The Relationship Between Functional Fitness and Coronary Heart Disease Risk Factors in Older Japanese Adults

Kiyoji Tanaka, Ryosuke Shigematsu, Masaki Nakagaichi, Hunkyung Kim, and Nobuo Takeshima

In Japan, two approaches have been adopted to assess health and functional status in older adults. One is a battery of physical-performance tasks. The other is estimation of physical vitality using biomedical risk factors. Previous research has examined strength and direction of the relationship between functional fitness and performance on activities of daily living. Vital-age tests have most often been used to assess risk for developing a variety of age-related diseases. The present study examined interrelationships among functional fitness and vital-age scores in Japanese women (N = 129, mean age = 71.9). The functional fitness test battery consisted of arm curls, walking around 2 cones, moving beans with chopsticks, and functional reach. The vital-age test battery consisted of 6 coronary heart disease risk factors (systolic blood pressure, total cholesterol, low-density lipoprotein cholesterol, triglycerides, abdominal girth, and hematocrit) and 5 physical-performance variables (oxygen uptake and heart rate at lactate threshold, side-to-side stepping, 1-leg balance with eyes closed, and forced expiratory volume).

Key Words: functional fitness, coronary risk factors, physical vitality, vital age

The past several decades have witnessed a dramatic increase in longevity throughout the industrialized world, including Japan, North America, and many European countries. Current trends demonstrate that people are living longer and are afflicted with fewer acute diseases than in the past. Consistent with this trend, average life expectancy doubled in the past century. Advances in medical care have enabled many older persons to live for long periods of time. Unfortunately, these increases in longevity are not always accompanied by good health, and many older

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persons suffer from multiple chronic diseases that adversely affect their quality of life.

There is considerable variability among older adults with regard to both longevity and physical health (Chodzko-Zajko, 1996; Tanaka & Chodzko-Zajko, 1998). In recent years, increasing attention has focused on developing preventive medicine and other strategies to help individuals age "successfully." Studies have shown that individuals who maintain a physically active lifestyle in old age are significantly less likely to experience age-related decrements in their ability to perform activities of daily living than are less active individuals of the same chronological age (Chodzko-Zajko; Tanaka, Matsura, Nakadomo, & Nakamura, 1990). It has been known for many years that physical inactivity is a significant risk factor for many chronic diseases (see U.S. Surgeon General’s Report, 1996, for a review of this literature). In addition, several recent investigations have suggested that physically active lifestyles might be associated with increased longevity. Specifically, physically active older adults have significantly lower mortality of all causes than do less active individuals of the same chronological age (Blair et al., 1995; Paffenbarger et al., 1993).

There is a growing appreciation that physical inactivity is a significant threat to public health not only in Japan (see Appendix) and in the United States (U.S. Surgeon General, 1996) but throughout the entire world (World Health Organization, 1997). Some of the most important public health challenges facing society today are to move our society away from being predominantly sedentary toward becoming more physically active and to help maintain adequate physical health and vitality for as long as possible throughout the life span. A major focus of our research at the Tsukuba Advanced Research Alliance has been the development of multivariate measures for assessing physical performance and functional status in old age (Kim & Tanaka, 1995; Lee et al. 1996; Shigematsu, Tanaka, Watanabe, & Hiyama, 1998; Tanaka et al., 1990, 1994, 1995). Our approach has been to compute an estimate of relative age or biological age that we refer to as vital age. Vital age has been shown to be useful for assessing functional status not only for healthy people but also for patients with coronary heart disease, stroke, hypertension, obesity, diabetes, and so on. Our approach to assessing vital age is consistent with a long tradition in Japanese gerontology involving the assessment of biological age by means of multivariate statistical approaches (e.g., Nakamura, Miyao, & Ozeki, 1988; Nakamura, Moritani, & Kanetaka, 1990). The principal difference between our research and previous approaches is our philosophical decision to include primarily functional fitness measures in our vital-age battery, rather than more traditional biological age measures.

Although habitual physical activity is known to be associated with functional fitness and activities-of-daily-living (ADL) performance, it is presently unclear whether functional fitness is similarly associated with other measures of health and well-being. For example, it is not clear whether cardiovascular disease risk and functional fitness are related. To our knowledge, no studies have systematically examined the association between functional fitness variables and coronary risk factors in older Japanese adults. If the correlation between these two sets of variables is high, it might not be necessary to assess both when examining health and well-being in seniors. However, if the correlation between the batteries is only modest, this would suggest that each construct assesses a different component of
health and well-being and that continued assessment with both types of test battery is recommended. Accordingly, the purpose of this study was to investigate the relationship between scores on a functional fitness test battery and performance on a battery of coronary risk-related variables in older Japanese women.

Methods

PARTICIPANTS

The participants included in this investigation were 129 Japanese women ranging in age from 60 to 87 years (mean 71.9 years ± 6.6). The participants lived in semiurban or urban areas close to Tokyo. All participants were recruited from either senior education programs organized by two local municipalities (Tsukuba and Toride) or from two senior exercise programs organized by two major universities (University of Tsukuba and Nagoya City University). In order to be included in the study, participants were required to be relatively healthy. Individuals who could not independently manage such daily activities (ADL) as shopping, eating, bathing, or dressing were excluded from the study. All participants were volunteers, and no attempt was made to select a random or representative sample of older Japanese women.

TESTING PROCEDURES

Measurement of coronary risk factors such as serum cholesterol level, blood pressure, and body fat was conducted on the same day as the functional fitness assessment. The investigation was conducted over an 18- to 20-week time period during the spring and fall of 1997. An approximately 1-hr orientation session was scheduled 3–5 days before the data collection. Participants were then assigned to one of two data-collection sessions that were scheduled a few days apart.

FUNCTIONAL FITNESS ASSESSMENT PROCEDURES

The functional fitness test items chosen were selected in order to examine four dimensions of ADL function (Duncan, Weiner, Chandler, & Studenski, 1990; Kim & Tanaka, 1995; Kimura et al., 1989; Nakao, Inoue, & Murakami, 1989; Osness, 1989; Shigematsu et al., 1998; Tokyo Metropolitan University, 1989). The four test items were administered and completed in approximately 15 min by most participants. The tests were designed to be administered with only one examiner per test and minimal test equipment. Adequate time between test items was allowed to minimize the effect of fatigue. The specific details of the tests are as follows.

Arm curls were measured with the participant sitting upright in a straight-backed chair. A 2.0-kg dumbbell was placed in the participant’s dominant hand and held in the extended position. The participant was then instructed to perform biceps curls with the dumbbell as many times as possible in 30 s (Osness, 1989). The nondominant hand rested in the lap. Performance was assessed by the number of completed repetitions.

Walking around two cones was measured with the participant sitting in a straight-backed chair located between two cones placed 1.8 m on one side of and
1.5 m behind the chair (Osness, 1989). At a signal, the participant rose from the chair, walked to her right, going to the inside and around the back of the cone (counterclockwise), and returned to a fully seated position on the chair. Without rest, the participant was asked to walk around the other cone (clockwise) and return to a fully seated position. One trial consisted of two complete circuits (Osness). Performance time was recorded in units of 0.1 s.

Moving beans with chopsticks was measured with the participant instructed to use chopsticks to transfer as many beans as possible (approximately 0.8 cm in diameter) from one dish (2.0 cm in depth, 20.0 cm in diameter) to another dish (3.5 cm in depth, 6.0 cm in diameter) in 30 s. The dishes were 20 cm apart. Performance was assessed as the number of beans successfully transferred. This item was modified from Kim and Tanaka (1995; Shigematsu et al., 1998).

Functional reach was measured with the participant instructed to stand and then raise both arms forward to horizontal, at shoulder level. Performance was assessed as the maximal distance the participant could reach forward beyond her own arms’ length while keeping her heels in contact with the ground (Duncan et al., 1990).

In order to assess reliability, performance was assessed on two occasions for each of the items, with retesting occurring within 3–7 days of the initial test. Interclass correlation coefficients were calculated using a one-way analysis of variance in order to assess test–retest reliability. Reliability coefficients were \( r = .92 \) for arm curls, \( r = .80 \) for walking around two cones, \( r = .82 \) for moving beans with chopsticks, and \( r = .90 \) for functional reach.

**Computation of the Functional Fitness Score.** A functional fitness score for each participant was calculated according to the following equations, which were developed for use with older Japanese women by Shigematsu et al. (1998).

\[
\text{FFS} = 0.072x_1 - 0.075x_2 + 0.090x_3 + 0.041x_4 - 2.11
\]

\[
\text{FFA} = -6.52\text{FFS} + 0.36\text{CA} + 46.43
\]

where

- \( \text{FFS} \) = functional fitness score
- \( \text{FFA} \) = functional fitness age
- \( x_1 \) = arm curls (# of reps. within 30 s)
- \( x_2 \) = walking around two cones (time in s)
- \( x_3 \) = moving beans with chopsticks (# of reps. within 30 s)
- \( x_4 \) = functional reach (cm)
- \( \text{CA} \) = chronological age

**VITAL-AGE ASSESSMENT PROCEDURES.**

The underlying rationale behind the concept of vital age has been described in detail previously (Tanaka et al., 1990, 1994; Tanaka, Matsuura, & Nakamura, 1992; Tanaka, Yoshimura, Maeda, Watanabe, & Hiyama, 1991). Vital age is in many ways similar to biological age (Clark, 1960; Hofecker, Skalicky, Kment, & Niedermuller, 1980; Nakamura et al., 1988, 1990); however we consider it a more complete index than either biological or functional age, because it includes physiological measurements taken not only at rest but also during exercise.
The vital-age assessment items were selected to evaluate coronary risk status and physical performance (Tanaka et al., 1990). Eleven test items were chosen for the computation of vital age. These test items were administered and completed within 1 hr in all participants. Adequate recovery time was allowed between test items in order to minimize the effects of fatigue. The specific details of the tests are as follows.

**Biochemical Analyses.** After each participant had fasted for a minimum of 12 hr, blood samples of approximately 10 ml were collected in the early morning by venipuncture from the antecubital vein. The samples were then centrifuged to obtain the serum, which was stored at 4 °C. All analyses were completed within 48 hr of the collection of the blood samples.

*Total cholesterol* (TC) concentration in the serum and *serum triglycerides* (TG) were measured using a commercially available enzymatic assay (DAOS, Wako Shiyaku Co., Ltd.).

*Low-density lipoprotein cholesterol* (LDLC) was calculated according to the method of Friedewald, Levy, & Fredrickson (1970), which assumes that very low-density lipoprotein cholesterol (VLDLC) is equal to TG/5 and that LDLC = TC − (HDLC + VLDLC).

*Hematocrit* (Hct) was calculated by a standard procedure and was used as an index of thrombotic function (Wannamethee & Shaper, 1994).

**Physical Fitness Measures.** Abdominal girth was calculated in cm using a cloth tape measure at the level of the umbilicus.

*Systolic blood pressure* was measured in mmHg. Blood pressure measurements were taken at the right brachial artery by the auscultatory method using a mercury sphygmomanometer. The patients were seated for at least 5 min with their arms resting comfortably. The systolic blood pressure was recorded at the moment when the first sounds were heard, and diastolic blood pressure during the fifth Korotkoff phase.

*Oxygen consumption at the lactate threshold* (VO\(_{2\text{LT}}\)) was defined as the VO\(_2\) corresponding to the point at which blood lactate concentration (La) exhibited a nonlinear increase above the level at rest. To determine the lactate threshold (LT), a series of venous blood samples (0.5 ml each) were drawn from an antecubital vein every minute during an incremental cycling exercise. Following a 2-min warm-up at 0 W, the exercise intensity was increased every minute by 15 W until exhaustion or a symptom-limited maximal exercise intensity was reached. Expired gas was analyzed continuously for O\(_2\) and CO\(_2\) using standard techniques of open-circuit spirometry (Oxycon alpha, Mijnhardt). Blood samples were analyzed by the electrochemical enzymatic method. For discerning LT, the log VO\(_2\) − log La transformation method was used.

*Heart rate at the lactate threshold* (HRLT) was expressed as beat/min and was telemetrically measured during the incremental exercise test. HRLT was the HR corresponded to LT and was expressed as beats/min.

*Side-to-side steps* were expressed as number of repetitions in 20 s. The participant stood astride the middle line of three lines positioned at intervals of 1 m. The participant was instructed to step onto or beyond the left-side line. Next, she returned to the starting position, after which she repeated the task with the right-side line.

*One-leg balance* with eyes closed, in seconds, was measured by having each participant balance, with eyes closed and hands touching the hips, on her preferred
foot, with the other foot approximately 10 cm off the floor. The score was the number of seconds for which the nonpreferred foot was raised or until balance was lost. Each participant performed three trials. The best score was recorded to the nearest second.

*Forced expiratory volume* for 1 s was expressed as liters. The participant was tested while standing for the assessment of pulmonary function. Immediately after a maximal inspiration, each participant breathed air out in 3 or 4 s as forcibly and rapidly as possible. The total volume expired was recorded as the forced vital capacity (FVC), and the volume expired just in the 1st s as FEV₁. Forced expiratory volume was determined on a Fukuda-Sangyo autospirometer (ST-200).

In order to assess test–retest reliability of the vital-age score, performance was assessed on two separate occasions for each of the 11 constituent items, with retesting occurring within 3–7 days of the initial test. An intraclass correlation coefficient for the combined vital-age score was calculated using a one-way analysis of variance. The reliability coefficient was found to be $r = .94$

**Computation of the Vital-Age Score.** Vital-age score of each participant was estimated from the following equations, which were developed for use with older Japanese women by Tanaka et al. (1990, 1994).

$$\begin{align*}
VS &= 0.016y_1 + 0.011y_2 - 0.064y_3 - 0.012y_4 + 0.004y_5 + 0.004y_6 + 0.006y_7 \\
&\quad + 0.034y_8 - 0.037y_9 - 0.005y_{10} - 0.367y_{11} - 1.035 \\
VA &= 8.90VS + 0.330(\text{age}) + 32.83
\end{align*}$$

where $VS =$ vital score

$VA =$ vital age

$y_1 =$ abdominal girth (cm)

$y_2 =$ systolic blood pressure (mmHg)

$y_3 =$ oxygen uptake at lactate threshold (ml · kg⁻¹ · min⁻¹)

$y_4 =$ heart rate at lactate threshold (beats/min)

$y_5 =$ total cholesterol (mg/dl)

$y_6 =$ low-density lipoprotein cholesterol (mg/dl)

$y_7 =$ triglycerides (mg/dl)

$y_8 =$ hematocrit (%)

$y_9 =$ side-to-side steps (# in 20 s)

$y_{10} =$ one-leg balance with eyes closed (s)

$y_{11} =$ forced expiratory volume for 1 s (L)

**Statistical Analyses**

Means and standard deviations ($SD$) were computed for all variables. Pearson's product–moment correlation was used to assess the univariate relationship among variables. One-way analysis of variance was used to test the significance of the differences between (a) chronological age and vital age and (b) functional fitness age and vital age. Canonical correlations were used in order to assess the strength of the multivariate relationship between the set of four functional fitness variables and the set of four coronary risk factors. Statistical significance was set at $p < .05$ in all analyses.
Results

Descriptive characteristics for the participants in the study are shown in Table 1. The height and weight of the participants averaged 148.7 ± 6.0 cm and 51.1 ± 7.7 kg. Mean values of $\dot{V}O_{2LT}$ and $\dot{V}O_{2peak}$ were 13.6 ± 2.8 ml · kg$^{-1}$ · min$^{-1}$ and 20.7 ± 4.9 ml · kg$^{-1}$ · min$^{-1}$, respectively. These values are generally consistent with those reported previously by Ohta, Zhang, et al. (1999); Tamura (1997); and Posner, Gorman, Klein, & Cline (1987) for older Japanese and American adults. Mean scores on the four functional fitness tests (i.e., arm curls, walking around two cones,

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>148.7</td>
<td>±6.0</td>
<td>133.5</td>
<td>161.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>51.1</td>
<td>±7.7</td>
<td>34.7</td>
<td>76.6</td>
</tr>
<tr>
<td>Abdominal girth (cm)</td>
<td>83.9</td>
<td>±9.1</td>
<td>58.0</td>
<td>102.1</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>141.1</td>
<td>±17.0</td>
<td>98</td>
<td>180</td>
</tr>
<tr>
<td>$\dot{V}O_{2peak}$ (ml · kg$^{-1}$ · min$^{-1}$)</td>
<td>20.7</td>
<td>±4.9</td>
<td>10.7</td>
<td>40.4</td>
</tr>
<tr>
<td>$\dot{V}O_{2LT}$ (ml · kg$^{-1}$ · min$^{-1}$)</td>
<td>13.6</td>
<td>±2.8</td>
<td>7.2</td>
<td>20.2</td>
</tr>
<tr>
<td>$\dot{V}O_{2LT}$ (%)</td>
<td>67.2</td>
<td>±11.2</td>
<td>41.6</td>
<td>96.0</td>
</tr>
<tr>
<td>HRLT (beats/min)</td>
<td>106.9</td>
<td>±13.3</td>
<td>84</td>
<td>151</td>
</tr>
<tr>
<td>Cholesterol (mg/dl)</td>
<td>216.9</td>
<td>±29.5</td>
<td>149</td>
<td>307</td>
</tr>
<tr>
<td>HDL cholesterol (mg/dl)</td>
<td>64.1</td>
<td>±16.2</td>
<td>34.0</td>
<td>120.0</td>
</tr>
<tr>
<td>LDL cholesterol (mg/dl)</td>
<td>131.0</td>
<td>±28.8</td>
<td>58.2</td>
<td>226.7</td>
</tr>
<tr>
<td>Triglycerides (mg/dl)</td>
<td>109.3</td>
<td>±47.2</td>
<td>34</td>
<td>293</td>
</tr>
<tr>
<td>Red blood cells (107/mm$^3$)</td>
<td>4.1</td>
<td>±0.4</td>
<td>3.2</td>
<td>5.1</td>
</tr>
<tr>
<td>Hemoglobin (g)</td>
<td>12.5</td>
<td>±1.2</td>
<td>8.9</td>
<td>15.1</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>38.1</td>
<td>±4.7</td>
<td>29.1</td>
<td>47.6</td>
</tr>
<tr>
<td>Hand-grip strength (kg)</td>
<td>23.9</td>
<td>±5.5</td>
<td>12.7</td>
<td>42.9</td>
</tr>
<tr>
<td>Side-to-side steps (number in 20 s)</td>
<td>21.9</td>
<td>±6.1</td>
<td>8</td>
<td>42</td>
</tr>
<tr>
<td>One-leg balance with eyes closed (s)</td>
<td>8.0</td>
<td>±9.1</td>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>Trunk flexion from a standing position (cm)</td>
<td>10.9</td>
<td>±7.4</td>
<td>−13.4</td>
<td>25.6</td>
</tr>
<tr>
<td>Trunk extension while lying prone (cm)</td>
<td>29.7</td>
<td>±7.8</td>
<td>13.1</td>
<td>50.1</td>
</tr>
<tr>
<td>Vertical jump (cm)</td>
<td>19.9</td>
<td>±5.6</td>
<td>6</td>
<td>41</td>
</tr>
<tr>
<td>Arm curls (number in 30 s)</td>
<td>23.5</td>
<td>±6.2</td>
<td>5</td>
<td>39</td>
</tr>
<tr>
<td>Walking around 2 cones (s)</td>
<td>23.3</td>
<td>±6.0</td>
<td>15.2</td>
<td>49.0</td>
</tr>
<tr>
<td>Moving beans with chopsticks (number in 30 s)</td>
<td>12.3</td>
<td>±3.0</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Functional reach (cm)</td>
<td>30.7</td>
<td>±6.9</td>
<td>6</td>
<td>47</td>
</tr>
<tr>
<td>Forced expiratory volume for 1 s (L)</td>
<td>1.5</td>
<td>±0.4</td>
<td>0.8</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Note. $\dot{V}O_{2peak}$ = peak oxygen uptake; $\dot{V}O_{2LT}$ = oxygen uptake corresponding to lactate threshold; HRLT = heart rate corresponding to lactate threshold; HDL = high-density lipoprotein; LDL = low-density lipoprotein.
moving beans with chopsticks, and functional reach) for the participants (71.9 $\pm$ 6.6 years) in the present study were also very similar to those obtained in a sample of 400 older Japanese women (73.0 $\pm$ 6.5 years) in a previously published study from our laboratory (Shigematsu et al., 1998).

Table 2 presents means and standard deviations for chronological age, functional fitness age, and vital age. In addition, means and standard deviations for the functional fitness score and vital score are reported. Vital scores averaged 0.00 $\pm$ 0.70, whereas functional fitness scores averaged 0.20 $\pm$ 1.05. The coefficients of variation for chronological age, functional fitness age, and vital age were 9.2%, 10.3%, and 11.9%, respectively. One-way ANOVA indicated that mean vital age was slightly but significantly less (2.6 years, $p < .05$) than mean chronological age, whereas mean functional fitness age did not differ significantly from mean chronological age.

Zero-order correlations between each functional fitness variable and each variable in the vital score equation are shown in Table 3. Coronary risk factors such as systolic blood pressure, total cholesterol, low-density lipoprotein cholesterol, triglycerides, abdominal circumference, and $\text{VO}_{2\text{L,T}}$ were only weakly or nonsignificantly correlated with the functional fitness variables. For example, both systolic blood pressure and $\text{VO}_{2\text{L,T}}$ were correlated significantly with walking around two cones ($r = .22$ and $-.26$, respectively) and functional fitness score ($r = -.21$ and $.22$, respectively). Triglycerides and abdominal circumference were correlated significantly with moving beans with chopsticks ($r = .22$ and $-.20$, respectively). Other significant correlations were observed between such variables as FEV1$s\text{s}$, single-leg balance with eyes closed, and side-to-side stepping and each functional fitness variable or standard functional fitness score. A scattergram illustrating the relationship between the functional fitness score and standard vital score is presented in Figure 1. When canonical correlations ($Rc$) was computed between the set of coronary risk factors and the set of functional fitness variables, it was found to be moderate ($Rc = .49$).

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>SD</th>
<th>CV</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronological age (yr)</td>
<td>71.9</td>
<td>$\pm$6.6</td>
<td>9.2</td>
<td>60.0</td>
<td>87.0</td>
</tr>
<tr>
<td>Vital score</td>
<td>0.00</td>
<td>$\pm$0.70</td>
<td>-</td>
<td>-1.94</td>
<td>1.61</td>
</tr>
<tr>
<td>Vital age (yr)</td>
<td>69.3</td>
<td>$\pm$7.2*</td>
<td>10.4</td>
<td>51.2</td>
<td>87.7</td>
</tr>
<tr>
<td>Physical fitness score</td>
<td>0.00</td>
<td>$\pm$0.85</td>
<td>-</td>
<td>-1.71</td>
<td>3.07</td>
</tr>
<tr>
<td>Physical fitness age (yr)</td>
<td>80.0</td>
<td>$\pm$10.4*</td>
<td>-</td>
<td>43.7</td>
<td>102.4</td>
</tr>
<tr>
<td>Functional fitness score</td>
<td>0.20</td>
<td>$\pm$1.05</td>
<td>-</td>
<td>-3.21</td>
<td>2.27</td>
</tr>
<tr>
<td>Functional fitness age (yr)</td>
<td>71.0</td>
<td>$\pm$8.5</td>
<td>9.6</td>
<td>56.4</td>
<td>98.7</td>
</tr>
</tbody>
</table>

*Note. CV = coefficient of variation (%).

*Significantly lower than chronological age in ANOVA ($p < .05$).
Table 3  Zero-Order Correlations Between Each Functional Fitness Variable and Each Constituting Variable of the Vital Score Equation

<table>
<thead>
<tr>
<th></th>
<th>Abdominal</th>
<th>BPS</th>
<th>VO₂LT</th>
<th>HRLT</th>
<th>TC</th>
<th>LDLC</th>
<th>TG</th>
<th>Hct</th>
<th>Steps</th>
<th>Balance</th>
<th>FEV₁</th>
<th>Vital score</th>
<th>Vital age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm curl</td>
<td>.16</td>
<td>-.16</td>
<td>.11</td>
<td>.06</td>
<td>-.01</td>
<td>.01</td>
<td>-.11</td>
<td>-.06</td>
<td>.49*</td>
<td>.16</td>
<td>.03</td>
<td>.27*</td>
<td>-.33*</td>
</tr>
<tr>
<td>Walking around 2 cones</td>
<td>-.01</td>
<td>.22*</td>
<td>-.26*</td>
<td>.16</td>
<td>-.07</td>
<td>-.04</td>
<td>-.09</td>
<td>-.03</td>
<td>-.61*</td>
<td>-.32*</td>
<td>-.27*</td>
<td>-.31*</td>
<td>.45*</td>
</tr>
<tr>
<td>Moving beans</td>
<td>-.20*</td>
<td>.02</td>
<td>.10</td>
<td>-.14</td>
<td>.09</td>
<td>.05</td>
<td>.22*</td>
<td>.08</td>
<td>.30*</td>
<td>.19</td>
<td>.08</td>
<td>.07</td>
<td>-.15*</td>
</tr>
<tr>
<td>Reaching arms forward</td>
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<tr>
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<td>.08</td>
<td>.02</td>
<td>.69*</td>
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<td>.32*</td>
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<tr>
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<td>-.24*</td>
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<td>-.06</td>
<td>-.08</td>
<td>-.04</td>
<td>-.70*</td>
<td>-.35*</td>
<td>-.28*</td>
<td>-.34*</td>
<td>.53*</td>
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*Note.* Abdominal = abdominal girth (cm); BPS = systolic blood pressure (mmHg); VO₂LT = oxygen uptake corresponding to lactate threshold (ml·kg⁻¹·min⁻¹); HRLT = heart rate corresponding to lactate threshold (ml·kg⁻¹·min⁻¹); TC = total cholesterol (mg/dl); LDLC = low-density lipoprotein cholesterol (mg/dl); TG = triglycerides (mg/dl); Hct = hematocrit (%); Steps = side-to-side steps; Balance = one-leg balance with eyes closed; FEV₁ = forced expiratory volume for 1 s.
Advancing age is often associated with functional decline. As an individual's vulnerability to illness increases with advancing age, a traumatic event such as an accident or exposure to an acute illness, which would usually be of minor consequence to a young individual, might be of much greater consequence, even fatal, in the older population (Shock et al., 1984). Because the process of aging is slow and incremental, it seems plausible that long-term behavioral and social interventions could potentially affect the direction taken by the aging process (Birren & Zarit, 1984). There is increasingly strong evidence to suggest that lifestyle interventions might provide a significant prophylactic benefit in old age.

A common finding in experimental gerontology is the presence of considerable variability among individuals with respect to the rate and extent to which functional fitness declines with advancing age (Chodzko-Zajko, 1996; Kim & Tanaka, 1995; Lee et al., 1996; Nakamura et al., 1988, 1990; Tanaka et al., 1990). Individuals in good physical health, as well as those with high levels of physical fitness, often exhibit markedly less performance decline with aging than less healthy or less fit individuals of the same chronological age.
In an attempt to increase our understanding of this heterogeneity of response to human aging, Tanaka et al. (1990, 1991, 1994) have developed an estimate of biological age that they call vital age (VA). These researchers have found VA to be a more sensitive index of individual differences in aging than chronological age (CA) alone. Similarly, the same research group has developed another equation of biological age, called functional fitness age (FFA), that can be used as a measure of the overall functional fitness required for independent living among older Korean and Japanese adults (Kim & Tanaka, 1995, 1999; Shigematsu et al., 1998).

Although both VA and FFA have been found to be better predictors of ADL performance and coronary risk status, respectively, than CA alone, the relationship between the two alternative measures of aging has not been thoroughly investigated. For example, it is unclear to what extent VA and FFA provide similar information about an individual’s health and fitness status. The purpose of the present investigation was to assess the degree of agreement between VA and FFA equations when they were used to predict the functional health status of a sample of older Japanese women.

Examining the results of the present study revealed that the functional fitness variables were only moderately associated with the VA variables, thereby indicating the independent usefulness of both sets of information. The correlation of \( r = .32 \) between functional fitness score and VA score indicates that only 10% of the variance in VA score is accounted for by the variance in functional fitness score. It is therefore apparent that functional fitness score and VA score do not assess the same construct. When canonical correlations are calculated between two sets of variables, the resultant multivariate correlation is usually appreciably larger than the univariate zero-order correlations between individual variables from both sets. In our study, however, the canonical correlations obtained were all relatively weak. This reinforces our conclusion that the functional fitness tests are assessing different aspects of performance than the VA items are.

In conclusion, in our study of 129 older Japanese women we examined the strength and direction of the relationship between two measures of biological age: vital age and functional fitness age. Univariate and multivariate analyses revealed only modest correlations between FFA and VA, ranging from \( r = .01 \) to .32. It is suggested that both a functional fitness test battery and a coronary risk factor assessment are needed to evaluate health and functional status in older Japanese women.

References


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