences, Bond University, Gold Coast, QLD, Australia

[2] Water Based Research Unit, Faculty of Health Sciences, Bond University, Gold Coast, QLD, Australia

[3] Exercise Health & Performance Faculty Research Group, Faculty of Health Sciences, The University of Sydney, Lidcombe, NSW, Australia

[4] Physical Education and Sport Sciences, University of Limerick, Ireland

[5] School of Human Movement and Nutritional Science, University of Queensland, Brisbane, QLD, Australia

[6] Southern Cross Care (SA & NT) Inc, Adelaide, South Australia, Australia

[7] Human Potential Centre, AUT University, Auckland, New Zealand

[8] Cluster for Health Improvement, Faculty of Science, Health, Education and Engineering, University of the Sunshine Coast, Sunshine Coast, QLD, Australia

Corresponding Author: Samantha Fien

Faculty of Health Sciences,

Bond University

14 University Drive, Robina, QLD, AUSTRALIA 4226

Phone: 0402 479 015   Fax: +61 7 5595 4480

Samantha.fien@student.bond.edu.au

Anthropometric, physical function and general health markers of Masters athletes: a cross-sectional study

INTRODUCTION

The field of gerontological research has sought to characterize the rate of age-related decline in physical function and overall health and wellness. For example, it has been found that in sedentary individuals VO_2max decreases by 10% per decade after the age of 30 years (Lepers & Stapley, 2016). The ageing process is also commonly associated with declines in muscle mass and strength that subsequently lead to functional declines, physical disability and falls (Wroblewski, Amati, Smiley, Goodpaster, & Wright, 2011). This age-related decline in muscle mass and physical function is termed sarcopenia. According to the European Working Group for Sarcopenia in Older People (EWGSOP), sarcopenia has been defined as '*the loss of skeletal muscle mass and strength that occurs with advanced aging'* and represents a diminished state of health (Cruz-Jentoft et al., 2010). The diagnosis of sarcopenia is based upon an individual's muscle mass, muscular strength and physical performance. While the EWGSOP endorsed a variety of assessments of muscle mass, strength and physical performance, Bioelectric impedance analysis (BIA), handgrip strength and gait speed are valid assessments that are commonly used during field based testing (Cruz-Jentoft et al., 2010).

A recent systematic review of studies using the EWGSOP sarcopenia diagnostic criteria has demonstrated sarcopenia prevalence rates of 1-29% in community dwelling adults over the age of 50 years, 14-33% in older adults in long-term care and 10% in acute hospital-care older populations (Cruz-Jentoft et al., 2014). Such results suggest that the rate of sarcopenia increases with age and the degree of aged care, with data from our group reporting sarcopenia prevalence rates of ~40% in Australian aged care settings (Senior, Henwood, Beller, Mitchell, & Keogh, 2015). It is perhaps even more alarming that residential aged care facilities may have up to 85% of residents below normal thresholds for muscle strength and 97% below the threshold for physical performance (Keogh, Senior, Beller, & Henwood, 2015). The increased prevalence of sarcopenic handgrip strength and gait speed is consistent with the study of 415 older adults between the age of 60 – 99 years, in which the age-related decline in handgrip strength and gait speed was greater than for muscle mass (Bai et al., 2016). There is also a general age-related increase in the number of chronic diseases and prescribed medications, with these again often being greater in residential aged care than community dwelling older adults. Specifically, Australian residential aged care adults have been reported to have an average of 14–15 chronic diseases and 11-15 prescribed medications (Fien, Henwood, Climstein, & Keogh, 2016; Keogh et al., 2015).

One segment of the middle-aged and older community dwelling community that would appear of interest to sarcopenia researchers are Masters athletes (McKean, Manson, & Stanish, 2006; Pantoja, De Villarreal, Brisswalter, PeyrÉ-Tartaruga, & Morin, 2016; Ransdell, Vener, & Huberty, 2009; Wroblewski et al., 2011). Masters athletes are typically individuals aged 40 years or older who systematically train and compete in one or more individual or team sports (Lepers & Stapley, 2016). With an ageing of the population and the growing interest in prolonging health and wellbeing there has been a rise in the number of Masters athletes, with recent data for the New York marathon indicating that more than 50% of the total male finishers and more than 40% of female finishers were Masters athletes (Lepers & Stapley, 2016). As some Master athletes may have extensive training backgrounds for many decades, they may be an ideal population for gerontological and sarcopenic research. Given their continued levels of sports and activity participation, it would be hypothesised that Masters athletes would have better health than their same aged, but less active peers. To this end, Masters athletes may allow researchers to better understand the true magnitude of the age-related decline in physical function (Geard, Reaburn, Rebar, & Dionigi, in press; Young, Weir, Starkes, & Medic, 2008).

Typically, studies of Masters athletes demonstrate age-related decline in anthropometry, physical function and general health markers, but ~~that~~ these declines are less pronounced and typically occur at an older age than in the wider population (Borges, Reaburn, Driller, & Argus, 2016). For example, in a cross sectional study of 40 high level Masters athletes (20 males and 20 female, aged 40 to 81 years) who trained 4-5 times week, age was significantly correlated to body mass index (BMI) and body fat percentage (Wroblewski et al., 2011). When all 40 participants were pooled together, significant declines in quadriceps peak torque were only observed for the participants 60 years and older (Wroblewski et al., 2011). In another study of 35 Masters athletes aged 30-35, 35-45 and >45 years, anaerobic capacity was assessed with the Wingate anaerobic test as well as lower body and upper body isoacceleration dynamometry. The major results of this study was that 30-35 and 35-45 year old groups were not significantly different across any of the anaerobic parameters; with significant decrements only being observed in those aged over 45 years. It was also observed that ~~the~~ age-related decline in muscular power for the Masters athletes 45 years and older was greater than that for muscular strength or velocity (Gacesa, 2017). Body mass index has also been used as an indicator of general health in several studies of Masters athletes (Climstein et al., in press; Walsh et al., 2011; Walsh, Climstein, Heazlewood, Kettunen, et al., 2013). The largest of these studies examined the BMI of 6,071 master’s athletes (51.9% male and 48.1% female) aged 2[illegible]91 years of age competing in the Sydney World Masters Games in 2009 (Walsh et al., 2011). While a significant positive correlation was found between age and BMI, Masters athletes demonstrated significantly lower BMI than age-matched controls (Walsh et al., 2011).

While a number of studies have described the BMI and performance of Masters athletes, little is known about Masters Athletes wider anthropometric, functional and general health characteristics; how these factors may change with ageing and how they compare to age-matched, community dwelling controls. The aims of this cross-sectional study were to: 1) characterize the body composition, muscle strength, physical function, number of chronic diseases and medications in Masters athletes; and 2) gain some insight into how these factors might be influenced by the age and gender of the Masters athletes. It was hypothesized that; 1) Masters athletes across multiple age groups will exhibit high levels of muscle mass, handgrip strength, gait speed and lower levels of chronic disease and prescribed medication usage; and 2) these outcomes will be significantly greater in male than female and younger rather than older Masters athletes. Masters athletes in this context may provide a suitable research model to look at the true physiological changes associated with age.

METHODS

Study design

This research utilized cross-sectional observational study design to characterize the body composition, muscle strength, physical function and overall health and wellness of Masters athletes competing at the 2014 Pan Pacific Masters Games, Gold Coast, Australia. This study received approval by the Bond University Human Research Ethics Committee (RO1823) in accordance with the ethical standards of the Helsinki Declaration of 1975 (revised in 2008).

Sample

Eligible participants for this study included all competitors (national and international) who were participating in at least one sport (out of 43 sports available at the 2014 Pan Pacific Masters Games. Following attainment of informed consent (verbal and written) to participate all participants initially completed a brief questionnaire, which included basic demographics (age, sport(s), and training time) and a medical health history questionnaire (chronic disease(s) and prescribed medications).

Anthropometry

Height was assessed using a stadiometer to an accuracy of 0.5cm. Body mass and body composition was assessed using a Tanita BIA body composition analyzer (Model MC-980MA, Illinois, USA) (Kelly & Metcalfe, 2012). The BIA analyzer was calibrated each morning prior to any assessments. Participants were to have avoided strenuous exercise for the previous 24 hours, bladder void and be hydrated prior to body composition assessment. The subjects were instructed to remove footwear, step onto the BIA machine and follow the directions of the machine whilst holding the electrodes in each hand. The BIA uses an algorithm based on the relative electrical resistance in lean tissue, fat and water to calculate body composition measures. The Tanita uses four reference points in the body, both hands and both feet and then produces a complete report of fat and muscle percentage. The Australian general population data was used (aged 35 years and older) available from the 2011-2012 Australian Bureau of Statistics Australian Health Survey were used for comparative purposes (Australian Bureau of Statistics, 2012).

The anthropometric data collected allowed for each participant to be screened for sarcopenia according to EWGSOP guidelines (Cruz-Jentoft et al., 2010). The EWGSOP screening algorithm consisted of assessing gait speed, handgrip strength and muscle mass (i.e., lean mass). Figure 1 depicts the EWGSOP tests.

Insert figure 1 about here

Handgrip strength

Handgrip strength was assessed on the dominant hand using a hand-held dynamometer (Jamar handgrip dynamometer, Sammons Preston Roylan, Bolingbrook, IL, USA). The dynamometer handle grip width was individualized for each participant. Individuals performed the handgrip by holding their preferred hand in front of the shoulder, with the elbow bent at a 90° angle and instructed to squeeze the dynamometer as hard as possible for three seconds. Two attempts were allowed with the maximum force (kg's) recorded (Reijnierse et al., 2017). Participants were allowed a brief rest period (~1min) between the two trials, with the maximum force produced across the two attempts utilised for statistical purposes.

Gait speed

Gait speed was recorded using a computer interfaced electronic system (GaitMat II, EQInc; Model GaitMat II, USA), which required participants to walk across a 3.66 m (11.91 ft.) long pressure mat system(McDonough, Batavia, Chen, Kwon, & Ziai, 2001). Participants completed two trials at their habitual gait speed in regular footwear. All participants were provided the following instructions: "Walk towards the end of the room in the center of the mat at a pace that is comfortable for you". All participants initiated from a standing start 2 m (6.56 ft.) from the gait analysis platform in order to minimize the effects that either acceleration or deceleration may have on the outcome measures (Kressig et al., 2004). Participants were permitted to have as much rest as was required between measures, with rest times typically being up to one minute. The fastest of each participant's two trials was kept for statistical analysis.

Self-reported data

Participants in this study were also asked a series of questions regarding their number of years participating in Master sports, the number of hours training they would average in a typical training week as well as their number of chronic diseases and prescribed medications.

Statistical analysis

All data was initially inspected for normality by investigating kurtosis, skewness, Q-Q plots, as well as the Kolmogorov-Smirnov test with the Lilliefors significance correction. Heteroscedasticity was also assessed using Levene's test for the equality of variances. Overall group data were presented as means and standard deviations for continuous measures and counts (percentages) for categorical data. Between group comparisons were conducted on the basis of gender (male and female) and age (40-49 years; 50-59 years; 60-69 years; or ≥ 70 years) using one-way ANOVA and Tukey post-hoc tests. As many significant gender-related differences were observed and as there were some gender-related variation in the proportions of athletes across the age groups, data is presented for the entire sample as well as for females and males separately. A single sample t-test was performed to compare the height, mass and BMI of the Masters athletes (genders combined) to Australian Bureau of Statistics (2012). All statistical analyses were performed with SPSS (Ver. 22.0.0.0), with statistical significance for all analyses accepted at $p < 0.05$.

RESULTS

A total of 156 individuals (78 males (aged 40 to 86 years) and 78 females (aged 40 to 77 years) Pan Pacific Master Games sports athletes volunteered to participate in this study. One hundred and forty-nine individuals competed in one sport at the Games, with the remaining seven competing in multiple sports. With regard to chronic diseases, a total of 40 participants (25.4%) reported having one or more chronic diseases, the most common of which was hypertension (55%), followed by diabetes mellitus (35%). A total of 18 participants reported having two or more chronic diseases, most commonly hypertension and dyslipidemia. The majority (77.6%) of the Masters athletes had no prescribed medications; with the majority of the remaining athletes (~11%) having one medication. There was no difference between genders with regard to the number of athletes being prescribed medications (males 16, females 19). The most commonly prescribed medications were anti-hypertension (55%) followed by oral hypoglycaemic agents (35%).

The anthropometric, functional, training and health descriptors of the overall sample is provided in Table 1. The only anthropometric variable where age-related differences were observed was height, where the 50 to 59 year-old athletes were significantly taller than the 60 to 69 year-old athletes ($p = 0.003$). From a functional perspective, there was a significant age-related decline in handgrip strength ($p = 0.003$) but no significant difference in habitual gait speed ($p = 0.673$). There was a significant age-related increase in the number of chronic diseases ($p = 0.017$) and prescribed medications ($p = 0.015$).

Please insert table 1 about here

With regard to comparison to the Australian general population, as a group the Masters athletes were significantly taller (+2.9%, $p<0.001$), slightly lighter (-2.7%) and a significantly lower BMI

(-8.5%, p<0.001). Figure 2 provides a representation of the proportion of individuals defined as underweight, normal weight, overweight or obese by sample and sex.

Please insert figure 2 about here

Due to their high level of lean muscle mass, no participants were described as being sarcopenic. However, the number of participants who were identified as having handgrip muscle strength (n = 6) or physical performance outcomes (n = 1) below the sarcopenic cut-points (Cruz-Jentoft et al., 2010) are included in Figure 3.

Please insert figure 3 about here

The anthropometric, functional, training and health descriptors of the 78 male Masters athletes are provided in Table 2. No significant age-related differences were observed for any anthropometric variables. Inspection of the functional outcomes revealed a significant age-related decline in handgrip strength ($p < 0.001$) but no significant differences in habitual gait speed ($p = 0.930$). There was a significant age-related increase in chronic diseases ($p < 0.001$) and prescribed medications ($p < 0.001$).

Please insert table 2 about here

The anthropometric, functional, training and health descriptors of the 78 female Masters athletes are provided in Table 3. There were typically no significant age-related differences observed for any anthropometric variables. The only exception was height which was found to be significantly greater in the 50 to 59 year than 60 to 69-year-old age group ($p = 0.003$). Inspection of the functional outcomes revealed a significant age-related decline in handgrip strength ($p = 0.003$) but no significant differences in habitual gait speed ($p = 0.673$). There was a significant age-related increase in chronic diseases (p = 0.017) and prescribed medications (p = 0.015).

Please insert table 3 about here

DISCUSSION

The primary results of this study indicated that the male and female Masters athletes who participated in this study possessed substantially better anthropometric, functional and health characteristics than their physically less active age-matched peers. Our data indicated that when the anthropometric, functional and health characteristics were compared for the Masters athletes across the 10 year age groups, almost no significant age-related differences were observed. In contrast, our data indicated significant age-related reductions in handgrip strength and increases in the number of chronic disease and prescribed medications.

When compared to the Australian Bureau of Statistics (2012) BMI data, it was apparent that the Masters athletes had better body composition. In particular, while only 29% of the general population have a BMI indicative of underweight or normal ~~body composition~~, approximately 49% of the Masters athletes were in these categories. Further, while ~32% of the Australian adult population was classified as obese (BMI $\geq$30.0kg/m^2), only ~13% of the Masters athletes were obese. Such results were consistent with previous research that demonstrated that a high proportion of Masters athletes maintain a healthy BMI even into older age (Climstein et al., in press; Walsh et al., 2011; Walsh, Climstein, Heazlewood, Kettunen, et al., 2013). As obesity is a well-recognized risk factor for many chronic diseases including hypertension (resting blood pressure $\geq$ 140/90mmHg), cardiovascular disease, type 2 diabetes mellitus, obstructive sleep apnea and a number of cancers (Lavie, Milani, & Ventura, 2009; Pi-Sunyer, 2009), it would appear that long-term Master sports participation minimizes the age-related increase in body fat and the risk for many chronic diseases (Climstein et al., in press; McKean et al., 2006; Pratley, Hagberg, Rogus, & Goldberg, 1995).

Subgroup analyses within the current study indicated that the differences in BMI and obesity rates between the Masters athletes and the wider Australian population were more pronounced for females than males. Specifically, ~63% of the female compared to ~35% male Masters athletes were classified as being underweight or normal weight; with only ~8% of female and 19% of male Masters athletes being obese. This tendency for the female Masters athletes to report greater relative benefits than the male Masters athletes in terms of their BMI and obesity rates appeared consistent with Climstein and colleagues (in press) for the rates of chronic disease. Such results may suggest that middle-aged and older females may obtain significantly greater body composition and chronic disease benefits from participation in Masters sport than men of similar age.

Another important aspect of maintaining health and function in ageing is the ability to maintain muscle mass. None of the 114 Masters athletes aged 50 years and older (48 of who were 60 years or older) in the current study were diagnosed as having sarcopenia, based upon the EWGSOP criteria. Such prevalence rates for sarcopenia in the current study are substantially lower than the 1-29% rates reported for community dwelling adults over the age of 50 years in a systematic review ~~of 15 studies assessing sarcopenia prevalence rates using the same EWGSOP criteria used in the current study~~ (Cruz-Jentoft et al., 2014). Inspection of the other components of the sarcopenia diagnosis (muscle strength and physical performance) indicated that only 3.8% of the participants were below the sarcopenic handgrip strength cutpoints and 0.6% were below the sarcopenic gait speed cutpoints. As ~85% and ~97% of Australian aged care residents may be below the sarcopenic handgrip strength and gait speed thresholds, respectively (Keogh et al., 2015), our data suggest that Master athletes levels of muscular strength and physical function place them at very low risk of adverse health events and entry into residential aged care (Abellan van Kan et al., 2009).

Results of the current study also indicated a very low prevalence of chronic diseases and medications in the Masters athletes. Such a result was consistent with Climstein and colleagues (in press) who observed a low rate of cardiovascular disease in Masters athletes. While the current study observed a significant age-related increase in the number of chronic diseases and prescribed medications, even those Masters athletes who were 70 years old or older only reported an average of one chronic disease and one prescribed medication per individual. This number of chronic diseases and medications was consistent with Climstein and colleagues (in press) and is substantially less than community dwelling older adults of similar age, especially those in residential aged care. This is exemplified by recent Australian data in which older adults living in residential aged care may average 14–15 chronic diseases and 11-15 prescribed medications per individual (Fien et al., 2016; Keogh et al., 2015).

The results of this current study and the remainder of the somewhat limited literature regarding Masters athletes strongly support the promotion of physical activity and sport across the lifespan. This promotion of a lifetime engagement in physical activity and sport may provide middle-aged and older individuals as well is the wider community a host of benefits. Physical activity and sport participation can have a variety of physiological benefits that reduce or even reverse the age-related declines in muscle mass, strength and performance (Fien et al., 2016; Kanamori et al., 2012). Sports participation also provides a range of social benefits (Kanamori et al., 2012), with this especially important for older adults who may experience declines in the size and quality of their social networks that accelerated when they retire from full-time employment

(Julien, Gauvin, Richard, Kestens, & Payette, 2013). From an economic perspective, older adults typically utilise a very high proportion of most nations' health care expenditure due to the number of their chronic diseases, prescribed medications and falls-related injuries (Manini & Pahor, 2009). Of particular concern is ~~that~~ the 20% of older adults who are no longer independent due to functional limitations have been shown to account for 46% of the health care expenditure (Manini & Pahor, 2009). In absolute terms, this represents a $5,000 per year greater healthcare expenditure for each older adult with functional limitations compared to those who have maintained their physical independence (Manini & Pahor, 2009). Such savings in healthcare expenditure compared to dependent older adults, may be even greater in Masters athletes than that reported for independent older adults. Specifically, data from the present study indicating that the 48 Masters athletes over the age of 60 years typically averaged only one chronic disease and one prescribed medication. This contrasts with Australian data in which over half of Australian adults aged 65 years and older have at least five chronic diseases (Australian Institute of Health and Welfare, 2014).

The primary strength of the study was the sample size of 156 Masters athletes. While a few studies of Masters athletes have had sample sizes that exceeded 400 participants (Climstein et al., in press; Walsh et al., 2011; Walsh, Climstein, Heazlewood, Debeliso, et al., 2013; Walsh, Climstein, Heazlewood, Kettunen, et al., 2013), all of these studies with the exception of Climstein and colleagues (in press) only collected BMI and used this to estimate obesity rates. In comparison, Masters athlete studies that involved a greater number of outcome measures or utilised more advanced data collection approaches have typically obtained much smaller sample sizes (n = 6–40) than that used in our study (Gacesa, 2017; Pantoja et al., 2016; Power et al., 2016; Pratley et al., 1995; Wroblewski et al., 2011; Young et al., 2008).

The major limitation of this study was that the study was cross-sectional rather than longitudinal in design. This meant that while age-related differences between the age groups could be described, true age-related changes that would be observed in individuals as they age could not be quantified (Young et al., 2008). Nevertheless, the data did indicate the favorable anthropometry, functional and health characteristics of the Masters athletes compared to data reported for less physically active, age-matched individuals. There was also some imbalance in the male and female ratios for 50-59 and 60-69 year old age groups which may have contaminated the overall sample data. Age-related analyses for the 78 male and 78 female Masters athletes were therefore performed separately in addition to data presented for the overall cohort of 156 athletes. It is also unclear how the athletes who participated in the study may differ to the athletes who did not participate in the study and if there was any recruitment bias whereby the more functional and healthy Masters athletes would be more likely to participate than their less functional or healthy peers.

CONCLUSIONS

The results of this study indicate that Masters athletes possess more favourable anthropometric, functional and health characteristics than the age-matched general community who are typically much less physically active. Further, comparisons of the decade age groups also indicated that the majority of these characteristics were well maintained from middle to older age in the Masters athletes. Such data supports the promotion of a lifespan physical activity and sport public health message, with such participation having a range of physical, social and economic benefits for the individual and the wider community. Future research in this area should look to include a wider range of health and functional outcomes and utilize longitudinal case-control research designs to better compare the age-related changes in these outcomes between Masters Athletes and their less active age-matched peers.

ACKNOWLEDGEMENTS

We would like to thank the organisers and athletes of the 2014 Pan Pacific Masters Games for their assistance in conducting the study. We would also like to thank the Bachelor of Exercise and Sport Science students from the Faculty of Sport and Exercise Science, Bond University who helped to collect the data.

References:

Abellan van Kan, G., Rolland, Y., Andrieu, S., Bauer, J., Beauchet, O., Bonnefoy, M., . . . Vellas, B. (2009). Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. *Journal of Nutrition, Health and Aging, 13*(10), 881-889.

Australian Bureau of Statistics. (2012). Australian Health Survey: First Results, 2011-12, http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0012011-12?OpenDocument.

Australian Institute of Health and Welfare. (2014). Australia's Health 2014 *Australia's health series no. 14. Cat. no. AUS 178*. Canberra: Australian Institute of Health and Welfare.

Bai, H. J., Sun, J. Q., Chen, M., Xu, D. F., Xie, H., Yu, Z. W., . . . Cheng, S. (2016). Age-related decline in skeletal muscle mass and function among elderly men and women in Shanghai, China: a cross sectional study. *Asia Pacific Journal of Clinical Nutrition, 25*(2), 326-332. doi: 10.6133/apjcn.2016.25.2.14

Borges, N., Reaburn, P., Driller, M., & Argus, C. (2016). Age-Related Changes in Performance and Recovery Kinetics in Masters Athletes: A Narrative Review. *Journal of Aging & Physical Activity, 24*(1), 149-157. doi: 10.1123/japa.2015-0021

Climstein, M., Walsh, J., Debeliso, M., Heazlewood, T., Sevene, T., & Adams, K. (in press). Cardiovascular risk profiles of world masters games participants. *Journal of Sports Medicine and Physical Fitness*.

Cruz-Jentoft, A. J., Baeyens, J. P., Bauer, J. M., Boirie, Y., Cederholm, T., Landi, F., . . . European Working Group on Sarco[illegible]a in Older, P. (2010). Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on

Sarcopenia in Older People. *Age & Ageing, 39*(4), 412-423. doi: 10.1093/ageing/afq034

Cruz-Jentoft, A. J., Landi, F., Schneider, S. M., Zuniga, C., Arai, H., Boirie, Y., . . . Cederholm, T. (2014). Prevalence of and interventions for sarcopenia in ageing adults: a systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). *Age and Ageing, 43*(6), 748-759. doi: 10.1093/ageing/afu115

Fien, S., Henwood, T., Climstein, M., & Keogh, J. W. L. (2016). Feasibility and benefits of group-based exercise in residential aged care adults: a pilot study for the GrACE programme. *PeerJ, 4*, e2018. doi: 10.7717/peerj.2018

Gacesa, J. (2017). Anaerobic Strength and Power in Master Athletes. *Sports Medicine International Open, 01*(01), E30-E36. doi: 10.1055/s-0042-123695

Geard, D., Reaburn, P., Rebar, A., & Dionigi, R. (in press). Masters Athletes: Exemplars of successful aging? *Journal of Aging & Physical Activity*. doi: 10.1123/japa.2016-0050

Julien, D., Gauvin, L., Richard, L., Kestens, Y., & Payette, H. (2013). The role of social participation and walking in depression among older adults: results from the VoisiNuAge study. *Canadian Journal on Aging, 32*(1), 1-12. doi: 10.1017/s071498081300007x

Kanamori, S., Kai, Y., Kondo, K., Hirai, H., Ichida, Y., Suzuki, K., & Kawachi, I. (2012). Participation in sports organizations and the prevention of functional disability in older Japanese: the AGES Cohort Study. *PLoS One, 7*(11), e51061. doi: 10.1371/journal.pone.0051061

Kelly, J. S., & Metcalfe, J. (2012). Validity and Reliability of Body Composition Analysis Using the Tanita BC418-MA. *Journal of Exercise Physiology Online, 15*(6), 74-83.

Keogh, J. W., Senior, H., Beller, E. M., & Henwood, T. (2015). Prevalence and risk factors for low habitual walking speed in nursing home residents: an observational study. *Archives* *of Physical Medicine and Rehabilitation, 96*(11), 1993-1999. doi: 10.1016/j.apmr.2015.06.021

Kressig, R. W., Gregor, R. J., Oliver, A., Waddell, D., Smith, W., O-Grady, M., . . . Wolf, S. L. (2004). Temporal and spatial features of gait in older adults transitioning to frailty. *Gait Posture., 20*(1), 30-35.

Lavie, C. J., Milani, R. V., & Ventura, H. O. (2009). Obesity and cardiovascular disease: risk factor, paradox, and impact of weight loss. *Journal of the American College of Cardiology, 53*(21), 1925-1932. doi: 10.1016/j.jacc.2008.12.068

Lepers, R., & Stapley, P. J. (2016). Master Athletes Are Extending the Limits of Human Endurance. *Frontiers in Physiology, 7*, 613. doi: 10.3389/fphys.2016.00613

Manini, T. M., & Pahor, M. (2009). Physical activity and maintaining physical function in older adults. *British Journal of Sports Medicine, 43*(1), 28-31. doi: 10.1136/bjsm.2008.053736

McDonough, A. L., Batavia, M., Chen, F. C., Kwon, S., & Ziai, J. (2001). The validity and reliability of the GAITRite system's measurements: A preliminary evaluation. *Arch Phys Med Rehabil., 82*(3), 419-425. doi: 10.1053/apmr.2001.19778

McKean, K. A., Manson, N. A., & Stanish, W. D. (2006). Musculoskeletal injury in the masters runners. *Clinical Journal of Sport Medicine, 16*(2), 149-154.

Pantoja, P. D., De Villarreal, E. S., Brisswalter, J., PeyrÉ-Tartaruga, L. A., & Morin, J.-B. (2016). Sprint acceleration mechanics in Masters Athletes. *Medicine & Science in Sports & Exercise, 48*(12), 2469-2476. doi: 10.1249/MSS.0000000000001039

Pi-Sunyer, X. (2009). The medical risks of obesity. *Postgraduate Medicine, 121*(6), 21-33. doi: 10.3810/pgm.2009.11.2074

Power, G. A., Minozzo, F. C., Spendiff, S., Filion, M. E., Konokhova, Y., Purves-Smith, M. F., .

. . Rassier, D. E. (2016). Reduction in single muscle fiber rate of force development with aging is not attenuated in world class older masters athletes. *American Journal of Physiology: Cell Physiology, 310*(4), C318-327. doi: 10.1152/ajpcell.00289.2015

Pratley, R. E., Hagberg, J. M., Rogus, E. M., & Goldberg, A. P. (1995). Enhanced insulin sensitivity and lower waist-to-hip ratio in master athletes. *American Journal of Physiology, 268*(3 Pt 1), E484-490.

Ransdell, L. B., Vener, J., & Huberty, J. (2009). Masters athletes: an analysis of running, swimming and cycling performance by age and gender. *Journal of Exercise Science & Fitness, 7*(2), S61-73.

Reijnierse, E. M., de Jong, N., Trappenburg, M. C., Blauw, G. J., Butler-Browne, G., Gapeyeva, H., . . . Maier, A. B. (2017). Assessment of maximal handgrip strength: how many attempts are needed? *Journal of Cachexia, Sarcopenia and Muscle*. doi: 10.1002/jcsm.12181

Senior, H. E., Henwood, T. R., Beller, E. M., Mitchell, G. K., & Keogh, J. W. L. (2015). Prevalence and risk factors of sarcopenia among adults living in nursing homes. *Maturitas, 82*(4), 418–423

Walsh, J., Climstein, M., Heazlewood, I., Burke, S., Kettunen, J., Adams, K., & DeBeliso, M. (2011). Variations in body mass index with age in Masters athletes (World Masters Games). *Journal of the World Academy of Science, Engineering and Technology, 7*(77), 1115-1119.

Walsh, J., Climstein, M., Heazlewood, I. T., Debeliso, M., Adams, K. J., Burke, S., & Kettunen, J. (2013). Body mass index of Masters basketball players. *Medicina Sportiva, 7*(4), 1700-1705.

Walsh, J., Climstein, M., Heazlewood, I. T., Kettunen, J., Burke, S., Debeliso, M., & Adams, K. J. (2013). Body mass index for athletes participating in swimming at the World Masters Games. *Journal of Sports Medicine and Physical Fitness, 53*(2), 162-168.

Wroblewski, A. P., Amati, F., Smiley, M. A., Goodpaster, B., & Wright, V. (2011). Chronic exercise preserves lean muscle mass in masters athletes. *Physician & Sportsmedicine, 39*(3), 172-178. doi: 10.3810/psm.2011.09.1933

Young, B. W., Weir, P. L., Starkes, J. L., & Medic, N. (2008). Does lifelong training temper age-related decline in sport performance? Interpreting differences between cross-sectional and longitudinal data. *Experimental Aging Research, 34*(1), 27-48. doi: 10.1080/03610730701761924

Table 1(on next page)

Anthropometric, Functional, Training and Health Characteristics of Total Sample.

All values are mean±SD except sarcopenic status whereby count is the number of individuals with sarcopenia in each category. [a] = significantly different to 50-59 years old group; [b] = significantly significant to 60-69 years old group; [c] = significantly significant to 70-79 years old group.

1 *Table 1. Anthropometric, Functional, Training and Health Characteristics of Total Sample.*

	40-49 years (n=42)	50-59 years (n=66)	60-69 years (n=30)	70-79 years (n=18)	Total (n=156)
Anthropometric Characteristics					
Height (cm)	172.6 ± 8.4	173.6 ± 7.9 [b]	167.9 ± 11.0	171.1 ± 11.7	171.9 ± 9.3
Mass (kg)	76.6 ± 14.4	77.5 ± 15.8	73.3 ± 13.7	77.1 ± 17.7	76.4 ± 15.2
Fat %	22.9 ± 8.3	22.2 ± 9.1	26.9 ± 9.7	27.1 ± 10.3	23.8 ± 9.3
Fat mass (kg)	17.5 ± 7.3	17.6 ± 9.5	19.7 ± 8.7	21.2 ± 10.1	18.4 ± 8.9
FFM (kg)	59.1 ± 13.1	59.8 ± 11.3	53.5 ± 12.6	55.8 ± 13.7	57.9 ± 12.5
BMI (kg/m^2)	25.5 ± 3.5	25.6 ± 4.3	25.9 ± 4.7	26.3 ± 5.7	25.7 ± 4.3
Sarcopenic Status (Count)	0	0	0	0	0
Functional Characteristics					
Grip strength (kg)	43.9 ± 13.2 [b,c]	43.8 ± 11.7 [b,c]	35.1 ± 12.4	31.9 ± 8.5	40.8 ± 12.7
Gait speed (m/s)	1.25 ± 0.18	1.28 ± 0.21	1.27 ± 0.19	1.26 ± 0.22	1.27 ± 0.20
Training and Health Characteristics					
Participation (years)	5.9 ± 5.9 [a,c]	10.4 ± 8.5	11.1 ± 10.6	15.8 ± 10.5	9.9 ± 9.0
Training (hours)	6.0 ± 3.7	4.5 ± 3.3	4.3 ± 3.9	6.8 ± 5.1	5.1 ± 3.8
Chronic diseases (number)	0.1 ± 0.2 [b,c]	0.2 ± 0.6 [b,c]	0.8 ± 1	1.0 ± 1.0	0.4 ± 0.8
Prescribed medications (number)	0.1 ± 0.2 [b,c]	0.2 ± 0.7 [c]	0.6 ± 1.0	1.2 ± 1.2	0.4 ± 0.8

2 All values are mean±SD except sarcopenic status whereby count is the number of individuals with
3 sarcopenia in each category. [a] = significantly different to 50-59 years old group; [b] = significantly
4 significant to 60-69 years old group; [c] = significantly significant to 70-79 years old group.

Table 2(on next page)

Anthropometric, Functional, Training and Health Characteristics of Male Sample.

All values are mean±SD except sarcopenic status whereby count is the number of individuals with sarcopenia in each category. [a] = significantly different to 50-59 years old group; [b] = significantly significant to 60-69 years old group; [c] = significantly significant to 70-79 years old group.

Table 2. Anthropometric, Functional, Training and Health Characteristics of Male Sample.

	40-49 years (n=19)	50-59 years (n=39)	60-69 years (n=11)	70-79 years (n=9)	Total (n=78)
Anthropometric Characteristics					
Height (cm)	180.1 ± 6.2	176.7 ± 6.7	177.2 ± 12.6	178.3 ± 10.2	177.8 ± 8.0
Mass (kg)	88.3 ± 10.5	83.7 ± 15.7	83.3 ± 11.2	87.5 ± 12.7	85.2 ± 13.6
Fat %	18.2 ± 7.0	18.4 ± 8.2	20.3 ± 6.4	23.2 ± 5.6	19.2 ± 7.5
Fat mass (kg)	16.4 ± 7.5	16.4 ± 10.6	16.6 ± 4.8	20.6 ± 7.4	16.9 ± 8.9
FFM (kg)	71.9 ± 7.7	67.3 ± 7.4	66.7 ± 11.6	66.9 ± 8.7	68.3 ± 8.4
BMI (kg/m^2)	27.2 ± 3.1	26.8 ± 4.5	26.6 ± 3.2	27.4 ± 2.8	26.9 ± 3.8
Sarcopenic Status (Count)	0	0	0	0	0
Functional Characteristics					
Grip strength (kg)	55.2 ± 9.4 [b,c]	51.3 ± 8.5 [c]	45.6 ± 14.0	37.5 ± 5.9	49.9 ± 10.7
Gait speed (m/s)	1.25 ± 0.19	1.25 ± 0.19	1.29 ± 0.14	1.24 ± 0.21	1.26 ± 0.18
Training and Health Characteristics					
Participation (years)	6.2 ± 6.3 [c]	12.6 ± 9.7	14.2 ± 11.0	19.6 ± 12.8	12.1 ± 10.2
Training (hours)	6.6 ± 4.2	4.1 ± 3.6	5.3 ± 4.3	7.2 ± 6	5.2 ± 4.3
Chronic diseases (number)	0.0 ± 0.0 [b,c]	0.1 ± 0.3 [b,c]	1.2 ± 1.0	1.0 ± 0.9	0.3 ± 0.7
Prescribed medications (number)	0.1 ± 0.2 [b,c]	0.1 ± 0.3 [b,c]	0.9 ± 1.2	1.1 ± 0.9	0.3 ± 0.7

All values are mean±SD except sarcopenic status whereby count is the number of individuals with sarcopenia in each category. [a] = significantly different to 50-59 years old group; [b] = significantly significant to 60-69 years old group; [c] = significantly significant to 70-79 years old group.

Table 3(on next page)

Anthropometric, Functional, Training and Health Characteristics of Female Sample.

All values are mean±SD except sarcopenic status whereby count is the number of individuals with sarcopenia in each category. [a] = significantly different to 50-59 years old group; [b] = significantly significant to 60-69 years old group; [c] = significantly significant to 70-79 years old group.

Table 3. Anthropometric, Functional, Training and Health Characteristics of Female Sample.

	40-49 years (n=23)	50-59 years (n=27)	60-69 years (n=19)	70-79 years (n=9)	Total (n=78)
Anthropometric Characteristics					
Height (cm)	166.4 ± 3.9	169.1 ± 7.1 [b]	162.6 ± 5	164 ± 8.6	166.1± 6.5
Mass (kg)	67.2 ± 9.9	68.6 ± 11	67.5 ± 11.7	66.6 ± 16.1	67.7 ± 11.3
Body Fat %	27.4 ± 6.7	27.7 ± 7.5	30.7 ± 9.4	31.0 ± 12.6	28.7 ± 8.4
Fat mass (kg)	18.9 ± 7	19.5 ± 7.5	21.6 ± 10	21.9 ± 12.7	20.1 ± 8.6
FFM (kg)	48.3 ± 4.3	49 ± 5.7	45.9 ± 3.8	44.7 ± 6.8	47.6 ± 5.2
BMI (kg/m^2)	24.3 ± 3.3	24 ± 3.7	25.7 ± 5.4	25.2 ± 7.6	24.6 ± 4.6
Sarcopenic Status (Count)	0	0	0	0	0
Functional Characteristics					
Grip strength (kg)	34.1 ± 6.4 [b,c]	33 ± 5.3 [c]	29.2 ± 5.9	26.4 ± 7.0	31.6 ± 6.5
Gait speed (m/s)	1.24 ± 0.17	1.31 ± 0.23	1.26 ± 0.20	1.27 ± 0.23	1.27 ± 0.21
Training and Health Characteristics					
Participation (years)	5.7 ± 6.0	7.3 ± 5.2	9.4 ± 10.2	12.1 ± 6.3	7.9 ± 7.2
Training (hours)	5.4 ± 3.2	5.2 ± 2.8	3.8 ± 6.7	6.4 ± 4.4	5.1 ± 3.4
Chronic diseases (number)	0.1 ± 0.3 [c]	0.5 ± 0.8	0.6 ± 1.1	1.1 ± 1.2	0.5 ± 0.9
Prescribed medications (number)	0.1 ± 0.3 [c]	0.5 ± 1.1	0.5 ± 0.9	1.3 ± 1.5	0.5 ± 1

All values are mean±SD except sarcopenic status whereby count is the number of individuals with sarcopenia in each category. [a] = significantly different to 50-59 years old group; [b] = significantly significant to 60-69 years old group; [c] = significantly significant to 70-79 years old group.

Figure 1(on next page)

EWGSOP algorithm for diagnosis of sarcopenia (Cruz-Jentoft, 2010).

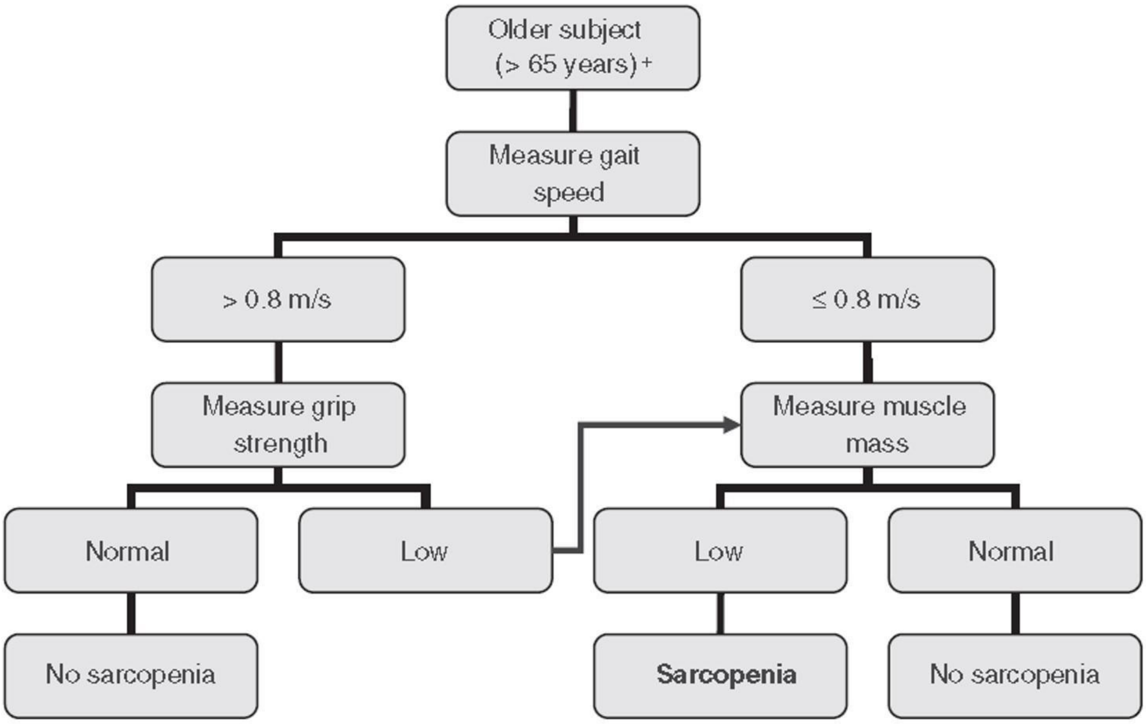

Figure 1. EWGSOP algorithm for diagnosis of sarcopenia (Cruz-Jentoft, 2010).

Figure 2(on next page)

Body Mass Index (BMI) classifications of overweight and obesity for the overall sample of Masters athletes as well as compared to Australian Bureau of Statistics (2012) data.

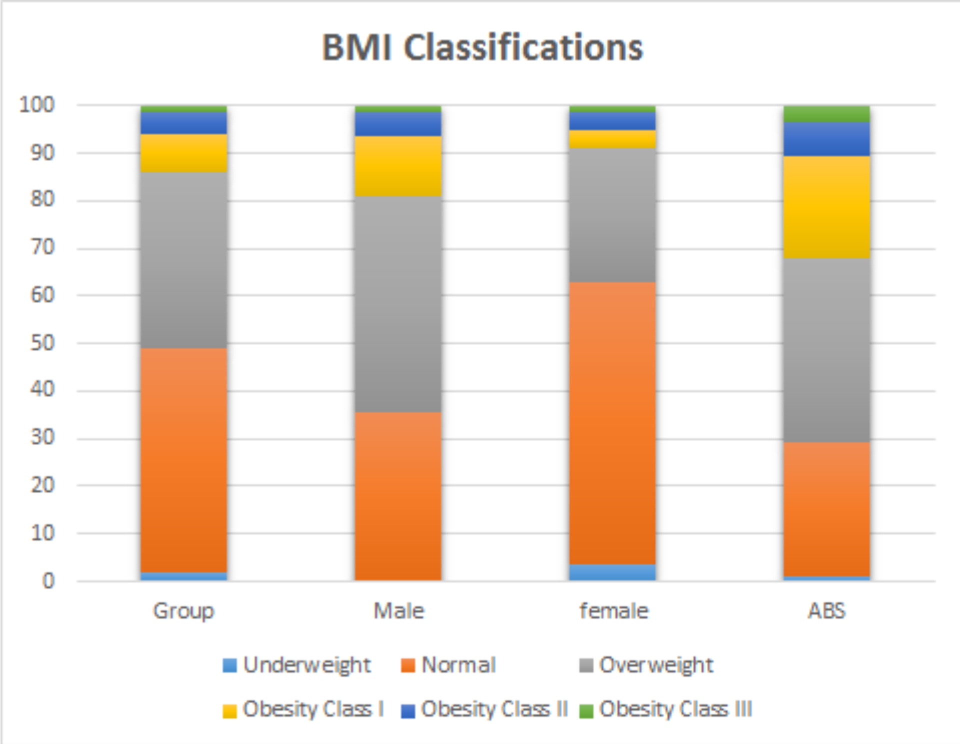

Figure 2. Body Mass Index (BMI) classifications of overweight and obesity for the overall sample of Masters athletes as well as male and female Masters athletes separately, compared to Australian Bureau of Statistics (2012) data.

Figure 3 (on next page)

Proportion and total number of Masters athletes who were below the EWGSOP gait speed and handgrip strength thresholds for the male and female Masters athletes across the 10 year age groups.

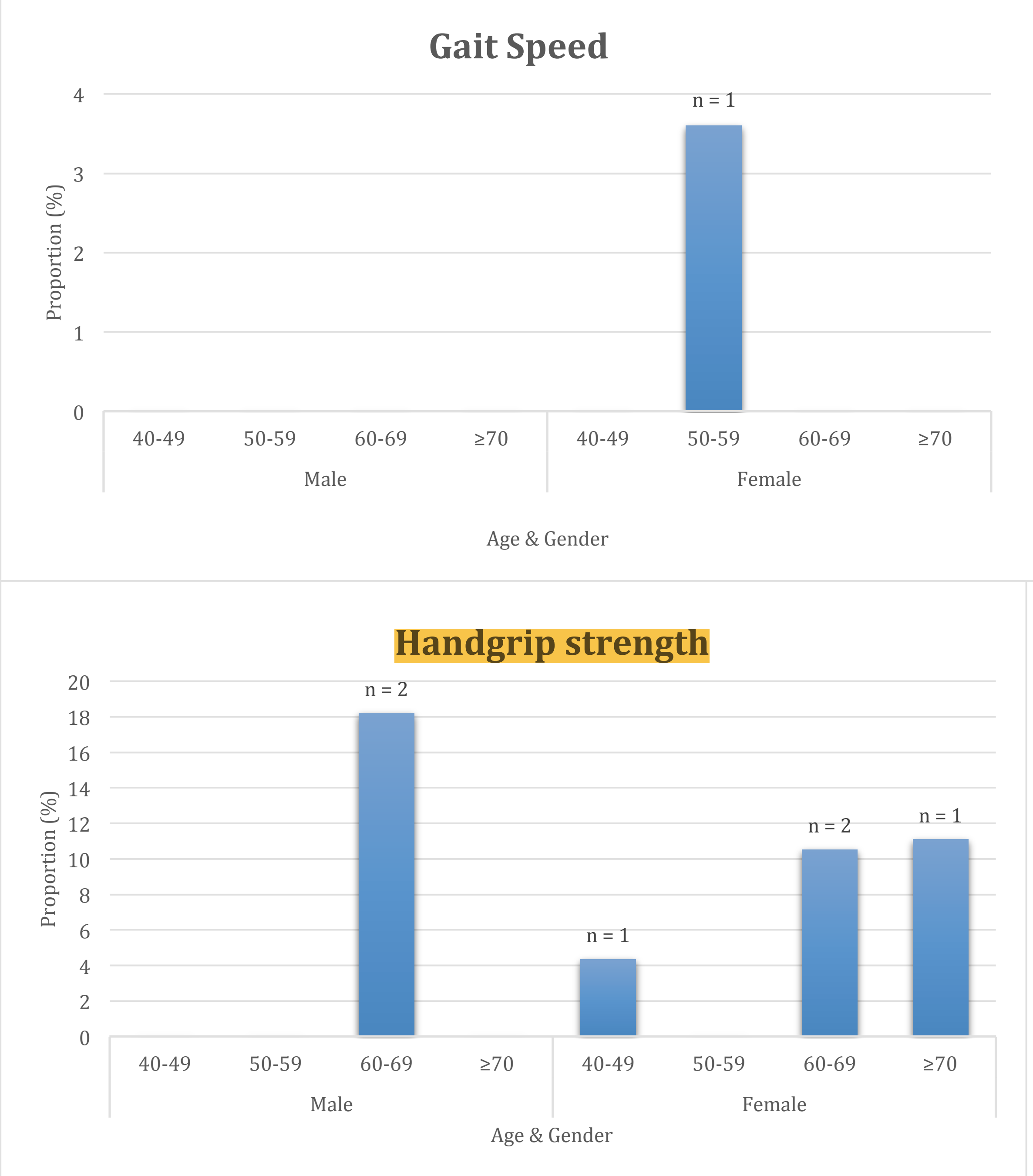

Figure 3: Proportion and total number of Masters athletes who were below the EWGSOP gait speed and handgrip strength thresholds for the male and female Masters athletes across the 10 year age groups.