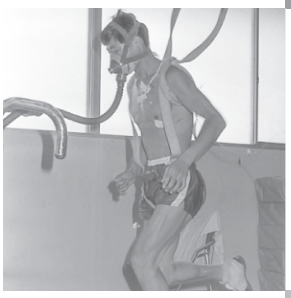
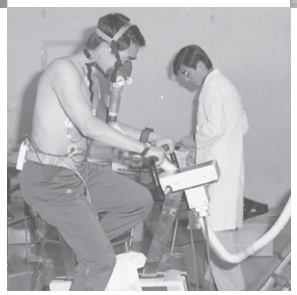
一流競技者の健康・体力追跡調査
—東京オリンピック記念体力測定—の総括

Follow up study on the TOKYO1964 Olympians

公益財団法人
日本スポーツ協会　Japan Sport Association (JSPO)








Project Summary

Chair, Sport Medicine and Science Research Committee, Japan Sport Association
KAWAHARA Takashi, M.D.

1. Project background

This project was originally started as the Olympic Medical Archives (OMA). The OMA was an initiative by the International Federation of Sports Medicine (FIMS), in collaboration with the International Olympic Committee (IOC), the National Olympic Committee (NOC), and the World Health Organization (WHO) to use the Games of the Olympiad held in Tokyo in 1964(hereafter, "TOKYO1964") as an opportunity to survey the health and physical fitness of athletes who took part in the Olympic Games over their entire lives and preserve a records of this survey in the Olympic Museum in Lausanne, Switzerland. However, the number of participating countries decreased in 1972, and the OMA was discontinued. Considering of the significance and importance of this initiative, the Sports Science Committee of the Japan Sport Association decided in 1968 to conduct surveys and measurements every four years under the name "Tokyo Olympic Commemoration Physical Fitness Study" and has continued to do so to the present. Since the 10th study in 2005, it has been conducted as joint research between the Japan Sport Association and the Japan Institute of Sports Sciences (JISS).

2. Survey subjects

Although 355 athletes (294 men and 61 women) competed in the TOKYO1964(hereafter, "TOKYO1964 Olympians"), the questionnaire surveys, physical fitness measurements, and medical examinations and consultations targeted 380 individuals (314 men and 66 women) that included candidate athletes. Figure 1 shows the changes in athletes who participated in the questionnaire surveys as well as those who participated in the physical fitness measurements and medical examinations and consultations for male and female separately. At the time of the most recent study (the 13th) in 2016, the questionnaire surveys were sent to 273 people, excluding 80 deceased individuals (75 men and 5 women) and 27 who could not be located. Of the 177 who responded, 132 were men and 45 women. The ages of the respondents were 75.4±3.6 (76.0±3.5 for the men and 73.5±3.3 for the women). Of these, 106 (79 men and 27 women) had undergone physical fitness measurements and medical examinations and consultations.

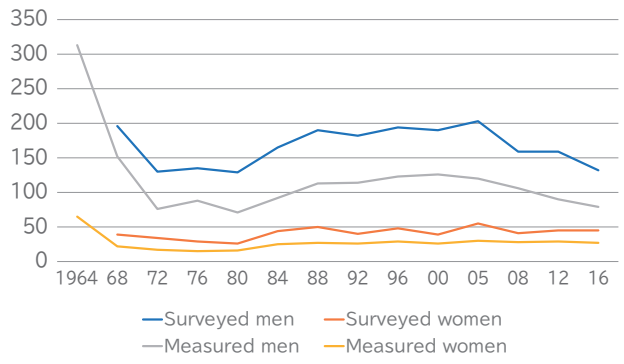


Figure 1: Changes in questionnaire survey and measurement participants

3. Survey items

The first time this study was done (1968), only the questionnaire surveys, physical fitness measurements, and general clinical examinations were conducted. Orthopedic examinations were added starting from the third in 1976, with internal medicine examinations added from the sixth in 1988 and dental examinations added from the 11th in 2008. Surveys of locomotive syndrome, frailty, and sarcopenia were conducted at the 13th in 2016. The survey items were as follows.

1) Questionnaire survey
   - Occupation, marital status, number of children, smoking, drinking, sleep, diet, sporting history, exercise habits, health status, injuries, diseases, etc.

2) Physical fitness measurements
   - Morphology: Body weight, body length, sitting height, chest circumference, abdominal circumference, subcutaneous fat, limb circumference
   - Function: Back strength, grip strength, arm flexion strength, leg extension strength, vertical jump, repeated side steps, whole body reaction time, anteflexion, upper body deflection, whole body endurance

   ＊ The ages of the subjects were also taken into consideration, and starting from the 10th measurements in 2005, only morphology, grip strength, long-seated anteflexion, one-leg standing with eyes closed, and one-leg standing with eyes open were investigated.

3) General clinical examinations: Blood pressure, electrocardiogram, chest x-ray, blood tests, urine tests

4) Orthopedic examinations
   - Survey on hip, knee, and other pain
   - Consultations, knee and hip x-ray examinations, bone density

5) Internal medicine consultations

6) Dental consultations

7) Frailty, sarcopenia, locomotive syndrome

4. Summary of survey results

Many of the TOKYO1964 Olympians continued exercise habits even after retiring from competition, and even in old age maintain higher muscle strength than in the general population. They had lower incidences of hypertension, diabetes, and dyslipidemia than the general population, and their mortality rates were low, however many cases of hyperuricemia and gout were observed. Also, although bone density had been maintained at a high level even after reaching old age, many complained of body pain, and a tendency to have lessened balance ability and walking speed than the elderly in general was observed.

It is often beneficial to one's health to devote oneself to sports in adolescence and stay in the habit of participating in sports afterwards, but as many athletes complain of body pain in old age, it seems important to prevent injury and disability when competing during adolescence to the greatest extent possible and avoid neglecting taking care of one's body.

Acknowledgments: This survey was conducted over a long period of time with the cooperation of a great many people, and we would like to thank all those who cooperated as well as the TOKYO1964 Olympians who agreed to undergo the measurements.

Changes in State of Physical Fitness and Engagement in Exercise/Sports in Athletes Who Represented Japan at the TOKYO1964 Olympians

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●Overview of study results

- Differences between the TOKYO1964 Olympians and Average Japanese in terms of strength, power, and agility tended to remain nearly constant until old age, but no clear differences between the two groups in the tendency for these to decline with age were observed.
- Individual differences (deviations) were great in terms of flexibility and balance, and a tendency for these to be worse in the TOKYO1964 Olympians than in Average Japanese was also observed.
- The ratio of both male and female of the TOKYO1964 Olympians who engage in exercise/sports at least once a week trended higher than that of Average Japanese from adolescence to middle age, but this difference with Average Japanese tended to gradually lessen as the athletes grew older.

●Physical fitness

About 20% of the total number of samples of male TOKYO1964 Olympians had lower strength (grip strength measured from the first through to 13th measurements) than Average Japanese (Society for Physical Fitness Standards Research in Tokyo Metropolitan University, 2007). However, almost all of the women far exceeded Average Japanese, and strength tended to be higher on average than Average Japanese in both male and female athletes. Also, strength in both male and female TOKYO1964 Olympians gradually declined starting from about age 30, and this downward trend with aging was similar to that of Average Japanese (Fig. 1). This tendency also held true for back strength measured from the first through ninth measurements.

In addition, power (vertical jump) decreased linearly with age for both the TOKYO1964 Olympians and Average Japanese, but the difference between the two tended to be maintained until old age (Fig. 2). Since the same tendency was also observed in agility (repeated horizontal jump), this can be said to suggest that the “carry-over effect” (Fig. 3) of the physical fitness element that had been heightened during adolescence can also be expected for power and agility in the same way as for strength.

Note that flexibility (standing-type body anteflexion, long seat-type body anteflexion) and balance (standing on one leg with eyes closed; standing on one leg with eyes open) deviated greatly for both men and women, and it was not possible to identify fixed trends including changes with age, such as most of the TOKYO1964 Olympians exhibiting lower values than Average Japanese. Changes in balance with age are said to be conspicuous especially among functional items, but it seems necessary to include such factors as aging mechanisms in balance functions and the influence of lower limb alignment when considering this point.

●State of engagement in exercise/sports

The ratio of individuals who engaged in exercise/sports

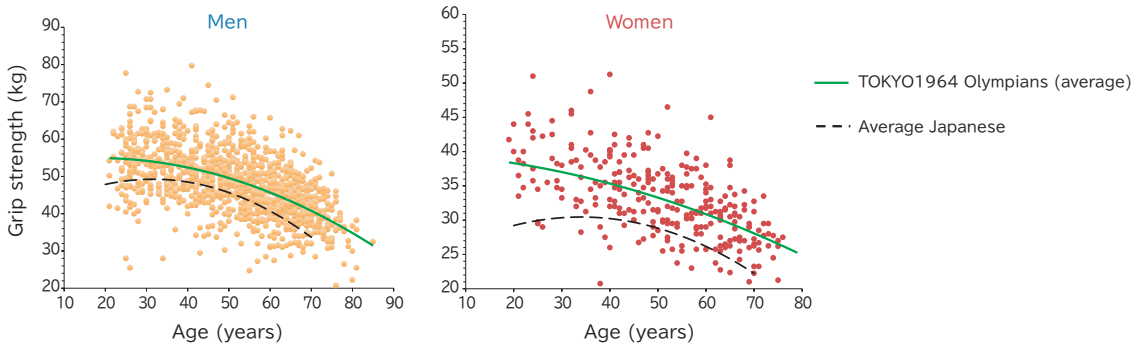

Figure 1: Strength (grip strength)

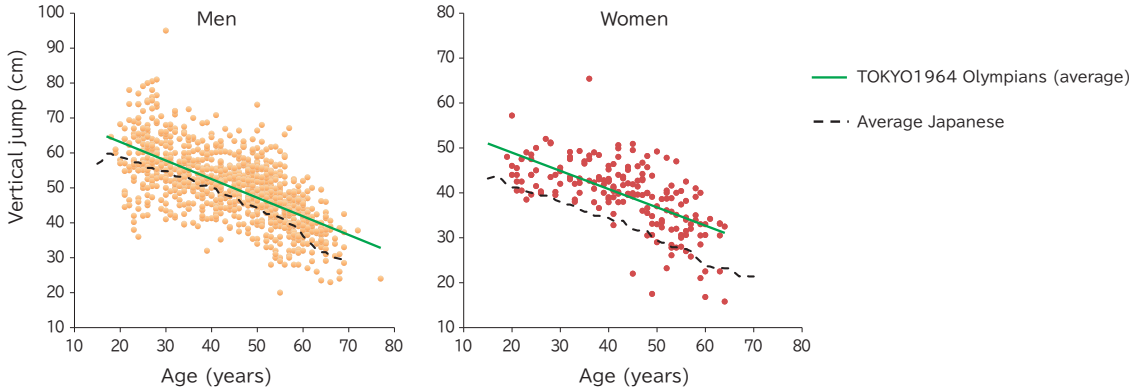

Figure 2: Power (vertical jump)

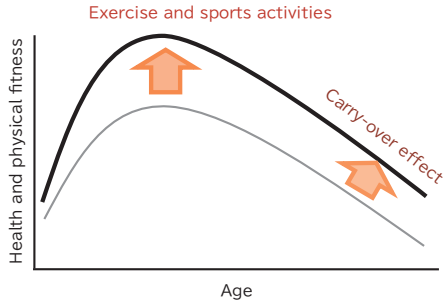

Figure 3: Carry-over effect on health and physical fitness (schematic)

(hereinafter, “the active”) more than once per week at the time of the fourth measurement (men 40.3 years old; women 38.4 years old) after the end of the TOKYO1964 when most of TOKYO1964 Olympians are thought to have ceased active competition was 56.1% for the male athletes and 72.7% for the female athletes, which was much greater than for Average Japanese, which for men in their 40s was 34.3% and for women in their 30s was 30.2% (Fig. 4: this data for Average Japanese used for comparison was obtained by referencing the data for the same time period and generation in the "Public Opinion Survey on Physical Fitness and Sports" by the Prime Minister's Office, Cabinet Office, and Ministry of Education, Culture, Sports, Science and Technology and "Public Opinion Survey on State of Engagement in Sports, Etc." by the Japan Sports Agency).

From their 40s to their mid-50s (men at 56.4 years old and women at 54.5 years old at time of the eighth measurement), the male TOKYO1964 Olympians went from 56.1% to 45.6% and the women from 72.7% to 56.0%, demonstrating a decline in both sexes, but these figures were as ever higher than those of Average Japanese (32.3% for men in their 50s and 41.7% for women). After that, until the 13th measurement (men at 76.0 years old and women at 73.5), both male and female TOKYO1964 Olympians showed an increase or decrease to about 60% (i.e., remained at a high level), but after around the age of 70 the ratio in Average Japanese was slightly higher.

●Conclusion

Opinions concerning whether there is a relationship between past exercise habits and current health and physical fitness are varied, but it also has been pointed out that there is a moderate correlation between past exercise experience and current exercise habits (Suzuki and Nishijima, 2005). The “carry-over effect” apparent in elements of physical fitness such as grip strength in the TOKYO1964 Olympians is presumed to be attributable to their higher rates of engagement in exercise/sports following retirement from active competition through the prime working years of middle age until reaching old age in comparison with Average Japanese. It has been pointed out in many domestic and international studies that grip strength is highly correlated with strength in many parts of one's entire body and is also associated with both overall and causal mortality as well as disease risk. The fact that exercise/sports habits and physical fitness factors from adolescence have been carried over to middle and old age while producing synergistic and cyclical effects suggests the possibility that the TOKYO1964 Olympians were more confident in their own health and physical fitness compared to Average Japanese, and this also relates to such matters as their tendency to have low rates of certification for nursing care (Japan Sports Association, 2016).

Therefore, it can probably be said that establishing exercise and sports practices in childhood and adolescence and habituating them throughout life is one of the necessary elements for living a healthy and prosperous life even through middle and old age.

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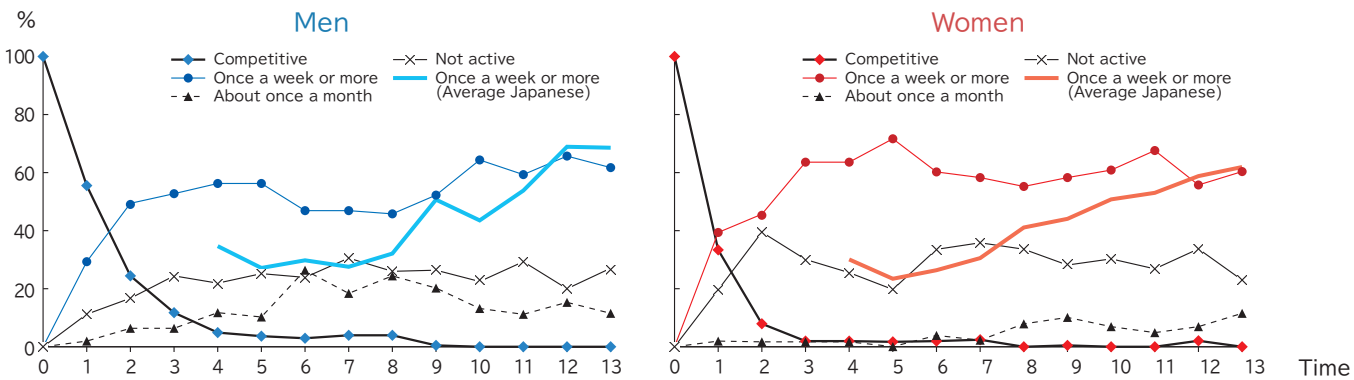

Figure 4: Changes in state of engagement in exercise/sports

Orthopedic Evaluation of Motor Organs
(Bone Mineral Density, Lumbar Spine/Knee Joint Pain, Degenaration and Locomoter Function)

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1) Japan Institute of Sports Sciences; 2) Saitama Medical Center

●Overview of study results

- We conducted a study of the bone mineral densities(BMD) as well as symptoms and changes in the locomotor organs of TOKYO1964 Olympians and were thought to have been exposed to high exercise load environments while young.
- The percentage of the athletes who **"experience pain"** in the lumbar spine and knee joints, which are typical locomotor organs, increased over time, and at the time of the 2016 (13th) survey when the average age of the athletes was 75.5 (average ages of men and women were 73.9 and 76.1, respectively), 48.5% (48.1% and 50.0% of the men and women, respectively) of the athletes experienced pain in the lumbar spine, and 40.6% (35.4% and 51.9% of the men and women, respectively) of the athletes experienced pain in the knee joints (Figure1, 2).
- Progression of **"osteoarthritis(OA)"** (Kellgren-Lawrence Classification Grade 2 or worse) in the lumbar spine and knee joint with time was evident even in simple radiography-based evaluations; 90.6% (91.4% and 88.9% of the men and women, respectively) of the athletes presented with OA in the lumbar spine and 50.9% (44.3% and 70.3% of the men and women, respectively) of the athletes presented with OA in the knee joint. However, it seems that their locomotor organs had been able to maintain a high level of functioning even while the athletes sensed pain and dysfunction in said organs.
- **"Bone Mineral Density; BMD"** was maintained at extremely high values compared to the average values of healthy young adults, and this was found to correlate with muscle strength and muscle mass.
- Based on the above, while it appears that a sufficiently high-load exercise environment during youth causes age-appropriate changes and symptoms in the motor organs, motor organ functioning and bone density can be maintained at high levels mainly due to muscle mass and muscle strength accumulated during youth.

●Characteristics of locomotor organs in the elderly

Locomotor organs are the only body organs that people can use at their will to move their body. However, it is known that upon reaching old age, various changes and impairments manifest in the structures and functioning of locomotor organs. For this reason, treatment of the osteoporosis that causes vulnerable fractures and exercise therapy for maintaining motor function are recommended as approaches for dealing with locomotor disorders in the elderly.

Also, it is said that the locomotor organs of the elderly are impacted by the past lifestyles and habits of individuals, and physical fitness measurements and medical checks of the TOKYO1964 Olympians thought to have had sufficient exercise loads and exercise habits while young have been conducted every year in the 52 years from the year in which the TOKYO1964 were held through 2016. These surveys can now be said to be valuable data on the locomotor organs of the elderly, and herein follows a description of the evaluations of the functioning and joints of the lumbar spine and knee, which are typical locomotor organs, as well as whole body BMD based on the results of the physical fitness measurements and medical checks conducted in 2016 (13th survey). Incidentally, the average age of the athletes who had represented Japan in the TOKYO1964 at the time of the 2016 survey was 75.5 (76.1 and 73.9 for women and men, respectively).

●Joint pain

We investigated the presence or absence of persistent pain in the lower back and knee joints at the time of each survey.

(1) Lower back pain (Fig. 1): The percentage of the athletes who responded that they "currently have persistent lower back pain" was 28.0% (28.1% and 29.1% for men and women, respectively) at the time of the 10th survey (with an average age at the time of the survey of 64.9) conducted in 2005, but afterwards this gradually increased and by 2016 (13th survey) 48.5% (48.1% and 50.0% for men and women, respectively) were experiencing lower back pain. Meanwhile, in surveys targeting the general population, it is said that there is little change with age from age 50, and the percentage of people who experienced lower back pain was approximately 30% (28.3% and 31.2% for men and women, respectively)[2)].

(2) Knee joint pain (Fig. 2): The percentage of the athletes who responded that they "currently have persistent knee joint pain" was 17.3% (17.2% and 34.5% for men and women, respectively) in 2005 (10th survey), but as was the case for lower back pain this had increased by 2016 (13th survey) to 40.6% (35.4% and 51.9% for men and women, respectively). In surveys targeting the general population, the incidence of this in those age 60 or older is 32.8% (24.1% and 37.6% for men and women, respectively)[3)], and a comparison of these

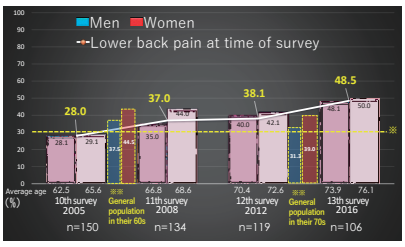

Figure 1: Presence/absence of lower back pain at time of survey (respective averages for men and women)
※Ratio of general population (age 50 or older) with lower back pain is 30% (28.3% and 31.2% for men and women, respectively)[2)] (Muraki et al., 2012)
※※Ratio of general population (60s and 70s) with lower back pain[5)] (Yoshimura et al., 2014)

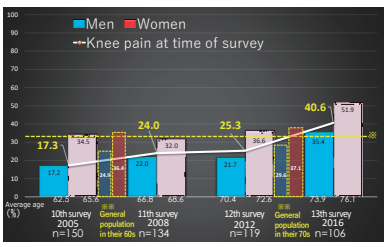

Figure 2: Presence/absence of knee pain at time of survey (respective averages for men and women)
※Ratio of general population (age 60 or older) with knee pain is 32.8% (24.1 % and 37.6% for men and women, respectively)[2)] (Muraki et al., 2012)
※※Ratio of general population (60s and 70s) with lower back pain[5)] (Yoshimura et al., 2014)

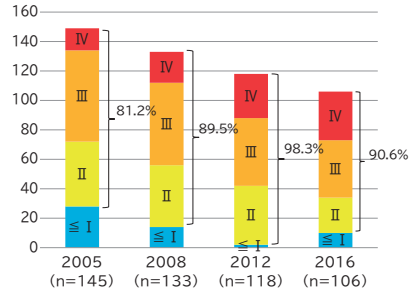

Figure 3: Ratio of lumbar spondylosis severity (K-L classification ≥ Ⅱ) at time of each evaluation

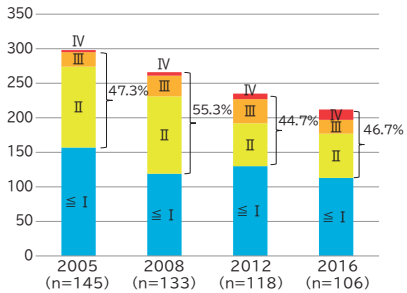

Figure 4: Ratio of gonarthrosis severity (K-L classification ≥ Ⅱ) at time of each evaluation

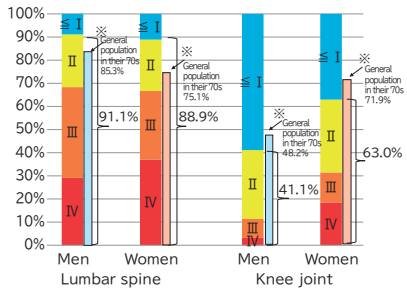

Figure 5: Ratio of OA (in lumbar spine/knee joint) severity at time of 2016 evaluation
※Ratio of general population (60s and 70s) with lower back pain[5)] (Yoshimura et al., 2014)

shows that, considering the increases attributable to age, there seems to be no major difference between them.

●Degenerative change of the joint

In the evaluations of the joints, radiography of the knee joint and lumbar spine (anterior-posterior/lateral) has been performed since the 4th survey (1980), and from the 10th survey (2005), joints have been evaluated using a 5-level evaluation (0 to IV) based on the Kellgren-Lawrence (K-L) classification[4] that is widely used to evaluate the severity of OA.

(1) Osteoarthritic changes in the lumbar spine (Fig. 3): The ratio of athletes who presented with changes attributable to OA of Grade 2 (mild) or worse under the K-L classification was 81.2% in 2005, but it had increased to 90.6% (91.1% and 88.9% for men and women, respectively) (Fig. 5) at the time of the evaluation in 2016.

(2) Osteoarthritic changes in the knee joint (Fig. 4): The ratio of athletes who presented with findings of mild or worse (K-L>II ; same level OA severity of the lumbar spine) OA in 2005 was 47.3%, but this did not change significantly by 2016 when it was 46.7% (41.1% and 63.0% for men and women, respectively). However, the ratio of athletes with severe symptoms seems to have increased, and 6 of them (all women) had undergone knee replacement surgery, etc. There was a difference between men and women with respect to the knee joint, with the changes in the joints of women describable as more conspicuous (Fig. 5). Compared with the reports[5, 6] on surveys targeting members of the general population of the same generation as the Tokyo athletes, changes attributable to OA were slightly more pronounced in the lumbar spine and slightly less in the knee joint, but there seems to have been no major difference.

●Locomotor organ function

The Japanese Orthopaedic Association posits that the overall decline of locomotor functioning in the elderly is a "Locomotive Syndrome" and has developed a locomotive syndrome test that uses locomotor function (stand up test/2-step test) and subjective symptoms (25-question Geriatric Locomotive Function Scale) as an index for evaluating said decline. This test divides severity into two levels, and when implemented for the athletes representing Japan in the TOKYO1964, the ratio of athletes who did not meet the standards for either locomotive syndrome level 1 or 2 in any test (i.e. locomotive syndrome level 0) was 46.1% when tested for subjective symptoms (using the 25-question Geriatric Locomotive Function Scale). In contrast with this, however, the ratios were very high when tested using the stand up test (66.0%) and 2-step test (78.4%) that can be described as motor function evaluations, and it seems that a high level of locomotor function had been maintained in comparison to when evaluated using subjective symptoms (Fig. 6).

●Bone Mineral Density

BMD(whole body) has been evaluated since the 8th survey (1997), but because the measurement instruments differed in the various times when measurements were conducted, it is difficult to make a simple comparison of changes over time. Throughout all the measurements of BMD, none of the male or female athletes had a BMD of less than 70% of the average value of bone mass for young people (ages 20 to 44; young adult mean, or YAM), and no athletes had clinically diagnosable osteoporosis (Table 1).

The body measurement values (body length, body weight, BMI, and grip strength) of the TOKYO1964 Olympians were compared to the values7) for members of the age matched general public in order to investigate the reasons why BMD had been maintained at a high level, and while maintaining standard BMI, the athletes had greater body length and body weight except for some age groups, with grip strength in particular being superior in all age groups, and it seems that the athletes representing Japan in the TOKYO1964 enjoyed superior physiques, with a great deal of muscle mass (Table 2). Also, a positive correlation was observed between BMD, muscle mass, and grip strength, and the greater the muscle mass or grip strength, the higher the BMD (Fig. 7).

However, we were unable to find any significant association between current exercise habits and muscle mass, grip strength, or BMD, and at the very least it seems likelier that exercise load and habits when young were what affected muscle mass, grip strength, and BMD rather than current exercise habits (Fig. 8).

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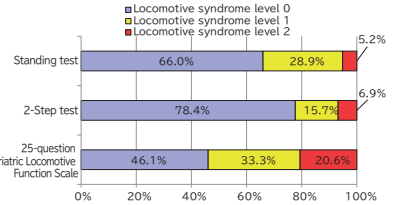


Figure 6: Distribution of locomotive syndromes in subjects in each locomotive syndrome test

Survey when implemented (year)	Measurement method	Men		Women	
		Average (minimum value /maximum value)	YAM≦ 80	Average (minimum value /maximum value)	YAM≦ 80
8th survey (1997)	Quantitative ultrasound (QUS) method	90.30% (71.0-113.0)	13(12.1%)	92.60% (77.0-135.0)	2(7.4%)
9th survey (2001)	Quantitative ultrasound (QUS) method	93.80% (74.0-118.0)	9(8.0%)	96.20% (78.0 -147.0)	2(8.0%)
10th survey (2005)	DEXA法 (※)	97.00% (78-118.7)	3(2.5%)	88.80% (75.6 -107.5)	4(13.8%)
11th survey (2008)	DEXA法 (※)	96.40% (75.0-117.3)	2(2.0%)	86.50% (75.5 -101.7)	4(14.3%)
12th survey (2012)	DEXA法 (※※)	106.60% (81.0-127.0)	0(0.0%)	94.40% (82.0 -118.0)	0(0.0%)
13th survey (2016)	DEXA法 (※※)	104.80% (80.0-125.0)	0(0.0%)	96.50% (81.0 -123.0)	0(0.0%)

Table 1: Comparison with young adult mean (YAM) BMD(whole body)
※, ※※: By measurements with the same instrument type

Sex	Age	n	Body length (cm)		Body weight (kg)		BMI	Grip strength (kg)	
			TOKYO1964	(for comparison)*	TOKYO1964	(for comparison)*	TOKYO1964	TOKYO1964	(for comparison)*
Men	65-69	19	170.3	*166.7*	69.7	*64.4*	23.9	40.9	*40.2*
	70-74	45	169.6	*164.8*	70.4	*62.4*	24.5	39.9	*38.1*
	75-79	18	169.3	*163.2*	67.8	*61.4*	23.6	37.9	*35.7*
	80≦	6	162.4		57		21.6	31.4	
(Average)			**169.2**		**68.8**		**24.0**	**39.1**	
Women	60-64	1	149.7	*155.5*	48.4	*53*	21.6	31.8	*26.6*
	65-69	11	163.3	*153.7*	58.9	*52.3*	22	29.9	*25.3*
	70-74	10	157.4	*152*	57.6	*51.1*	23.1	28.4	*23.9*
	75-79	6	160	*150.6*	56.1	*50.2*	21.9	25.1	*22.8*
(Average)			**160.0**		**57.5**		**22.4**	**28.6**	

Table 2: Comparison of physiques (body length, body weight, BMI) and grip strength of athletes representing Japan in the TOKYO1964 to those of the general public
*: Report on 2017 Survey of Physical Fitness and Sports Proficiency (Japan Sports Agency)

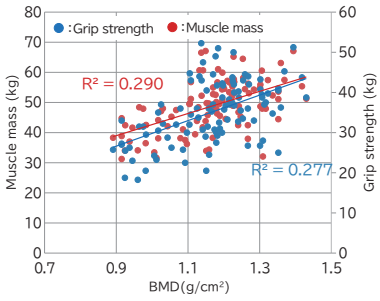


Figure 7: Correlation with BMD, muscle mass, and grip strength (2016)

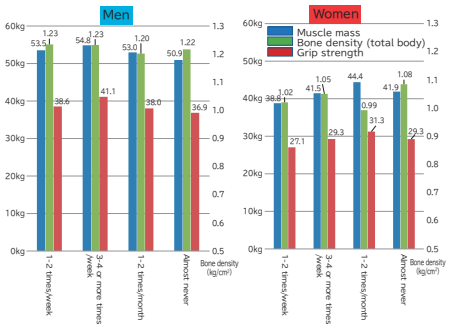


Figure 8: Relationship of exercise habits (frequency) with muscle mass, BMD(whole body), and grip strength (2012)

Prevalence of Lifestyle-related Disease

Kazuyuki Kamahara[1)], Michiko Dohi[1)]

1) Japan Institute of Sports Sciences

●Overview of study results

380 athletes (314 men and 66 women) were the subjects of a follow-up survey of TOKYO1964 Olympians. The survey was conducted for the first time in 1968, and then every four years thereafter. Most recently, it was conducted for the 13th time in 2016. 106 athletes (average age of 75.5 ± 3.6) received medical examinations in the 13th survey, comprising 79 men (average age of 76.1 ± 3.4) and 27 women (average age of 74.0 ± 3.5).

We used the data obtained in the surveys through that point to examine what happens to the effects of having engaged in sports while young including daily vigorous exercise as one ages. With respect to the medical survey items, the items tested in the medical surveys such as specific blood test items at times differed during each study due to changes in how the diseases are conceptualized over time, but the main items that have been investigated are family history, past history (including surgeries), current medical history (disease under treatment, medicines for internal use, presence or absence of subjective symptoms), blood pressure, pulse, physical findings, blood testing, urinalysis, thoracic radiography, and resting electrocardiogram. The prevalence of so-called lifestyle-related diseases such as hypertension, dyslipidemia, and diabetes generally increases with age, and this prevalence increased with every successive survey even among the TOKYO1964 Olympians. We therefore compared the prevalence of lifestyle-related disease in the athletes who participated in the latest (13th) survey with that of the elderly in general. The results are given below.

●Hypertension

Individuals who had a systolic blood pressure of 140 mmHg and a diastolic blood pressure of 90 mmHg or more in the blood pressure measurement conducted at the 13th survey, or who had been diagnosed with hypertension and took medicine for it by the 13th survey, were defined as hypertensive. In the 13th survey, 41 men (51.9%) and 11 women (40.7%) had hypertension. In the results of the *2014 Japan National Health and Nutrition Survey*[1)] by the Ministry of Health, Labour and Welfare, the percentage of men aged 70 and over with hypertension was 72.1%, and that of women was 70.9%, suggesting that the results for both male and female TOKYO1964 Olympians were low (Fig. 1). In the 13th survey, 3 men and 2 women had comorbid hypertension and diabetes, and 6 men and 1 woman had comorbid hypertension and dyslipidemia. Of these, 2 of the men had comorbid hypertension, diabetes, and dyslipidemia.

●Obesity

Body Mass Index (BMI) was calculated based on body length and body weight measured during the 13th survey, with a BMI of 25 or greater defined as obese. Of the TOKYO1964 Olympians who had a BMI of 25 or greater in the 13th survey, 26 (32.9%) were men and 5 (18.5%) were women. However, the ratio among those age 70 or older in the same generation in the general population was 24.7% for both men and women (Ministry of Health, Labour and Welfare, *2014 Japan National Health and Nutrition Survey*[1)]), indicating that the rate of obesity among female TOKYO1964 Olympians was lower than the general population (Fig. 2).

●Dyslipidemia

The current diagnostic criterion for dyslipidemia is to meet one or more of LDL-C ≥ 140 mg/dl, HDL-C <40 mg/dl, and/or TG ≥ 150 mg/dl. However, only HDL-C and TG were measured in blood testing conducted during the 13th survey. In the results of the 2014 Japan National Health and Nutrition Survey1) conducted by the Ministry of Health, Labour and Welfare, those with HDL-C <40 mg/dl or those undergoing treatment were suspected of having dyslipidemia. Statistics were collected, with prevalence of 33.7% and 36.2% of men and women, respectively, in the general population of individuals age 70 or older. In the results of the 13th survey of the TOKYO1964 Olympians using the same criteria, 14 men (17.7%) and 6 women (22.2%) were suspected of having dyslipidemia, and the ratio of both male and female

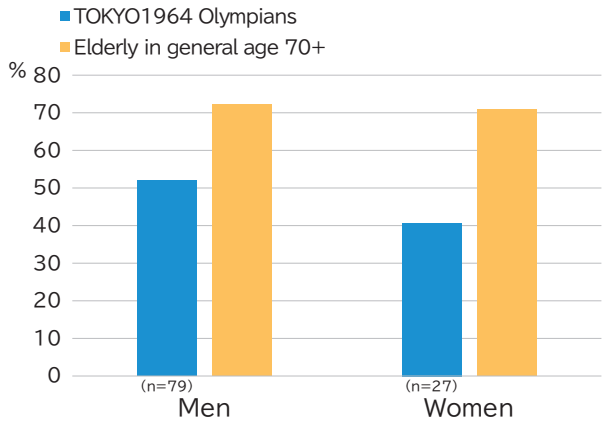


Figure 1: Comparison of prevalence of hypertension (during 13th survey)

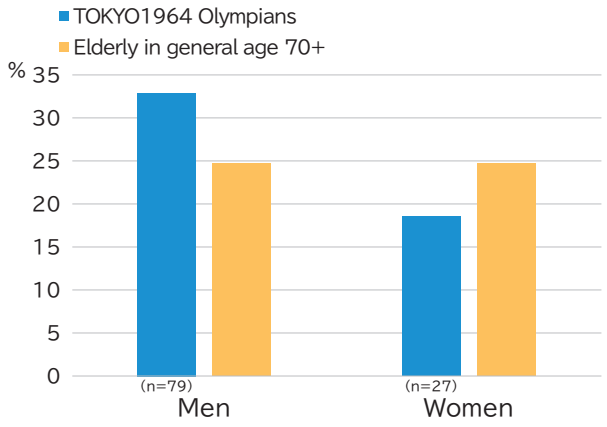


Figure 2: Comparison of BMI (during 13th survey)

TOKYO1964 Olympians suspected of having dyslipidemia was low (Fig. 3).

●Diabetes

Individuals who had an HbA1c of 6.5% or greater during the blood testing conducted in the 13th survey or who had been diagnosed with diabetes and took medicine for it by the 13th survey, were defined as diabetic. The results indicated that 10 men (12.7%) and 5 women (18.5%) had diabetes during the 13th survey of TOKYO1964 Olympians. In the results of the *2014 Japan National Health and Nutrition Survey*[1] by the Ministry of Health, Labour and Welfare, the percentage of men aged 70 and over "strongly suspected as having diabetes" was 22.3%, and that of women was 17.0%, suggesting that the results for male TOKYO1964 Olympians were low (Fig. 4).

●Hyperuricemia

Individuals who had a blood uric acid level of 7.0 mg/dl or greater during the blood testing conducted in the 13th survey or who had been diagnosed with hyperuricemia or gout and had taken medicine for their condition by the 13th survey were defined as hyperuricemic. In the 13th survey, 18 men (22.8%) and 1 woman (3.7%) had hyperuricemia (blood uric acid level of 7.0 mg/dl or greater). In the results of the *2014 Japan National Health and Nutrition Survey*[1] by the Ministry of Health, Labour and Welfare, the percentage of men aged 70 and over with hyperuricemia was 13.6%, and that of women was 4.6%, indicating that the results for male TOKYO1964 Olympians were high (Fig. 5).

●summary

The incidence of so-called "lifestyle-related diseases" such as hypertension, dyslipidemia, and diabetes was lower in both male and female TOKYO1964 Olympians when compared to the elderly in general over the age of 70, while obesity (BMI of 25 or greater) was lower only in the female TOKYO1964 Olympians. Also, the rate of hyperuricemia in male TOKYO1964 Olympians was higher when compared to the general population. No relationship between the incidences of these diseases and current exercise habits was observed, nor was any between their incidences and the types of sports in which the athletes had engaged. No relationships between the incidences of the diseases and the sports in which the athletes engaged or current exercise habits could be clarified in this study because the population parameter for each sport was too small.

Reference

1) Ministry of Health, Labour and Welfare: Report on 2014 Japan National Health and Nutrition Survey https://www.mhlw.go.jp/bunya/kenkou/eiyou/h26-houkoku.html

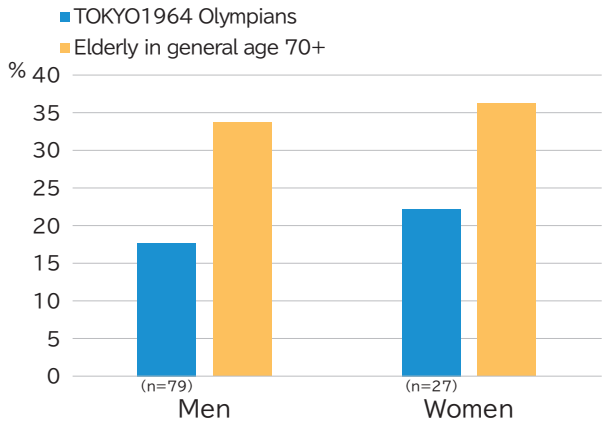


Figure 3: Comparison of prevalence of dyslipidemia (during 13th survey)

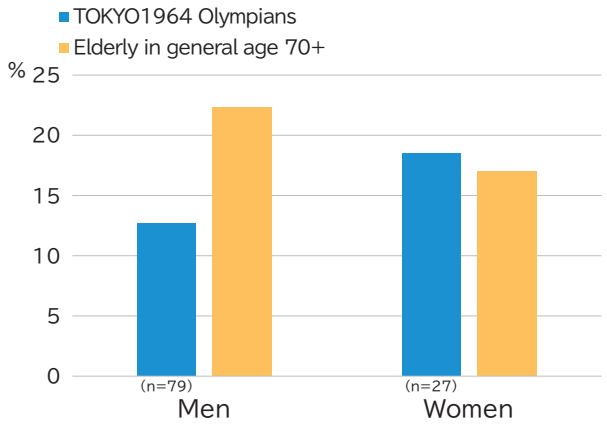


Figure 4: Comparison of prevalence of diabetes (during 13th survey)

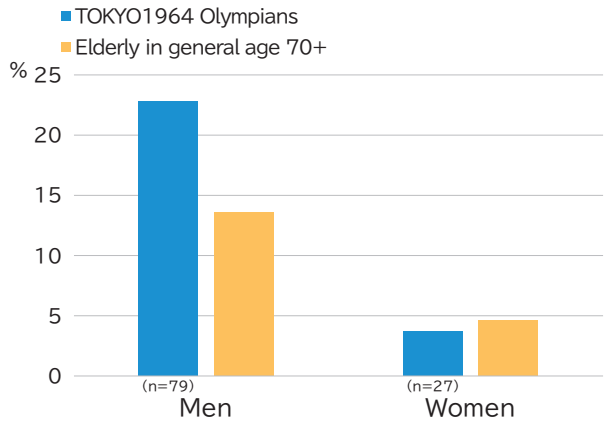


Figure 5: Comparison of prevalence of hyperuricemia (during 13th survey)

The Relationship Between the State of Engagement in Exercise/ Sports and Medical Evaluations: Dental Evaluations

Toshiaki Ueno[1)], Yukako Toyoshima[2)]

1) Tokyo Medical and Dental University; 2) Japan Institute of Sports Sciences

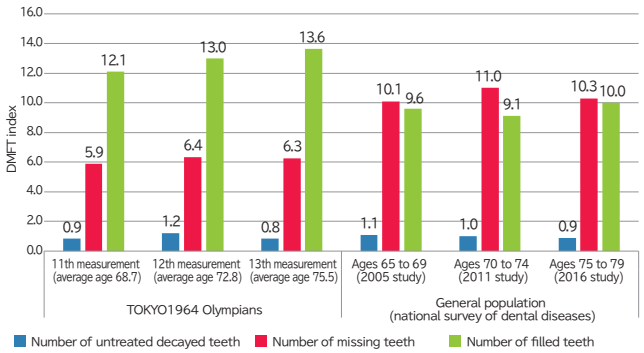
●Overview of study results

Tokyo Olympic Commemoration Physical Fitness Study is a major research project that has been conducted every four years since 1968 for more than five decades since the Tokyo Olympic Games were held in 1964. Dental examinations have been conducted since the 11th measurement in 2008 and, together with the dental examinations in the 12th and 13th measurements, examination data from a total of three measurements has been accumulated. The following findings were obtained as a result of analytically evaluating the data again on the occasion of this study.

- There is a high risk of caries (tooth decay) and many teeth have been treated.
- Although many subjects exhibited no periodontal disease findings, subjects tended to be polarized in this respect.
- Few of the subjects' teeth were missing, and they retained four to five more teeth than the elderly in general.
- Even in their 70s, they maintained a high level of masticatory functioning.

The above findings suggest that the dental and oral health conditions of the former first-class competitors were better maintained than those of the elderly in general. Considering the fact that they have maintained good exercise habits not only during their active careers but also after retirement, it may be the case that the carry-over effect of exercise is also manifest in the health of their teeth and oral cavities.

●The risk of caries is high, and many teeth have been treated



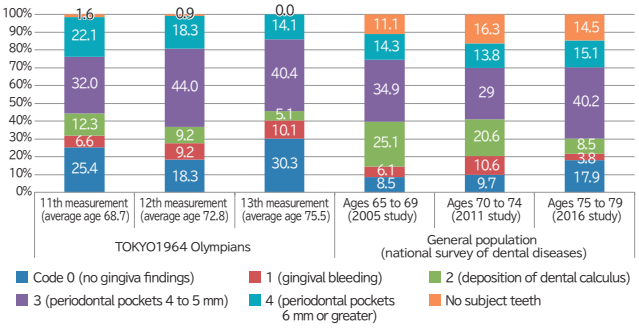
This graph compares the average number of decayed, missing, or filled teeth in the TOKYO1964 Olympians and the elderly in general in Japan. The Decayed, Missing, and Filled Teeth (DMF or DMFT) index is one of the epidemiological indexes that show the morbidity of caries that cannot be expected to heal naturally and their progression up to that point. It expresses the total number of untreated decayed teeth (D), missing teeth (M), and filled teeth (F).

The average numbers of untreated decayed teeth, missing teeth, and filled teeth of the TOKYO1964 Olympians who underwent dental examinations at the 11th measurement in 2008, the 12th measurement in 2012, and the 13th measurement in 2016 are plotted in the left half of the graph, and the data concerning the elderly in general obtained from the national survey of dental diseases conducted by Ministry of Health, Labour and Welfare in 2005, 2011, and 2016 are plotted in the right half of the graph. The number of Tokyo Olympians measured in the 11th, 12th, and 13th measurements were 123 (99 men and 24 women with an average age of 68.7), 109 (84 men and 25 women with an average age of 72.8), and 99 (75 men and 24 women with an average age of 75.5), respectively.

A characteristic finding of the former top athletes was the large number of their teeth that had been treated for caries. The former top athletes had an average of 2.5 more teeth than the general population between the 11th measurement and the 2005 national survey of dental diseases, 3.9 more between the 12th measurement and the 2011 study, and the 3.6 more between the 13th measurement and the 2016 study. It has been reported in Japan and abroad that the risk of caries in sports athletes is higher than that of the general population and their prevalence of caries is also high. It is presumed that many of the former first-class competitors also had caries in their teeth while actively competing and received treatment and fillings. As a result, it is probably reasonable to think that the number of treated teeth had increased.

Another matter of note was the small number of missing teeth. The tendency for there to be four or fewer missing teeth among the former athletes than in the elderly in general of the same generation remained consistent from the 11th measurement through the 12th and 13th. According to the 2016 national survey of dental diseases, an average of 4.6 teeth are lost in the early 60s, 6.7 in the late 60s, 8.6 in the early 70s, and 10.3 in the late 70s. This is the image of the elderly in general in Japan. However, the average number of missing teeth in the TOKYO1964 Olympians in later old age (average age of 75.5) was only 6.3. This means that their oral age was equivalent to their late 60s, which was more than 10 years younger than their actual age.

●Although many subjects exhibited no periodontal disease findings, the Olympians tended to be polarized in this respect



This graph compares the TOKYO1964 Olympians with the CPITN ratios of the elderly in general in Japan. The Community Periodontal Index of Treatment Needs (CPI or CPITN) is a periodontal examination method advocated by the WHO in 1982. It is an index for determining the condition of periodontal disease and the need for treatment in a community.

The ratio of individuals designated as Code 0 (no periodontal disease findings) at the time of the 13th measurement was 30.3%. The ratio of individuals designated as Code 0 in the 2016 national survey of dental diseases was 17.9%, so it seems that the TOKYO1964 Olympians were

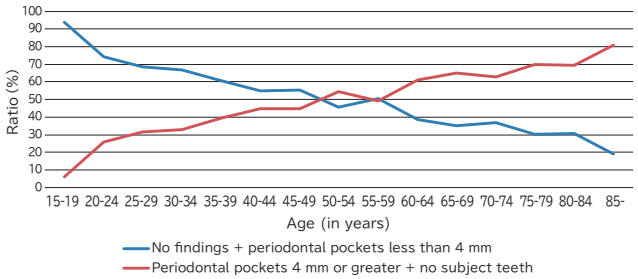
a population with few individuals afflicted with periodontal disease. However, if you add the ratios of individuals designated as Code 3 (shallow periodontal pockets) and Code 4 (deep periodontal pockets) the figure rises to 54.1%~62.3% - a majority. Because of this, it seems that there was a trend toward polarization. Even so, following the changes from the 11th measurement, the number of individuals designated as Code 4 gradually decreased to 22.1%, 18.3%, and 14.1%, and the number of individuals designated as Code 2 (deposition of dental calculus) also decreased by 7 points, so there was a trend toward improvement.

●The three keys to preventing periodontal disease are "maintenance of normal body weight," "good diet," and "active exercise habits."

In the same way as hypertension, diabetes, and the like, periodontal disease is also a lifestyle-related disease. Based on this approach, three keys to preventing periodontal disease are advocated: (1) maintenance of normal body weight (BMI: 18.5~24.9 m/kg$^{2)}$, (2) good diet (Healthy Eating Index: 80+), and (3) active exercise habits (moderate-intensity exercise at least five times a week or high-intensity exercise at least 3 times a week). In particular, the benefits of exercise should be emphasized, as it has been reported in epidemiological studies conducted outside Japan that the prevalence of periodontal disease in a population with active exercise habits is significantly lower.

With respect to the state of engagement in exercise by the TOKYO1964 Olympians, of the 273 Olympians who cooperated with the survey at the time of the 13th measurement, 50 (18.3%) were exercising one or two days a week, and 56 (20.5%) were exercising three or four days a week without fail. Considering that this is a population that had maintained good exercise habits after retirement, not to mention during their youthful eras of active competition, this could probably be interpreted as another data point that supports the efficacy of maintaining exercise habits in the prevention of periodontal disease. This suggests, therefore, that many of the former first-class competitors have healthy periodontal tissue and are less prone to developing periodontal disease.

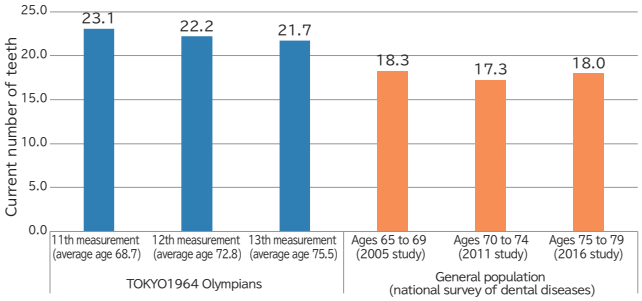
●In general, periodontal disease becomes serious from one's 50s onwards, necessitating regular checkups and preventive measures



Generally speaking, from what age does periodontal disease become serious? In order to clarify this point, a graph of the results calculated based on the 2016 data of national survey of dental diseases is provided. Usually, when the periodontal pocket is 4 mm or more, it becomes difficult to control plaque with self-care alone, so treatment is required. When the subjects were divided into two groups with one consisting of individuals designated as Codes 0, 1, and 2 (no findings + periodontal pockets of less than 4 mm) and the other consisting of individuals designated as Codes 3 and 4 as well as individuals with no subject teeth (periodontal pockets of 4 mm or greater + no subject teeth), two points of convergence in the subjects' 50s were confirmed. It can thus be said that periodontal disease becomes serious starting from one's 50s.

Periodontal disease is also called "silent disease" of the mouth. Subjective symptoms are unlikely to manifest, and it often progresses without its sufferers being aware. Therefore, it is important to work to prevent it by undergoing regular medical examinations while observing the three keys.

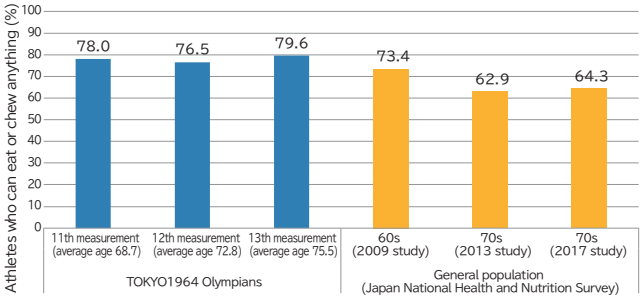
●The TOKYO1964 Olympians retained four or five more teeth than the elderly in general



This graph compares the numbers of teeth in the TOKYO1964 Olympians and the elderly in general in Japan. The average number of teeth in the data for the Tokyo Olympians from the 11th measurement through the 13th measurement in the left half of the graph is 22.3. Meanwhile, the average number of teeth for the elderly in general in the right half of the graph is 17.9, a difference of 4.4.

As mentioned above, the TOKYO1964 Olympians had lost a small number of teeth due to caries, and many had healthy periodontal tissue, so it seems that this is related to the study result indicating that they had four or five more teeth than the elderly in general. For reference, the number of human teeth is 28, with 14 in each of the upper and lower jaws, excluding third molars (dens serotinus, or "wisdom teeth").

●The Olympians maintained a high level of masticatory force even in their 70s



This graph compares masticatory force in the TOKYO1964 Olympians and the elderly in general in Japan. Data on the ratio of individuals in the populations who responded "I can eat and chew anything" is plotted in the graph, and about 80% of the Tokyo Olympians reported good mastication even in later old age (average age of 75.5), a difference of more than 15 points from the elderly in general of the same generation.

It is likely that the inevitable conclusion to draw from this is that many of the former top-level competitors maintain a high level of masticatory strength due to their retention of a large number of teeth and having healthy periodontal tissue to support them.

Physiological Response of the Athletic Heart – The Athletic Heart is a Reversible Change

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2) Sports Medicine, St. Marianna University School of Medicine

●Overview of study results

Electrocardiographic testing was conducted on 365 TOKYO1964 Olympians before the Games took place in order to investigate changes in the electrocardiograms of elite athletes undergoing high-intensity training. The revised results of this testing are shown in Table 1 (1). Left ventricular hypertrophy was observed in more than half of the athletes, and sinus bradycardia was observed in more than 40%. Each of the electrocardiogram findings was confirmed at a higher ratio in the male athletes than in the female athletes.

Table 2 shows the results of the follow-up survey conducted by Maruyama et al. that targeted 88 male athletes for whom electrocardiograms in 1964 and 1976 could be evaluated in order to assess the relationship between changes in the electrocardiograms and sporting activities (1).

Though most of the changes in the electrocardiograms that had been confirmed in 1964 had disappeared by the time of the measurements in 1976, findings such as left ventricular hypertrophy persisted in some of the athletes. In the findings, the ratio in which sinus bradycardia and left ventricular hypertrophy persisted was significantly higher in the athletes who continued to compete than in those that had retired.

Changes to electrocardiogram findings were examined for the 32 of these 88 athletes who continued to undergo electrocardiogram evaluations every 4 years for 12 years after retiring from competition. The number of years after retirement and changes in the ratios of electrocardiogram findings are shown in Table 1.

The ratio of electrocardiogram findings that had been noted while the athletes were active declined with the passage of time after their retirement from competition, but symptoms of incomplete right bundle branch block and left ventricular hypertrophy persisted in about 20% of the athletes even 12 years after retirement. Atrioventricular block and sinus bradycardia had disappeared in all the athletes 4 years after retirement.

The effects of high-intensity training on the heart were tested with both electrocardiography and chest radiography. The results of tracking of the cardiac shadow area that were calculated using the Moritz method (2) based on the same testing for 10 athletes conducted before retirement from active competition and 12 years after retirement are shown in Fig. 2 (1).

More than half the athletes presented with cardiac dilatation at the time they were active competitors, but it was observed that their dilated hearts had tended to shrink after about 4 to 8 years had passed since retiring from active competition. Ultimately, the hearts of most of the athletes shrank to a size within the normal range for Japanese people.

Elite athletes perform dynamic and static exercises depending on the sport(s) in which they compete. Although the frequency of occurrence of each finding by the type of sport was not been evaluated in this study, it was confirmed that sinus bradycardia and atrioventricular block, which are thought to be caused by high-intensity training, disappeared after the athletes had ceased to actively compete. However, left ventricular hypertrophy and cardiac dilatation noted in the electrocardiograms or x-ray images had persisted in some of the athletes even 12 years after retirement.

An example of a track and field athlete for whom it was possible to perform follow-up examinations for about 50 years in order to examine the long-term progression in

Table 1. ECG findings for TOKYO1964 Olympians

	Men (301)	Women (64)	Overall (365)
Sinus bradycardia	135 (44.9%)	20 (31.3%)	155 (42.5%)
Left ventricular hypertrophy	192 (63.8%)	13 (20.3%)	205 (56.2%)
Incomplete right bundle branch block	15 (5.0%)	1 (1.6%)	16 (4.4%)
First or second degree atrioventricular block	3 (0.1%)	0	3 (0.1%)

Table 2. Evaluations of electrocardiograms of male athletes (88) in 1964 and 1976

	1964(88)	1976	
		Active (14)	Post-retirement (74)
Sinus bradycardia	45 (51.1%)	2 (14.3%)	1 (1.4%)
Left ventricular hypertrophy	66 (75.0%)	7 (50.0%)	16 (21.6%)
Incomplete right bundle branch block	5 (5.7%)	2 (14.3%)	2 (2.7%)
First or second degree atrioventricular block	2 (2.2%)	0	0

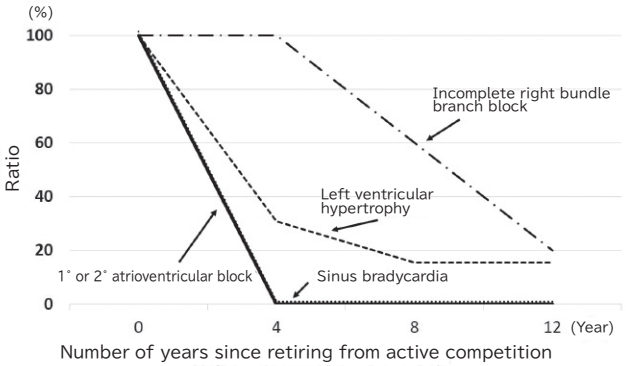

Figure 1. Number of years since retirement from competition and ratio of electrocardiogram findings

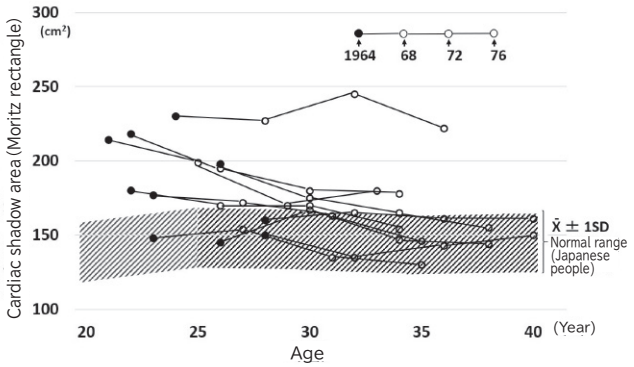

Figure 2. Relationship between cardiac shadow area derived using Moritz method and number of years since retirement

athletes that had presented with this sort of athletic heart is given below. The findings were compared while presenting the electrocardiogram and chest radiography examinations in 1968 and 2016.

The subject continued to compete actively even when the measurements were taken in 1968 and remained physically active until the time of the 2016 measurements. The electrocardiograms for 1968 and 2016 are shown in Fig. 3. In the findings of the 1968 measurements, the patient presented with incomplete right bundle branch block and left ventricular hypertrophy. Those findings were not observed in 2016, but left axis deviation was observed in the findings. A chest x-ray photograph taken at the same time as an electrocardiogram is shown in Fig. 4. The respective ratios of the lateral diameter of the cardiac shadow to the lateral diameter of the lung field (cardiothoracic ratio) in these were 41% and 42%, with almost no difference observed, however the estimated area of the cardiac shadow was clearly reduced in 2016 compared to 1968. It was also observed in the 2016 x-ray image that the position (tilt) of the heart in the thorax was more lateral compared with the 1968 examinations, and that there was meandering of the aorta. The left axis deviation in the electrocardiogram and the meandering of the aorta in the x-ray image were thought to have been attributable to the hypertension noted in the patient.

While the results of this study suggest that the effects

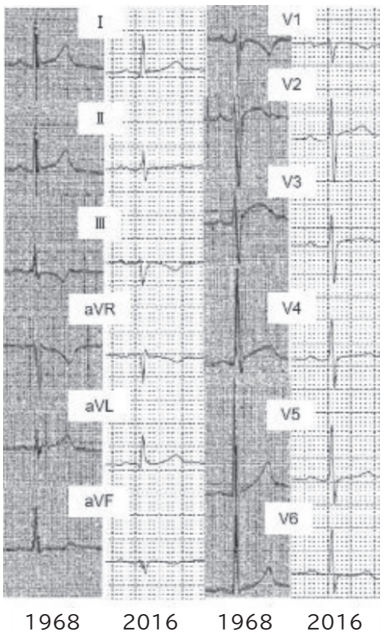

Figure 3. Electrocardiogram

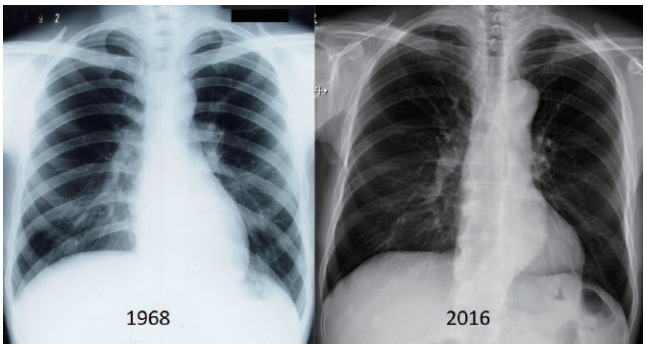

Figure 4. Chest x-ray photograph

of high-intensity training cause elite athletes to undergo electrophysiological and morphological changes, most of these are reversible changes, and such findings are normalized if the athletes stop actively competing.

It has been reported that the lifespans of elite athletes are generally longer than lifespans overall (3). However, there are still many unclear points with regards to the mechanism behind this longevity and the long-term effects on athletes for whom the electrocardiogram findings persist long-term, so further research in the future is needed.

(1) Murayama M. et al., Cardiovascular Future of Athletes. J Physical Fitness Japan 1980; 29: 117-123.
(2) Moritz F. Ueber die Norm der Groesse and Form des Herzens beim Mann. Deut. Arch, klin. Med. 1931; 171: 431-476.
(3) Lemez S. et al., “Do Elite Athletes Live Longer? A Systematic Review of Mortality and Longevity in Elite Athletes.” Sports Med Open 2015; 1:16.

New findings with a focus on frailty from a comparison between the TOKYO1964 Olympians and local elderly people in general: the TOKYO1964 Olympians representing Japan have high muscle mass and strength even in old age, but tend to have musculoskeletal pain and reduced walking speed

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1) University of Tokyo, Institute of Gerontology
2) University of Tokyo, Institute for Future Initiatives

●Are the physical abilities of the TOKYO1964 Olympians top-notch even in old age?

Many of the TOKYO1964 Olympians held are now elderly. They are top-notch competitors, and heroes in our nation's long history of sports. Although there are differences between the sports in which they competed, their musculature, muscle strength, and physical abilities that were maximized by their exercise habits in the prime of their life would likely have far surpassed those of the general population. So, have the top athletes who were exceptional enough to be chosen as Olympic athletes been able to maintain their superior physical abilities compared to the general population even in old age? We obtained surprising results when we attempted to answer this question by comparing muscle mass, maximum muscle strength, and physical functioning using the data accumulated over many years from the TOKYO1964 Olympians and the data from local elderly people in general. What follows is a report on these results.

●What sort of data were compared?

We used the data from the 101 participants (average age 75.0 ± 4.4 years, 26% of whom were women) in the Tokyo Olympic Commemoration Physical Fitness Study, and who also took part in the 13th measurements survey conducted in 2016 from whom all data concerning muscle mass, etc. was obtained, as well as data from 1,529 elderly people (average age 74.1 ± 5.5 years, 49% of whom were women) living in Kashiwa City, Chiba Prefecture, in order to compare lifestyle habits, nutritional status, physical capabilities, musculoskeletal pain, clinical histories, etc. In addition, considering that differences in sports in which subjects had competed and exercise habits after retirement would have a significant effect on results, we also investigated these. Specifically, the sports in which the subjects of this study had engaged were classified into three types of exercise intensity – static exercise intensity, dynamic exercise intensity, and cardiopulmonary exercise intensity, with each of these further divided into low, medium, and high intensity – per the 8th Task Force classifications in the Olympic sports categories of the American College of Cardiology (Fig. 1). In addition, the intensity of physical contact during sports competition was evaluated based on the definitions of the American Academy of Pediatrics, and the Olympic sports events were evaluated in three groups: no physical contact, limited physical contact, and full physical contact (Fig. 1). The post-TOKYO1964 exercise habits of the subjects were evaluated for the presence or absence of exercise habits of at least 1 - 2 times a week before the age of 50, using data from a self-administered questionnaire survey conducted every four years.

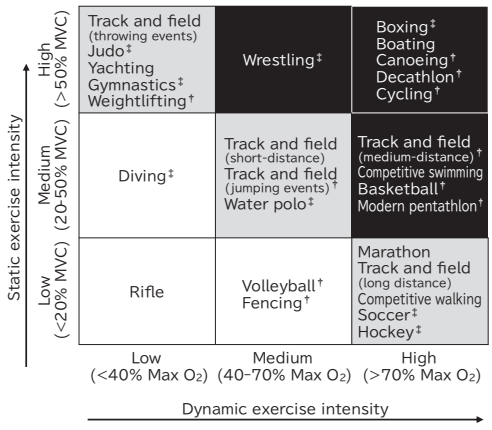

Figure 1: Olympic sport classification (exercise intensity and absence/presence of physical contact)
MVC, maximal voluntary contraction (Maximum voluntary muscle strength)
Cardiopulmonary exercise intensity is classified into three levels: low (white), medium (gray), and high (black).
†, ‡: Classification by absence/presence of physical contact († indicates limited physical contact; ‡ indicates occurrence of physical contact)

●Are there any differences in the clinical histories and lifestyle habits of the TOKYO1964 Olympians up to old age?

When we compared clinical histories through the present of the TOKYO1964 Olympians and the elderly in general, there were no statistically significant differences in the numbers of those who had a history of hypertension, diabetes, heart disease, and stroke, though these tended to be slightly less common in the TOKYO1964 Olympians. On the other hand, we found that the number of people who are prone to depression is rather high among the female TOKYO1964 Olympians. Regarding lifestyle habits, while there were no differences in exercise habits in old age, differences in dietary habits and drinking/smoking habits were observed. Specifically, former Olympic athletes were more likely to eat meat, seafood, eggs, vegetables, and fruits at least once every two days. Well-balanced dietary habits are important even in old age, and frequent consumption of the protein that comprises the building blocks of the body is especially recommended. The former Olympic athletes were superior in this respect, and they may have put to use the body-building know-how cultivated during their time as athletes to consume a healthy diet in old age. Also, in terms of smoking habits, there were fewer smokers among the TOKYO1964 Olympians. Alcohol intake was more frequent among the TOKYO1964 Olympians surveyed, especially among women.

●TOKYO1964 Olympians have high muscle mass and maximum muscle strength even in old age

Comparing the TOKYO1964 Olympians with the elderly in general, although there were no differences in BMI (body mass index), we found that the TOKYO1964 Olympians had higher skeletal muscle mass in their limbs and maximum muscle strength (grip strength). In particular, TOKYO1964 Olympians maintained extremely high amounts of skeletal muscle mass in their limbs compared to elderly women in general (Figs. 2 and 3). This is partly due to innate differences in their bodies, but it seems possible that insufficient exercise habits and low muscle mass in the younger generations of women in general have resulted in reduced skeletal muscle mass in their limbs in old age more than expected. Incidentally, the muscle weakness that is often observed in old age is called "sarcopenia." Sarcopenia is defined as "progressive and systemic skeletal muscle disease resulting in an increased risk of health problems such as falls, fractures, physical dysfunction, and death," and is diagnosed as a state in which a decline in skeletal

muscle mass in the limbs is comorbid with decline in maximum muscle strength and body functioning. In fact, we found in our analysis results that few TOKYO1964 Olympians are in a sarcopenic state because of their high skeletal muscle mass in their limbs and maximum muscle strength. These conditions tended to be especially pronounced in athletes who had continued their exercise habits even after the age of 50, and in athletes in types of sports that have high exercise intensity. On the other hand, male athletes in sports with low exercise intensity lost their statistically significant difference from the elderly in general. From this, it can be said that in order to prevent sarcopenia in old age, it is necessary to engage in at least moderately intense exercise and important to continue the habit of exercising.

●TOKYO1964 Olympians are prone to having musculoskeletal pain in old age, and at times their balance ability and walking speed are rather low

We found that muscle mass and maximum muscle strength were higher in TOKYO1964 Olympians when compared with the elderly in general. However, we also found a reversal phenomenon of TOKYO1964 Olympians having a lower balance ability and walking ability than the elderly in general. Specifically, we found that TOKYO1964 Olympians were able to stand on one leg with their eyes open for a shorter duration and walked at a slower speed (Fig. 4). Additionally, when asked about musculoskeletal pain in the questionnaire, more TOKYO1964 Olympians reported having pain than the elderly in general, and the intensity of their pain was worse (Fig. 5). This tendency was more pronounced in athletes who quit exercising before the age of 50 and/or athletes who engaged in sports with high exercise intensity and physical contact. Although it cannot be said with certainty that these are all attributable to sports injuries caused by excessive training, etc., it seems possible that they could cause deterioration of physical functioning and chronic musculoskeletal pain in old age. Also, it is known that the proportion of people with chronic musculoskeletal pain generally increases with age, and musculoskeletal pain in old age is also considered to be a risk factor for decreased levels of activity of daily living and depressive tendencies. Therefore, although it is important to improve physical functioning starting from youth through old age as stated above, it seems possible that prevention and countermeasures for wounds and sports injuries will have a great impact on allowing athletes to live long and full lives.

●Summary

We attempted to compare TOKYO1964 Olympians with local elderly people in general residing in Kashiwa City, Chiba Prefecture. Based on the results we were able to confirm that TOKYO1964 Olympians had superior skeletal muscle mass in their limbs and maximum muscle strength, as well as the importance of continuing to exercise after retirement from competition. It was apparent that establishing a foundation of healthy and active lifestyle habits starting from adolescence favorably influenced lifestyle habits in old age, and that these in combination with muscle mass and muscle strength that were increased earlier in life were also carried over into old age. It also became clear that many of the TOKYO1964 Olympians suffer from musculoskeletal pain, and lowered physical functioning. The TOKYO1964 will be held again in 2021, 57 years after 1964, and in order to utilize what was learned in the lives of the TOKYO1964 Olympians, it will be necessary to promote continued exercise from adolescence to prevent sarcopenia in old age, and especially to conduct further educational interventions and environmental improvements to foster prevention of injuries, etc. for competitors in sports. It is expected that a thesis summarizing the results of this study was published in an international academic journal (*Journal of Cachexia, Sarcopenia, and Muscle*).

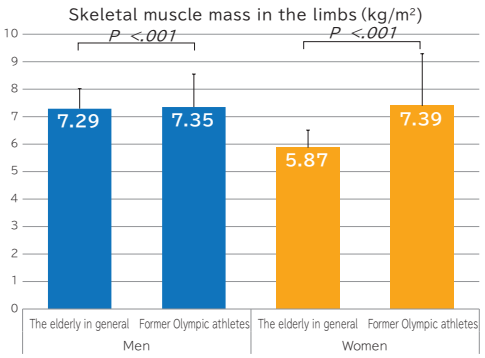

Figure 2: Comparison of average (standard deviation) skeletal muscle mass (kg/m2) in the limbs of the TOKYO1964 Olympians and the elderly in general

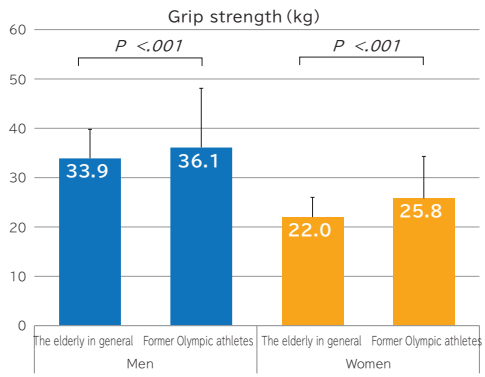

Figure 3: Comparison of average (standard deviation) normal walking speed (m/second) in the TOKYO1964 Olympians and the elderly in general

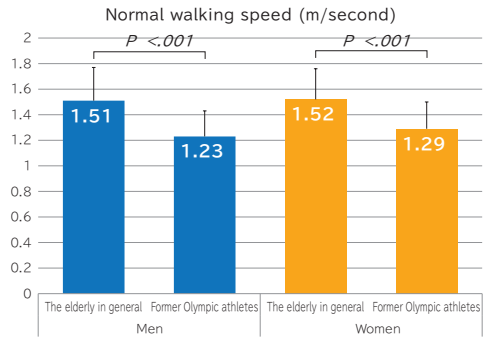

Figure 4: Comparison of average (standard deviation) normal walking speed (m/second) in the TOKYO1964 Olympians and the elderly in general

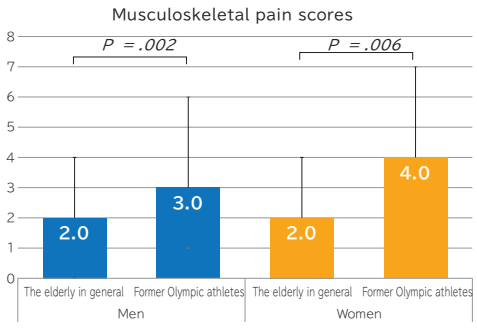

Figure 5: Comparison of median (interquartile range) musculoskeletal pain scores in the TOKYO1964 Olympians and the elderly in general
*The higher the pain score, the more intense the musculoskeletal pain

Do Athletes Who Compete in the Olympic Games Live a Long Time? ~ Vital prognoses of the TOKYO1964 Olympians ~

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●Overview of study results

We used survival/mortality information and physical fitness measurement data as of December 31, 2017 for 355 athletes (295 men and 60 women) who competed in the TOKYO1964 Olympians to perform a survival time analysis and multivariate analysis with mortality as an outcome. Using information publicly available on the Internet, etc., we analyzed a total of 342 athletes (283 men and 59 women) who remained after eliminating those athletes for whom outcomes were unknown, in the Tokyo Olympic Commemoration Physical Fitness Study. A total of 15974.8 person-years were observed, with an average observation period of about 47 years.

We analyzed their vital prognoses compared to the general population based on our calculation of a Standardized Mortality Ratio (hereinafter, "SMR") using mortality rates by gender and age class every 5 years based on the Japanese Vital Statistics (1950 ~ 2015). Their overall SMR was estimated to be 0.64 (95% confidence interval: 0.50, 0.81), indicating that their mortality rate was about 40% lower than that of the general population; i.e. the TOKYO1964 Olympians lived longer.

Next, we performed a multivariate analysis (using the Cox Proportional Hazards Model) of the factors related to mortality rates using the physical fitness measurement data from the baseline and first-time (1964 and 1968) measurements with exercise intensity categories of the sports in which the athletes competed, the total number of times they competed in the Olympic Games, lifestyle habits (smoking history, body mass index categories: BMI <23, 23-25, 25 <BMI), etc. as covariates. The results of a comparative investigation within the cohort indicated a hazard ratio of 3.18 (95% CI: 1.34, 7.55) in the group with a BMI of 25 kg/m^2 or more when the group with a BMI of less than 23 kg/m^2 (=1) was used as the standard; thus, it was demonstrated that their risk was about three times higher – a significant difference. Also, a tendency was observed for the mortality rate to increase the more times athletes participated in the Olympic Games. Although no statistically significant difference was shown, it appears that this does not conflict with the results (Takeuchi et al., 2019) of our earlier study that tracked successive generations of postwar Olympic athletes. Additionally, it was observed in the results of our investigation of the relationship between mortality rates and exercise habits after retirement that compared to the group who responded that they exercised "never" or "almost never," the risk of death was reduced (HR: 0.78 to 0.83) by about 20% among those who reported exercising habits of "once or twice a month (i.e. frequency)" to "competitive level," but no statistical significance was shown.

The majority of the health surveys for general local residents are conducted for the purpose of investigating the effects of lifestyle habits on people aged 40 and older. In the case of TOKYO1964 Olympians, however, it is necessary to consider that the average age is around 23 years old and the targets constitute an extremely young cohort. It cannot be denied that factors that increase the risk of death may be related to factors other than obesity, etc.

In general, exercise habits are effective in preventing such lifestyle-related diseases as cardiovascular disease, hypertension, and cancer, so apparently few would argue against the proposition that athletes live longer lives. However, there has been hardly any investigation of the effect on disease risk and mortality in populations subjected to long-term excessive training, high-intensity exercise, significant dietary restrictions, use of anabolic steroids, etc. in the manner of Olympic athletes. We sincerely hope that a system able to track all Olympic athletes for their entire lives and a mechanism capable of managing and operating a valuable database will be established in the future.

●Breakdown of subjects analyzed (Tables 1-1 and 1-2):

Of the 355 TOKYO1964 Olympians (295 men and 60 women), 342 remained after excluding those whose survival information or dates of decease were not known. Of these 342, it was confirmed that 70 (64 men and 6 women) had died. Table 1-1 gives the number of athletes who died and their mortality ratios by the sports in which they competed. At the time of the analysis, the highest number of deaths (12) was among athletes who had competed in track and field events, but judo (50%) had the highest ratio of deaths among the TOKYO1964 Olympians. Table 1-2 gives the data for the baseline physical fitness measurements in 1964.

●Standardized Mortality Ratio (SMR): Results of Standardized Mortality Ratio-based general population comparison:

We used the mortality rate by sex and age group every five years in the Japanese Vital Statistics (1950 ~ 2015) to calculate SMR by observation period and by the number of elapsed years since competing in the TOKYO1964 (Table 2). Having taken into consideration differences attributable to the historical background, we conducted an analysis by dividing the

Table 1-1 (Breakdown of survival information by event)

Event name	Number of participants	Number of individuals confirmed deceased (%)
Athletics	67	12 (17.9)
Swimming	58	9 (15.5)
Volleyball	24	7 (29.2)
Rowing	23	4 (17.4)
Football	19	7 (36.8)
Hockey	16	3 (18.8)
Wrestling	15	4 (26.7)
Cycling	15	2 (13.3)
Fencing	15	1 (6.7)
Artistic Gymnastics	14	1 (7.1)
Sailing	12	2 (16.7)
Canoe	12	2 (16.7)
Basketball	11	3 (27.3)
Boxing	9	3 (33.3)
Equestrian	9	3 (33.3)
Rifle shooting	8	2 (25)
Weightlifting	7	3 (42.9)
Judo	4	2 (50)
Clay shooting	2	0 (0)
Modern pentathlon	2	0 (0)
Total	342	70

Table 1-2: (Distribution by lifestyle risk factors at time of baseline physical fitness measurements)

	Men n; 283	Women n; 59	Unknown, n (%)
Age (mean ± Sd)[in years]	23.8 ± 3.8	22.3 ± 4.7	3 (0.9)
Obesity coefficient BMI, n (%)			
<19 [kg/m^2]	11 (3.9)	5 (8.6)	4 (1.2)
19-<21 [kg/m^2]	55 (19.6)	16 (27.6)	
21-<23 [kg/m^2]	107 (38.2)	17 (29.3)	
23-<25 [kg/m^2]	70 (25)	18 (31)	
≥25 [kg/m^2]	37 (13.2)	2 (3.4)	
Smoking, n (%)			
Nonsmoker	104 (52)	44 (92)	95 (27.8)
Occasional smoker	30 (15)	1 (2)	
Daily smoker	65 (33)	3 (6)	
Grip strength segment, n (interquartile range [kg])			
Q1; 1st quartile	73 (33.0-48.5[kg])	15 (27.3-32.5[kg])	15 (4.4)
Q2; 2nd quartile	66 (48.5-53.0[kg])	13 (32.5-35.1[kg])	
Q3; 3rd quartile	66 (53.0-58.3[kg])	16 (35.1-38.0[kg])	
Q4; 4th quartile	66 (58.3-80.5[kg])	12 (38.0-49.5[kg])	
Drinking, n (%)			
Nondrinker	64 (32)	35 (73)	93 (27.2)
Social drinker	105 (52)	12 (25)	
Daily drinker	32 (16)	1 (2)	

observation period into three segments so that the number of observed deaths was roughly equalized and dividing the elapsed years into four categories. In the SMR by observation period, there was a significant decline in mortality rates during the most recent period (2008 to 2017). In the SMR by elapsed years, a significant decline in the mortality rate was shown for the group for whom more than 30 years had passed.

●Investigation of mortality-related factors using the Cox Proportional Hazards Model (Table 3)

The results of a multivariate analysis with death as an outcome are given in Table 3. A tendency for the risk of death to increase was observed for the group that had participated in the Olympic Games multiple times compared to the athletes who had done so only once, but no statistical significance was shown. In the same way, in the hazard ratios by exercise intensity by event name, a tendency for the risk of death to increase was observed for the moderate-intensity and high-intensity events, but no statistical significance was shown. With respect to BMI (body mass index), it was shown that the risk increased by about three times only in the group of 25 kg/m^2 or more – a statistically significant increase.

●Exercise habits and risk of death at baseline (baseline physical fitness measurements) (Fig. 1, Table 4)

A Kaplan-Meier curve stratified by exercise habits (reported in a questionnaire) as of 1968 is given in Fig. 1. Exercise habits were classified into three groups: "almost never (or never)," "about once or twice a month or 1 to 4 times a week," and "competitive level." No significant difference was shown in a logrank test (p = 0.99). Adjusted hazard ratios derived using the Cox proportional hazards model are given in Table 1. No statistical significance was shown as much data concerning exercise habits was missing, but a reduction in risk of death by about 20% was observed in the groups whose exercise habits were "about once or twice a month or 1 to 4 times a week" or "competitive level" compared to the "almost never (or never)" group (Fig. 1, Table 1 on page 15 of the 2nd report).

Rreference

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Table 2 (SMR by observation period/elapsed years)

	Total number of person-years observed	Number of deaths	Number of expected deaths	SMR (95% CI)
Observation period				
1964-1997	10696.74	24	32.01	0.75 (0.49-1.10)
1998-2007	3049.08	23	32.67	0.70 (0.46-1.04)
2008-2017	2704.75	23	58.82	0.39 (0.25-0.58)
Elapsed years (years)				
0 to less than 10	3395.22	4	5.49	0.73 (0.23-1.76)
10 to less than 20	3341.92	6	7.66	0.78 (0.32-1.63)
20 to less than 30	3272.19	10	15.40	0.65 (0.33-1.16)
30 or more	6441.23	50	94.96	0.53 (0.40-0.69)

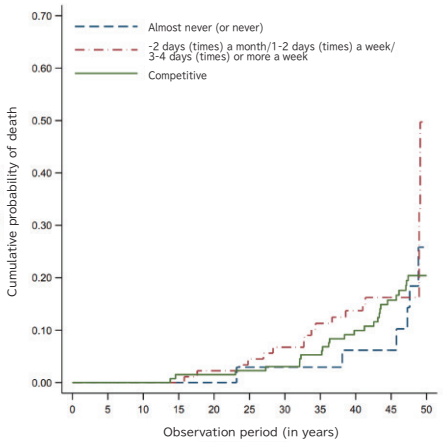

Figure 1. Survival curves (Kaplan-Meier plots) by the exercise habit at the first measurement in 1968.

Table 3 (Relationship between various exposure factors and risk of death)

	Number of applicable individuals (%)	Total number of person-years observed	Number of deaths	Adjusted hazard ratio (HR)		
				HR	95% CI	P for trend
Total number of times participants competed (times)						
1	228 (66.67%)	11174.03	43	Ref		0.727
2	86 (25.15%)	4105.45	20	1.18	0.55-2.55	
3 or more	28 (8.19%)	1179.98	7	1.14	0.32-4.06	
Exercise intensity (dynamic)						
Low	76 (22.22%)	3591.58	16	Ref		0.352
Medium	73 (21.35%)	3548.05	16	1.69	0.67-4.25	
High	173 (50.58%)	8353.44	35	1.61	0.63-4.09	
Unknown	20 (5.85%)	966.39	3			
Smoking history						
No	149 (43.57%)	7339.65	25	Ref		0.786
Yes	99 (28.95%)	4834.42	18	1.1	0.57-2.12	
Unknown	94 (27.49%)	4285.39	27			
BMI						
Less than 23	211 (61.70%)	10147.77	39	Ref		0.017
23 or more but less than 25	88 (25.73%)	4399.8	13	1.28	0.6-2.75	
25 or more	39 (11.40%)	1743.15	16	3.18	1.34-7.55	
Unknown	4 (1.17%)	168.74	2			

Table 4 (Relationship between exercise habits after competing in the TOKYO1964 and risk of death)

	Total number of person-years observed	Number of individuals who died	Adjusted hazard ratio		
			Hazard ratio	95% confidence interval	P-value
Exercise Habits					
Almost never (or never)	1549.0	6	Ref		0.802
About once or twice a month/about 1-4 times a week	3941.8	16	0.78	0.28-2.14	
Competitive	6008.6	25	0.83	0.31-2.20	
Missing	3676.8	23			

Effects of Post-Retirement Changes in Physical Fitness and Weight on the Health of the TOKYO1964 Olympians

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3) Japan Institute of Sports Sciences;
4) Japan Association for University Athletics and Sport (UNIVAS)

●Overview of study results

- In order to clarify the relationship between cardiorespiratory fitness in the TOKYO1964 Olympians at the time of their participation and the onset of hypertension after their retirement from active competition, we investigated the relationship between cardiorespiratory fitness at the time of their participation in the Olympic Games and their incidence of hypertension during the follow-up period in which they were tracked until 2016.
- Based on the results of the investigation, it was confirmed that, even for top athletes, low cardiorespiratory fitness is a risk factor for developing hypertension similar to the results reported in studies of the general population.
- We also compared their weights at the time of their participation in the TOKYO1964 with their weights 8 or 12 years later, and investigated the relationship between the incidence of hypertension and diabetes relative to changes in body weight.
- Based on the results of the survey, it was confirmed that athletes who gained more weight after participating in the Olympic Games tended to have a higher incidence of hypertension and diabetes, and even top athletes who gained weight after retiring from active competition were more likely to develop hypertension and diabetes than those who maintained their weight.

●Relationship between the physical fitness of the TOKYO1964 Olympians and their incidence of hypertension after retiring from active competition

It is known that the aspect of physical fitness that has the strongest correlation with health is cardiorespiratory fitness. Even for athletes who participated in the Olympic Games, it seems that there is variation in cardiorespiratory fitness that is dependent on the type of sport in which they engaged and the training levels of the individual athletes. In this study we investigated the relationship between the cardiorespiratory fitness of athletes at the time of their participation in the TOKYO1964 and their incidence of hypertension during the follow-up period in which they were tracked until 2016, in order to clarify the relationship between cardiorespiratory fitness and hypertension in top athletes.

(1) Methods

The subjects analyzed in this study were 156 athletes whose cardiorespiratory fitness was measured in the first Commemorative Tokyo Olympic Commemoration Physical Fitness Study that were held in 1964, and who participated at least once in the measurements held in 2005, 2008, 2012, and 2016. Next, we classified these athletes into three groups based on the results of their cardiorespiratory fitness measurements: “relatively low fitness,” “average fitness,” and “relatively high fitness.” We then checked the states of hypertension onset in each group during the follow-up period.

(2) Results

We calculated the relative risk of the “average fitness” and the “relatively high fitness,” groups using the “relatively low fitness” group as the baseline. The results of these calculations indicated that the “average fitness” group had a 25% lower relative risk compared to the “relatively low fitness” group. In addition, the relative risk value exhibited by the “relatively high fitness” group was 41% lower compared to the “relatively low fitness” group, and the higher the fitness, the lower the risk of developing hypertension (Fig. 1). Based on these results, it was confirmed that low fitness is a risk factor for developing hypertension even for top athletes similar to the results reported in the study of the general population.

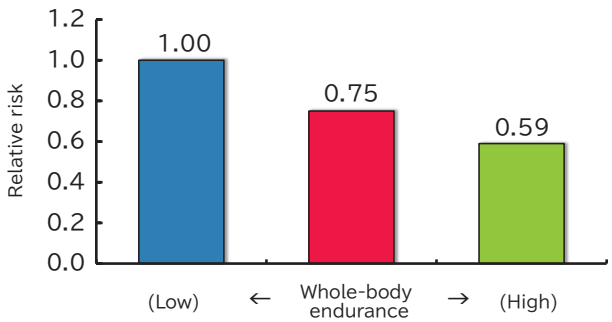


Figure 1: Relative risk of developing hypertension observed in different levels of fitness

●Relationship between changes in the weights of the TOKYO1964 Olympians and the incidence of hypertension and diabetes after retiring from active competition

Obesity is associated with a myriad of health problems, making it a major world health issue. Even for top-level athletes who participated in the Olympic Games, changes in weight due to changes in the environment, such as retirement from active competition after participating in the Olympic Games and a decrease in the amount of training, may affect their health. Therefore, in this study we checked how much the weights of the athletes changed 8 or 12 years after their participation in the TOKYO1964 and investigated the relationship between the amounts of these changes in weight and the development of hypertension and diabetes in order to clarify how weight changes after participating in the Olympic Games affected the development of hypertension and diabetes.

(1) Methods

The subjects analyzed in this study were 109 athletes whose physical fitness was measured in the first Tokyo Olympic Commemoration Physical Fitness Study, participated in the measurements held in 2005, 2008, 2012, and 2016 at least once, and underwent blood pressure measurement and blood testing. We calculated the differences in the weights of the athletes 8 years (1972) or 12 years (1976) after their participation in the TOKYO1964 using their weights measured in the first Tokyo Olympic Commemoration Physical Fitness Study conducted in commemoration of the TOKYO1964 as the baseline and classified the athletes into three groups: “lost weight,” “marginal weight gain,” and “substantial weight gain” groups. Then, we checked the states of hypertension and diabetes onset in each group based on the results of blood pressure measurements and blood testing conducted during the follow-up period.

(2) Results

We calculated the relative risk of developing hypertension and diabetes in the “marginal weight gain” and the “substantial weight gain” groups using the “lost weight” group as a baseline. The results of these calculations indicated that the “marginal weight gain” group had a relative risk of developing hypertension that was 1.57 times higher compared with the “lost weight” group. Also, the “marginal weight gain” group had a relative risk of developing diabetes that was 3.04 times greater than that of the “lost weight” group. Additionally, the “substantial weight gain” group had relative risks of developing hypertension and diabetes that were 2.93 and 4.28 times greater, respectively, compared to the “lost weight” group. The results indicated that the more weight is gained, the higher the risk of developing hypertension and diabetes (Figs. 2 and 3). Based on these results, it was confirmed that even for top athletes, gaining weight after retirement from active competition was a risk factor in developing hypertension and diabetes similar to the results that were reported in studies of the general population.

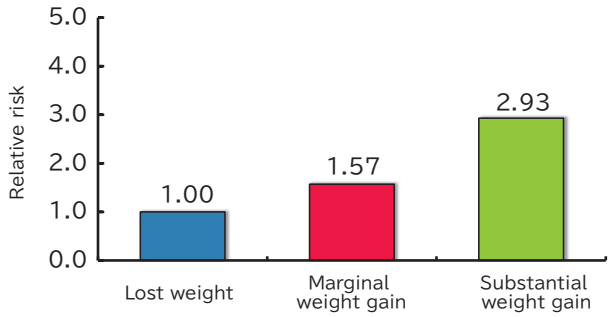


Figure 2: Relative risk of developing hypertension observed in different amounts of changes in weight

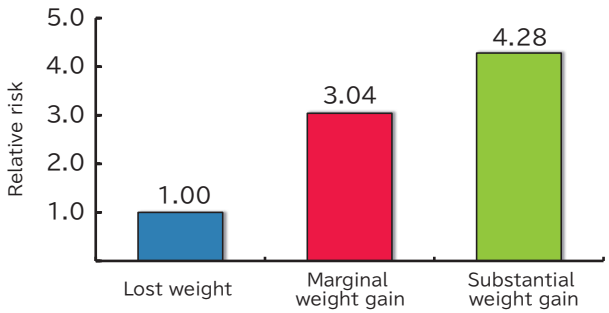
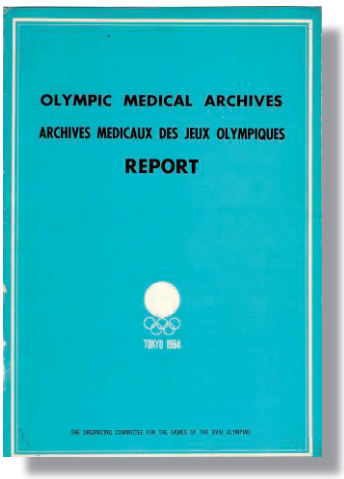


Figure 3: Relative risk of developing diabetes observed in different amounts of changes in weight

一流競技者の健康・体力追跡調査
―東京オリンピック記念体力測定― 報告書



1964年に東京で開催された第18回オリンピック競技大会に出場した日本代表選手の生涯にわたる健康と体力を調査すべく、4年に1度、オリンピック競技大会が開催される年にアンケート調査と体力測定を行う「東京オリンピック記念体力測定」を実施してきました。この「東京オリンピック記念体力測定」では、1968年から2016年の間に計13回に渡り、生活習慣、運動習慣、健康状態および病歴などが調査されてきました。

また、2019年および2020年には、「東京オリンピック記念体力測定」の「総括」として、50年以上にわたる膨大な調査結果を縦断・総合的に分析するとともに、循環器学や疫学、老年医学等の視点からも分析を行いました。

本冊子や研究報告書は日本スポーツ協会公式ホームページにて閲覧することができます。

JSPO 五輪測定 検索

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一流競技者の健康・体力追跡調査 –東京オリンピック記念体力測定– の総括

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Follow up study on the TOKYO1964 Olympians

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