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***Keywords:*** sport, exercise, health

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## Abstract

**Purpose:** To test confirmatory factor analyses of successful aging composed of physical, psychological, cognitive, and social functioning factors in masters athletes ($n = 764$) and non-sporting adults ($n = 404$), and compare the physical, psychological, cognitive, and social functioning of masters athletes versus non-sporting adults. **Method:** Self-reported cross-sectional data were analysed with confirmatory factor analyses. **Results:** Physical, psychological, cognitive, and social functioning latent factors significantly loaded onto a higher-order successful aging latent factor ($p < .05$). Masters athletes had higher physical and social functioning than non-sporting adults ($p < .05$). Psychological and cognitive functioning did not differ between groups. **Conclusions:** Successful aging should be considered as a multi-faceted construct consisting of different domains of functioning for both masters athletes and non-sporting adults. Masters athletes were aged successfully relative to the non-sporting adults across the physical and social functioning domains. Physical, psychological, cognitive, and social functioning domains constitute an appropriate model to use in future experimental research investigating the effect of masters sport for successful aging.


***Keywords:*** sport, exercise, health

Better living conditions and medical breakthroughs have significantly decreased early mortality, increased global life expectancy, and contributed to an aging of the global population (United Nations, 2017). While an increased number of people living longer lives is a laudable achievement of both medical research and public policy, an aging population is forecast to strain societal healthcare, welfare, and financial systems (Bloom, Canning, & Lubet, 2015). Hence, there is both a humanitarian and societal incentive to discover strategies that promote “successful aging” (Cosco, Prina, Perales, Stephan, & Brayne, 2014).

There is a lack of consensus within the academic literature regarding the definition of successful aging. Researchers have conceptualized successful aging in a number of different ways such as adapting to getting older, having a low probability of disease, and being actively engaged in life (Dillaway & Byrnes, 2009). The variation in conceptualization has led to the development of conceptual-based (Rowe & Kahn, 1997), theory-based (Baltes & Carstensen, 1996), and statistically generated (Vahia, Thompson, Depp, Allison, & Jeste, 2012) successful aging models. A major limitation of successful aging research to date has been that researchers have developed concepts, models, and definitions of successful aging that reflect their own academic discipline (Bowling, 2007).

A consequence of conceptualizing, modeling, and defining successful aging in a discipline-specific manner is demonstrated in the results of the most recent and comprehensive systematic review of the academic literature which identified 84 different researcher-driven operationalizations of successful aging (Cosco et al., 2014). However, researchers are increasingly viewing successful aging through a multidisciplinary lens as a multidimensional, desired, health-related phenomenon that people experience as they age chronologically across the physical, psychological, cognitive, and social functioning domains (Cosco et al., 2014). Therefore, in line with recent literature (Cheng, 2014; Geard, Reaburn, Rebar, & Dionigi, 2017; Kok et al., 2017), we operationally define successful aging as high physical, psychological, cognitive, and social functioning as people age chronologically.

Masters athletes train for and compete in sporting events that are held for adults who exceed the typical age of elite, open-age sports performances (Ransdell, Vener, & Huberty, 2009). Through their sports training and competition, masters athletes develop physiological adaptations (Louis, Nosaka, & Brisswalter, 2012) that allows them to remain involved in their chosen sport well into later life (Ransdell et al., 2009). Consequently, masters athletes have been proposed to be models of successful physiological aging (Louis et al., 2012), as well as exemplars of successful aging across the physical, psychological, cognitive, and social functioning domains (Geard et al., 2017).

Prior to investigating if masters athletes are exemplars of successful aging across the physical, psychological, cognitive, and social functioning domains, a recent study tested the strength of this hypothesized model of successful aging relative to three alternative conceptual models of successful aging that were formulated from the systematic review literature (Geard, Rebar, Reaburn, & Dionigi, 2018). Researchers found that compared to the three alternative models—that were comprised of varied combinations of the physical, psychocognitive, and social functioning domains—the hypothesized model was the strongest for the measurement of successful aging in masters swimmers (Geard et al., 2018). However, the researchers concluded that the successful aging model should be tested on a broader range of masters athletes and a comparison group of non-sporting adults. Moreover, results from the previous study suggested that the cognitive functioning factor did not load significantly onto the higher-order successful aging factor because of the low internal consistency of the measures used, and the single social functioning item was insufficient to measure the broad social functioning domain.

Therefore, the primary aim of the present study was to utilize a more internally consistent and broad selection of cognitive and social functioning measures, respectively, to determine if the model of successful aging proposed by Geard et al. (2018) is an appropriate approach to evaluate the aging status or trajectory of masters athletes and non-sporting adults in future research. We hypothesized that physical, psychological, cognitive, and social functioning data from both masters athletes and non-sporting adults would load significantly onto a higher-order successful aging factor and thus confirm the structure of the hypothesized successful aging model. A secondary aim was to compare the physical, psychological, cognitive, and social functioning status of masters athletes versus non-sporting adults. We hypothesized that masters athletes would have higher functioning than non-sporting adults across the four physical, psychological, cognitive, and social functioning domains of successful aging. This research is important because it provides a framework for future experimental research on the causal relationship between sport and successful aging.

## Methods

The local Human Research Ethics Committee pre-approved all study procedures (H14/10-219). The data that support the findings of this study are available from the corresponding author, [Author initials not provided for blind peer-review], upon reasonable request.

### Participants

Participants were a representative sample of masters athletes who competed at the 2014 Pan Pacific Masters Games in Australia, and a convenience sample of non-sporting adults who attended an informal learning organization for Australian retirees called the University of the Third Age. Self-reported data was collected from masters athletes and non-sporting adults between November 2014 and July 2016 with a web-based survey that was emailed to participants through their respective organizations. Before starting the survey all participants provided informed consent.

## Survey Measures

**Participant Characteristics.** Participants reported their age (years), sex (male/female), height (cm), and body mass (kg).

**Masters Athlete Status.** To ensure correct group classification we asked participants to indicate if they were a masters athlete (*yes*/*no*) based on the following description; "…an adult who trains for and competes in individual or team, recreational or competitive masters sport" (Geard et al., 2017).

**Sport Category.** For descriptive purposes, we asked masters athletes to report the category of sport (e.g., pool or open water swimming) they participated in from a list compiled directly from the Pan Pacific Masters Games website.

**Physical Activity.** To estimate the levels of physical activity undertaken by the two samples, we used the International Physical Activity Questionnaire-Short Form (IPAQ-SF) which is a reliable, subjective physical activity surveillance metric that has been validated on adults aged 18-65 years (Craig et al., 2003). The IPAQ-SF asked participants how long (minutes per day) and frequently (days per week) they engaged in vigorous, moderate, and walking intensity physical activity. Weekly minutes at each intensity were multiplied by 8.0, 4.0, and 3.3 metabolic equivalents (MET's) respectively, and summed into a continuous variable (MET.mins per week).

**Subjective Successful Aging.** Previous research (Geard et al. 2018) used three subjective successful aging items (Pruchno & Wilson-Genderson, 2014) to gather data on masters athletes' perceptions of successful aging and determine if they aligned with the physical, psychological, cognitive, and social functioning data related to the hypothesized successful aging model. Therefore, the same subjective successful aging items were included in the present study to determine the model-data fit. Items asked participants; (1) how successfully have you aged (0 = *not successful* to 10 = *completely successful*), (2) how well are you aging (0 = *not well* to 10 = *extremely well*), (3) rate your life these days (0 = *worst possible* to 10 = *best possible*).

**Functioning.** To extend the findings from previous research (Geard et al., 2018) using the same measurement instrument we measured physical, psychological, and part of social functioning with the Veterans RAND 12-Item Health Survey (VR-12). The VR-12 is a valid, reliable abbreviation of the Veterans RAND 36-Item Health Survey that was developed from the MOS RAND SF-36 Version 1.0 (Iqbal et al., 2007). Large-scale studies applying factor analyses and multivariate scaling tests have previously demonstrated that the VR-12 measures separate subscales of functioning with strong internal consistency, and structural, convergent, and discriminant validity with greater explanatory power and more between-person sensitivity than similar quality of life measures (Jones et al., 2001; Kazis, Miller, Clark, et al., 2004; Kazis, Miller, Skinner et al., 2004).

***Physical functioning.*** We measured physical functioning with the "physical functioning" and "role limitations due to physical problems" items from the VR-12 ($\alpha$ = .82). Physical functioning questions asked if health had limited respondent's activities such as (1) moving a table, pushing a vacuum cleaner, bowling, playing golf etc., and (2) climbing stairs. Response options were; 0 = *limited a lot*, 5 = *limited a little*, 10 = *not limited*. Role limitations due to physical problems items asked if respondents (1) had accomplished less than they would like, and (2) were limited in the kind of work or activities they could do as a result of physical health problems over the past month. Response options were; 0 = *all the time*, 2.5 = *most of the time*, 5 = *some of the time*, 7.5 = *a little of the time*, 10 = *none of the time*.

***Psychological functioning.*** We measured psychological functioning with the "mental health" and "role limitations due to emotional problems" items from the VR-12 ($\alpha = .81$). The first mental health question asked how often over the past month participants felt calm and peaceful. Response options were; 0 = *none of the time*, 2 = *a little of the time*, 4 = *some of the time*, 6 = *good bit of the time*, 8 = *most of the time*, 10 = *all the time*. The second mental health question asked how often over the past month participants felt downhearted or blue. Response options were; 0 = *all the time*, 2 = *most of the time*, 4 = *good bit of the time*, 6 = *some of the time*, 8 = *a little of the time*, 10 = *none of the time*. Role limitations due to emotional problems questions asked if due to emotional problems during the past month participants (1) had accomplished less than they would like, and (2) didn't do work or activities as carefully as usual. Response options were; 0 = *all the time*, 2.5 = *most of the time*, 5 = *some of the time*, 7.5 = *a little of the time*, 10 = *none of the time*.

***Social functioning.*** We measured part of social functioning with the "social functioning" item from the VR-12 that asked participants how often physical or emotional problems interfered with social activities with friends or relatives. Response options were; 0 = *all the time*, 2.5 = *most of the time*, 5 = *some of the time*, 7.5 = *a little of the time*, 10 = *none of the time*. Even if socially active, people can feel lonely. Therefore, we measured another aspect of social functioning with the Three-Item Loneliness Scale that has shown to have convergent and construct validity via correlations with measures of emotion and mood that previous research demonstrates are associated with loneliness (Hughes, Waite, Hawkley, & Cacioppo, 2004). Questions asked how often participants felt (1) lacking in companionship, (2) left out, (3) isolated. Response options were; 0 = *often*, 5 = *some of the time*, 10 = *hardly ever*. The single social functioning item from the VR-12 and the three loneliness items were internally consistent (α = .80).

***Cognitive functioning*.** We measured cognitive functioning with the highest factor loaded items from the memory, distractibility, blunders, and names subscales of the Cognitive Failures Questionnaire (CFQ), to be consistent with recent successful aging research related to masters athletes (Geard et al., 2018). These questions asked participants if they (1) forget appointments, (2) read something and must read it again, (3) fail to hear people when doing something else, and (4) forget people's names, respectively. Response options were; 0 = *very often*, 2.5 = *quite often*, 5 = *occasionally*, 7.5 = *rarely*, 10 = *never*. Correlating factor scores of conceptually related measures such as attention and concentration indicate that the CFQ has construct validity (Wallace, Kass, & Stanny, 2002). To increase internal consistency and the cognitive functions measured, we also implemented the Revised 6-Item Medical Outcomes Study Cognitive Functioning Scale (MOS Cog-R). The MOS Cog-R asked if respondents had (1) difficulty reasoning or solving problems, (2) issues concentrating or thinking, (3) become confused, (4) forgotten appointments, (5) not kept their attention focused, and (6) reacted slowly to external stimuli over the past month. Response options were; 0 = *all the time*, 2.5 = *most of the time*, 5 = *some of the time*, 7.5 = *a little of the time*, 10 = *none of the time*. The direction and magnitude of correlations with criterion measures of psychological status and health outcomes, and mean score differences across these criterion outcomes indicate that the MOS Cog-R has good convergent validity and adequate discriminant validity (Yarlas, White, & Bjorner, 2012). Together the CFQ and the MOS Cog-R were internally consistent (α = .85).

**Data Analyses**

We used structural equation modeling and ran Confirmatory Factor Analyses in OpenMx (Boker et al., 2011) with *R* version 3.1.1 (R Core Team, 2013) to test the successful aging model and compare the functioning of masters athletes versus non-sporting adults. Structural equation modeling is robust on normal or non-normal data and estimates the statistical fit, strength, and interrelated dependence of a hypothesized network of variables in a single analysis. We removed cases that did not have a response to both the informed consent and masters athlete status questions ($n$ = 157), removed $n$ = 13 multivariate outliers based on robust Mahalanobis methods and generalized Cook's distances (Flora, LaBrish, & Chalmers, 2012), and imputed missing data (3.3%) with multiple imputation by chained equations (van Buuren & Groothuis-Oudshoorn, 2011). Data was originally collected from $n$ = 859 masters athletes and $n$ = 458 non-sporting adults. After removing cases based on insufficient data and multivariate outliers final analyses were run on data from $n$ = 764 masters athletes and $n$ = 404 non-sporting adults.

**Model Test.** The model test consisted of a data fit comparison and separate calculations of factor loadings of physical, mental, social, and psychological functioning onto the higher-order successful aging factor for masters athletes and non-sporting adults. As in previous research (Geard et al., 2018) all manifest variables (i.e., survey question responses) were loaded onto their respective physical, psychological, cognitive, and social functioning latent factor to partition out item-specific variability.

The present study's hypothesized model of successful aging was the best fit for similar data from masters swimmers in previous research (Geard et al., 2018). Therefore, we did not compare the data fit of alternative successful aging models. To ensure the data fit of the models were not completely disparate between populations, we compared the data fit of a homogeneous (i.e., same free and fixed factor loadings estimated for masters athletes and non-sporting adults) and heterogeneous (i.e., unique factor loadings, intercepts, and variances estimated for masters athletes and non-sporting adults) model.

Negative 2 log-likelihood (-2LL) and Akaike Information Criterion (AIC) (Fox, Byrnes, Boker, & Neale, 2012) were the chosen data fit indices. A smaller -2LL and AIC indicates a better fitting model as they estimate the amount of unexplained variance and information lost after the models are fitted. We calculated factor loadings and standard errors from the output of the better fitting model to determine if the relationships between model variables were statistically significant.

**Masters Athletes vs Non-sporting Adults.** Latent means are robust population inferences derived from the simultaneous estimation of covariance and means associated with the latent and manifest variables respectively (Hancock, 1997). Latent means and 95% confidence intervals were calculated from the better fitting model's output, and used to compare physical, psychological, cognitive, and social functioning and subjective and overall successful aging of masters athletes versus non-sporting adults.

## Results

Masters athletes were significantly taller and more physically active ($p < .05$) than non-sporting adults. However, non-sporting adults were older and more often female ($p < .05$) compared to masters athletes (Table 1).

<Table 1 near here>

Masters athletes predominantly participated in court and field sports. Many participants that identified as a masters athlete did not declare a sport category (Table 2), possibly because they were involved in more than one sport.

<Table 2 near here>

**Model Test**

Smaller -2LL and AIC indicated that the heterogeneous model (-2LL = 67705.97, AIC = 9539.98, *df* = 29083) fit the data significantly better ($p < .01$) than the homogeneous model (-2LL = 73563.51, AIC = 15281.51, *df* = 29141).

Figure 1 shows that the physical, psychological, cognitive, and social functioning latent factors, and the three subjective successful aging manifest variables loaded significantly onto the higher-order successful aging factor for masters athletes and non-sporting adults ($p < .05$). Physical, psychological, cognitive, and social functioning manifest variables loaded significantly onto their respective latent factor for masters athletes and non-sporting adults ($p < .05$); however, these factor loading values are not depicted in Figure 1 for clarity.

<Figure 1 near here>

**Masters Athletes vs Non-sporting Adults**

Figure 2 shows that masters athletes had significantly higher physical and social functioning than non-sporting adults did ($p < .05$). However, psychological and cognitive functioning did not differ between groups. We supply overall and subjective successful aging latent means for descriptive purposes only. Therefore, they are not shown in Figure 2. However, overall (6.5) and subjective (5.0) successful aging for masters athletes was significantly higher ($p < .05$) than overall (5.3) and subjective (3.5) successful aging for non-sporting adults.

<Figure 2 near here>

## Discussion

**Model Test**

The present study’s primary aim was to test a model of successful aging to determine if it is an appropriate approach to evaluate the aging status or trajectory of masters athletes and non-sporting adults in future research. As expected, the factor loading values within the hypothesized model indicated that physical, psychological, cognitive, and social functioning are all essential aspects of successful aging for both masters athletes and non-sporting adults. Historically, researchers defined successful aging as a unidimensional construct (Cosco et al., 2014). However, as in the present study, investigators now routinely view successful aging through a multidimensional lens and utilize sophisticated statistical techniques to develop and test their proposed successful aging models (Brown & Bond, 2016; Parslow, Lewis, & Nay, 2011; Vahia et al., 2012). While conceptualizing successful aging with the same (Cheng, 2014; Kok et al., 2017) or similar (Parslow et al., 2011; Vahia et al., 2012) domains as those used in the present study is becoming more frequent, there are differences to consider.

Mental health (Parslow et al., 2011) and emotional functioning (Vahia et al., 2012) are examples of other domains used in previously published successful aging models. While named differently, researchers (Parslow et al., 2011; Vahia et al., 2012) measured these domains with survey items derived from the same metric used to evaluate psychological functioning in the present study, suggesting the conceptualization of the same or similar construct. Additionally, education, health-behaviors (Parslow et al., 2011), and partner status (Kok et al., 2017) have been previously analyzed as predictors of successful aging. However, we did not investigate predictors of successful aging in the present study because the cross-sectional data we collected did not permit us to determine if the variability from any predictive factor we chose to analyze came from causal or correlational interactions. Indeed, the predominance of cross-sectional over longitudinal successful aging research may explain why successful aging predictors and domains are often confused (Cheng, 2014).

In conclusion, the findings from the present study's model test indicate that the perceptions of both masters athletes and non-sporting adults regarding the meaning of successful aging align with the multidimensional characterization of successful aging that is found within the recent academic literature (Cheng, 2014; Cosco et al., 2014; Kok et al., 2017). Consequently, we argue that the hypothesized model of successful aging from the present study is an appropriate approach to use in future research that investigates the effect of masters sport participation on aging status or trajectory.

**Masters Athletes vs Non-sporting Adults**

Previous successful aging investigations on masters athletes have primarily been reviews that have conceptualized successful aging as a physiological phenomenon (Louis et al., 2012). Therefore, we will discuss the present study's findings within the context of the research that has investigated the link between masters sport participation and the physical, psychological, cognitive, and social functioning domains respectively.

Physical activity is the stimulus that induces the physiological adaptations that promotes better physical functioning (Lazarus & Harridge, 2017). Although physical activity could not be controlled for in the present study, the masters athletes reported doing significantly more physical activity than the non-sporting adults. Therefore, as expected, the masters athletes reported significantly higher physical functioning. This finding agrees with previous studies which show that masters athletes have significantly better lower body strength and power (Glenn, Gray, Vincenzo, & Stone, 2016), walking speed (Glenn, Vincenzo, Canella, Binns, & Gray, 2015) and dynamic balance (Leightley et al., 2017) than age-matched less physically active people. While this research suggests masters sport participation is a primary driver of better physical functioning, physical functioning does decline over time due to biological aging (Hayflick, 2007). Therefore, although we could not control for age in the present study, we suspect that the older age of the non-sporting adults also contributed to their lower physical functioning.

As hypothesized, masters athletes from the present study reported significantly higher social functioning than non-sporting adults. This finding supports observations from previous studies that have found female netball and tennis players, and male runners to report more social activity than similarly aged non-sporting adults (Eime, Harvey, Brown, & Payne, 2010; Latorre-Román et al., 2015). Masters athletes are highly social because they often train or compete with others, and regularly congregate at masters sporting events such as that used to sample the athletes for the present study (Gayman, Fraser-Thomas, Dionigi, Horton, & Baker, 2016). Moreover, social belonging and interaction appear to be central reasons why masters athletes participate in sport (Gayman et al., 2016). Indeed, the social interaction with new and significant others that is available to masters athletes through their sports participation (Gayman et al., 2016) has shown to reduce loneliness in large non-athletic adult populations across numerous interventions (Masi, Chen, Hawkley, & Cacioppo, 2010).

Previous evidence shows that masters athletes have reported better psychological functioning on measures of depression, anxiety, and stress relative to normative data (Bardhoshi et al., 2016). Moreover, the physical activity masters athletes typically undertake through their sports participation is known to promote mental health and psychological benefits (Rebar et al., 2015). Given this previous evidence, we hypothesized that the masters athletes would report higher psychological functioning than the non-sporting adults. However, psychological functioning was not significantly different between the masters athletes and non-sporting adults.

A possible explanation for this finding could be that adults report feeling more positive and less negative with age (Carstensen & DeLiema, 2018). Again, controlling for age was beyond the modeling capacity of the data. However, the non-sporting adults were significantly older. Given the non-sporting adults were significantly older. Therefore, their psychological functioning may have been trending upward for longer, offsetting any benefits sport participation may have conferred. Alternatively, when masters athletes compete, undertake excessive exercise, or cannot sustain previous performance levels, they report feeling stressed and frustrated (Grant, 2001). Therefore, given that the masters athletes in the current study provided data immediately before, during, or soon after competing, competition- and/or performance-related negative emotions may have adversely influenced their psychological functioning.

Based on the evidence of the benefits of physical activity and sport participation for the neurologic system (Leach & Ruckert, 2016), we expected the masters athletes to have better cognitive functioning than the non-sporting adults. However, we did not find a significant difference between groups. While more physical activity has been associated with better cognitive functioning (Leach & Ruckert, 2016), the available research suggests that some forms of masters sport may not benefit cognitive functioning. For example, with the exception of fluency and attention (Tseng et al., 2013), masters triathletes, runners, cyclists, and swimmers (> 50 years) have not demonstrated better cognitive functioning on a vast number of tests (Young, Dowell, Watt, Tabet, & Rusted, 2016).

The brain can endure substantial degeneration before cognitive decline is detectable (Leach & Ruckert, 2016). Therefore, we suggest that if cognitive functioning differences between masters athletes and non-sporting adults were to occur, they would not emerge until participants are significantly older than the cohorts examined in the present study. Moreover, the non-sporting adults in the current investigation attended adult learning classes, and were thus presumably involved in activities that are cognitively and/or socially stimulating. Therefore, both the chronological age of all participants in the present study, and the cognitive and social activity the non-sporting adults participated in, may explain why the non-sporting adults in the present study reported equally high cognitive functioning compared to the masters athletes.

**Study Strengths**

The model test findings are a major strength of the present study. We extended on the results from a recent successful aging model test study on a single cohort of masters swimmers (Geard et al., 2018) by showing that the proposed model also fits data from a broader range of masters athletes and non-sporting adults. A second strength of the present study is that high physical, psychological, cognitive, and social functioning is a valid approach for conceptualizing successful aging because these four domains of successful aging represent the broad areas within which people change as they age chronologically (Cosco et al., 2014). Indeed, if researchers adopt these domains in future studies, they may facilitate a reduction in the heterogeneity of successful aging models, and an improvement in the generalizability of research findings. Third, if successful aging research is to be a public health initiative with high social utility, most people must be able to attain or maintain successful aging. Although the “absence of disease” has been a popular successful aging criterion for an extended period, this criterion is the predominant reason why researchers have historically excluded the majority of study participants from the successfully aged or successful aging category (Brown & Bond, 2016). Therefore, as has been previously proposed, the present findings support functioning criteria to evaluate the four domains of successful aging because, even in the presence of well managed diseases such as diabetes, osteoarthritis, or hypertension, people can remain highly functional (Cheng, 2014; Kok et al., 2017).

**Limitations and Future Directions**

The present study has a number of limitations. First, due to difficulty recruiting participants, we used a convenience sample of non-sporting adults that were older, predominantly female, and less physically active relative to the masters athletes. More extreme values were added into the covariance matrices when physical activity, age, or sex were entered into the model as covariates. In turn, the model would not converge. This is a common problem with structural equation modeling work when variables have discrepant covariance profiles (Neale et al., 2016), as was the case in the present study. Given that research suggests functioning within certain domains varies with physical activity, chronological age, and sex in both masters athletes and non-sporting adults (Geard et al., 2018; Kok et al., 2017), future researchers should ensure these variables are controlled.

Second, the survey instrument used in the present study did not require masters athletes to indicate their sport category, or non-sporting adults to provide details of any health-enhancing activities they may have been involved in. Thus, we advise future researchers to collect these data to ensure they identify relevant influences on the outcome(s) of interest.

Third, self-reports were used to evaluate objectively measurable physical and cognitive functioning, and study participants were not screened for physical, cognitive, or emotional impairment. Moreover, we did not measure participants' cognitive and social activity level. Factors such as these can influence functioning across the domains of the present study's successful aging model. Therefore, future researchers should evaluate functioning with objective measures, screen participants for pre-existing conditions, and measure the cognitive and social aspects of sport when feasible.

Fourth, despite the international nature of the Pan Pacific Masters Games, it is very common for the majority of participants in such events to be residents of the country hosting the event. Therefore, we acknowledge that the results of the present study may be specific to the geographical location (Australia) in which the study took place.

Finally, the data derived from the present study is cross-sectional and thus cannot be used to infer a causal relationship between masters sport and successful aging. Therefore, experimental research on the effect of masters sports for successful aging that addresses the limitations identified in the successful aging research on masters athletes that has been conducted to date is recommended.

**Conclusion**

As the global population ages, providing the conditions to enable successful aging is an important goal for both individuals and global governments. The present study suggests that the proposed model is a suitable approach for evaluating the success with which masters athletes and non-sporting adults are aging, and that masters sport participation is associated with successful physical and social aging status according to our definition. Experimental research on the effect of masters sport for multidimensional successful aging is needed to extend these findings.

## What Does This Article Add?

The key message from the present study is that successful aging is broadly conceptualized as a health-related phenomenon that adults desire as they age chronologically across the physical, psychological, cognitive, and social functioning domains. Given their capacity to continue participating in sport well into later life, masters athletes are increasingly proposed to be exemplars of successful aging from a multidimensional perspective. However, very little research has been conducted to investigate this hypothesis. The present study adds to the body of knowledge by proposing an operational definition of successful aging to use in future research on masters athletes. Moreover, the present study suggests that experimental study designs be the primary method used to investigate the hypothesis that masters sport promotes, and masters athletes exemplify successful aging from a multidimensional perspective.

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**Table 1.** Study participants' characteristics and physical activity level

| Variable | Masters Athletes | Non-sporting Adults | Δ |
|---|---|---|---|
| *N* | 764 | 404 | |
| Age (years) | 56.1 ± 9.9 | 61.2 ± 11.2 | $t(1166) = 15.23$, $p < .001$ |
| Sex (female %) | 50 | 66 | $\chi^2(1) = 27.25$, $p < .001$ |
| Height (cm) | 172 ± 11.9 | 167 ± 12.0 | $t(1166) = 6.10$, $p < .001$ |
| Mass (kg) | 78.1 ± 16.1 | 79.3 ± 17.1 | $t(1166) = 1.10$ , $p = .291$ |
| Physical activity | 3938.6 ± 3962.4 | 2079.2 ± 3436.5 | $t(1144) = 7.82$, $p < .001$ |

***Note.*** Unless otherwise stated, values are mean ± standard deviation. Physical activity values are mean MET.mins per week ± standard deviation.

Significant difference between masters athletes and non-sporting adults set at $p < .05$ for all analyses.

**Table 2.** Masters athlete (*n* = 764) sport category

| **Sport category** | ***n* (%)** |
|---|---|
| Track running and cycling | 35 (4.6) |
| Road running and cycling | 14 (1.8) |
| Athletic field events | 23 (3) |
| Pool or open water swimming | 62 (8.1) |
| Court sports (e.g., netball, basketball, tennis, squash) | 156 (20.4) |
| Field sports (e.g., rugby, soccer, hockey, touch football) | 139 (18.3) |
| Rowing or canoeing | 52 (6.8) |
| Martial arts | 13 (1.7) |
| Golf, tenpin bowling, archery | 13 (1.7) |
| Horse and motorcycle riding | 7 (0.9) |
| Not declared | 250 (32.7) |

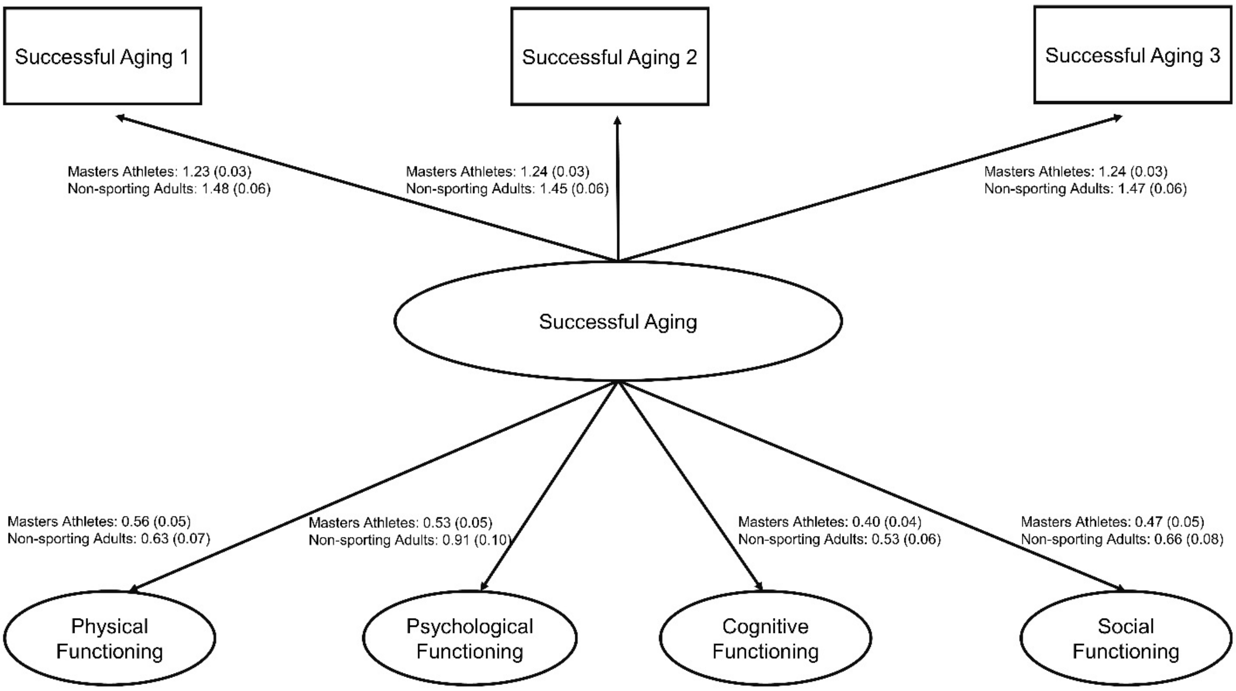


**Figure 1.** Heterogeneous successful aging model for masters athletes ($n$ = 764) and non-sporting adults ($n$ = 404). Rectangle shapes represent manifest variables. Oval shapes represent latent factors. Successful Aging 1, 2, 3 manifest variables are the subjective successful aging survey questions. Values are factor loadings with standard errors (SE) in parentheses. Solid path lines indicate statistically significant relationships, defined as ($\beta \geq 1.96 \times$ SE).

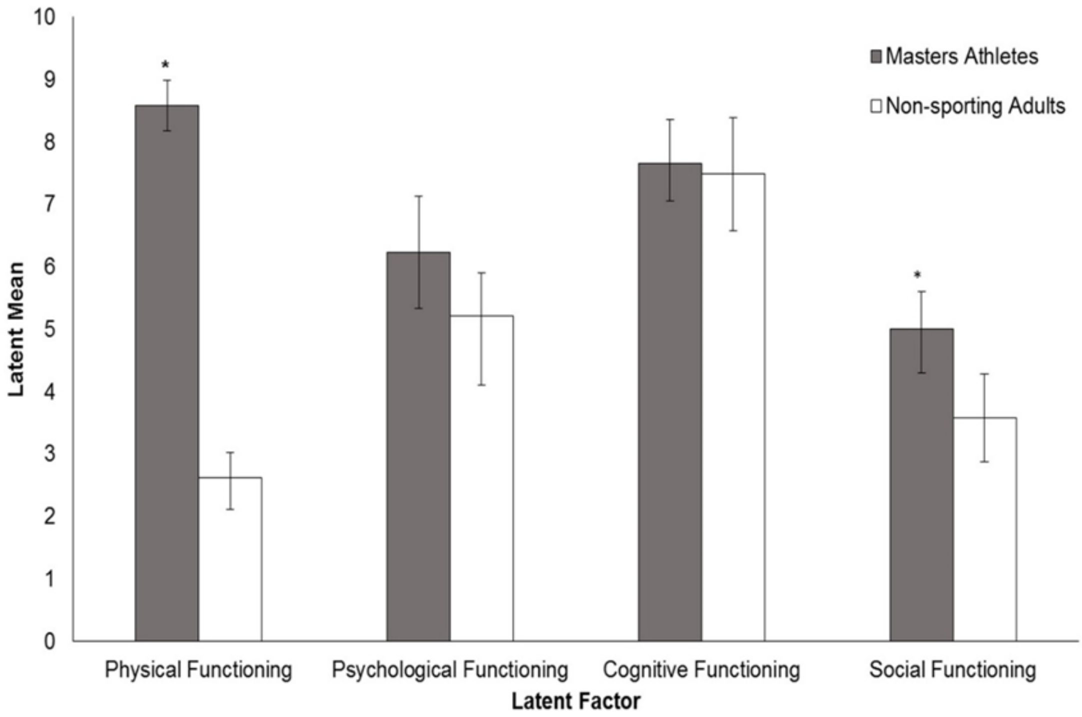


**Figure 2.** Comparison of masters athletes ($n$ = 764) and non-sporting adults ($n$ = 404) physical, psychological, cognitive, and social functioning latent means. The latent means response scale is 0 to 10. Error bars are 95% confidence intervals. Statistically significant difference between groups, $p < .05$.