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Variations of Body Mass Index with Age in Masters Athletes (World Masters Games)

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***Abstract*—**Whilst there is growing evidence that activity across the lifespan is beneficial for improved health, there are also many changes involved with the aging process and subsequently the potential for reduced indices of health. The nexus between health, physical activity and aging is complex and has raised much interest in recent times due to the realization that a multifaceted approached is necessary in order to counteract a growing obesity epidemic. By investigating age based trends within a population adhering to competitive sport at older ages, further insight might be gleaned to assist in understanding one of many factors influencing this relationship.

BMI was derived using data gathered on a total of 6,071 masters athletes (51.9% male, 48.1% female) aged 25 to 91 years ($\bar{x}$=51.5, s =±9.7), competing at the Sydney World Masters Games (2009). Using linear and loess regression it was demonstrated that the usual tendency for prevalence of higher BMI increasing with age was reversed in the sample. This trend in reversal was repeated for both male and female only sub-sets of the sample participants, indicating the possibility of improved prevalence of BMI with increasing age for both the sample as a whole and these individual sub-groups.

This evidence of improved classification in one index of health (reduced BMI) for masters athletes (when compared to the general population) implies there are either improved levels of this index of health with aging due to adherence to sport or possibly the reduced BMI is advantageous and contributes to this cohort adhering (or being attracted) to masters sport at older ages. Demonstration of this proportionately under-investigated World Masters Games population having an improved relationship between BMI and increasing age over the general population is of particular interest in the context of the measures being taken globally to curb an obesity epidemic.

***Keywords*—**Aging, masters athlete, Quetelet Index, sport.

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I. Introduction

THE World Masters Games (WMG) is the largest international sporting competition in terms of participant numbers. In 2009, the Sydney WMG attracted 28,089 competitors who represented 95 countries competing in 28 sports[1]. The most represented country at the games was the host nation, Australia[1].

Masters games athletes have either pursued a physically active lifestyle for an extended period of time or have initiated exercise/sport in later life. Regardless of their motivation(s), this unique cohort of middle to older-aged adults remains under investigated with regards to the incidence of diverse chronic disorders and associated measures of health.

There is growing evidence that regular exercise across the lifespan is beneficial for improved health and decreased incidence of various diseases and disorders[2-4]. The genetic mechanisms that cause the aging process remain uncertain[5], however its existence and the declines associated with aging are well established. Masters athletes may display an age related increase to the range of pathologies present in this population as well as physiological changes due to the aging process[3,6,7]. Due to these changes, there are possibilities of reduced physical activity levels, reduced metabolism and thus altered body mass index (BMI)[8] compared to younger, active populations.

BMI is regarded as an important health characteristic that is recognized as a risk factor to health. The importance of BMI, with regard to the negative burden of health from high BMI as well as the extent of the global obesity epidemic are documented in Walsh et al. (2011)[9].

BMI has been shown to be related to age with a general trend of increasing BMI with age for many populations including the Australian national population[10,11,12]. Additionally it has been shown that any elevated BMI has a greater negative burden on health of a population as age increases[12,13,14].

While the physiological demands of the 28 sports played at the WMG are different, all involved a degree of physical activity by the participants. The hypothesis of this study was that despite the usual trend for higher BMI with age, due to physical activity at older ages, the BMI of competitors at the Sydney WMG was such that the higher BMI with age for a control national population would not be replicated to the same extent in the masters athletes.

The aim of this study was to better investigate the nature of BMI for those who are physically active at older ages in an attempt to gain insight into the complex relationships that govern the nexus between physical activity, aging and the chronic disease and cardiovascular disease health risk factor that is BMI.

II. Methods

Approval for this study was granted by the research ethics committee (at the Australian Catholic University) in accordance with the ethical standards of the Helsinki Declaration of 1975 (revised in 2008).

An online survey created using Limesurvey^{tm} was utilized to investigate participants' demographics. Electronic invitations were sent to masters games athletes who provided a valid email address upon registration for the games. Data collection included demographic data for participants such as height (nearest cm), body mass (nearest kg) and age (total years). BMI was derived from this self-reported data and classified using conventional cut-off values[8]. Permission to access data collected as part of the Australian Bureau of Statistics National Health Survey 2007-2008 was granted via agreement for the purposes of this study. The data contained categorical data for a large sample (n=12,346) drawn from the Australian population. This data was planned for use as a control population.

Analysis of the data was completed using SPSS (Ver. 18.0.0).

III. Results

The Sydney WMG featured 28,089 competitors representing 95 countries and competing in competing in 28 sports. A total of 6,071 masters athletes completed the online survey, indicating heights and weights required for calculating BMI. In total 3150 (51.9%) of the participants were male, whilst 2921 (48.1%) were female. The ages ranged from 25 to 91 years ($\bar{x}$=51.5, s =±9.7). The most represented nationality within the sample was Australia (n=4,450, 73.3%). Due to the high sample size (n=6,071), after examination of the distribution of participant ages, it was deemed suitable to use a Pearson Product Moment Correlation, which indicated that there was a low, but statistically significant (r=-0.036, p=0.003) negative linear correlation between Age and BMI. There was however a very low coefficient of determination (r^2=0.001). Linear regression gave the equation representing this relationship as:

BMI= -(0.016Age±0.060) +26.498±0.290
With units: BMI(kg/m^2), Age(years)

Plotting the regression standardized residuals against predicted BMI showed a violation of normality (Fig. 1), echoed quantitatively (skewness=1.3, kurtosis=3.4), but confirmed dramatically in Q-Q plots (Fig. 2). For linear comparative purposes between age and BMI the linear relationship statistically significantly represented the WMG sample database and would be appropriate for establishing a difference in direction of trend. However for representation of the relationship between Age and BMI for WMG athletes a non-parametric, non-linear regression method was sort. As the function form was unknown and the sample was both large and densely populated, with a small standard deviation relative to the mean, loess local regression[15], a more modern methodology was a logical selection of technique. In order to fit the loess models to localized subsets of data, the window width of nearest neighbours was set such that the proportion of data points used to calculate a local smoother was 50%. A tri-weight kernel function was used to give greater weight to data near the current data observation and reduce weight of outliers. Results of the loess regression, namely a curvilinear representation of trend between BMI and age within the sample, is shown in Fig. 3. Fig. 3 also demonstrates the linear relationship that was produced by linear regression.

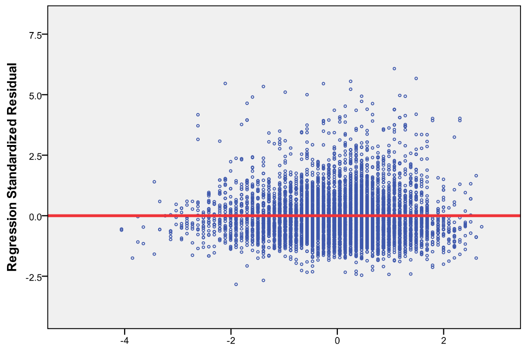

Fig. 1 Scatter plot for regression standardized residuals against predicted BMI, with distribution skewed towards the outliers in the positive region of the plot

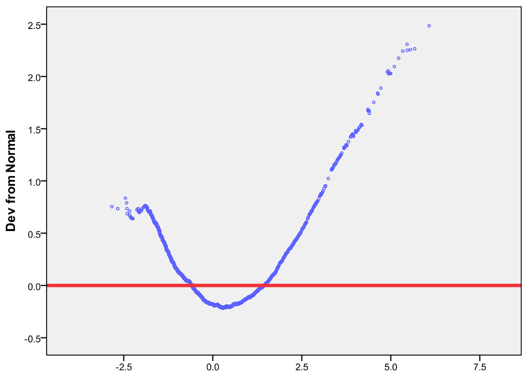

Fig. 2 Detrended normal Q-Q plot of standardized residual indicating a clear curvilinear pattern

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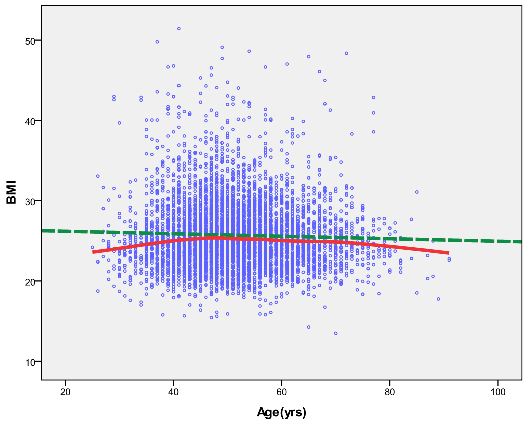

Fig. 3 Scatter plot of data observation scores for BMI and age. Linear regression relationship (dotted green) and local polynomial loess regression relationship (solid red), both superimposed for clarity

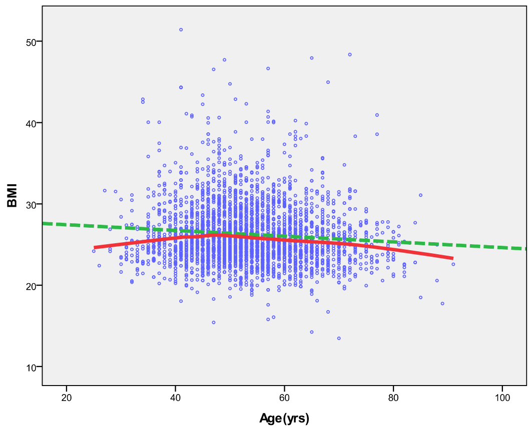

Fig. 4 Scatter plot of data observation scores for BMI and age for male gender participants. Linear regression relationship (dotted green) and local polynomial loess regression relationship (solid red), both superimposed for clarity

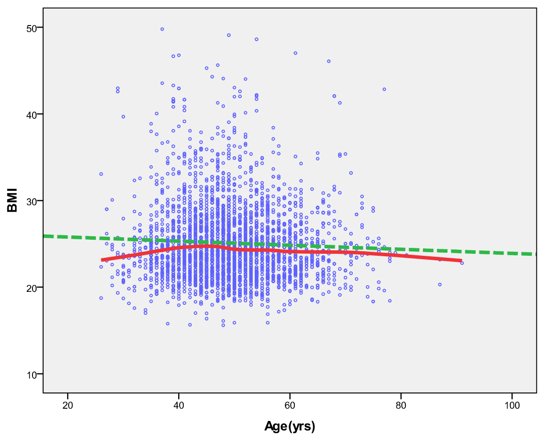

Fig. 5 Scatter plot of data observation scores for BMI and age for female gender participants. Linear regression relationship (dotted green) and local polynomial loess regression relationship (solid red), both superimposed for clarity

Due to the categorical nature of data within the Australian Bureau of Statistics 2007-2008 National Health Survey control population (n=12,346), 49% male, 51% female (categorical range 25-29 to 85+, mode classification 35-39), a Spearman Correlation was run for participants from ages 25 and over. This correlation between age and BMI calculated from self-reported heights and weights (as per the WMG sample) revealed a statistically significant ($r=0.064$, $p<0.001$), slightly positive trend of higher BMI with age as per reported findings[11,12]. The low coefficient of determination was noted however. Loess regression was performed with consistent parameter selection, to the previous cases and indicated a steady increase in BMI across the age categories. There was a drop in BMI at higher ages as for the WMG populations, however this was only present at higher ages than for the WMG sample. This is represented in Fig. 6 below, it should be noted that the data is primarily in categorical format.

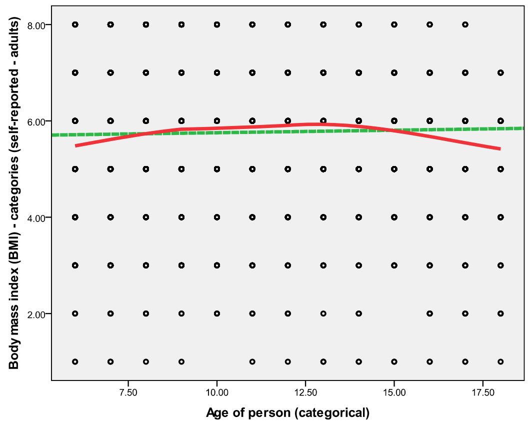

Fig. 6 Scatter plot of control group scores for BMI and age. Linear regression relationship (dotted green) and local polynomial loess regression relationship (solid red), both superimposed for clarity. Note due to categorical nature of data, regression relationships only, as opposed to graphical distribution of individual values, should be interpreted from this graph

IV. Discussion

Due to the large number of respondents, 6,071 respondents can be considered as a representative sample of 28,089 competitors at the Sydney WMG. Using this data, there is the potential to promote this form of physical activity across the lifespan for this unique cohort as having many positive outcomes in terms of health related fitness, general motor fitness, injury reduction, sport specific fitness and mental health.

There was concern over possibilities of range restriction affecting correlations and regressions prior to examination of data. After analysis of the data, it was clearly spread across a large portion of the lifespan and sample size was large for both groups, thus this was considered to not be a concern. Analysis using linear regression showed a linear relationship between BMI and Age. This relationship is of negligible value for predictive purposes due to the low coefficient of determination, however it has other uses. It is clear from the results of linear regression that the relationship of increasing BMI with age, though also present in an appropriate age matched control population from the most represented nationality at the games, is not prevalent in the Sydney 2009 WMG athletes, technically it is slightly reversed. The nexus between health physical activity and aging is a multifaceted complex problem, however the results of this study give evidence that in this unique population of older to middle aged adults the trend of increasing BMI with age is not present. This shows significantly improved health in terms of one health risk factor for masters athletes as age increases compared to the usual trend of higher BMI with age.

Results of polynomial loess regression were closely matched to those of linear regression for the bulk of observational values (40-80yrs) and showed further reduced BMI predictive values outside this range, though these areas were not as reliable for predictive purposes due to the lower density of observational readings in these areas. Despite a visually altered array of observational readings across the two genders, consistent negative gradient linear regression lines, as well as consistent loess regression curves were very encouraging results and confirmed the pattern within the data as being more reliable and non-gender specific on a macroscopic level.

It should be noted that the issue of causation must also be considered. Namely, the question of whether playing masters sport promotes reduced prevalence of higher BMI with aging and lowers associated health risks or alternatively whether people with lower BMI's participate in masters sport by preference or simply because they are still physically capable of competing as they age. Future studies, including factor analysis using psychological data gathered as well as injury medical history also gathered can be used to build on these findings and further investigate this concern of causation. It was deemed appropriate to compare data from the sample and control population as both populations were composed in principle (or entirely) of Australian nationals and both datasets were comparable, being based on BMI data derived from self reported height and mass measurements.

V. Conclusion

While there is potential for reduced health with aging, it is a commonly held conception that adherence to exercise improves indices of general health. For a large representative sample of athletes competing at the world masters games, it is shown that for both male and female athletes, as well as for the sample as a whole, they have reversed the more common trend of higher prevalence of higher BMI with increased age. As BMI is an important factor in the chronic disease burden within a population and given the current obesity epidemic and the multifaceted steps being taken in an attempt to find solutions to this epidemic on a global scale, these findings on this unique cohort of individuals is of special interest. While the issue of causation must still be addressed, these results of a provisional stage of this large cross-sectional epidemiological observational study are promising for eventually improving the understanding of the nexus between, health, physical activity and aging.

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