Material

Estimation equation for the evaluation of the health status of middle-aged and elderly individuals based on the results of physical fitness tests: a proposal for use as an initial screening test

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This study prepared an estimation equation for the evaluation of health status of middle-aged and elderly males and females on the basis of physical fitness tests easily performed at fitness facilities not equipped to conduct medical checkups. The participants were 2,096 males and females aged 30 to 69 years. All participants underwent medical checkups and physical fitness tests, which, based on the judgment of a medical doctor, determined categorization into two groups; namely, a healthy group and an unhealthy group. Multiple discriminant analysis was applied to prepare an estimation equation, and correct discriminant probabilities were used to evaluate the validity of the equation. Physical fitness variables selected for the equations were height, weight, body mass index, percent body fat, grip strength, one leg balance with eyes closed, reaction time, sit-ups, $\dot{V}o_2max$, and age. The correct discriminant probabilities of discriminant functions obtained for males and females were 66.5 % to 76.6 % and 62.7 % to 76.4 %, respectively. This suggested that health status could be evaluated with relatively high accuracy by the estimation equation derived from the physical fitness test. The equation presented in this study as an initial screening test is useful in the practical field of exercise instruction for the promotion and maintenance of health in middle-aged and elderly individuals.

Key words : health status, physical fitness, middle-aged and elderly individuals, multiple discriminant analysis, estimation equation for health status

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1. Introduction

As a result of recent measures taken by the government aimed at promoting health, the number of individuals, especially the middle-aged and elderly, engaging in physical exercise at fitness facilities for the purpose of preventing life-style diseases, one cause of which being the lack of exercise in daily life, is increasing.

Safe and effective exercise aimed at maintaining good health requires an advance awareness of health status (American College of Sports Medicine, 2006). Approval by the Japanese Ministry of Health, Labour and Welfare obliges fitness facilities to employ sports instructors and to determine the health status of users in cooperation with medical institutions (Ministry of Health, Labour and Welfare, 2005). However, the actual number of facilities with systems for the determination of health status, including medical checkups and physical fitness tests, is limited due to the lack of operating funds and staff able to handle the equipment used for such purposes (Japan Federation of Health & Sports, 2006). Furthermore, the decision to undergo medical checkups is left to the individuals when using the facilities. Therefore, while the intention is that medical checkups be carried out on all individuals when using fitness facilities, in actuality not everyone is examined. Given these circumstances, it is necessary to establish a system that makes it easy to evaluate individual health staus using the results of physical fitness tests at fitness facilities.

Sato et al. (2005; 2006; 2007) examined the relationship between health status and level of physical fitness in middle-aged and elderly individuals and quantified the contribution of each component of physical fitness. The results indicated that health status and level of physical fitness were closely correlated. Furthermore, the degree of contribution of each component was shown to be different according to sex and age. Therefore, the creation of an estimation equation that evaluates health status based on physical fitness tests by utilizing the relationship between health status and level of physical fitness for sex and age would enable fitness facilities without a system for medical checks to carry out initial screening to determine the health status of each individual. In addition, the data from such an equation could be used effectively for guidance at medical checkups or in the creation of physical fitness programs.

In this study, we used physical fitness test results obtained from actual fitness facilities at which middle-aged and elderly individuals engaged in exercise to maintain and improve health in order to create an estimation equation for health status.

2. Method

2.1 Participants

Participants were 2,096 middle-aged and elderly males and females aged between 30 and 69 years living in and around Kasugai City, Aichi Prefecture, Japan who participated in a *Physical Exercise Checkup Program* involving medical checkups and physical fitness tests at the Kasugai City Health Center. Participation in this study was limited to middle-aged and elderly individuals whose level of health and physical fitness allowed them to engage in normal daily activities, who had no difficulty in participating in medical checkups or physical fitness tests, and who had a relatively high degree of interest in the maintenance and improvement of their health and physical fitness. The left side of Table 1 shows the number of participants in each age group (in 10-year increments). In order to utilize multiple classification analysis, we attempted to secure samples from more than 100 individuals for each sex and age group. Participants received an explanation of the test contents, and informed consent was obtained from each participant before the start of this study.

Table 1. Number of participants.

Age (yrs)	Male	Female	Male		Female	
			HG	UG	HG	UG
30-39	197	200	172	25	178	22
40-49	102	309	71	31	230	79
50-59	166	554	86	80	345	209
60-69	203	365	81	122	166	199
Total	668	1,428	410	258	919	509

HG: healthy group, UG: unhealthy group

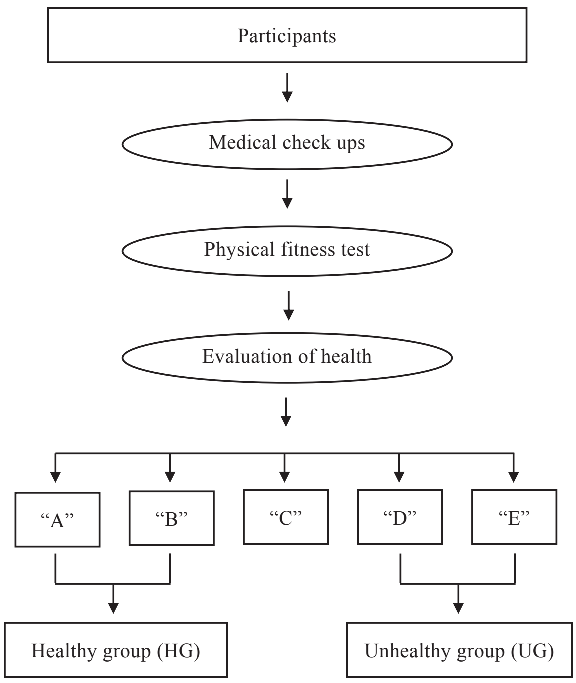
2.2 Evaluation of health status

Participants were classified into two groups, a healthy group and an unhealthy group based on an evaluation of their health status. A physician evaluated individual health status on a five-point scale according to the presence or absence of abnormality in medical tests (blood pressure measurement, chest x-ray test, electrocardiography, pulmonary function test, urine test, blood test, and exercise stress test), height, weight, body mass index (BMI), percent body fat, and an interview. A comprehensive evaluation by the physician was based on reference values adopted by the Japan Society of Ningen Dock (2005). According to Japan Society of Ningen Dock criteria, a systolic BP of 160mm Hg or greater, a diastolic BP of 100mm Hg or greater, a total cholesterol level of 240 mg/ dl or greater, a neutral fat level of 250 mg/ dl or greater, and a fasting blood sugar of 126 mg/ dl or greater require medical treatment.

Final determination was based on the above-mentioned evaluations (tentative) with the degree of excess from the reference values, BMI, percent body fat, and maximum oxygen consumption used as secondary information. That is, based on the reference values, participants not categorized according to the Japan Society of Ningen Dock criteria as requiring treatment, which means (A) *nothing abnormal found* or (B) *slight abnormality but no need for treatment*, were placed into the healthy group. Meanwhile, individuals categorized according to the criteria as requiring treatment were categorized into one of three types based on the degree to which their reference values exceeded those adopted by the Japan Society of

Ningen Dock: (C) *need to monitor progress*; (D) *need for treatment*; (E) and *under for medical treatment*, and (D) and (E) were placed into the treatment group.

Because health status is often indicated merely as “healthy” or “unhealthy”. In this study, we evaluated health status as shown above and individuals who were classified as having the *need to monitor progress* (C), which is equivalent to 3 on the 5-point scale, were excluded from the data analysis in order to clarify the differences between the two groups. The right side of Table 1 shows the breakdown of participant classified by health status evaluation conducted by the physician cooperating with this study. The procedure for health status evaluation is as shown in Figure 1.



A; Nothing abnormal found
B; Slight abnormality but no need for treatment
C; Need to monitor progress
D; Need for treatment
E; Under medical treatment

Figure 1. Evaluation procedure of health status.

2.3 Physical fitness tests

The morphologic aspect was evaluated by height, weight, BMI, and percent body fat, and the functional aspect was evaluated by grip strength, sit and reach, one leg balance with eyes closed, reaction time (light stimulus), sit-ups, and $\dot{V}O_2max$. The details of the physical fitness tests are shown in Table 2. The average values and standard deviations by sex and age for each physical fitness test item for both groups are shown in Tables 3 and 4.

2.4 Data analysis

For the purpose of creating an estimation equation to evaluate the health status of the participants, age and 10 variables, namely, height, weight, BMI, percent body fat, grip strength, sit and reach, one leg balance with eyes closed, reaction time, sit-ups, and $\dot{V}O_2max$, employed discriminant analysis for each age (Cooley and Lohnes, 1971; Betzm 1987). Sato et al. (2005; 2006; 2007) applied this method to examine the relationship between health status and level of physical fitness of middle-aged and elderly individuals. The result suggested that there were differences in the contribution of each physical fitness component to health performance (Sato et al., 2006; 2007). In this study, we carried out an analysis by sex and age focusing on the corresponding relationships in these studies. In addition, because we placed top priority on effective determination by minimum variables, we proposed an estimation equation to evaluate health status that uses the stepwise procedure (step-up method). SPSS12.0, computer software, was used for all data analysis in this study.

3. Results and Discussions

3.1 Discriminant probability

First, we calculated the most appropriate function to classify participants into healthy and unhealthy groups based on a physician’s evaluation utilizing age and 10 variables. Then, we created an estimation equation for health status by minimum variables at the same level of accuracy utilizing the stepwise procedure (step-up method) (Table 5). The canonical correlation coefficient was between 0.353 and 0.443 for males, and between 0.373 and 0.523 for females, which was judged significant ($p<0.05$) by Wilks’ lambda. In other words, independent variables are useful for discrimination of health status. In addition, coefficients are shown to three decimal places in considering use in actual situations. The correct discriminant probability between healthy and unhealthy groups with the discriminant function obtained was 76.6% for males in their 30s, 66.7% for males in their 40s, 69.3% for males in their 50s, and 66.5% for males in their 60s. The discriminant function was 76.0% for females in their 30s, 76.4% for females in their 40s, 64.4% for females in their 50S, and 62.7% for females in their 60s. The details regarding discrimination are shown in Table 6.

The correct discriminant probability between the healthy and unhealthy groups show a probability of 60 to 80 % for middle-aged and elderly individuals utilizing the physical fitness tests results, a finding that is consistent with existing studies (Sato et al., 2005; 2006; 2007).

3.2 Estimation equations for health status on the basis of physical fitness tests

Although there are various studies on the relationship between health and physical fitness both at home and abroad, many are largely conceptual or contain mere hypotheses. While health status has qualitative characteristics, level of physical fitness has quantitative characteristics, and this difference makes it difficult to quantify the relationship between them. Furthermore, health-related physical fitness focusing on the relationship of physical fitness and health has attracted attention; however, relatively little quantitative data exists on the

Table 2. Assessment of physical fitness

Element	Test (unit)	Method
Physique	Height (cm)	Height was a linear measurement of the distance from the floor or standing surface to the top (vertex) of the skull.
	Weight (kg)	The weight of the clothes was measured and subtracted from the overall weight.
	BMI; body mass index	Weight (kg)/Height (m)^2
Body composition	Body fat (%)	The participant rested on the bed looking up. A pole was put at the wrist and the ankle for measurement by the bioelectric impedance method.
Muscular strength	Grip strength (kg)	The participant held a handgrip dynamometer in the preferred hand with arm at the side and squeezed using maximal force. The best result of two trials determined the score.
Flexibility	Sit and reach (cm)	The participant sat on the floor with legs outstretched toward a box. The participant then bent forward and pushed the slide bar on the box with fingertips as far as possible. The distance the slide bar moved was recorded. The best trial determined the score.
Balance	One leg balance with eyes closed (s)	The participant stood on one leg with eyes closed. The standing time was recorded. The best of two trials determined the score.
Agility	Reaction time (s)	The participant stood in front of a signal box. The participant jumped toward the light signal on the signal box as quickly as possible. The reaction time in response to the light signal was recorded. The average time of five trials determined the score.
Muscular endurance	Sit-ups (time/30s)	The participant lay face up on a bench with both ankles fixed, and then drew knees up to a right angle with both hands crossed behind the head. The participant lifted the upper part of the body to the knees at the sound of a buzzer and lay back on the bench as quickly as possible. The frequency of this action determined the score.
Cardio respiratory endurance	$\dot{V}O_2max$ (ml/kg/min)	A bicycle ergometer was used. Load was gradually added in three or four stages (three minutes per stage). The measurement value is the value per weight indirectly estimated by heart rate monitored with an electrocardiogram during pedaling.

Table 3. Physical characteristics of male participants in the healthy group (HG) and unhealthy group (UG).

Variables [unit]	Group	Age [yrs]			
		30-39	40-49	50-59	60-69
Height [cm]	HG	170.9 (5.7)	169.7 (4.4)	165.7 (5.8)	165.1 (5.6)
	UG	168.9 (7.0)	168.4 (4.6)	164.5 (5.1)	163.7 (6.0)
Weight [kg]	HG	64.7 (8.9)	64.6 (6.4)	62.4 (6.4)	61.1 (7.9)
	UG	72.0 (12.4)	67.0 (9.0)	64.0 (7.4)	63.3 (7.7)
BMI; body mass index	HG	22.2 (2.7)	22.5 (1.9)	22.7 (1.9)	22.4 (2.5)
	UG	25.2 (3.5)	23.8 (3.0)	23.7 (2.7)	23.6 (2.4)
Body fat [%]	HG	19.1 (3.9)	18.7 (3.4)	19.5 (3.6)	19.8 (4.2)
	UG	22.4 (6.3)	20.9 (3.9)	20.7 (4.9)	21.5 (3.5)
Grip strength [kg]	HG	50.5 (6.5)	47.6 (5.4)	43.8 (6.8)	39.6 (5.2)
	UG	50.0 (7.1)	46.4 (4.9)	42.5 (6.4)	38.5 (5.5)
Sit and reach [cm]	HG	8.2 (8.1)	7.6 (7.2)	7.2 (9.3)	3.9 (8.1)
	UG	4.1 (9.3)	4.8 (7.2)	5.9 (10.1)	1.4 (9.7)
One leg balance with eyes closed [s]	HG	79.4 (69.7)	54.9 (52.5)	32.1 (32.2)	12.7 (12.1)
	UG	43.0 (55.3)	34.9 (30.8)	20.3 (17.8)	13.5 (22.1)
Reaction time (light) [s]	HG	.343 (.038)	.366 (.047)	.376 (.052)	.414 (.054)
	UG	.357 (.040)	.373 (.049)	.385 (.060)	.420 (.087)
Sit-ups [times/30s]	HG	21.2 (4.9)	17.4 (5.9)	16.1 (5.0)	13.6 (3.8)
	UG	20.5 (4.0)	17.2 (4.9)	14.5 (5.4)	11.6 (4.6)
$\dot{V}o_2max$ [ml/kg/min]	HG	42.3 (10.6)	39.6 (10.3)	36.1 (7.2)	31.7 (7.1)
	UG	35.6 (10.0)	34.6 (8.7)	31.4 (8.6)	30.0 (8.1)
participants	HG	172	71	86	81
	UG	25	31	80	122

Mean (SD)

Table 4. Physical characteristics of female participants in the healthy group (HG) and unhealthy group (UG).

Variables [unit]	Group	Age [yrs]			
		30-39	40-49	50-59	60-69
Height [cm]	HG	158.0 (5.4)	155.4 (4.7)	154.7 (4.9)	151.9 (4.9)
	UG	158.7 (3.8)	155.0 (4.9)	153.7 (5.1)	151.8 (4.7)
Weight [kg]	HG	51.2 (6.0)	52.4 (5.5)	51.8 (5.8)	50.1 (6.2)
	UG	55.7 (7.7)	58.7 (9.7)	55.8 (8.1)	54.7 (6.7)
BMI; body mass index	HG	20.5 (2.2)	21.7 (2.0)	21.7 (2.1)	21.7 (2.5)
	UG	22.1 (3.0)	24.4 (3.6)	23.6 (3.2)	23.7 (2.9)
Body fat [%]	HG	25.5 (4.6)	26.0 (5.3)	26.7 (4.4)	27.7 (5.7)
	UG	25.1 (5.7)	27.8 (6.8)	29.1 (5.7)	30.4 (6.3)
Grip strength [kg]	HG	30.6 (3.9)	29.5 (3.8)	27.1 (3.8)	24.6 (3.7)
	UG	31.2 (5.0)	29.4 (4.6)	26.7 (4.1)	24.8 (3.7)
Sit and reach [cm]	HG	10.9 (7.1)	11.6 (7.5)	11.7 (6.9)	10.7 (7.4)
	UG	12.2 (7.1)	9.7 (7.4)	10.2 (7.2)	10.4 (7.2)
One leg balance with eyes closed [s]	HG	55.6 (52.8)	48.2 (48.8)	28.6 (39.8)	15.6 (27.0)
	UG	40.9 (28.4)	45.9 (56.3)	19.8 (23.9)	10.0 (11.7)
Reaction time (light) [s]	HG	.378 (.040)	.387 (.049)	.411 (.053)	.447 (.074)
	UG	.397 (.053)	.409 (.062)	.422 (.059)	.455 (.081)
Sit-ups [times/30s]	HG	15.1 (4.0)	11.4 (5.4)	7.5 (5.5)	5.3 (5.1)
	UG	12.8 (5.7)	9.5 (5.1)	6.4 (6.0)	4.4 (4.9)
$\dot{V}o_2max$ [ml/kg/min]	HG	30.7 (5.6)	28.2 (6.0)	26.5 (5.6)	24.1 (4.8)
	UG	27.5 (6.7)	25.2 (5.5)	24.7 (6.1)	22.8 (6.2)
participants	HG	178	230	345	166
	UG	22	79	209	199

Mean (SD)

Table 5. Multiple discriminant functions to discriminate healthy and unhealthy groups for each age group.

Male

30-39 yrs

$Y = +0.041X_1-0.246X_3+0.041X_6+0.004X_7+0.029X_{10}-0.141X_{11}+1.523$

40-49 yrs

$Y = +0.117X_1-0.207X_4+0.068X_6-16.333$

50-59 yrs

$Y = -0.963X_1+1.326X_2-3.847X_3+0.016X_7+0.078X_{10}+161.323$

60-69 yrs

$Y = +0.052X_1-0.310X_3+0.182X_9-3.658$

Female

30-39 yrs

$Y = +0.080X_1-0.181X_2+0.168X_4+0.091X_9+0.075X_{10}-11.152$

40-49 yrs

$Y = -0.448X_3+0.106X_4-0.004X_7-4.405X_8+0.054X_{10}-0.102X_{11}-12.250$

50-59 yrs

$Y = -0.345X_3+0.057X_5+0.006X_7+0.056X_{10}+4.594$

60-69 yrs

$Y = -0.347X_3-0.136X_{11}+16.492$

Y: Discriminant score representing health status, X_1: Height (cm), X_2: Weight (kg), X_3: BMI; body mass index, X_4: Percent body fat (%), X_5: Grip strength (kg), X_6: Sit and reach (cm), X_7: One leg balance with eyes closed (s), X_8: Reaction time (s), X_9: Sit-ups (times/30s), X_{10}: $\dot{V}O_2max$ (ml/kg/min), X_{11}: Age (yrs)

relationship between each element in health-related physical fitness and health status.

In preceding studies on the relationship between health status and level of physical fitness, in order to evaluate health status, disease incidence, mortality rate, and cause of death were often used. In order to evaluate level of physical fitness, an element that was closely associated with health status was selected as a variable to examine the relationship between single variables (Lee and Blair, 2002; Kawasaki et al., 1993; Oshida et al., 1989). In other words, there are only a few studies focusing on a multidimensional clarification of the relationship between physical fitness and health, meaning that quantification of the relationship has been insufficient.

On the other hand, multiple discriminant analysis can clarify the relationship between both variables in multivariate data by utilizing qualitative data for dependent variables and several quantitative data for independent variables (Cooley and Lohnes, 1971; Betz, 1987). In other words, with the obtained correct discriminant probability, it is possible to evaluate the relationship between both variables. Therefore, this method is thought to enable the evaluation of the relationship between health status and several physical fitness tests results.

The correct discriminant probability, which indicates the accuracy of the discriminant function, between healthy and unhealthy groups by age and physical fitness tests results consisting of 10 items was 66.5 to 76.6% in male participants and 62.7 to 76.4% in female participants. These results show that it is possible to correctly discriminate the health status of six to eight out of 10 individuals by level of physical fitness, which is usually considered independent of health. This also means that health status can be discriminated with a relatively high degree of accuracy by age and physical fitness tests results. These results were obtained due to the fact that the relationship between

Table 6. Discriminant probabilities for discriminant function.

【Male】

Age(yrs)	group	participants	discrimination of healthy and unhealthy groups with multiple discriminant function		correct discriminant probabilities(%)
			HG	UG	
30-39	HG	172	134	38	76.6
	UG	25	8	17	
40-49	HG	71	48	23	66.7
	UG	31	11	20	
50-59	HG	86	58	28	69.3
	UG	80	23	57	
60-69	HG	81	58	23	66.5
	UG	122	45	77	

【Female】

Age(yrs)	group	participants	discrimination of healthy and unhealthy groups with multiple discriminant function		correct discriminant probabilities(%)
			HG	UG	
30-39	HG	178	135	43	76.0
	UG	22	5	17	
40-49	HG	230	179	51	76.4
	UG	79	22	57	
50-59	HG	345	230	115	64.4
	UG	209	82	127	
60-69	HG	166	103	63	62.7
	UG	199	73	126	

HG: healthy group, UG: unhealthy group

health status and level of physical fitness in middle-aged and elderly individuals and physical fitness tests variables used for the creation of an estimation equation for health status in this study contain physical fitness components of health-related physical fitness (Caspersen et al., 1985) which are thought to contribute to the prevention of life-style diseases and to be important for the promotion and maintenance of health.

Hisamichi reported that the results of clinical laboratory tests conducted by physicians matched estimated results at a rate of 90% or greater (1986), and the correct discriminant probability in this study, which indicates the accuracy of the estimation equation, was relatively high, as stated above, in spite of the fact that we estimated the health status of individuals with different characteristics using several physical fitness tests results that consisted of quantitative elements. This is thought to suggest that the estimation equation created by utilizing multiple discriminant analysis can be used for each health state.

In this study, we also attempted to create an estimation equation to evaluate health status by age and physical fitness tests results that can be measured at facilities that do not provide medical checkups. Furthermore, we set a final goal of creating an estimation equation with fewer variables by focusing on practicality at exercise sites.

Tanaka et al. (1992; 2004) proposed the concept of vital age as an index of health and aging. However, determination of this variable requires an exercise load test and the measurement of serum lipids. In order for a means of evaluating health status to be practical, however, it is essential that the means being proposed be easy to conduct. Therefore, we proposed the estimation equation shown in Table 2 that utilizes the stepwise procedure (step-up method) to evaluate age and the 10 measurement items.

Basically, the effective variables for estimating the degree of health were height, BMI, sit and reach, one leg balance with eyes closed, $\dot{V}O_2max$, and age for males in their 30's, height, percent body fat, and sit and reach for males in their 40's, height, weight, BMI, one leg balance with eyes closed, and $\dot{V}O_2max$ for males in their 50's, height, BMI, and sit-ups for males in their 60's. The effective variables were height, weight, percent body fat, sit-ups, and $\dot{V}O_2max$ for females in their 30's, BMI, percent body fat, one leg balance with eyes closed, reaction time, $\dot{V}O_2max$, and age for females in their 40's, BMI, grip strength, one leg balance with eyes closed, and $\dot{V}O_2max$ for females in their 50's, and BMI and age for females in their 60's. These measurement items are practical and convenient because they are included in general physical fitness tests. However, as age increases, the correct discriminant probability for both male and female participants decreased. In addition, a tendency for the number of effective estimation equation variables to decrease was also seen. These results suggest that there is a need for medical checkups as the individual ages. If the accuracy of the estimation equation can be maintained, we can examine the utilization of heart rate, even as an indirect method, instead of $\dot{V}O_2max$, which is relatively difficult to obtain.

3.3 Proposal for use as an initial screening test

Discrimination scores can be obtained from the estimation equation shown in Table 5. When the score is 0 or greater, the individual is classified into the healthy group, and if the score is less than 0, the individual is classified into the unhealthy group. Normally, an individual's status is indicated as "healthy" or "unhealthy" (Ohtsuki, 1995), with the determination by physicians being qualitative rather than quantitative. However, the estimation equation created in this study enables health status to be indicated as a continuous variable by expressing the individual health status with discrimination scores. In other words, discrimination scores that indicate health quantitatively can be used as a measure to, for example, set goals or increase motivation at the actual site of physical exercise. In addition, the discrimination scores can be calculated not only by specialists involved in health instruction but also non-specialists engaged in physical exercise, making it easy for any individual to use them for the purpose of health maintenance.

As stated above, medical checkups are important for the prevention of injury during physical exercise and should be conducted whenever possible. However, the estimation equation proposed in this study can be used as an initial screening of health status at fitness facilities and fitness clubs that do not provide medical checkups. However, the estimation equation is not an alternative to health care for a detailed determination of health status and is not intended for use as a final evaluation. It is, rather, offered as a supplementary means of easily conducting an initial screening of health status. In addition, the estimation equation created in this study is used to evaluate health status with an emphasis on items related to life-style diseases. Therefore, this estimation equation is not useful for the elderly individuals, for whom the focus is on the prevention of falls rather than the prevention of life-style diseases, and it is inappropriate for orthopedic screening, such as joint pain, in elderly individuals. It will be necessary in the future to include physical functions and to propose an estimation equation according to the purpose of health promotion for each age. Furthermore, in order to increase the accuracy and practicality of the estimation equation, it is necessary to continue examining variables to be included in the estimation equation.

4. Conclusion

This study was conducted for the purpose of creating an estimation equation to discriminate the health status of both males and females between 30 and 69 years of age. By classifying the participants into healthy and unhealthy groups by physicians based on the results of medical checkups, we calculated the best function to appropriately discriminate participants using age and the 10 items in their physical fitness tests results for each sex and age. Furthermore, we examined the effectiveness of the variables and proposed an estimation equation to discriminate their health status. The validity of the estimation equation was evaluated by the correct discriminant probability. The percentage was between 66.5 and 76.6% in male participants and between 62.7 and 76.4% in female participants. Finally, focusing on effective discrimination using the minimum variables, we proposed an estimation equation for the health status of each sex and age which uses the stepwise procedure (step-up method). The details of the estimation equation are shown in Table 5.

The estimation equation for health status proposed in this study is thought to be useful as a supplementary means to easily carrying out an initial screening of health status for fitness facilities and fitness clubs that do not provide medical checkups. However, it is also necessary to create an easier estimation equation by taking into account the actual situation of each site and the variables used in the estimation equation.

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