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Mortality of Japanese Olympic athletes in 1964 Tokyo Olympic Games

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ABSTRACT

Objectives To compare the mortality of Japanese athletes in the 1964 Tokyo Olympic Games with that of the Japanese population, and to elucidate factors associated with their mortality.

Methods We obtained from the Japan Sport Association study subjects' biographical information, information on lifestyles and medical data. Missing data were obtained from online databases. Standardised mortality ratio (SMR) was calculated to compare athletes' mortality with the Japanese population. Cox proportional hazards model was applied to estimate the HR for each category of body mass index (BMI), smoking history and handgrip strength. This analysis was limited to male athletes due to the small number of female athletes.

Results Among 342 (283 men, 59 women) athletes, deaths were confirmed for 70 (64 men, 6 women) athletes between September 1964 and December 2017. Total person years was 15 974.8, and the SMR was 0.64 (95% CI 0.50 to 0.81). Multivariate analysis performed on 181 male athletes. Mortality was significantly higher for BMI≥25 kg/m^2 than for 21–23 kg/m^2 (HR: 3.03, 95% CI 1.01 to 9.07). We found no statistically significant associations between smoking history and mortality; the HR (95% CI) for occasional and daily smokers were 0.82 (0.26 to 2.57) and 1.30 (0.55 to 3.03) compared with never smokers. We also found no statistically significant associations between handgrip strength and mortality (P for trend: 0.51).

Conclusion Japanese athletes in the 1964 Tokyo Olympic Games lived longer than the Japanese population. BMI≥25 kg/m^2 was associated with higher mortality, but smoking history and handgrip strength were not associated with mortality.

What are the new findings?

- ► Japanese athletes in the 1964 Tokyo Olympic Games lived longer than the Japanese population.
- ► Body mass index ≥25 kg/m^2 was associated with higher mortality, whereas smoking history and handgrip strength were not associated with their mortality.

How might it impact on clinical practice in the future?

- ► Elucidating factors associated with mortality among elite athletes will help improve careful support for these athletes.

INTRODUCTION

Olympic athletes are representative of elite athletes. Although they are exposed to strenuous exercises and psychological stress for a long period,[1] previous studies demonstrated lower mortality among Olympic athletes in other countries compared with the general population.[2–7] However, it is yet to be elucidated what kinds of factors are associated with mortality among Olympic athletes.

In 1964, the International Olympic Committee proposed to conduct research on lifelong health and physical strength of Olympic athletes who participated in the 1964 Tokyo Olympic Games, and compile the results as the Olympic Medical Archives (OMA). Twenty-three countries participated in this project, and medical data on 1110 Olympic athletes were collected. In Japan, the Japan Sport Association (JSPO) played a central role in this project and collected medical data on Japanese athletes who participated in the 1964 Tokyo Olympic Games. Although the OMA project ended in 1972, only Japan continued to follow athletes who had participated in the 1964 Tokyo Olympic Games. The JSPO continued to collect physical measurements every 4 years, and medical data on the participants were continuously collected. However, these valuable data have never been analysed from an epidemiological point of view.

The objective of this study was to evaluate the mortality of Japanese athletes who participated in the 1964 Tokyo Olympic Games compared with that of the Japanese population, and also to elucidate factors associated with mortality among Olympic athletes.

METHODS

Study subjects

This research is a part of 'Follow up study on 1964 Tokyo Olympians'; the project of Sport

Medicine and Science Research conducted by JSPO. Study subjects included 355 (295 men, 60 women) Japanese athletes who had participated in the 1964 Tokyo Olympic Games. Athletes with missing information on vital status or date of death were excluded from this study.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Study design and data collection

Biographical information on the study subjects was obtained from the JSPO and included date of birth, vital status, date of latest confirmation of survival (for Olympians whose vital status was 'alive'), and date of death (for Olympians whose vital status was 'dead'). This biographical information was collected through inquiries to families or acquaintances of athletes, responses to a questionnaire or measurements from physical examinations. For data on study subjects whose biographical information was missing, we searched four online databases; SR/OLYMPIC SPORTS (https://www.sports-reference.com/olympics/), Kikuzo II Visual (https://database.asahi.com/index.shtml), MAISAKU (https://mainichi.jp/contents/edu/maisaku), Wikipedia (https://en.wikipedia.org/wiki/Main_Page).

The JSPO conducted questionnaire surveys and measured physical fitness between July and September 1964. The questionnaire collected information on lifestyle (history of drinking, history of smoking), and physical fitness measures (including height, weight, right and left handgrip strength, systolic blood pressure, and diastolic blood pressure) were collected from physical examinations, chest X-rays, electrocardiograms and blood/urine tests. These medical data were collected to explore their association with physical strength and skilled performance. JSPO obtained written confirmation on the participation in this project from the athletes. The use of these data was approved on 17 March 2020 by the institutional review board of Osaka University Medical Hospital (approval number: 19319). Data cannot be shared publicly because of participants confidentiality. This manuscript does not contain any personal and/or medical information about an identifiable individual. Categories of smoking history and history of drinking were as follows: never, occasionally, every day. Body mass index (BMI) was calculated as weight divided by the square of height, and was categorised as follows: <19, 19–<21, 21–<23, 23–<25 and ≥25 kg/m^2. Handgrip strength was evaluated by the mean of right-side and left-side handgrip strength. Sex-specific categories of handgrip strength were created by quartile.

Follow-up and outcome

Follow-up started at the Olympian's participation date in the 1964 Tokyo Olympic Games (10 October 1964). For Olympians whose vital status was 'dead', follow-up continued until the date of death. For Olympians whose vital status was 'alive', follow-up was continued until the date of the latest confirmation of survival or 31 December 2017, whichever came first. Outcome was defined as all-cause mortality.

Statistical analyses

Standardised mortality ratio (SMR) was calculated to assess mortality among the study subjects compared with the Japanese population.[8] The overall SMR was calculated by dividing total number of observed deaths among study subjects by the expected number of deaths if the age-period specific mortality rates among the study subjects were the same as those of the Japanese population. Sex-age-period specific mortality rates of the Japanese population are available at the Portal Site of Official Statistics of Japan (e-Stat).[9] Observed and expected number of deaths were then categorised according to attained age group (0–<30, 30–<40, 40–<50, 50–<60, 60–<70, 70–<80 and ≥80 years). Subgroup analysis was also conducted to calculate SMR according to sex.

Cox proportional hazards model was applied to evaluate the association between BMI, handgrip strength, history of smoking and mortality among the study subjects. We limited this analysis to male athletes due to the small number of outcomes in each category of covariates for women. Subjects with missing data on either of these covariates were excluded from the analyses. The reference category was set at 21–23 kg/m^2 (BMI), never (history of smoking) and the lowest quartile (handgrip strength). In this model, age group at baseline (10–<20, 20–<25, ≥25 years), systolic blood pressure, history of drinking (never, occasionally, every day), BMI, history of smoking and handgrip strength were mutually adjusted.

All of the analyses were conducted using Stata/MP V.15.0, and the statistical significance level was set at 0.05.

RESULTS

Among 355 Japanese athletes who participated in the 1964 Tokyo Olympic games, 342 (283 men, 59 women) had a confirmed vital status and were eligible for analysis: 292 athletes were confirmed by JSPO between September 1964 and December 2017, and 50 were confirmed by online databases. Top five sports disciplines with the greatest number of participants were athletics (67 athletes), swimming (58 athletes), volleyball (24 athletes), rowing (23 athletes) and football (19 athletes). Of the 342 athletes with a confirmed vital status, 272 (219 men, 53 women) were alive and 70 (64 men, 6 women) were dead. Of the 272 athletes who were alive, the JSPO confirmed date of latest confirmation of survival for 224, and online databases confirmed date of latest confirmation of survival for 48 athletes (online supplemental table 1). Two hundred and eleven athletes' (77.6%) latest confirmation of survival was confirmed between 2016 and 2017: more than 50 years of follow-up. Of the 70 dead athletes (64 men, 6 women), the JSPO confirmed date of death for 67 and online databases confirmed date of death for three athletes. Vital status was unknown for three athletes and date of death was unknown for 10 athletes, therefore, these 13 athletes were excluded from the analysis.

Table 1 describes baseline characteristics of the study population. Age at baseline was higher in men compared with women. Percentage of overweight athletes, defined as BMI ≥25 kg/m^2, was 13.2% among men and 3.4% among women. About half of the male athletes had no history of smoking, while 92% of female athletes had no history of smoking. The IQR of handgrip strength was 48.5–58.3 kg for men and 32.5–38.0 kg for women. No history of drinking was seen in 32% of men and 73% of women. Both systolic and diastolic blood pressure were higher among males compared with women.

Total person years was 15974.8, and overall SMR for the study population was 0.64 (95% CI 0.50 to 0.81) (table 2). SMR was categorised according to the attained age group. Mortality among the older attained age groups was significantly lower than the Japanese population (60–<70: 0.54, 95% CI 0.33 to 0.83; 70–<80: 0.49, 95% CI 0.29 to 0.76), but this significantly lower mortality was not observed in younger attained age groups. Online supplemental table 2 describes the result of subgroup analysis according to sex. Mortality among male athletes was significantly lower than the Japanese population (SMR: 0.64, 95% CI 0.50 to 0.81), whereas we did not observe significantly lower mortality among female athletes compared with the Japanese population (SMR: 0.68, 95% CI 0.27 to 1.40).

Table 3 describes HR for each covariate in the Cox proportional hazards model. Among 283 male athletes, information on either of the covariates was missing for 102 athletes, and 181 athletes were therefore included in this analysis. Correlation coefficients between variables in the Cox proportional hazards model are described in online supplemental table 3. The HR for the BMI≥25 was significantly higher than for the reference category (3.03, 95% CI 1.01 to 9.07). No statistically significant associations between smoking history and mortality were observed. Compared with never smokers, the HR for occasional and daily smokers were 0.82 (95% CI 0.26 to 2.57) and 1.30 (95% CI 0.55 to 3.03), respectively. We also observed no significant associations between handgrip strength and mortality. Compared with lowest quartile (Q1) of handgrip strength, the HR for Q2, Q3 and Q4 were 0.66 (95% CI 0.20 to 2.19), 1.20 (95% CI 0.45 to 3.24) and 1.14 (95% CI 0.37 to 3.53), respectively.

Table 1 Baseline characteristics of the study population

	Male n=283	Female n=59	Missing, n (%)
Age at baseline, years	23.8±3.8	22.3±4.7	3 (0.9)
BMI (kg/m^2)			
<19	11 (3.9%)	5 (8.6%)	4 (1.2)
19–<21	55 (19.6%)	16 (27.6%)	
21–<23	107 (38.2%)	17 (29.3%)	
23–<25	70 (25%)	18 (31%)	
≥25	37 (13.2%)	2 (3.4%)	
History of smoking, n (%)			
Never	104 (52)	44 (92)	95 (27.8)
Occasionally	30 (15)	1 (2)	
Every day	65 (33)	3 (6)	
Range of handgrip strength, kg			
Q1 (lowest quartile)	33.0–48.5 (n=73)	27.3–32.5 (n=15)	15 (4.4)
Q2	48.5–53.0 (n=66)	32.5–35.1 (n=13)	
Q3	53.0–58.3 (n=66)	35.1–38.0 (n=16)	
Q4 (highest quartile)	58.3–80.5 (n=66)	38.0–49.5 (n=12)	
History of drinking, n (%)			
Never	64 (32)	35 (73)	93 (27.2)
Occasionally	105 (52)	12 (25)	
Every day	32 (16)	1 (2)	
Blood pressure, mm Hg			
Systolic	118 (110–122)	110 (100–112)	19 (5.6)
Diastolic	70 (60–74)	60 (50–70)	19 (5.6)

BMI, body mass index.

DISCUSSION

In this cohort study of Japanese Olympic athletes who participated in the 1964 Tokyo Olympic Games, it was elucidated that Olympic athletes lived longer than

Table 2 Standardised mortality ratio (SMR) for the study population categorised by attained age group

Attained age group	Person years	Number of deaths	Crude mortality rate	Expected number of deaths	SMR (95% CI)
0–<30	1859.9	3	161.3	2.4	1.24 (0.32 to 3.38)
30–<40	3274.3	6	183.3	5.0	1.21 (0.49 to 2.51)
40–<50	3275.8	5	152.6	8.9	0.56 (0.21 to 1.25)
50–<60	3186.5	16	502.1	18.5	0.86 (0.51 to 1.37)
60–<70	2853.8	18	630.7	33.4	0.54 (0.33 to 0.83)
70–<80	1437.7	17	1182.5	35.0	0.49 (0.29 to 0.76)
≥80	86.9	5	5753.7	5.9	0.85 (0.31 to 1.89)
Total	15 974.8	70	438.2	109.1	0.64 (0.50 to 0.81)

Table 3 HR by Cox proportional hazards model for the male athletes

	Number of athletes	Person years	Number of deaths	Adjusted HR		
				HR	95% CI	P for trend
BMI (kg/m^2)						
<19	6 (3.3%)	305.14	2	2.12	0.42 to 10.69	0.18
19–<21	40 (22.1%)	1928.19	6	1.51	0.50 to 4.62	
21–<23	73 (40.3%)	3557.72	8	Ref		
23–<25	43 (23.8%)	2057.08	10	2.49	0.94 to 6.58	
≥25	19 (10.5%)	886.49	7	3.03	1.01 to 9.07	
History of smoking, n (%)						
Never	93 (51.4%)	4531.99	17	Ref		0.61
Occasionally	27 (14.9%)	1335.14	4	0.82	0.26 to 2.57	
Every day	61 (33.7%)	2867.50	12	1.30	0.55 to 3.03	
Handgrip strength, kg						
Q1 (lowest quartile)	46 (25.4%)	2241.51	8	Ref		0.51
Q2	45 (24.9%)	2196.29	6	0.66	0.20 to 2.19	
Q3	47 (26.0%)	2284.62	10	1.20	0.45 to 3.24	
Q4 (highest quartile)	43 (23.8%)	2012.22	9	1.14	0.37 to 3.53	

In this analysis, age group at baseline (10–<20, 20–<25, ≥25 years), systolic blood pressure, history of drinking (never, occasionally, every day), BMI (<19, 19–<21, 21–<23, 23–<25, ≥25), history of smoking (never, occasionally, every day) and handgrip strength (Q1–Q4) were mutually adjusted.
BMI, body mass index.

the Japanese population. It was also elucidated that BMI≥25 kg/m^2 was significantly associated with higher mortality, whereas smoking history or handgrip strength was not associated with mortality among Olympic athletes. Our findings would be beneficial to understand what kind of factors are associated with mortality among elite athletes and to promote their health after they retire from competitions.

In the present study, Japanese athletes who participated in the 1964 Tokyo Olympic Games had an overall SMR of 0.64, which indicated that they lived longer than the Japanese general population. The same trend was observed in other studies targeting Olympic athletes in foreign countries.[2–7] A prior study in Poland compared the mortality of Polish former athletes who participated in 20th century Olympics since 1924 with the male population in Poland.[2] The overall mortality was 50% lower than the general population (SMR: 0.50, 95% CI 0.44 to 0.56). Another study in France compared overall mortality of former French Olympic athletes with the French general population.[5] The overall mortality was 51% lower than the general population (SMR: 0.49, 95% CI 0.26 to 0.85). In the present study, we observed a similar extent of reduction in mortality among Japanese Olympic athletes.

When we categorised SMR by attained age group, mortality among older attained age groups was significantly lower than the Japanese population. However, this lower mortality was not observed among younger attained age groups, although we expected reduction in mortality among younger attained age groups due to selection bias. This might be explained in part by sudden deaths among young athletes, which have been previously described.[10–15] A prior study in the USA[11] reported a higher incidence of sudden deaths (2.3 in 100 000 per year) among competitive athletes aged 12–35 years compared with non-athletes (0.9 in 100 000 per year) aged 12–35 years. The relative risk of sudden deaths among competitive athletes compared with non-athletes was 1.95 (95% CI 1.3 to 2.6) for men and 2.00 (95% CI 0.6 to 4.9) for women. Another prior study targeted college student-athletes in the USA,[13] and reported that during a 10-year follow-up period, 182 sudden deaths occurred among 4 052 369 athletes, and the top three causes were cardiovascular disease, suicide and drugs. Although mortality rates of cardiovascular diseases and suicide were lower than in these athletes than in the general population of a similar age, the mortality rate of suicide was significantly higher compared with non-athlete college students.

The association of BMI with all-cause mortality has been reported in previous studies.[16–22] As far as we know, few previous studies reported the association of BMI with mortality among elite athletes. Since BMI does not differentiate fat mass and muscle mass,[23] information on fat mass and muscle mass would be needed to determine whether high BMI among elite athletes is due to large fat mass or large muscle mass.[23–25] However, high BMI among Japanese Olympic athletes in 1964 Tokyo Olympic games may be explained by large muscle mass rather than large fat mass. In our study population, higher BMI was observed among sports disciplines which require large muscle mass including weightlifting and martial arts. These sports disciplines are classified into a higher level of cardiovascular demand,[26] which may explain higher mortality among these sports disciplines. Therefore, higher mortality among athletes with BMI≥25 kg/m^2 in this study population may be explained by characteristics of sports disciplines that require large muscle mass.

Although smoking is a known risk factor for various kinds of diseases among the general population, no significant association between history of smoking and mortality was observed in the present study. This may be explained in part by a low smoking rate and a low smoking dose among competitive athletes. A prior study reported that the smoking rate among 504 National Football League players (8%) was lower than the general population.[27 28] Another prior study reported low rate of daily or heavy smokers among competitive athletes.[29] In the present study, the percentage of Olympians with no history of smoking was 59.9%, which is much higher than that of the Japanese population in the same era. According to a nation-wide survey conducted by the Japan Tobacco and Salt Public Corporation, the sex-age specific smoking rate among the Japanese population in 1965 was 80.5% for men in their 20s and 6.6% for women in their 20s.[30]

Handgrip strength is widely used as an index of muscle mass and strength.[31–40] Although the underlining mechanism is yet to be fully elucidated, previous epidemiological studies revealed that a lower level of handgrip strength was associated with all-cause mortality,[33–35 40] chronic diseases[39] and cardiovascular mortality.[38 40] However, we did not observe an association between handgrip strength and mortality in our study population. This may be due to the high level of handgrip strength among Olympic athletes. According to results of a national nutrition survey in 1964, the average handgrip strength of Japanese men during that year was 22.4 kg (men aged 10–14 years), 39.5 kg (men aged 15–19 years) and 43.4 kg (men aged 20–24 years).[30] In contrast, the average handgrip strength of Japanese athletes in the 1964 Tokyo Olympics was 53.0 kg (men aged 15–19 years) and 54.4 kg (men aged 20–24 years), which suggests that this study population consisted of athletes with a high level of handgrip strength.

This study has several strengths. First, to the best of our knowledge, this is the first study to elucidate factors associated with mortality among elite athletes. The results indicated that BMI≥25 kg/m^2 was significantly associated with higher mortality. Second, subjects in the present study were followed until relatively recently, which meant that the observation period was long enough to conduct survival analyses.

This study had several limitations. First, in the present study, we analysed the questionnaire on lifestyle and the results of physical fitness measures which was conducted in 1964. Therefore, we could not evaluate the impact of changes in lifestyle and physique after they participated in the Olympic games on their mortality. Second, small sample size could have affected the results. We did not observe significantly lower mortality among female athletes compared with the Japanese population (online supplemental table 2). In the Cox-regression analysis, we did not observe significant association of handgrip strength or smoking history with mortality (table 3). These results should be interpreted as inconclusive because of the limited statistical power in this study. Third, we could not conduct analyses stratified by cause of death because we did not have access to such information. In particular, we could not show that sudden deaths were associated with a higher SMR in the younger attained age group. And finally, the interpretation of high BMI among elite athletes would be different from the general population. As we described in the Discussion section, high BMI among elite athletes may be explained by muscle mass rather than fat mass. However, since BMI does not differentiate between fat mass and muscle mass, further information on other parameters including fat mass and muscle mass would be needed.[23–25]

Future research

Further studies would be needed to investigate the causes of deaths by incorporating national mortality statistics of Japan into our analyses, especially causes of deaths among Olympic athletes who died during a younger attained age.

CONCLUSION

Japanese athletes who participated in the 1964 Tokyo Olympic Games lived longer than the Japanese population. It was also elucidated that BMI≥25 kg/m^2 was significantly associated with higher mortality among these athletes. Understanding factors associated with mortality would be beneficial to help athletes promote their health after they retire. Further studies would be needed to evaluate the impact of changes in their lifestyles after their participation in the Olympic games on their mortality.

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