Associations of various exercise types with health-related physical fitness: Focus on physical fitness age

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Abstract The health-related physical fitness status of habitual exercisers with different exercise types has not been adequately described previously. Therefore, we aimed to evaluate the various benefits in health-related physical fitness associated with participation in various exercises. The study was a cross-sectional study on 164 Japanese adult males (age: 45–80 years), who were classified into seven groups according to their most frequently practiced exercise: non-exercisers (n = 48), walking (n = 38), jogging (n = 23), rhythm calisthenics (n = 13), bowling (n = 20), tennis (n = 13), and cycling (n = 9). Anthropometric and health-related physical fitness data were measured, and exercise habit was investigated using a questionnaire survey. Physical fitness age (PFA) was estimated in all study participants. Compared to 48 non-exercisers, joggers obviously had superior cardiorespiratory endurance (maximal oxygen uptake: 45.5 ± 1.1 mL/kg/min). Tennis players showed better flexibility (trunk flexion: 6.8 ± 2.5 cm), agility (side-to-side stepping: 39.8 ± 1.6 reps), balance (one-legged stand with eyes closed: 24.9 ± 3.3 s), and lower-limb strength (vertical jump: 38.9 ± 1.6 cm). The difference between chronological age and PFA was approximately 13 years in joggers, 10 years in tennis players, and 5 years in rhythm calisthenics practitioners, all of which were significantly better when compared to the difference in non-exercisers. Various exercises appeared to confer different advantages on health-related physical fitness status. Exercise type with different skills was considered as a factor to maintain or promote physical fitness for habitual exercisers, especially older individuals.

Keywords: health-related physical fitness, habitual exercisers, exercise type, physical fitness age, physical fitness score

Introduction

Developing a healthy lifestyle includes maintaining appropriate levels of health-related physical fitness and exercise habituation7,8. Health-related physical fitness is a physiological state of well-being and the ability to carry out daily tasks with vigor7. Improvements in health-related physical fitness are frequently equated with improvements in health status or disease prevention9. Exercise habituation is tightly associated with cardiovascular fitness, muscle strength, and functional capacity10. Exercise habituation can help maintain functional independence in elders and prevents or markedly attenuates the age-related increase in risk factors for coronary heart disease5,6. Available research also indicates that participation in habitual exercise could effectively reduce and prevent a number of functional and health-associated impairments that occur with advancing age7.

Although exercise habituation is proved to enhance or maintain physical fitness, overall health status, and wellness of individuals10, previous studies and public health recommendations for physical activity have focused primarily on the duration and intensity of exercise10. However, apart from the amount of exercise, the mode or type...
of exercise is also considered a unique characteristic. Various types of exercise are associated with markedly different improvements in life expectancy\(^1\). Exercise type classified by motor skills was confirmed to be associated with self-rated health status after adjusting for confounding factors\(^2\). With different exercise types or modes, exercise practitioners were capable of learning unique exercise skills that could affect exercise motivation\(^3\). Skillful performance or progress in skill acquisition could also enhance or maintain self-efficacy, which is considered as an important volitional variable for the maintenance of physical exercise\(^4\,\,^5\). Multifaceted physical activities, such as tai chi, Chinese qigong, and yoga, are beneficial as part of a comprehensive exercise program for older individuals, especially to improve balance, agility, muscle strength, and reduce the risk of falls\(^6\,\,^7\). Tanasescu et al.\(^1\,\,^7\) found that running, jogging, rowing, and racquet sports (tennis and racquetball) were associated with reduced coronary heart disease risk in age-adjusted analyses in men (40–75 years old) compared to men (40–75 years old) who did not engage in these activities, while cycling and swimming were not associated with the aforementioned reduction in risk.

Although the health benefits of regular exercise have been established, the health-related physical fitness status of habitual exercisers who perform different types of exercise has not been adequately described. The purpose of this study was to describe health-related physical fitness status in habitual exercisers who participate in different types of exercise.

Materials and Methods

Participants

One hundred and sixty-four Japanese male participants (age: 45–80 years, mean ± standard deviation: 63.7 ± 9.9 years) (Table 1) living in Ibaraki Prefecture were enrolled through fliers or information magazines. The inclusion criteria were that the participants had to be without a history of cardiovascular and cerebrovascular diseases and without restriction from exercising by a physician. The investigation was carried out from November 2015 to August 2016. The participants were classified into seven groups according to their most frequently practiced exercise: non-exercisers (n = 48), walking (n = 38), jogging (n = 23), rhythm calisthenics (n = 13), bowling (n = 20), tennis (n = 13), and cycling (n = 9). The procedures, purpose, and risks associated with the study were fully explained and written consent was obtained before the study. This study was approved by the ethics committee of the University of Tsukuba, Japan (approval number: TAI 27-68).

Measured variables

The participants were made to undergo the physical fitness tests mentioned below. All the testers were master or doctoral students in sports medicine at the University of Tsukuba, as were several of the authors of this study. All the testers received special training in advance. The test items were administered and completed within 2 hours for each participant.

Anthropometry and body composition

We instructed the participants neither to engage in any vigorous physical activity nor to consume alcohol for 24 hours prior to the measurements. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer (YG-200; Yagami, Nagoya, Japan) and weight and body fat was measured using a bioelectrical impedance analyzer (InBody 770; InBody Japan, Tokyo, Japan), to the nearest 0.05 kg (weight) and 0.1% (body fat). Body mass index (BMI) was calculated as the weight divided by the height squared (kg/m\(^2\)). Waist circumference was measured horizontally around the waist twice at the level of the navel, and the result was recorded as the average value if the two measured values did not differ by more than 1 cm. If the two measured values differed by more than 1 cm, the tester took a third measurement.

<table>
<thead>
<tr>
<th>Category</th>
<th>Non-exercisers (n=48)</th>
<th>Walking (n=38)</th>
<th>Jogging (n=23)</th>
<th>Rhythm calisthenics (n=13)</th>
<th>Bowling (n=20)</th>
<th>Tennis (n=13)</th>
<th>Cycling (n=9)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height, cm</td>
<td>167.4 ± 6.2</td>
<td>166.2 ± 7.1</td>
<td>168.6 ± 6.7</td>
<td>166.9 ± 4.4</td>
<td>165.6 ± 6.7</td>
<td>162.2 ± 5.3</td>
<td>167.7 ± 4.6</td>
<td>0.153</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>68.0 ± 10.4</td>
<td>64.1 ± 10.0</td>
<td>60.5 ± 6.7(^*)</td>
<td>62.3 ± 6.2</td>
<td>64.0 ± 8.7</td>
<td>59.3 ± 6.9(^*)</td>
<td>67.8 ± 14.7</td>
<td>0.016</td>
</tr>
<tr>
<td>BMI, kg/m(^2)</td>
<td>24.2 ± 3.5</td>
<td>23.2 ± 2.9</td>
<td>21.3 ± 1.4(^*)</td>
<td>22.4 ± 2.0</td>
<td>23.0 ± 2.4</td>
<td>22.5 ± 1.9</td>
<td>24.1 ± 4.3</td>
<td>0.003</td>
</tr>
<tr>
<td>Waist circumference, cm</td>
<td>88.0 ± 9.0</td>
<td>86.2 ± 8.1</td>
<td>76.4 ± 4.3(^*)</td>
<td>82.3 ± 4.8</td>
<td>84.1 ± 5.6</td>
<td>81.0 ± 8.7</td>
<td>87.5 ± 10.8</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Body fat, %</td>
<td>24.6 ± 7.1</td>
<td>23.1 ± 5.0</td>
<td>20.8 ± 5.1</td>
<td>24.3 ± 3.2</td>
<td>22.1 ± 3.8</td>
<td>21.7 ± 4.0</td>
<td>23.1 ± 3.5</td>
<td>0.172</td>
</tr>
</tbody>
</table>

\(^*\) Significant group differences by post hoc test (compared to non-exercisers).

\(^P\) values were from one-way analysis of variance.

BMI: body mass index.
Physical fitness measures

Forced expiratory volume for one second. The forced expiratory volume was measured by a Spiro Analyzer (SP-310; Fukuda Denshi) and expressed as liters. The test was performed twice, and the greater result of the two was recorded as the FEV_{1.0}s measurement.

Hand-grip strength. Participants were asked to grip a dynamometer (Grip-D, TKK5401; Takei Scientific Instruments, Tokyo, Japan) in each hand alternately with maximum effort while lowering the arm naturally to the side of the body^{38}. The measurement was performed twice for each hand, and the greater result of the two was recorded as the handgrip strength for each hand.

Trunk flexion. Trunk flexion was measured by using a standing trunk flexion meter (measuring range: -20.0–35.0 cm) (T.K.K.5003 Flexion-A; Takei Scientific Instruments, Tokyo, Japan) for measuring the flexibility of the leg, hip, and trunk. The participants needed to stand with the heels kept together and big toes 5 cm apart, put the fingertips on the cursor of the instrument, and bend the body gradually forward without bending the knees, so that the cursor was pushed downwards. The value at the point on the scale corresponding to the upper surface of the cursor was read and recorded^{19}.

Trunk extension. The participants were asked to lie face down with hands on the back of waist and slowly raise their upper body off the floor and hold for specified period for the staff to measure the distance between the floor and the participant’s chin. The test was performed twice and the greater distance was recorded as the result^{39}.

One-legged stand with eyes closed. The participants were asked to stand on their preferred leg for a maximum of 60 seconds, raising gradually from the floor to a height of 10–20 cm, maintain balance if possible, with their hands on the waist and with the eyes closed. Timing was stopped if the participant moved his foot from the given position, opened his eyes during the trials, or reached the maximum balance time of 60 seconds. The test was performed twice. The greater score, in seconds, was used in the statistical analysis^{21}.

Vertical jump. Vertical jump was conducted to measure the lower-limb strength. The test was performed as follows: The participants placed their feet on the circular board of a jump meter (Jump-MD, T.K.K.5106; Takei Scientific Instruments, Tokyo, Japan). The participants leaped vertically as high as possible using knee counter-movement and landing on the circular board of the dynamometer. The jumps were performed twice per participant and the highest score was recorded. The scores were recorded in centimeters (cm) with one decimal point^{22}.

Side-to-side stepping. The side-to-side stepping test was measured on a flat floor with 3 parallel lines. Participants stood at the center line, then jumped 1 meter to one side and touched or crossed a line with the closest foot and jumped back to the center then jumped 1 meter to the other side, and back to the center again. Touching or crossing a line was counted for one time. The subjects were asked to try to complete as many times as possible within 20 seconds. The measurement was performed only once and the result was expressed as reps^{9}.

Maximal oxygen uptake (VO_{2max}) and oxygen uptake at the anaerobic threshold (VO_{2AT}). The participants performed an incremental exercise test using a cycling ergometer (Aerobike 75XL III; Combi Wellness Co., Tokyo, Japan) to determine their VO_{2max} and VO_{2AT}. Following a 2-min warm-up at 15 W or 30 W, the workload increased every minute by 15 W until volitional exhaustion. Participants cycled at a cadence of 60 rpm. During the test, ventilation and expiratory gases were measured using an indirect calorimeter (Aeromonitor AE-310s; Minato Medical Science, Osaka, Japan). The highest oxygen uptake achieved over 30 s was determined as the VO_{2max}. VO_{2max} was achieved when at least two of the following criteria^{23} were met: (1) leveling-off of VO_{2max}, (2) respiratory exchange ratio (RER) greater than 1.1, and (3) heart rate higher than 90% of predicted maximal heart rate. The point of VO_{2AT} was detected using the v-slope technique^{24} from which the ventilation equivalent of oxygen (VE/VO_{2}) was computed, and the point where VE/VO_{2} started rising was automatically detected by the computer software.

Physical fitness age (PFA) assessment procedures. In addition to the specific indicators of physical fitness, such as cardio-respiratory endurance, muscular endurance, muscular strength, flexibility, and body composition, Lee et al.^{25} developed the concept of physical fitness age (PFA) for assessing physical fitness level and functional status in middle-aged and older adults. PFA is associated with exercise habituation and can be used to evaluate the overall physical fitness status^{26}. PFA is computed from 8 independent variables measured during exercise with different motor skills. The PFA of each participant was estimated from the following equation, which was developed for use with Japanese male adults by Lee et al.^{25}

\[
PFA = -15.3 \cdot PFS + 48.0 + Z,
\]

where:

\[
PFS = \frac{\frac{0.021}{X1} + \frac{0.037}{X2} + \frac{0.020}{X3} + \frac{0.024}{X4} + \frac{0.017}{X5} + \frac{0.017}{X6} + \frac{0.008}{X7} + \frac{0.001}{X8} + 4.92}{0.12 \cdot \text{Age} - 5.8}
\]

X1 = VO_{2max} (mL/kg/min), X2 = VO_{2AT} (mL/kg/min), X3 = hand-grip strength (kg), X4 = side-to-side stepping (reps/20 s), X5 = trunk extension (cm), X6 = trunk flexion (cm), X7 = one-legged stand with eyes closed (s), and X8 = vertical jump (cm)
Participation in exercise or sports and lifestyle variables. Participants were asked to identify their most frequent exercise if they exercised regularly. Participants were instructed to mention the habitual exercise (practiced at least twice a week, 30 minutes or more per exercise session, continued for over a year) as the answer when they participated in more than one sport activity. The exercise frequency, time, and subjective exercise intensity (rating of perceived exertion [RPE]) data were also collected (Table 2). Participants were asked to choose from the following RPE options that best described their level of exertion during exercise: very hard, hard, somewhat hard, and light.

The status of alcohol consumption (current alcohol drinker or not) and tobacco smoking (current smoker or not) were also asked.

Statistical analyses
The measurement values were expressed as means ± standard deviations. The exercise information of habitual exercisers was expressed as n / % obtained by the chi-squared test. One-way analysis of variance (ANOVA) was performed to analyze the differences in basic information among the seven groups. The RPE was used to calculate the amount of weekly exercise, with the intensity of daily exercise rated as vigorous (RPE: very hard) = 3, moderate (RPE: hard or somewhat hard) = 2, and light (RPE: light) = 1. One-way analysis of covariance (ANCOVA), with the amount of weekly exercise (frequency/week × time × intensity) and duration as covariates, was utilized to test for the significance of PFA and the difference between chronological age and PFA (CA-PFA) among the seven groups. The Bonferroni post hoc test was used when the ANOVA and ANCOVA results exhibited significant differences (P < 0.05). Statistical analyses were performed using the statistical package for SPSS software, version 18.0 (IBM, Inc., Armonk, NY, USA).

Results
The overall study sample consisted of 164 adult males aged 45–80 years. Table 1 shows the basic information for participants in the present investigation. The ANOVA results demonstrated that weight, BMI, and waist circumference differed significantly among the seven groups. Mean values of BMI and waist circumference were lowest in the joggers compared to the non-exercisers.

Table 2 shows the exercise information of 116 habitual exercisers. The exercise frequency (4–7 d/week or 1–3 d/week), subjective exercise intensity (vigorous, moderate, or light), and duration (10 years or more, 5–9 years, or 1–4 years) showed significant differences (P < 0.05) among the 6 exercise types. There were no significant differences in the exercise time (2 hours or more, 1–2 hours, or less than 1 hour).

Table 3 shows the results of the physical fitness test. To avoid the influence of age on the results, ANCOVA was performed with chronological age as a covariate. The post hoc tests demonstrated significant differences among groups for all the variables. The maximal oxygen uptake of the joggers (45.5 ± 1.1 mL/kg/min) was significantly higher (P < 0.05) than those of the other six groups.

| Table 2. Exercise information of study participants with exercise habituation (n=116) |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | Walking (n=38)  | Jogging (n=23)  | Rhythm calisthenics (n=13) | Bowling (n=20) | Tennis (n=13) | Cycling (n=9) | P value        |
| Frequency       |                 |                 |                              |                 |                 |                 | 0.025          |
| 4-7 days/week, n / % | 32 / 84.2      | 19 / 82.6       | 7 / 53.8                     | 4 / 20.0        | 4 / 30.8       | 7 / 77.8       |
| 1-3 days/week, n / % | 6 / 15.8       | 4 / 17.4        | 6 / 46.2                     | 16 / 80.0       | 9 / 69.2       | 2 / 22.2       |
| Intensity       |                 |                 |                              |                 |                 |                 | 0.026          |
| Vigorous, n / % | 3 / 7.9         | 15 / 65.2       | 2 / 15.4                     | 3 / 15.0        | 7 / 53.8       | 3 / 33.3       |
| Moderate, n / % | 23 / 60.5       | 4 / 17.4        | 6 / 46.1                     | 9 / 45.0        | 3 / 23.1       | 5 / 55.6       |
| Light, n / %   | 12 / 31.6       | 4 / 17.4        | 5 / 38.5                     | 8 / 40.0        | 3 / 23.1       | 1 / 11.1       |
| Time            |                 |                 |                              |                 |                 |                 | 0.673          |
| > 2 hours, n / % | 9 / 23.7        | 7 / 30.4        | 2 / 15.4                     | 7 / 35.0        | 4 / 30.8       | 4 / 44.4       |
| 1-2 hours, n / % | 20 / 52.6       | 12 / 52.2       | 8 / 61.5                     | 13 / 65.0       | 7 / 53.8       | 5 / 55.6       |
| < 1 hour, n / % | 9 / 23.7        | 4 / 17.4        | 3 / 23.1                     | 0 / 0.0         | 2 / 15.4       | 0 / 0.0        |
| Duration        |                 |                 |                              |                 |                 |                 | 0.006          |
| > 10 years, n / % | 15 / 39.5       | 15 / 65.2       | 2 / 15.4                     | 7 / 35.0        | 12 / 92.3      | 5 / 55.6       |
| 5-9 years, n / % | 15 / 39.5       | 4 / 17.4        | 2 / 15.4                     | 4 / 20.0        | 1 / 7.7        | 1 / 11.1       |
| 1-4 years, n / % | 8 / 21.0        | 4 / 17.4        | 9 / 69.2                     | 9 / 45.0        | 0 / 0.0        | 3 / 33.3       |

P values were from chi-squared test.
Compared to non-exercisers, tennis players’ trunk flexion (6.8 ± 2.5 cm), one-legged stand with eyes closed (24.9 ± 3.3 s), vertical jump (38.9 ± 1.6 cm), and side-to-side stepping (39.8 ± 1.6 reps/20 s) were higher (P < 0.05). The joggers’ vertical jump (37.8 ± 1.2 cm) and rhythm calisthenics practitioners’ side-to-side stepping (36.3 ± 1.6 reps/20 s) were better (P < 0.05) than those for non-exercisers.

The jogger group PFS (physical fitness score) (0.21 ± 0.68) were significantly higher (1.14 ± 0.16) than that of non-exercisers (-0.93 ± 0.66). And jogger PFA (46.1 ± 11.2) were also significantly younger (-17.6 ± 2.7) than non-exercisers (63.7 ± 11.0). The difference between chronological age and PFA in non-exercisers (-3.4 ± 7.7) was 16.4 ± 1.8 years less than that of joggers (13.0 ± 7.5), 13.7 ± 2.2 years less than that of tennis players (10.4 ± 5.8), and 7.9 ± 2.2 years less than that of rhythm calisthenics practitioners (4.6 ± 8.7) (Table 4). The difference between chronological age and PFA in joggers was 12.8 ± 1.8 years greater than that of walkers (0.2 ± 6.4), 12.2 ± 2.1 years greater than that of bowlers (0.8 ± 5.1), 10.4 ± 2.7 years greater than that of cyclists (3.5 ± 6.5), and 8.4 ± 2.4 years greater than that of the rhythm calisthenics group (Fig. 1). All statistical-significance levels were P < 0.05.

### Table 3. Health-related physical fitness of study participants (n=164)

<table>
<thead>
<tr>
<th></th>
<th>Non-exercisers</th>
<th>Walking</th>
<th>Jogging</th>
<th>Rhythm calisthenics</th>
<th>Bowling</th>
<th>Tennis</th>
<th>Cycling</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV$_{1.0s}$, L</td>
<td>3.21 ± 0.72</td>
<td>3.05 ± 0.68</td>
<td>3.15 ± 0.50</td>
<td>2.89 ± 0.24</td>
<td>3.08 ± 0.77</td>
<td>2.95 ± 0.58</td>
<td>3.35 ± 0.44</td>
<td>0.518</td>
</tr>
<tr>
<td>Grip_right, kg</td>
<td>38.0 ± 0.9</td>
<td>38.4 ± 1.1</td>
<td>40.1 ± 1.4</td>
<td>40.7 ± 1.8</td>
<td>39.7 ± 1.4</td>
<td>37.4 ± 1.8</td>
<td>40.1 ± 2.1</td>
<td>0.400</td>
</tr>
<tr>
<td>Grip_left, kg</td>
<td>37.1 ± 0.9</td>
<td>37.0 ± 1.0</td>
<td>38.3 ± 1.3</td>
<td>38.0 ± 1.7</td>
<td>37.7 ± 1.3</td>
<td>37.3 ± 1.7</td>
<td>40.1 ± 2.0</td>
<td>0.696</td>
</tr>
<tr>
<td>Trunk flexion, cm</td>
<td>-3.2 ± 1.3</td>
<td>3.3 ± 1.5</td>
<td>2.4 ± 1.9</td>
<td>2.1 ± 2.5</td>
<td>2.0 ± 2.0</td>
<td>6.8 ± 2.5$^*$</td>
<td>3.4 ± 3.0</td>
<td>0.003</td>
</tr>
<tr>
<td>Trunk extension, cm</td>
<td>33.4 ± 1.3</td>
<td>34.2 ± 1.4</td>
<td>35.4 ± 1.8</td>
<td>35.0 ± 2.4</td>
<td>35.4 ± 1.9</td>
<td>35.3 ± 2.4</td>
<td>40.0 ± 2.8</td>
<td>0.069</td>
</tr>
<tr>
<td>One-legged stand with eyes closed, s</td>
<td>9.8 ± 1.8</td>
<td>12.3 ± 2.0</td>
<td>11.5 ± 2.5</td>
<td>12.0 ± 3.4</td>
<td>10.1 ± 2.7</td>
<td>24.9 ± 3.3$^*$</td>
<td>16.5 ± 4.0</td>
<td>0.021</td>
</tr>
<tr>
<td>VO$_2$ max mL/kg/min</td>
<td>26.6 ± 0.8</td>
<td>27.8 ± 0.9</td>
<td>45.5 ± 1.1$^*$</td>
<td>30.3 ± 1.5</td>
<td>27.5 ± 1.2</td>
<td>32.5 ± 1.5</td>
<td>28.7 ± 1.8</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>VO$_2$ AT mL/kg/min</td>
<td>18.2 ± 2.2</td>
<td>18.9 ± 2.4</td>
<td>27.2 ± 5.4$^*$</td>
<td>17.4 ± 3.4</td>
<td>19.1 ± 2.9</td>
<td>20.4 ± 1.8</td>
<td>20.7 ± 2.0</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Vertical jump, cm</td>
<td>32.9 ± 0.9</td>
<td>34.0 ± 0.9</td>
<td>37.8 ± 1.2$^*$</td>
<td>36.3 ± 1.6</td>
<td>36.0 ± 1.3</td>
<td>38.9 ± 1.6$^*$</td>
<td>37.4 ± 1.8</td>
<td>0.003</td>
</tr>
<tr>
<td>Side-to-side stepping, reps</td>
<td>31.5 ± 1.0</td>
<td>32.7 ± 0.9</td>
<td>35.2 ± 1.2</td>
<td>36.3 ± 1.6$^*$</td>
<td>33.5 ± 1.3</td>
<td>39.8 ± 1.6$^*$</td>
<td>31.4 ± 1.9</td>
<td>0.002</td>
</tr>
</tbody>
</table>

* Significant group differences by post hoc test (compared to non-exercisers).

### Table 4. Physical fitness score and physical fitness age of participants (n=164)

<table>
<thead>
<tr>
<th></th>
<th>Non-exercisers</th>
<th>Walking</th>
<th>Jogging</th>
<th>Rhythm calisthenics</th>
<th>Bowling</th>
<th>Tennis</th>
<th>Cycling</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronological age, years</td>
<td>60.3 ± 9.8</td>
<td>66.7 ± 9.1$^*$</td>
<td>59.1 ± 9.9</td>
<td>69.5 ± 4.3$^*$</td>
<td>65.3 ± 11.7</td>
<td>67.3 ± 6.7$^*$</td>
<td>62.0 ± 9.6</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>PFS, year</td>
<td>-0.93 ± 0.66</td>
<td>-1.07 ± 0.57</td>
<td>0.21 ± 0.68$^*$</td>
<td>-0.94 ± 0.53</td>
<td>-0.95 ± 0.72</td>
<td>-0.44 ± 0.54</td>
<td>-0.48 ± 0.61</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>PFA, year</td>
<td>63.7 ± 11.0</td>
<td>66.5 ± 9.6</td>
<td>46.1 ± 11.2$^*$</td>
<td>64.9 ± 8.2</td>
<td>64.5 ± 12.3</td>
<td>57.0 ± 8.8</td>
<td>58.5 ± 9.4</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>PFA$^2$, year</td>
<td>63.7 ± 11.0</td>
<td>68.2 ± 1.7</td>
<td>45.3 ± 2.0$^*$</td>
<td>65.6 ± 2.9</td>
<td>64.9 ± 2.2</td>
<td>56.1 ± 3.4</td>
<td>57.8 ± 2.9</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>CA-PFA, year</td>
<td>-3.4 ± 7.7</td>
<td>0.2 ± 6.4</td>
<td>13.0 ± 7.5$^*$</td>
<td>4.6 ± 8.7$^*$</td>
<td>0.8 ± 5.1</td>
<td>10.4 ± 5.8$^*$</td>
<td>3.5 ± 6.5</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>CA-PFA$^2$, year</td>
<td>-3.4 ± 7.7</td>
<td>0.05 ± 6.69</td>
<td>12.5 ± 7.6$^*$</td>
<td>5.4 ± 8.5$^*$</td>
<td>0.7 ± 5.3</td>
<td>10.1 ± 6.0$^*$</td>
<td>1.3 ± 5.3</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

* Significant group differences by post hoc test (compared to non-exercisers).

P values were from one-way analysis of covariance.

FEV$_{1.0s}$: forced expiratory volume for one second; VO$_2$max: maximal oxygen uptake; VO$_2$AT: oxygen uptake at the anaerobic threshold.

P values were from one-way analysis of covariance. PFS: physical fitness score; PFA: physical fitness age; CA: chronological age.

# Adjusted for amount of weekly exercise (frequency/week × time × intensity) and duration.

* Significant group differences by post hoc test (compared to non-exercisers).
showed that $\text{VO}_{2}\text{max}$ was increased from 25.4 $\pm$ 4.6 mL/kg/min to 28.2 $\pm$ 5.2 mL/kg/min after 6 months of low-intensity training ($P < 0.05$), and to 32.9 $\pm$ 7.6 mL/kg/min after an additional 6 months of higher-intensity training ($P < 0.01$). In our study, we observed similar results wherein participants with the highest exercise intensity showed the greatest $\text{VO}_{2}\text{max}$, which may be the cause of the better PFS and PFA in joggers.

Tennis has evolved from a sport in which exercise skill was the primary prerequisite for successful performance into a sport that also requires complex interaction of several physical components (i.e., strength and agility)\(^{30}\). In many sports, such as tennis and soccer, sport-specific technical skills are predominant factors\(^{31,32}\). In our study, tennis players showed better flexibility (trunk flexion: 6.8 $\pm$ 2.5 cm), agility (side-to-side stepping: 39.8 $\pm$ 1.6 reps/20 s), balance (one-legged stand with eyes closed: 24.9 $\pm$ 3.3 s), and lower-limb strength (vertical jump: 38.9 $\pm$ 1.6 cm) than non-exercisers (Table 3). Therefore, in addition to better cardiopulmonary function, various technical skills are also the possible reasons for the difference between chronological age (CA) and PFA in tennis players.

In our study, when compared to non-exercisers (-3.4 $\pm$ 7.7 years), the difference in chronological age and PFA of the rhythm calisthenics group (4.6 $\pm$ 8.7 years) was significant and remarkably better. A series of investigations have shown that individuals who maintain a physically active life-style in middle and old age are significantly less likely to experience age-related decrements in their ability to perform activities of daily living compared to less active individuals of the same chronological age\(^{33,34}\). Rhythm exercise is a kind of performance form consist-

**Discussion**

The purpose of this study was to assess the health-related physical fitness of habitual exercisers of various types of exercise among 164 Japanese male adults aged 45–80 years. Our most striking finding was that PFS and PFA were different in practitioners of different exercise types. Joggers showed higher PFS and younger PFA than non-exerisers. The difference between the chronological age and PFA of joggers, tennis players, and rhythm calisthenics practitioners was significantly greater than that of non-exercisers.

In eight physical fitness test items, the joggers’ maximal oxygen uptake was significantly higher than for the other six groups in our study. Joggers showed an obvious advantage in cardiorespiratory endurance. For this result, we first considered the effect of exercise time and intensity (i.e., volume or amount) on cardiopulmonary function. A randomized intervention study\(^{27}\) of endurance training on nonsmoking, sedentary men conducted at a high- (jogging) and a low- (walking) exercise intensity level showed that after a 6-month endurance training period, joggers (90 $\pm$ 41 min/week) and walkers (121 $\pm$ 72 min/week) showed a similar statistically significant increase in $\text{VO}_{2}\text{max}$. It seems that higher intensity and/or longer duration of exercise results in better body function and physical fitness. In our study, joggers showed the highest proportion of vigorous intensity (65.2%) (Table 2) and the best $\text{VO}_{2}\text{max}$ (45.5 $\pm$ 1.1 mL/kg/min) among the seven groups ($P < 0.001$) (Table 3). Vigorous-intensity exercise resulted in a greater increase in aerobic capacity than moderate-intensity exercise\(^{28}\). Seals et al.\(^{29}\) studied the effects of prolonged endurance training on $\text{VO}_{2}\text{max}$ in older individuals and showed that $\text{VO}_{2}\text{max}$ was increased from 25.4 $\pm$ 4.6 mL/kg/min to 28.2 $\pm$ 5.2 mL/kg/min after 6 months of low-intensity training ($P < 0.05$), and to 32.9 $\pm$ 7.6 mL/kg/min after an additional 6 months of higher-intensity training ($P < 0.01$). In our study, we observed similar results wherein participants with the highest exercise intensity showed the greatest $\text{VO}_{2}\text{max}$, which may be the cause of the better PFS and PFA in joggers.

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**Fig. 1** Difference in chronological age and physical fitness age in seven groups

![Chart](chart.png)
ing of purposefully selected sequences of human movement, generally performed with the accompaniment of music. Rhythm exercise probably improves stability and flexibility with the skills of stepping, bending, swaying, and stretching. The rhythm calisthenics practitioners in our study showed better side-to-side stepping (36.3 ± 1.6 reps/20 s) than non-exercisers. We noticed that even though each group of exercisers showed better health-related physical fitness levels than non-exercisers, participants in different exercise types showed different advantages on physical fitness. Therefore, we believe that in addition to exercise intensity and duration, the various types of exercise also have varying positive effects on enhancing physical fitness.

We also obtained similar results for PFA and CA-PFA after adjusting for the amount of weekly exercise and duration (Table 4). Obviously, we cannot ignore the effect of exercise intensity, time, and duration on health-related physical fitness. Joggers in our study showed the highest VO2max. As an evaluation index of cardiopulmonary function, VO2max has a greater influence on the calculation of PFS and PFA. The improvement of cardiopulmonary function requires the participants to maintain a certain intensity and time for daily exercise, such as jogging. Although the VO2max of tennis players was lower than that of joggers, as participants of an exercise requiring certain skills, tennis players showed better flexibility, agility, balance, and lower-limb strength, which resulted in better CA-PFA. Moreover, the participants of rhythm calisthenics also showed better results for CA-PFA with even light or moderate intensity (Table 2).

The evaluation was based solely on the most frequently practiced exercise and lacked discussion on the effects of multiple exercise types on health-related physical fitness. We only evaluated male participants in the present study; female habitual exercisers will be discussed in a future study. Because this is an observational study, it remains uncertain whether this relationship is causal. Longitudinal studies are needed to further explore these associations.

Conclusions

Various exercises appeared to confer different advantages on health-related physical fitness status. Exercise type with different skills was considered as a factor to maintain or promote physical fitness for habitual exercisers, especially older individuals.

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Conflict of Interests

The authors have no conflict of interests to report.

References


