Body mass index of Australian Army reservists and the Australian population — is there a difference?

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Synopsis

Objective: To investigate the existence of a difference in the body mass index (BMI) of Australian Army Reserve (ARES) personnel and the Australian population.

Design: Cross-sectional study of ARES personnel and secondary analysis of data presented in the Australian Diabetes, Obesity and Lifestyle Study conducted by the International Diabetes Institute in 1999–2000.

Participants: 562 ARES personnel of both sexes aged 17 and over based in Perth and 704 Perth residents of both sexes aged 20 and over selected randomly from the Commonwealth electoral roll.

Main outcome measures: BMI based on measured height and weight.

Results: ARES males aged 17–29 had a lower BMI than the Australian male population aged 20–29, and their mean BMI was in the healthy weight range (BMI 20–24.9). The mean BMI of ARES males aged 30–54 was in the overweight category (BMI, 25–29.9) and was no different from the mean BMI of the Australian male population aged 30–54. There was no difference in BMI between ARES females aged 17–44 and the Australian female population aged 20–44. The mean BMI for women was in the healthy weight range up to the age of 34, and in the overweight category for age 35–44.

Conclusion: ARES males aged 17–29 have a lower BMI than the Australian male population and a BMI in the healthy weight range, possibly due to a selection effect. ARES males aged 30–54 have the same overweight BMI as Australian males aged 30–54. Membership of the ARES does not have any impact on the BMI of males aged 30–54.

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THE BODY MASS INDEX (BMI) of the Australian population is increasing, with more people entering the overweight and obese categories.[1] By late 1995, over 64% of Australian men and 49% of Australian women aged over 18 were overweight or obese.[2] This contrasts with figures from 1989 showing that 52% of Australian men and 38% of Australian women aged over 20 were overweight or obese.[3]

Maintaining BMI within the healthy weight range of 20–25 kg/m^2 is important, as this range is associated with the longest high quality life expectancy and the lowest death rate.[4] A BMI in the overweight or obesity category is associated with increased mortality[5,6] and/or morbidity from type 2 diabetes, hypertension, gallbladder disease, some types of cancers and coronary heart disease.[4] Overweight men (BMI, 25–30) have 1.7 times the risk of coronary heart disease as those in the healthy weight range.[7] Overweight and obesity are caused by a combination of low activity,[8] high caloric intake[4] and genetic factors.[9]

The men and women of the Australian Army Reserve (ARES) are a subset of the Australian population who, while working in the ARES on a part-time volunteer basis, must nonetheless fulfil and maintain all the health and fitness

criteria of their regular Army, full-time volunteer counterparts.[10]

The entry criteria for the ARES are quite strict: applicants must be aged between 17 and 35, and must have a BMI within the healthy weight range.[11] Applicants outside the healthy weight range who wish to gain entry to the ARES must attain the healthy weight range within six months of application, and then maintain themselves within the healthy weight range for a further six months before their application will be processed.[11] Exceptions to this procedure are occasions when the BMI is not a likely indicator of morbidity; for example, people with a muscular frame. In these cases, chest minus waist difference, waist-to-hip ratio, neck and abdominal measurement, or skinfold thickness may be used to assess weight and health.[11]

Once selected and trained, ARES members are medically reviewed every three years up to the age of 35, and then on an annual basis.[12] This review consists of a physical examination, which includes measuring and recording the member's height and weight.[12] Results are recorded on a standard form, which is filed with the member's medical file at their military unit. If a member is overweight or obese, he or she is counselled by a medical officer on the military requirement to attain the healthy weight range and given dietary and exercise advice to achieve this aim.[13] Members who are overweight or obese and consequently unable to fulfil some part of their service responsibility temporarily or permanently are subject to administrative action, which may lead to their discharge from the ARES.[10,13]

Physical fitness testing is conducted twice-yearly by the member's unit in a separate procedure to the medical review. The fitness testing consists of a timed 2.4 km run and "sit-up" and "push-up" exercises.[14] Failure to pass these tests results in administrative action, ultimately leading to discharge if the member does not attain the required level of pass.[10]

Given the stringent entry criteria, medical reviews and stringent physical fitness tests, one would expect the ARES population to have a lower mean BMI and lower overweight and obesity-related morbidity than the non-ARES Australian population.

We conducted an epidemiological study comparing the BMI of ARES members to that of the Australian population, matched for age group and sex, to determine if there is a difference in the BMI between the ARES and the Australian population.

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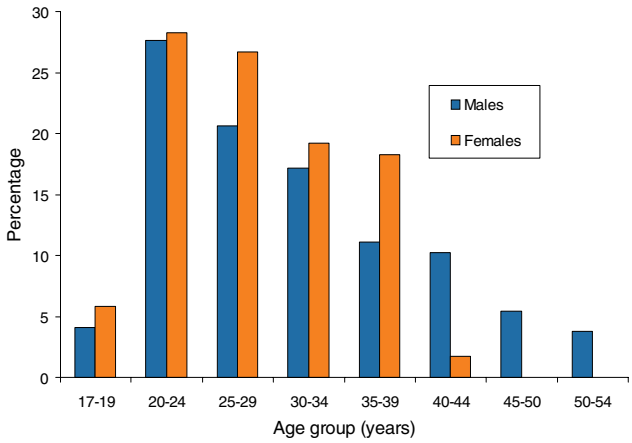
1: Sex distribution, by age group, of a sample of Australian Army Reserve personnel



Methods

We extracted data from the medical records of four ARES units in Perth (the ARES personnel were Perth residents). Two were infantry units and two were administrative units. Regular army personnel were excluded. These data were then compared with data for the general Perth population obtained from the Australian Diabetes, Obesity and Lifestyle Study (AusDiab).[15] The study was approved by the Australian Defence Human Research Ethics Committee (protocol 223/00).

Data collection

All unit medical files on hand were accessed and the most recent medical board results (recorded on a standard form) were located. The member's unit, sex, year of birth, height and weight were recorded on standard forms by the researchers and transcribed onto a standard Excel spreadsheet (Excel 97 SR-1; Microsoft 1997).

Internal data analysis (ARES)

The data were analysed using SPSS (SPSS 9.0.1; SPSS 1999) and Excel. The BMI of each ARES member was calculated from the most recently recorded height and weight found in their medical file. The oldest measurements were three years old. BMI was measured as a ratio of body weight in kilograms to height in metres squared. Underweight was defined as a BMI of under 20, overweight was defined as a BMI of 25 or over, and obesity was defined as a BMI of 30 or over, according to NHMRC and Australian Defence Force guidelines.[13,16]

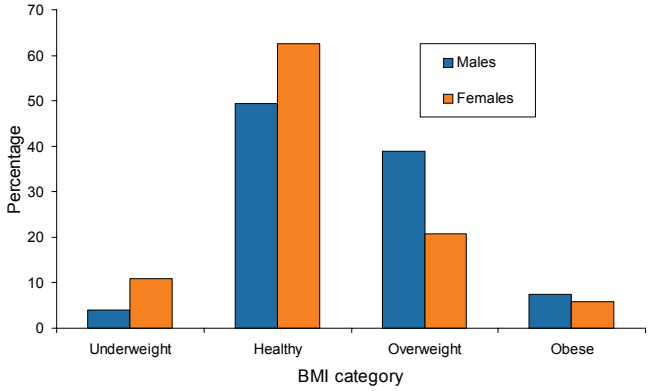
Data were initially examined using simple frequency tables. Sex-specific mean BMI was calculated by age group (five year) and by type of military unit (infantry or non-infantry) and differences were assessed using *t* tests and analysis of variance. Linear regression was used to determine the association between age and BMI (separately for each sex). Linear regression was also used to examine the association between BMI with age, sex and type of military unit.

External data analysis (Australian population)

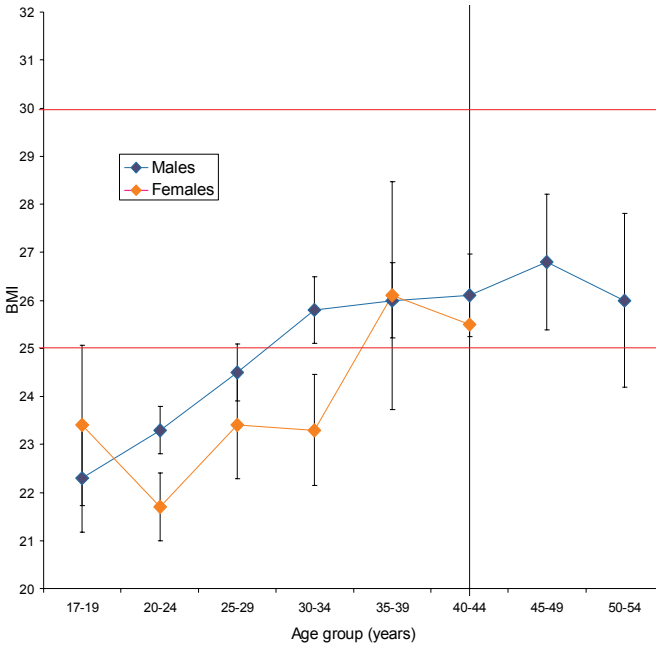
The AusDiab Study is a nationwide study involving nine "catchment" areas with a standard sample size of 1500 per catchment area.[15] The sample was selected using Commonwealth electoral rolls and included people aged between 20 and 69. The sample did not include rural voters. Respondents completed questionnaires and were invited to the survey centre, where their height and weight were measured (among other measurements). Data collection staff were trained using standardised methods. Subjects were weighed in socks and light street clothing, and 1 kg was deducted from the recorded weight as an allowance for clothing.

For this study, only the data from the 1999 survey in the Perth catchment area were used for comparative purposes. The mean ARES BMI matched for age group (five year) and sex was compared with the Perth population mean BMI matched for age group (five year) and sex. If the mean ARES BMI was outside the 95% confidence interval of the Perth population means, then the means were considered to be different (ie, $P < 0.05$).

2: Distribution of BMI, by sex, of a sample of Australian Army Reserve personnel



3: Mean BMI, by age and sex, of a sample of Australian Army Reserve personnel



Age group	Male BMI (95% CI)	Female BMI (95% CI)
17–19	22.3 (21.2–23.4)	23.4 (21.8–25.1)
20–24	23.3 (22.8–23.8)	21.7 (21.0–22.4)
25–29	24.5 (23.9–25.1)	23.4 (22.3–24.5)
30–34	25.8 (25.1–26.5)	23.3 (22.1–24.5)
35–39	26 (25.2–26.8)	26.1 (23.7–28.5)
40–44	26.1 (25.2–27.0)	25.5 (18.5–32.5)
45–49	26.8 (25.4–28.2)	
50–54	26 (24.2–27.8)	

Results

Internal analysis (ARES)

The total metropolitan personnel strength of the four ARES units sampled was 849, of which 562 samples were taken. Two hundred and eighty-seven samples were unavailable, mostly due to members providing military support to the Sydney Olympic Games. Females represented 21.4% of the sample population. Twenty-five per cent of the female sample population and 64.5% of the male sample population were in infantry (combat) units.

The distribution of sex by age group is represented graphically in Box 1. Most (92.5%) of the female population were in the 20–39 years age groups, only 1.7% were in the 40–44 years age group, and none were in the age groups beyond. This contrasts to the 76.5% of the male population in the 20–39 years age groups, with 10.2% in the 40–44 years age group, 5.4% in the 45–49 years age group and 3.8% in the 50–54 years age group. The mean age of males was 30.8 years (range, 18–57) and the mean age of females was 28.2 years (range, 18–43).

The distribution of sex within the BMI categories is shown in Box 2: 62.5% of females and 49.5% of males were in the healthy weight range, while 20.8% of females and 38.9% of males were in the overweight BMI category. The percentages of members in the underweight and obese BMI categories were considerably less: 10.8% of females and 4.1% of males were underweight, and 5.8% of females and 7.5% of males were obese.

BMI by sex and age group are shown in Box 3. The mean BMI for males aged over 30 fell within the overweight category, as did the mean BMI for females within the 35–39 years age group. The sample size of the female age group 40–44 was too small to make meaningful deductions.

On average, the mean BMI of males increased by 0.13 for every year of age (95% CI, 0.10–0.16) and the mean BMI of

females increased by 0.19 for every year of age (95% CI, 0.90–0.30). The mean BMI for all males was 24.8 (95% CI, 24.5–25.1) and the mean BMI for all females was 23.4 (95% CI, 22.7–24.1). After adjusting for age and sex there was no significant difference in BMI between infantry and non-infantry units.

External analysis (ARES population compared with Australian population)

The mean BMI by sex and age group for the Perth population (704 samples) was extracted from the AusDiab Study and is displayed in Box 4 and Box 5, where it is compared with the ARES population. The error bars in the graphs are the 95% confidence intervals.

ARES males had a statistically significant lower BMI than the Australian male population in the age groups 20–29. In the age groups 30 and over, there were no significant differences between the ARES males and the Australian male population.

Among the female population, no significant differences were found in any of the age groups.

Discussion

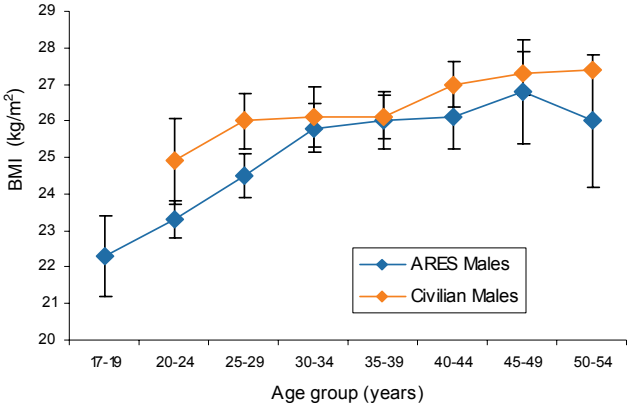
We found that ARES males had a lower BMI than the Australian male population up to the age of 29. From the age of 30 years onwards, there was no difference in BMI between ARES males and the Australian male population. The mean BMI of males aged 30+ years was in the overweight range. We also found no statistically significant differences in BMI between ARES females and the Australian female population. The mean BMI of females was in the healthy weight range up to the age of 34, and then in the overweight range.

The units selected for the ARES sample (two infantry units and two administrative units) were chosen to be representative of a typical ARES population. The composition of ARES units, the recruitment and training of ARES members, and their medical reviews and fitness testing are standardised nationally, so results for this sample can probably be generalised to the entire Australian ARES population.

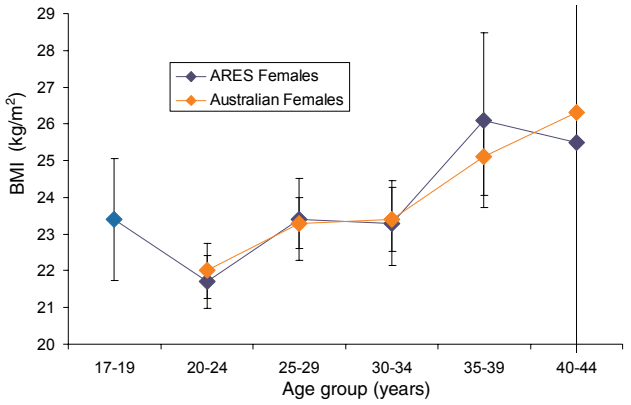
At the time of the study, the medical records of some of the eligible sample population could not be accessed because they were absent as support staff for the Sydney Olympic Games. This is unlikely to have biased the results, as the only selection criterion for acting as Olympic Games support staff was availability, and this did not depend on BMI, height or weight.

The results from the Perth subjects in the AusDiab Study can be generalised to the metropolitan Australian population, as standard techniques were used in the recruiting and measuring of all subjects in all cities, and the metropolitan subjects have been shown to have the same levels of risk factors for heart disease.[15]

4: Mean BMI of ARES males vs Australian males, by age



5: Mean BMI of ARES females vs Australian females, by age



The height and weight entered at the time of the ARES member's medical review were recorded onto standard medical forms. In the process of data collection, the recorded heights and weights were transcribed by the researchers onto standardised forms. The height and weight measurements were taken at different centres by different medical personnel; however, standardised weighing equipment with regular calibration checks and standardised height-measuring equipment were employed. It is policy procedure to weigh the member in underwear;[11] however, it has been reported that some centres weighed members in camouflage uniform and combat boots and then deducted three kilograms from the weight shown on the scales. A camouflage uniform and boots weigh less than two kilograms, so this practice would underestimate the member's weight. If this practice was widespread, then the results of this study would underestimate mean BMI.

This study appears to be the first English-language study to compare the BMI of a national population to the subset of that population rendering part-time military service. Other studies have conducted cross-sectional studies of the BMI of

full-time military personnel, with similar results to ours. In a study of 19 185 Canadian Forces full-time volunteer personnel, it was found that 50% of the men and 25% of the women had a BMI over 25, while 26% of the men and 12% of the women had a BMI over 27.[17] In our study, we found that 46.4% of the ARES men and 26.6% of the ARES women had a BMI over 25, and 21.9% of the ARES men and 11.7% of the ARES women had a BMI over 27. In a Danish study, 220 full-time volunteer Danish military personnel were compared with the general Danish population. That study found that the frequency of overweight males (BMI 25–30) was significantly higher among the male army personnel than in the general population.[18]

It is possible that the overweight mean BMI of the ARES males in the 30 and over age groups could be due to their having muscular frames with little body fat, as the BMI does not distinguish between fat and muscle ratios.[4] If this were indeed the case, then we would expect to see this trend emerge well before the age of 30. Nonetheless, it could be argued that infantry males are more likely to have a muscular frame with little body fat, and, because they are the majority of the population sample, they have skewed the mean BMI into the overweight range. However, our results showed that, after adjusting for age and sex, there was no difference in the BMI between infantry and non-infantry males.

The younger ARES male population had a BMI significantly lower than the Australian male population. This may be due to a "selection effect", similar to the "healthy worker effect"[19] (ie, that the age-standardised mortality ratio of an occupational population is lower than that of the general population, as it necessarily comprises individuals healthy enough to be employable). Younger age groups are targeted and recruited into the ARES, and are excluded if their BMI is outside the healthy weight range. With time, this younger ARES male population then increases in weight until, by age 30, its mean BMI is no different to that of the Australian population.

The weight gain over time in members of the ARES male population occurs despite their regular medical reviews, physical fitness testing and routine combat training. The regular army (full-time) has a component of fitness training that the ARES lacks, requiring compulsory physical fitness training for all its members at least three times a week. The mean BMI of the regular army has not been reported, so it is not known if this regular fitness training has beneficial effects on BMI. However, a reasonable hypothesis is that the increase of the BMI of the ARES male population as it ages is due to the selection effect wearing off, combined with a lack of compulsory physical fitness training.

The economic burden of morbidity due to overweight and obesity in Australia was $840 million for the financial year 1992–93. This did not include the consumer cost of attending weight loss centres, estimated at $500 million per year.[1] The prevalence of overweight and obesity is continuing to rise,[2] and the associated health costs will also rise. As it currently stands, the ARES male population over 30 has the same overweight and obesity risk factors for mortality, type 2 diabetes, hyperlipidaemia, hypercholesterolaemia, hypertension, arthritis and some cancers as the general Australian population.[9]

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