「健康づくりのための運動基準 2006 英訳」

Exercise and Physical Activity Reference for Health Promotion 2006 (EPAR2006): Physical Activity, Exercise, and Physical Fitness

Outline

Prepared in August, 2006

By the Office for Lifestyle-Related Diseases Control,

General Affairs Division, Health Service Bureau,

Ministry of Health, Labour and Welfare of Japan

Translated in April, 2007

by Dr. Izumi Tabata,

Director of Health Promotion and Exercise Program

National Institute of Health and Nutrition, Japan

This English report was prepared under the Health and Labour Sciences Research Grants of Dr. Izumi Tabata for the research on exercise and physical activity guidelines, awarded from the Ministry of Health, Labour and Welfare, Japan.

Executive summary

We reviewed the recommended exercise allowances for health promotion (1989) and set reference values for physical activity, exercise, and physical fitness for Japanese aged 20-69 years. Specifically, for individuals who intend to promote health mainly through physical activity, a daily walk of 8,000 to 10,000 steps is set as the target. For those who rely on exercise for health promotion, the target was set at 35 min of jogging or playing tennis or one hour of brisk walking every week.

1. This report, which concerns the quantity of physical activity and exercise for health promotion, specifically for preventing lifestyle-related diseases, is promulgated by the "Preparation Committee for the Recommended Exercise Allowance and Exercise Guidelines" that was established on August 8, 2005. The basis for the report was the "Recommended Exercise Allowances for Health Promotion" compiled in 1989, utilizing the latest scientific findings.
2. The content of this report differs markedly from the Recommended Exercise Allowances for Health Promotion established in 1989, with the emphasis placed on the prevention of lifestyle-related diseases. Some of the outstanding features in the report are: (1) both domestic and overseas publications were thoroughly examined (systematic review) and the references for the quantity of physical activity, exercise and physical fitness (maximal oxygen uptake) are indicated; and (2) the relationship between the prevention of lifestyle-related diseases and physical fitness (including muscle strength) was also evaluated.
3. Reference values for the quantity of physical activity and exercise for health promotion

(1) Quantity of physical activity: 23 METs·hour/week

(Equivalent of an activity lasting aproximatley 60 min per day at an intensity of 3 METs. If the activity is composed mainly of walking, the quantity is equivalent to 8,000 to 10,000 steps per day)

(2) Quantity of exercise: 4 METs·hour/week

(e.g., 60 min of fast walking or 35 min of jogging or playing tennis)

4. Reference values for the maximal oxygen uptake for health promotion by gender and age ($mL \cdot kg^{-1} \cdot min^{-1}$)

Gender/Age	20-29 years	30-39 years	40-49 years	50-59 years	60-69 years
Males	40	38	37	34	33
Females	33	32	31	29	28

5. This report incorporates the latest scientific findings concerning the relationship between health and physical activity, exercise and physical fitness. To amass new findings that may emerge later, including findings on questions that have not been elucidated, it is necessary to continue studies, acquire new scientific findings and periodically update this report.

Exercise and Physical Activity Reference for Health Promotion 2006

(EPAR2006)

—Physical Activity, Exercise, and Physical Fitness—

A Report

Preparation Committee for the Recommended Exercise Allowances and Exercise Guidelines

2006

1. Introduction

As an all-out approach to formulate a national policy for health promotion, the First National Program for Health Promotion was issued in 1978, followed by the Second one in 1988. In 2000, the "National Health Promotion in the 21st century (Health Japan 21)" was established. As a legislative support for health promotion and disease prevention in citizens, with special reference to "Health Japan 21," the Health Promotion Law was formulated in 2002 and various programs for health promotion have been well on its way since then.

In view of the global trends for health promotion, "Health Japan 21" purports to achieve objectives such as extending one's healthy life expectancy: specifically, topics were selected that relate to improving one's lifestyle affecting the development and progression of lifestyle-related diseases (e.g., cancer, cardiovascular diseases, stroke and diabetes). Target values were set for 70 specific indicators in 9 areas; "Nutrition and diet," "Physical activity and exercise," "Rest and the promotion of mental health," "Tobacco," "Alcohol," "Dental health," "Diabetes," "Cardiovascular diseases" and "Cancer." Currently, efforts are being made to promote health in these areas.

As the starting point in promoting health through physical activity and exercise, the committee, based on scientific findings, established the "Recommended Exercise Allowances for Health Promotion" in 1989 to set the target quantity of exercise considered necessary to maintain one's health. To create a happy, active and healthy life, in 1993, the "Exercise Guidelines for Health Promotion" was established. This was followed in 1997 by a report from the "Study Committee on Physical Activity for Health throughout One's Life."

Recently, however, with rapid aging of the population, the major health problems have changed: the morbidity rates of lifestyle-related diseases (e.g., cancer, ischemic heart disease, cerebrovascular diseases and diabetes) increased. Among the causes of death, about 60% was attributed to lifestyle-related diseases (cancer 30.5%, ischemic heart diseases 15.7%,

cerebrovascular diseases 13.0%, diabetes 1.3% and hypertensive diseases 0.6%). In fiscal year 2003, the medical cost for these diseases amounted to 10.2 trillion (2.8 trillion for each of hypertensive diseases and cancers; 2.0 for cerebrovascular diseases; 1.9 for diabetes including its complications; and 800 billion for ischemic heart diseases). Within the framework of health insurance, the total amount accounts for about 30% of the national medical expenditures, indicating the increased burden of health insurance among the nations. As these diseases increase in severity, the burden on national nursing care insurance will also increase.

Consequently, in May 2004, the "Health Frontier Strategic Plan" was formulated at a meeting by the Secretary General and the Chairman of the Policy Research Council from each of the Ruling Parties. In response to this development, the Government adopted the following as central policies to extend one's healthy life expectancy by about 2 years: 1) "plan to assure health during the productive years," 2) "urgent anti-cancer policy for women," 3) "a 10-year strategy for nursing care and disease prevention," and 4) "promotion of scientific technology to extend healthy life expectancy." Starting in 2005, active programs are being and will be developed over the succeeding 10 years.

2. Background

The "Recommended Exercise Allowances for Health Promotion (1989)" was formulated mainly to prevent coronary artery diseases. Having passed more than 15 years since the establishment of this standard, the nation's morbidity pattern changed, where lifestyle-related diseases - such as diabetes, hypertension and hyperlipidemia - come to the forefront. Furthermore, the disease concept and diagnostic standard for "metabolic syndrome," the basis for the aforementioned conditions, were explicated at the related 8 academic societies in April 2005.(1)

Metabolic syndrome is a pathophysiologic condition manifested by elevated fasting blood glucose, blood fat disorders and elevated blood pressure, all of which share a common etiology: a visceral-type obesity. If one has these disease conditions concurrently, the risk for developing ischemic heart diseases and cerebrovascular disorders increases; therefore the basic rationale concerning this metabolic syndrome is that such a risk may be reduced when the visceral fat is minimized.

By promoting the policies to control lifestyle-related diseases, incorporating the concept of metabolic syndrome, in particular by encouraging people to engage in physical activity and exercise and improving the understanding on the importance of "prevention" among the population and also the personnel concerned with public health, it is believed that the current policies may be effectively carried out.

According to the "National Health and Nutrition Survey in Japan, 2004," the proportion of those who were regularly exercising was 30.9% for men and 25.8% for women after the establishment of the Recommended Exercise Allowances for Health Promotion in 1989. In spite of the efforts represented by "Health Japan 21," these percentages failed to increase, showing that two-thirds of the population did not have the habit of exercising regularly.

While the general public is becoming increasingly more aware of the policies concerning lifestyle-related diseases, the Community Health Promotion and Nutrition Section of the Health Sciences Council formulated "The Promotion of Future Policies concerning Lifestyle-Related Diseases (an interim report). Thus, following the slogan of "Firstly, physical activity and exercise. Secondly, diet and complete smoking cessation. Lastly, medication", further emphasis was placed on policies for physical activities and exercise.

Under this circumstance, it was decided to draw up the "Recommended Exercise Allowance for Health Promotion (1989)" to show the references for physical activity,

exercise and physical fitness. These references, based on the latest scientific findings, were designed to maintain and promote the health of people and prevent lifestyle-related diseases through improving their habits on physical activity and exercise.

3. Basic concepts

Health promotion and control of lifestyle-related diseases

With a rapid aging of the population over the last few decades, the country's health problems have changed drastically: the morbidity rates of lifestyle-diseases, such as cancer, ischemic heart diseases, cerebrovascular diseases and diabetes have increased. Likewise, lifestyle-related diseases also accounts for about 60% of the causes of death. Besides, when these diseases become more severe, many patients require nursing care.

Association between prevention of lifestyle-related diseases and physical activity/exercise has been explored in both domestic and foreign studies. It is therefore expected that promotion of people's physical activity and exercise would have a notably positive effect on the prevention of lifestyle-related diseases.

The present "Exercise and Physical Activity Reference for Health Promotion 2006 (EPAR2006)", therefore, aims to prevent lifestyle-related diseases for health promotion of the population.

Association between the prevention of lifestyle-related diseases and physical activity, exercise and physical fitness

Scientific studies on physical activity, exercise, lifestyle-related diseases, and total mortality have rapidly advanced during the last quarter of a century: the preventive effects of physical activity and exercise, not only on coronary artery diseases but also on lifestyle-related diseases, such as diabetes, have been scientifically proven. A considerable amount of

evidence on prevention of lifestyle-related diseases through physical activity and exercise has been amassed, in particular, since the previous Recommended Exercise Allowances (1989). For the current EPAR2006, therefore, it was decided to employ a systematic review based on the accumulated scientific evidence and to indicate the quantity of physical activity and exercise that is necessary to prevent lifestyle-related diseases.

In general, the level of physical fitness is higher in a person who is physically active.[2-4] However, there is a lower limit in the exercise intensity to enhance physical fitness,[5] and the correlation between the physical activity that is quantified by the total energy expenditure (kcal/day) and physical fitness is not necessarily evident.[6] Especially, a large quantity of physical activity with low intensity is not always associated with high physical fitness.[7]

There is also significant genetic influence on physical fitness.[8] According to the recent studies conducted in the West, not only the quantity of physical activity but also physical fitness act as independent factors to predict the development of a lifestyle-related disease.[9] Therefore in the EPAR2006, a reference for physical fitness was independently defined, in addition to those for physical activity and exercise.

Standardization of Terminology

Definitions of the terminology related to physical activity and exercise described in this report are given in the section of reference materials.

4. Physical activity and exercise for health promotion

A systematic review of the domestic and foreign literature was conducted on the relationship between physical activity/exercise and lifestyle-related diseases to define the

reference that is given below. In this instance, separate references were selected for physical activity and exercise, both intensities being over 3 metabolic equivalents (METs).

Since there was no evidence to require the classification by gender or age for the subject aged under 69 years, the references for physical activity and exercise (METs·hour/week) were set regardless of the gender or age.

Quantity of physical activity

For physical activity, the reference was set as 23 METs·hour/week.

The results from the systematic review indicated that the lower threshold of physical activity that is effective for preventing lifestyle-related diseases is distributed between 19 and 26 METs·hour/week. The necessary time to attain the same quantity of physical activity falls between 54 and 74 min per day, with intensity of 3 METs (walking at normal pace). However, it is not easy for the general people to determine the time for physical activity at an intensity of 3 METs; nor is it possible to fully recognize the range of 20 min. Thus, a single value - the mean of the values extracted from the systematic review - was used as a reference for physical activity.

People are expected to exceed this reference, depending on one's current level of physical activity. By which, it is expected that the risk of developing lifestyle-related diseases will be reduced.

Physical activity with intensity of 3 METs or higher include exercise as well as walking (e. g., shopping, commuting), cleaning floors, gardening, carrying materials and playing with children. The reference of 23 METs·hour/week (≒ 3.3 METs·hour/day), therefore, corresponds to undertaking these activities with intensity ≥ 3 METs for about 60 minutes per day. Most of these activities with intensity ≥ 3 METs would, even not always, involve walking. If one's daily activity is composed mainly of walking, it is equivalent to

walking for about 60 min per day (about 6,000 steps, if 1,000 steps per 10 min). In daily activities, one takes 2,000 to 4,000 steps with low intensity unconsciously, [10] hence, approximately 8,000 to 10,000 steps in total per day. By which, the energy expenditure can be about 1,450kcal and 1,700kcal per week for a person with 60kg and 70 kg respectively.

Quantity of exercise

The reference and its range for exercise were set as 4 METs·hour/week and 2~10 METs·hour/week, respectively.

These are based on the systematic review where the exercise quantity distributed between 2 and 10 METs·hour/week and the mean value was 4 METs·hour/week. Depending on the current exercise level, a person should set his/her target above the reference value or its range. For example, a person who has no habit of exercise should set the goal at 2 METs·hour/week; one whose habitual exercise quantity is below the reference value should target the reference; and for a person whose exercise quantity exceeds the reference should aim at 10 METs·hour/week. It is expected that, consequently, the risk for developing lifestyle-related diseases will be reduced

Specific examples of exercises with intensity of 3 METs and more include brisk walking, physical exercises (with active movements), jogging, running, swimming and ball games. For example, brisk walking (90~100m/min) has intensity of 4 METs·hour/week. Therefore, 4 METs·hour/week corresponds to brisk walking for 60 min per week. Similarly, it corresponds to jogging or playing tennis with intensity of 7 METs for about 35 min per week. By these exercises, the energy expenditure can be about 250kcal and 300kcal per week for a person with 60kg and 70 kg respectively.

5. Physical fitness for health promotion

Based on the systematic review of domestic and foreign articles on the association between physical fitness and lifestyle-related diseases, the reference value for physical fitness was defined using maximal oxygen uptake, an index for endurance fitness. As for muscle strength, the evidence for setting the reference value was less, thus it was described qualitatively.

Maximal oxygen uptake

The references for maximal oxygen uptake and its range were defined by gender and age group (see **Table 1**), based on the systematic review of the domestic and foreign articles on the association between maximal oxygen uptake and lifestyle-related diseases. The systematic review provided us with the lowest values (of the maximal oxygen uptake) that show the significant difference in the risk of developing lifestyle-related diseases. The reference value for maximal oxygen uptake to prevent lifestyle-related diseases should be defined by gender and age group, for which the mean values were calculated in each category.

Table 1. Reference values for the maximal oxygen uptake for health promotion by gender and age ($mL \cdot kg^{-1} \cdot min^{-1}$)

Gender/Age	20-29 years	30-39 years	40-49 years	50-59 years	60-69 years
Males	40	38	37	34	33
Females	33	32	31	29	28

In addition to the reference values, the current study exhibits the range for the maximal oxygen uptake for health promotion. These figures show the range of lowest values of the maximal oxygen uptake for which at least one study revealed, during the systematic review, the preventive effect of the maximal oxygen uptake on lifestyle-related diseases. Therefore, if one's maximal oxygen uptake is below this range, s/he should first make efforts to reach to the lower values of the range. If one's maximal oxygen uptake is below the reference, s/he should target this reference value. And, even though one's maximal oxygen

uptake is higher than the reference or the upper values of the range shown in **Table 2**, s/he should ensure that lifestyle-related diseases are effectively prevented by improving his/her physical fitness.

Table 2. Range of maximal oxygen uptake that is effective for health promotion ($mL \cdot kg^{-1} \cdot min^{-1}$)

Gender/Age	20-29 years	30-39 years	40-49 years	50-59 years	60-69 years
Males	23-47	31-45	30-45	26-45	25-41
Females	27-38	27-36	26-33	26-32	26-30

Muscle strength

Regarding the association between muscle strength and reductions in total mortality risk, several studies indicated that muscle strength is inversely associates with total mortality risk among men, whereas in most of these studies, no association was detected among women. On the other hand, when the analyses were not performed by gender, all these studies showed that muscle strength was inversely associated with the total mortality risk.

There are various methods to measure muscle strength. Regardless of the method adopted, the total mortality is significantly lower in those who have muscle strength exceeding the mean value of the study group. Maintaining a certain level of muscle strength is important also to prevent osteoporosis and fractures.

Muscle strength and muscle volume decrease with age. Reductions in the total mortality or the risk of fractures due to osteoporosis have been observed in those who have muscle strength exceeding the mean values in each group. Therefore, maintaining muscle strength over the current mean values of each age group can be suggested as a reference for the present Japanese.

Other parameters for physical fitness

It has been known that the risk for fractures due to osteoporosis is lower in those who have good balance and nimbleness. However, no study has yet examined the association

between balance/nimbleness and reductions in mortality or prevention of lifestyle-related diseases. Therefore, we did not define quantitative reference for these parameters.

6. Notes for applying these references

Sufficient care must be taken because excessive or inappropriate exercise may have adverse effects on one's health. If a person with a certain illness plans to start exercise, s/he should follow the guidance of a physician.

7. Future objectives and directions

The impacts of physical activity and exercise practiced following the EPAR2006 should be evaluated after a certain period. In addition, the references should be periodically revised, considering the above results as well as the findings of new studies.

Based on the current study, the followings are considered necessary as future research:

- Accumulation of scientific evidence on physical activity, exercise and physical fitness (including muscle strength and muscle volume) of Japanese, as well as on their association with prevention of lifestyle-related diseases.
- Standardization of methods to assess physical activity
- Evaluation of physical activity, exercise and physical fitness according to gender and age group (from childhood to elderly), as well as to the type of life-related diseases
- Evaluation of specific indices for muscle strength and muscle volume
- Evaluation of the upper limit of physical activity and exercise for health promotion
- Determination of the effect of moderating medical expenses by pursuing the reference quantity of physical activity and exercise

[**Reference Materials]**

Standardization of terminology and its explanation (definition of the terms)

1) Exercise and Physical Activity for Health Promotion 2006 (physical activity, exercise, and physical fitness)

The "recommended allowances" in the previously issued "recommended exercise allowance for health promotion (1989)" was applied in the same way as that in "Recommended Dietary Allowance for Japanese, 4th Revision in 1989". The concept of "recommended dietary allowances" was that "The recommended intake values of energy and each nutrient per day for people to achieve healthy growth, to maintain and promote health as well as to prevent diseases". Likewise, the "recommended exercise allowances" means the recommended quantity of exercise for maintaining health."

In practice, a medial regression line was drawn for maximal oxygen uptake, which was indirectly estimated by extrapolating a linear relationship with heart rate, and each risk factor for lifestyle-related diseases (then called adult diseases); in particular the risk factors for coronary arteriosclerosis (expressed by systolic and diastolic blood pressures, total cholesterol and HDL cholesterol levels and percentage of body fat). Next, maximal oxygen uptake, at which none of the aforementioned risk factors showed abnormal values, was derived from the intersections with abnormal values of the above-mentioned risk factors for coronary arteriosclerosis, according to gender and age group. Finally, the quantity of exercise to maintain this maximal oxygen uptake (time per week, when exercise is performed with intensity of 50% of the maximal oxygen uptake) was calculated, which was set as the recommended quantity of exercise.

Since the concept of dietary reference intakes was recently adopted, the expression of the recommended dietary allowance (RDA) was replaced by the Dietary Reference Intakes (DRIs). Consequently, in order to ensure consistency of the terminology, it was decided not to use the term of "recommended exercise allowance", and instead "reference" is used in the present reference.

Method to determine the reference value

Quantity of physical activity and exercise

Epidemiological studies on the association between physical activity, exercise and lifestyle-related diseases cover a wide range of issues, including all types of physical activity in one's daily life and exercise mainly by sport activities. These studies showed that moderate level of physical activity, not necessarily called exercise, has a preventive effect on lifestyle-related diseases. Considering that in modern society, many have difficulty in exercising regularly, a number of studies focused not only on exercises but also on physical activity of at least an intermediate level after the CDC/ACSM report was published in 1995.[11)] Yet, many of the articles extracted by our systematic review include epidemiological findings on exercise as well. This study therefore sets references of both physical activity and exercise for health promotion.

The border values of physical activity and exercise of the group who showed significantly lower risk for developing lifestyle-related diseases (compared to the group with the lowest level of physical activity and exercise) or the ones of the group who showed significantly higher risk (compared to the group with the highest level of physical activity and exercise) were calculated using the data obtained by the systematic review. If the figure is derived from a single study, the decision of its application is easy. However, in reality, a number of research results have been presented by the efforts of many researchers, and the

reported values tend to vary widely. It is likely that this variability was due to the research methods employed (e.g., numbers of groups, survey methods and subjects of the studies). Nevertheless, careful examination of these articles failed to show any systematic cause of this variability. When the data were examined by gender and age group, no logical basis was found for classifying subjects by these variables. Thus, the means of these values were computed and a single value for quantity of physical activity and exercise (METs·hour/week) was used as the reference regardless of gender or age.

Maximal oxygen uptake

The maximal oxygen uptake was also taken up in the Recommended Exercise Allowance for Health Promotion in 1989, and has been explored as a risk factor for developing lifestyle-related diseases independent of the quantity of physical activity and exercise in many recent studies. The border values of the maximal oxygen uptake of the group who showed significantly lower risk of developing lifestyle-related diseases (compared to the group whose maximal oxygen uptake is lowest) or the ones of the group who showed significantly higher risk (compared to the group whose maximal oxygen uptake is highest) were obtained. It is appropriate to set the reference value for the maximal oxygen uptake to prevent lifestyle-related diseases between the minimum and maximum border values according to gender and age group; so a mean value was calculated and used as the reference.

Concept of the reference value

As stated earlier, these values for physical activity/exercise and the maximal oxygen uptake were the minimum ones with which the group showed significantly lower morbidity for each lifestyle-related disease, compared to the group whose physical activity, exercise and physical fitness are at the lowest within the cohort. Therefore in a simple sense, these are the

minimum values at which the effect of preventing lifestyle-related diseases is expected from physical activity, exercise and physical fitness. However, lifestyle-related diseases are associated not only with physical activity, exercise and physical fitness, but also with diet and other lifestyle habits. Therefore even if one meets the reference values of physical activity, exercise and physical fitness, s/he is not necessarily protected from lifestyle-related diseases. Thus, it is not appropriate to use the phrase of the "minimum values of physical activity, exercise and physical fitness that will protect one from developing lifestyle-related diseases".

According to The Dietary Reference Intake for Japanese (2005), a tentative dietary goal (DG) for the proportion of energy from fat is set as "20-30%" for prevention of lifestyle-related diseases. The present references for physical activity, exercise, and physical fitness also have similar concept to DG, though our references are not "goal" in a strict sense. In order to coordinate with the discipline of nutrition, the use of "goal" was avoided and instead, "reference" was used.

Validity of reference values in view of the current quantity of physical activity and exercise

Quantity of physical activity

The reference for the quantity of physical activity is 8,000 to 10,000 when converted to the number of steps. This is more than the current average number of steps among Japanese, according to the results of the National Health and Nutrition Survey in Japan in 2004 (7,532 and 6,446 steps for men and women, respectively). The reference corresponds to the target of "Health Japan 21" (over 9,200 and 8,300 steps for men and women, respectively) and is considered to be an appropriate target.

Quantity of exercise

The reference, 4 METs·hour/week corresponds to brisk walking for 60 min/week (30 min, twice), which is also the category of "regular exerciser" in the National Health and Nutrition Survey (30 min or more per time, twice or more per week, continued for at least one year). The proportions of "regular exerciser" are 30.9% of men and 25.8% of women, indicating that two-thirds of the population do not meet the reference values. This value is the minimum at which the effect of preventing lifestyle-related diseases is evident, which is also the target at which the majority of the population should aim.

Maximal oxygen uptake

The reference for the maximal oxygen uptake was found to be slightly lower than the mean value of Japanese. This reference therefore can be regarded both practical and appropriate for those people whose physical fitness level is low, having high risk for developing lifestyle-related diseases.

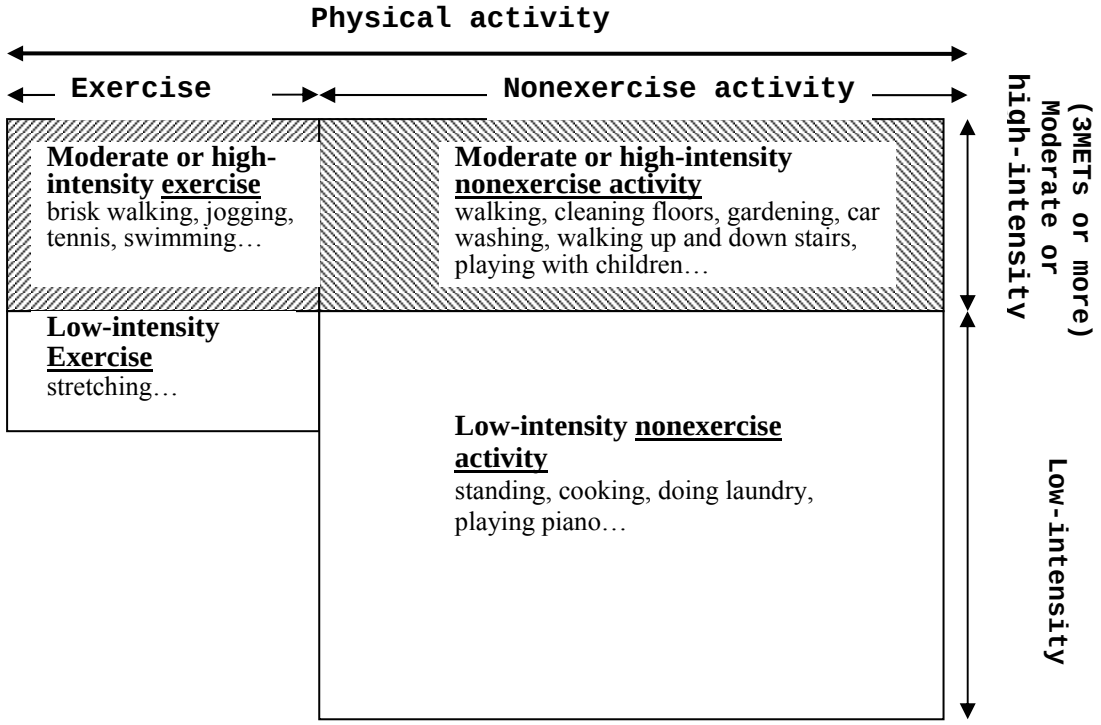
As described above, the references adopted for the present revision are designed for the overall purpose of preventing lifestyle-related diseases. They are considered suitable for those people who are not exerting themselves enough in physical activity and not exercising adequately. At a low level of physical fitness, they should recognize the importance of physical endeavors in preventing these lifestyle-related diseases. Needless to add, those people who exceed the reference values for physical activity, exercise and physical fitness should target the upper values of the range shown in **Table 2**.

2) Physical activity

Physical activity is defined as any bodily movement produced by skeletal muscles results in energy expenditure above resting energy expenditure. The physical activity can be divided into two; one is nonexercise physical activity (e.g. daily work, housework,

commuting to office/school) and the other is exercise that is practiced intentionally for maintaining and improving one's physical fitness. Here, the present reference counts only physical activities with intensity of 3 METs or more (see the figure below).

Fig 1: Physical activity and exercise



3) Exercise

Exercise is defined as a kind of physical activity that is planned, structured, repetitive, and designed to improve or maintain one or more components of physical fitness (including both sports performance-related fitness and health-related fitness). For the current reference, exercises with intensity of 3 METs or more, such as brisk walking, jogging, running, bicycling, swimming, tennis, badminton and soccer are concerned, and the activities with lower intensity (such as stretching) are excluded.

4) Physical fitness

There have been various definitions of physical fitness, which encompass a wide range of components. In the present reference, physical fitness is defined as a composite of multifaceted elements (latent potentials) related to the capacity to perform physical activity, or in a narrow sense, as the status that can be comprehended objectively and quantitatively. It is composed of the followings: 1) endurance, 2) muscle strength, 3) balance, 4) flexibility and 5) others.

5) Maximal oxygen uptake (Vo_2max)

Maximal oxygen uptake is defined as the maximum amount of oxygen taken in per unit time (l/min or ml/kg/min). The amount of oxygen uptake during exercise reflects the amount of energy produced in the active muscles. The higher its maximum value, the greater the capacity to produce energy, indicating an ability to engage in exercise with greater intensity for a longer duration. In other words, the maximal oxygen uptake is an index for evaluating one's endurance.

The maximal oxygen uptake is measured by physical activity in which a large muscle group is used. This is often measured by walking or running on a treadmill or by using a bicycle ergometer. The amount of oxygen uptake at the increment of exercise intensity is measured by the analyzing expired gas. With the increase in exercise intensity, oxygen uptake linearly increases and its highest amount is called "maximal oxygen uptake". In this process, it is important to confirm the point where oxygen intake starts leveling-off. This is clearly different from the definition of the peak oxygen uptake measured by the protocol of a graded exercise load [12] Yet, this peak oxygen intake may often be used as a substitute for the maximal oxygen uptake. In general, the maximal oxygen uptake while running is 5 to 10% higher than the one measured by a bicycle ergometer.[13] In the current systematic review, about 70% of the data on maximal oxygen uptake were derived from the studies by treadmill,

while the remainder used a bicycle ergometer. Therefore, the current reference reflects the results of running exercise, and thus care should be taken when we estimate the outcomes of exercise using a bicycle ergometer.

Measurement of the maximal oxygen uptake requires not only expensive equipments, such as the one for exercise loading apparatus , the expired gas analyzer and an electrocardiogram recording device. In addition, a number of skilled personnel are required. Therefore, several simple methods to estimate the maximal oxygen uptake have been developed (e.g. the one that does not impose the maximum effort on the subject, the one without using the gas analyzer). Since their adequacy and reproducibility have been confirmed, they are utilized in many studies.

6) Muscle strength

The value for muscle strength varies widely, depending on the method adopted or the site where the measurement is made. Commonly used methods for evaluating muscle strength include: 1) Maximum isometric muscle strength that is measured when the muscle length remains unchanged [maximum voluntary contraction: MVC (kg weight)] and 2) isotonic maximum muscular strength that is measured when the muscle length is shortened with applying the constant tension to the muscle [1 RM(repletion max)(kg weight)]. By using these methods, muscle strength in the articular movement of the extremities and truncal region can be determined.

To determine the isometric maximum muscle strength of handgrip exercise, grip strength (kg weight) has been used because of its safety and simplicity. As the references, the nationwide data are compiled according to gender and age, based on the results of a sports test (test for physical fitness) conducted by the Ministry of Education, Culture, Sports,

Science and Technology and other related studies. These data are used as an index for muscle strength in, not only domestic but also international, epidemiological studies.

7) MET

MET (metabolic equivalent) is an index for physical activity intensity, calculated as energy expenditure (oxygen untake, mL/kg/min) during specific physical activity and exercise divided by sitting/resting energy expenditure (equivalent to 3.5 mL/kg/min in oxygen uptake) .

8) METs · hour

METs·hour is defined as METs multiplied by hours spent in physical activity and exercise. If the oxygen consumption of 1.0 liter is converted into the energy expenditure of 5.0 kcal, 1.0 MET·hour corresponds to 74 and 63 kcal with a body weight of 70 and 60 kg, respectively. For a standard body composition, 1.0 MET·hour can be the energy expenditure almost equal to body weight. In this way, METs·hour is frequently used to quantify physical activity. The energy expenditure for 2, 4, 10 and 23 METs·hour used for the current references, is shown in the Table below. It should be noted that these values are total energy expenditure for physical activity or exercise, and they do not represent the excess energy consumption over that when the subject is at rest.

METs·hour and corresponding kcal

METs·hour	With body weight of 60 kg (kcal)	With body weight of 70 kg (kcal)
2	130	150
4	250	200
10	630	740
23	1450	1690

The following computation was made with a metabolism at rest set at 3.5 mL/kg/min and 5.0 kcal per L of oxygen uptake:

Example: energy expenditure for a person weighing 60 kg with 4 METs·hour:

= (3.5 ml/kg/min x 60 kg/1000) x 5.0 kcal/L x (4 x 60 min)

≒ 250 kcal

To simplify, energy expenditure (kcal) may be calculated from METs·hour, using METs and body weight (kg) as follows:

1.05 x METs·hour x body weight (kg)

MET values for major activities are shown below.

Nonexercise physical activity of 3 METs or more (included in the computation of the reference for the quantity of physical activity)

(The time equivalent of 23 MET·hours is expressed per day, not per week)

METs	Examples of activity	Time (min/day) corresponding to 23 MET·hours
3.0	Walking (level, 67m/min.), walking with small child(ren), walking the dog, shopping	66
3.0	Fishing (from boat, sitting (2.5) to fishing in stream (6.0))	66
3.0	House cleaning, putting away household items, carpentry, packing, etc.	66
3.0	Playing guitar, rock and roll band (standing)	66
3.0	Loading/unloading a car	66
3.0	Walking down the stairs	66
3.0	Child care, standing	66
3.3	Carpet sweeping, sweeping floors	60
3.3	Walking (level, 80m/min., moderate pace) commuting	60
3.5	Mopping, vacuuming, packing/unpacking boxes, carrying light load	56
3.5	Electrical work and plumbing	56
3.8	Scrubbing floor on hands and knees, scrubbing bathroom/bathtab	52
3.8	Walking for exercise (level, 94 m/min.)	52
4.0	Walking at a brisk pace (level, 95-100 m/min.)	49
4.0	Bicycling: < 16 km/h, leisure, to work or for pleasure	49
4.0	Walk/run - playing with child(ren)or animals, moderate	49
4.0	Raking roof with snow rake	49
4.0	Playing drums	49
4.0	Pushing a wheelchair	49
4.0	Playing with a child (walk or run, at a moderate intensity)	49
4.5	Planting seedlings/shrubs, weeding, cultivating garden	44
4.5	Farming: feeding cattle/horses	44
5.0	Walk/run – playing with child(ren) or animals, vigorously	39
5.0	Walking at a very brisk pace (on level ground, very brisk pace = 107 m/min.)	39
5.5	Mowing lawn, walk, power mower	36
6.0	Moving furniture, household items, carrying boxes	33
6.0	Shoveling snow by hand	33
8.0	Carrying heavy loads	25
8.0	Farming: forking straw bales, cleaning corral or barn, poultry, vigorously	25
8.0	Climbing the stairs	25
9.0	Carrying load upstairs	22

Exercise of 3 METs or more (included in the computation of the reference for the quantity of exercise)

METs	Examples of activity	Time (min/day) corresponding to 4 METs·hour
3.0	Bicycling using a stationary ergometer: 50 watts, very light effort	80
3.0	Weight lifting, light or moderate effort	80
3.0	Bowling	80
3.0	Playing frisbee	80
3.0	Volleyball	80
3.5	Calisthenics, home exercise, light or moderate effort	69
3.5	Playing golf, using power cart	69
3.8	Walking for exercise (level, 94 m/min.)	63
4.0	Walking at a brisk pace (level, 95-100 m/min.)	60
4.0	water exercises or water calisthenics	60
4.0	table tennis, ping-pong	60
4.0	Tai chi	60
4.0	water aerobics, water calisthenics	60
4.5	badminton	53
4.8	ballet or modern dance, twist, jazz or tap dancing	50
5.0	softball or baseball	48
5.0	children's games (hopscotch, dodge ball, playground apparatus, marbles etc.)	48
5.0	Walking (level, very brisk pace, 107 m/min.)	48
5.5	Bicycling using a stationary ergometer: 100 watts, light effort	44
6.0	Weight lifting (power lifting or body building), vigorous effort	40
6.0	slimnastics, jazzercise	40
6.0	Jog/walk combination (jogging component of less than 10 min)	40
6.0	basketball	40
6.0	Swimming, leisurely	40
6.5	Aerobics	37
7.0	Jogging	34
7.0	Skating	34
7.0	Soccer	34
7.0	Tennis	34
7.0	Swimming, backstroke	34
7.0	Skating, skiing	34
7.5	Mountain climbing with 1-2 kg load	32
8.0	Cycling (approx. 20 km/h), leisure, moderate effort	30
8.0	Running: 134 m/min.	30
8.0	Swimming, slow crawl (approx. 45 m/min.), moderate or light effort	30
10.0	Running: 161 m/min.	24
10.0	judo, jujitsu, karate, kick boxing and tae-kwan-do	24
10.0	rugby	24
10.0	Swimming, breaststroke	24
11.0	Swimming, butterfly	22
11.0	Swimming, fast crawl (approx 70 m/min.), vigorous effort	22
15.0	Running, stairs, up	16

Reference: Activities of less than 3 METs (excluded in the calculation of the reference for the quantity of physical activity and exercise)

METs	Examples of activity
1.0	Sitting quietly (or lying down), watching television or listening to music; reclining; riding in a car
1.2	Standing quietly
1.3	Sitting - reading book or newspaper
1.5	Sitting - talking or talking on the phone, reading, eating, driving a car, light desk work, knitting, doing a manual craft and typing (in a sitting position)
1.5	Taking care of a pet (in a sitting position, light intensity)
1.5	Bathing (sitting)
1.8	Standing – talking or talking on the phone, reading and doing a manual craft
2.0	Cooking or food preparing - standing or sitting
2.0	Implied standing - laundry, fold or hang cloths, put clothes in washer or dryer, packing
2.0	Playing guitar, classical or folk (sitting)
2.0	Dressing, undressing
2.0	Talking and eating or eating only (standing)
2.0	Grooming (washing, shaving, brushing teeth, washing hands, putting on make-up)
2.0	Showering, toweling off (standing)
2.0	Walking slowly (level, outdoors or indoors, less than 54 m/min.)
2.3	Wash dishes (standing), ironing, Implied walking - putting away clothes, gathering cloths to pack, putting away laundry
2.3	Standing - casino gambling, duplicating machine
2.3	Standing - light work (bartening, store clerk, duplicating etc.)
2.5	Stretching* and hatha yoga*
2.5	Light cleaning (dusting, straightening up, changing linen and carrying out trash)
2.5	Serving food, setting table, cooking or food preparation, and putting away (walking), etc.
2.5	Watering plants
2.5	Sitting - playing with child(ren) or animals
2.5	Child care (sitting/kneeling)
2.5	Playing piano or organ
2.5	Farming, driving harvester, cutting hay, irrigation work
2.5	Playing catch (football or baseball)*
2.5	Operating a motor scooter or motorcycle
2.5	Pushing or pulling stroller with child or walking with children
2.5	Walking (level, slow pace, 54 m/min.)
2.8	Standing - playing with child(ren), playing with animals

*Indicates exercise: the others are classified as physical activities.

(Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc, 2000; 32 (Suppl): S498-S516.)

Note 1: When there are multiple values for a single activity, the one that is considered to appear more frequently is listed (c.f., taking the value for leisure activity over that for competitive sport).

Note 2: Each value represents that while engaged in activity, not while resting.

8) The target values of "Healthy Japan 21" in comparison with provisionally selected most recent value

The target values of "Healthy Japan 21" in comparison with provisionally selected most recent actual value.

Target		Baseline value for setting the reference	Goal	Provisionally selected most recent actual value
ADULT(20 years or older)				
2.1	Increasing the number of "people who intentionally and actively participate in physical activities to maintain and promote their health in their daily life"	Male 51.8%[1)]	63%or more	54.2%[2)*]
		Female 53.1%[1)]	63% or more	55.5%[2)*]
2.2	Increasing the number of steps walked in daily life	Male 8,202 steps[3)]	9,200 steps or more	7,532 steps[4)]
		Female 7,282 steps[3)]	8,300 steps or more	6,446 steps[4)]
2.3	Increasing the number of individuals who do regular physical exercise	Male 28.6%[3)]	39 % or more	30.9%[4)]
		Female 24.6%[3)]	35% or more	25.8%[4)]
Elderly				
2.4	Increasing the number of elderly who take a positive attitude toward going outside	Male (60-yr or older) 59.8%[5)]	70% or more	51.8%[2)*]
		Female (60-yr or older) 59.0%[5)]	70% or more	51.4%[2)*]
		All (60-yr or older) 46.3%[5)]	56% or more	38.7%[2)*]
2.5	Increasing the percentage of the elderly who join certain local community activity programs	Male (60-yr or older)48.3%[6)]	58% or more	66.0%[2)*]
		Female (60-yr or older)39.7%[6)]	50% or more	61.0%[2)*]
2.6	Increasing the number of steps walked in daily life	Male (70-yr or older) 5,436 steps[3)]	6,700 steps or more	5,386 steps [4)]
		Female (70-yr or older) 4,604 steps[3)]	5,900 steps or more	3,917 steps [4)]

1) Health and Welfare Statistics, 1996
2) National Health and Nutrition Survey in Japan, 2003
3) National Nutrition Survey in Japan, 1997
4) National Health and Nutrition Survey in Japan, 2004
5) Awareness Survey on Daily Living of the Elderly, 1999
6) Awareness Survey on Participation of the Elderly in Community Activities 1998

Notes:
Data for the "provisionally selected most recent actual value" are the ones as of March 8, 2006.
* The survey for the baseline data and the one for the latest data are different.

9) Systematic review

(1) Purpose

A systematic review was conducted to set the reference quantity of physical activity and exercise for health promotion: the target populations are healthy individuals, as well as those who were found to have minor abnormalities (such as an elevated blood pressure and an elevated fasting blood glucose) at a health examination and told to improve their lifestyle.

(2) Method for search

A literature search was conducted on observational studies on the effects of physical activity, exercise and physical fitness (major components of reference quantity of physical activity and exercise for health promotion) on the development of lifestyle-related diseases.

① Databases: PubMed and *Japana Centra Rebuo Medicina*

② Published date: Before April 11, 2005

③ Search format: In PubMed, the following was used;

("physical activity" OR exercise OR "physical training" OR fitness) AND (each disease entity) AND (follow* OR observation* OR prospective OR longitudinal OR retrospective)

④ Search limited to: human studies

⑤ Publication category: original articles

⑥ Age: from school age (6 years and older) to the elderly

⑦ Target lifestyle-related diseases:

obesity, hypertension, hyperlipemia, diabetes, cerebrovascular disorders, death due to circulatory diseases, osteoporosis, ADL and total mortality

(3) Inclusion criteria

Among the articles that were retrieved through the search, those that met the following criteria were selected to obtain the necessary quantitative information;

① Studies in which individuals who, as a rule, were free of severe illnesses (healthy people or those having minor symptoms but capable of doing exercise) were observed

for a long term (over 2 years) and their mortality or incidences of disease were analyzed according to physical activity, exercise, and physical fitness.

② Studies clearly indicating information on quantity of physical activity and exercise that were evaluated by quantitative methods (type, intensity, duration: min/week or min/day, frequency: times/week). If the information on "frequency" is not available, the data may be calculated using the data of "type, intensity and min/week."

③ Studies clearly indicating information on physical fitness that was determined by quantitative methods.

④ Studies in which quantity of physical activity and exercise and physical fitness are divided into groups and the cut-off lines are set logically.

⑤ Studies in which the effects of physical activity and exercise are individually analyzed [the effect of other factors (sex, age, smoking, metabolic risk factors, etc.) are statistically adjusted].

⑥ The number of subjects is determined by the method of analysis or the accuracy of measurement.

(4) Results

The search formula given above retrieved 8,134 articles. Following the primary screening by examining their titles and abstracts, the number decreased to 794. The full text of each article was obtained for a thorough examination. Finally, the number of the articles that satisfied the inclusion criteria given in the above was 84.

References

I. Literature cited in this paper

(1) The Committee on Diagnosis Standard of Metabolic Syndrome. Definition and diagnosis of metabolic syndrome. Nippon Naika Gakkai Zasshi (J Jpn Soc Intern Med) 2005;94:188-203. (in Japanese)

(2) Carroll S, Cooke CB, Butterly RJ. Physical activity, cardiorespiratory fitness, and the primary components of blood viscosity. Med Sci Sports Exerc 2000;32:353-8.

(3) Dipietro L, Caspersen CJ, Ostfeld AM, Nadel ER. A survey for assessing physical activity among older adults. Med Sci Sports Exerc 1993;25:628-42.

(4) Nagaya T, Kondo Y, Shibata T. Effects of sedentary work on physical fitness and serum cholesterol profile in middle-aged male workers. Int Arch Occup Environ Health 2001;74:366-70.

(5) Huang G, Gibson CA, Tran ZV, Osness WH. Controlled endurance exercise training and VO2max changes in older adults: a meta-analysis. Prev Cardiol 2005;8:217-25.

(6) Rauramaa R, Tuomainen P, Vaisanen S, Rankinen T. Physical activity and health-related fitness in middle-aged men. Med Sci Sports Exerc 1995;27:707-12.

(7) Leon AS, Casal D, Jacobs D, Jr. Effects of 2,000 kcal per week of walking and stair climbing on physical fitness and risk factors for coronary heart disease. J Cardiopulm Rehabil 1996;16:183-92.

(8) Wolfarth B, Bray MS, Hagberg JM, et al. The human gene map for performance and health-related fitness phenotypes: the 2004 update. Med Sci Sports Exerc 2005;37:881-903.

(9) Talbot LA, Morrell CH, Metter EJ, Fleg JL. Comparison of cardiorespiratory fitness versus leisure time physical activity as predictors of coronary events in men aged < or = 65 years and > 65 years. Am J Cardiol 2002;89:1187-92.

(10) Hatano Y, ed. Sciences in walking and daily foot steps. Tokyo: Fumaidoushuppan, 1998. (in Japanese)

(11) Pate RR, Pratt M, Blair SN, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995;273:402-7.

(12) Washburn RA, Seals DR. Peak oxygen uptake during arm cranking for men and women. J Appl Physiol 1984;56:954-7.

(13) Hermansen L, Saltin B. Oxygen uptake during maximal treadmill and bicycle exercise. J Appl Physiol 1969;26:31-7.

II. Literature used in selecting reference quantity of exercise in addition to those listed above.

1) Literature referred to in determining the quantity of physical activity and exercise required in maintaining and promoting health

1. Salonen JT, Puska P, Tuomilehto J. Physical activity and risk of myocardial infarction, cerebral stroke and death: a longitudinal study in Eastern Finland. Am J Epidemiol 1982;115:526-37.
2. Paffenbarger RS, Jr., Wing AL, Hyde RT, Jung DL. Physical activity and incidence of hypertension in college alumni. Am J Epidemiol 1983;117:245-57.
3. Paffenbarger RS, Jr., Hyde RT, Wing AL, Hsieh CC. Physical activity, all-cause mortality, and longevity of college alumni. N Engl J Med 1986;314:605-13.
4. Slattery ML, Jacobs DR, Jr., Nichaman MZ. Leisure time physical activity and coronary heart disease death. The US Railroad Study. Circulation 1989;79:304-11.
5. Helmrich SP, Ragland DR, Leung RW, Paffenbarger RS, Jr. Physical activity and reduced occurrence of non-insulin-dependent diabetes mellitus. N Engl J Med 1991;325:147-52.
6. Manson JE, Rimm EB, Stampfer MJ, et al. Physical activity and incidence of non-insulin-dependent diabetes mellitus in women. Lancet 1991;338:774-8.
7. Manson JE, Nathan DM, Krolewski AS, Stampfer MJ, Willett WC, Hennekens CH. A prospective study of exercise and incidence of diabetes among US male physicians. JAMA 1992;268:63-7.
8. Wannamethee G, Shaper AG. Physical activity and stroke in British middle aged men. BMJ 1992;304:597-601.
9. Lindenstrom E, Boysen G, Nyboe J. Lifestyle factors and risk of cerebrovascular disease in women. The Copenhagen City Heart Study. Stroke 1993;24:1468-72.
10. Lindenstrom E, Boysen G, Nyboe J. Risk factors for stroke in Copenhagen, Denmark. II. Life-style factors. Neuroepidemiology 1993;12:43-50.

11. Paffenbarger RS, Jr., Kampert JB, Lee IM, Hyde RT, Leung RW, Wing AL. Changes in physical activity and other lifeway patterns influencing longevity. Med Sci Sports Exerc 1994;26:857-65.
12. Lee IM, Hsieh CC, Paffenbarger RS, Jr. Exercise intensity and longevity in men. The Harvard Alumni Health Study. JAMA 1995;273:1179-84.
13. Ching PL, Willett WC, Rimm EB, Colditz GA, Gortmaker SL, Stampfer MJ. Activity level and risk of overweight in male health professionals. Am J Public Health 1996;86:25-30.
14. Lynch J, Helmrich SP, Lakka TA, et al. Moderately intense physical activities and high levels of cardiorespiratory fitness reduce the risk of non-insulin-dependent diabetes mellitus in middle-aged men. Arch Intern Med 1996;156:1307-14.
15. Morioka S. A cohort study on the relationship between lifestyles and total mortality. Nippon Koshu Eisei Zasshi (Jpn J Public Health) 1996;43:469-78. (in Japanese)
16. Haapanen N, Miilunpalo S, Vuori I, Oja P, Pasanen M. Association of leisure time physical activity with the risk of coronary heart disease, hypertension and diabetes in middle-aged men and women. Int J Epidemiol 1997;26:739-47.
17. Kushi LH, Fee RM, Folsom AR, Mink PJ, Anderson KE, Sellers TA. Physical activity and mortality in postmenopausal women. JAMA 1997;277:1287-92.
18. Yoshioka T, Iwai N, Oshiro H, Kurozawa Y, Morita S. A cohort study of lifestyle in a rural area: relationship between mortality and lifestyle. Yonago Igaku Zasshi (J Yonago Med Asssoc) 1997;48:164-70. (in Japanese)
19. Joakimsen RM, Fonnebo V, Magnus JH, Stormer J, Tollan A, Sogaard AJ. The Tromso Study: physical activity and the incidence of fractures in a middle-aged population. J Bone Miner Res 1998;13:1149-57.
20. Kujala UM, Kaprio J, Sarna S, Koskenvuo M. Relationship of leisure-time physical activity and mortality: the Finnish twin cohort. JAMA 1998;279:440-4.
21. Lee IM, Paffenbarger RS, Jr. Physical activity and stroke incidence: the Harvard Alumni Health Study. Stroke 1998;29:2049-54.
22. Hayashi T, Tsumura K, Suematsu C, Okada K, Fujii S, Endo G. Walking to work and the risk for hypertension in men: the Osaka Health Survey. Ann Intern Med 1999;131:21-6.
23. Hu FB, Sigal RJ, Rich-Edwards JW, et al. Walking compared with vigorous physical activity and risk of type 2 diabetes in women: a prospective study. JAMA 1999;282:1433-9.

24. Hu FB, Stampfer MJ, Colditz GA, et al. Physical activity and risk of stroke in women. JAMA 2000;283:2961-7.
25. Kujala UM, Kaprio J, Kannus P, Sarna S, Koskenvuo M. Physical activity and osteoporotic hip fracture risk in men. Arch Intern Med 2000;160:705-8.
26. Okada K, Hayashi T, Tsumura K, Suematsu C, Endo G, Fujii S. Leisure-time physical activity at weekends and the risk of Type 2 diabetes mellitus in Japanese men: the Osaka Health Survey. Diabet Med 2000;17:53-8.
27. Hoidrup S, Sorensen TI, Stroger U, Lauritzen JB, Schroll M, Gronbaek M. Leisure-time physical activity levels and changes in relation to risk of hip fracture in men and women. Am J Epidemiol 2001;154:60-8.
28. Feskanich D, Willett W, Colditz G. Walking and leisure-time activity and risk of hip fracture in postmenopausal women. JAMA 2002;288:2300-6.
29. Manson JE, Greenland P, LaCroix AZ, et al. Walking compared with vigorous exercise for the prevention of cardiovascular events in women. N Engl J Med 2002;347:716-25.
30. Roy DK, O'Neill TW, Finn JD, et al. Determinants of incident vertebral fracture in men and women: results from the European Prospective Osteoporosis Study (EPOS). Osteoporos Int 2003;14:19-26.
31. Yu S, Yarnell JW, Sweetnam PM, Murray L. What level of physical activity protects against premature cardiovascular death? The Caerphilly study. Heart 2003;89:502-6.
32. Bak H, Petersen L, Sorensen TI. Physical activity in relation to development and maintenance of obesity in men with and without juvenile onset obesity. Int J Obes Relat Metab Disord 2004;28:99-104.
33. Hernelahti M, Kujala U, Kaprio J. Stability and change of volume and intensity of physical activity as predictors of hypertension. Scand J Public Health 2004;32:303-9.
34. Hu G, Barengo NC, Tuomilehto J, Lakka TA, Nissinen A, Jousilahti P. Relationship of physical activity and body mass index to the risk of hypertension: a prospective study in Finland. Hypertension 2004;43:25-30.
35. Petersen L, Schnohr P, Sorensen TI. Longitudinal study of the long-term relation between physical activity and obesity in adults. Int J Obes Relat Metab Disord 2004;28:105-12.
36. Tammelin T, Laitinen J, Nayha S. Change in the level of physical activity from adolescence into adulthood and obesity at the age of 31 years. Int J Obes Relat Metab Disord 2004;28:775-82.

2) Literature referred to in determining physical fitness (maximal oxygen uptake) required in maintaining and promoting health.

1. Blair SN, Goodyear NN, Gibbons LW, Cooper KH. Physical fitness and incidence of hypertension in healthy normotensive men and women. JAMA 1984;252:487-90.
2. Ekelund LG, Haskell WL, Johnson JL, Whaley FS, Criqui MH, Sheps DS. Physical fitness as a predictor of cardiovascular mortality in asymptomatic North American men. The Lipid Research Clinics Mortality Follow-up Study. N Engl J Med 1988;319:1379-84.
3. Blair SN, Kohl HW, 3rd, Paffenbarger RS, Jr., Clark DG, Cooper KH, Gibbons LW. Physical fitness and all-cause mortality. A prospective study of healthy men and women. JAMA 1989;262:2395-401.
4. Blair SN, Kohl HW, 3rd, Barlow CE, Gibbons LW. Physical fitness and all-cause mortality in hypertensive men. Ann Med 1991;23:307-12.
5. Blair SN, Kohl HW, Gordon NF, Paffenbarger RS, Jr. How much physical activity is good for health? Annu Rev Public Health 1992;13:99-126.
6. Hein HO, Suadicani P, Gyntelberg F. Physical fitness or physical activity as a predictor of ischaemic heart disease? A 17-year follow-up in the Copenhagen Male Study. J Intern Med 1992;232:471-9.
7. Kohl HW, Gordon NF, Villegas JA, Blair SN. Cardiorespiratory fitness, glycemic status, and mortality risk in men. Diabetes Care 1992;15:184-92.
8. Blair SN, Kohl HW, Barlow CE. Physical activity, physical fitness, and all-cause mortality in women: do women need to be active? J Am Coll Nutr 1993;12:368-71.
9. Sandvik L, Erikssen J, Thaulow E, Erikssen G, Mundal R, Rodahl K. Physical fitness as a predictor of mortality among healthy, middle-aged Norwegian men. N Engl J Med 1993;328:533-7.
10. Sawada S, Tanaka H, Funakoshi M, Shindo M, Kono S, Ishiko T. Five year prospective study on blood pressure and maximal oxygen uptake. Clin Exp Pharmacol Physiol 1993;20:483-7.
11. Blair SN, Kohl HW, 3rd, Barlow CE, Paffenbarger RS, Jr., Gibbons LW, Macera CA. Changes in physical fitness and all-cause mortality. A prospective study of healthy and unhealthy men. JAMA 1995;273:1093-8.

12. Blair SN, Kampert JB, Kohl HW, 3rd, et al. Influences of cardiorespiratory fitness and other precursors on cardiovascular disease and all-cause mortality in men and women. JAMA 1996;276:205-10.
13. Kampert JB, Blair SN, Barlow CE, Kohl HW, 3rd. Physical activity, physical fitness, and all-cause and cancer mortality: a prospective study of men and women. Ann Epidemiol 1996;6:452-7.
14. Lynch J, Helmrich SP, Lakka TA, et al. Moderately intense physical activities and high levels of cardiorespiratory fitness reduce the risk of non-insulin-dependent diabetes mellitus in middle-aged men. Arch Intern Med 1996;156:1307-14.
15. Lee CD, Jackson AS, Blair SN. US weight guidelines: is it also important to consider cardiorespiratory fitness? Int J Obes Relat Metab Disord 1998;22 Suppl 2:S2-7.
16. Lee CD, Blair SN, Jackson AS. Cardiorespiratory fitness, body composition, and all-cause and cardiovascular disease mortality in men. Am J Clin Nutr 1999;69:373-80.
17. Wei M, Gibbons LW, Mitchell TL, Kampert JB, Lee CD, Blair SN. The association between cardiorespiratory fitness and impaired fasting glucose and type 2 diabetes mellitus in men. Ann Intern Med 1999;130:89-96.
18. Sawada S, Muto K. Prospective study on the relationship between physical fitness and all-cause mortality in Japanese men. Nippon Koshu Eisei Zasshi (Jpn J Public Health) 1999;46:113-21. (in Japanese)
19. Lakka TA, Laukkanen JA, Rauramaa R, et al. Cardiorespiratory fitness and the progression of carotid atherosclerosis in middle-aged men. Ann Intern Med 2001;134:12-20.
20. Laukkanen JA, Lakka TA, Rauramaa R, et al. Cardiovascular fitness as a predictor of mortality in men. Arch Intern Med 2001;161:825-31.
21. Farrell SW, Braun L, Barlow CE, Cheng YJ, Blair SN. The relation of body mass index, cardiorespiratory fitness, and all-cause mortality in women. Obes Res 2002;10:417-23.
22. Myers J, Prakash M, Froelicher V, Do D, Partington S, Atwood JE. Exercise capacity and mortality among men referred for exercise testing. N Engl J Med 2002;346:793-801.
23. Carnethon MR, Gidding SS, Nehgme R, Sidney S, Jacobs DR, Jr., Liu K. Cardiorespiratory fitness in young adulthood and the development of cardiovascular disease risk factors. JAMA 2003;290:3092-100.

24. Evenson KR, Stevens J, Cai J, Thomas R, Thomas O. The effect of cardiorespiratory fitness and obesity on cancer mortality in women and men. Med Sci Sports Exerc 2003;35:270-7.
25. Gulati M, Pandey DK, Arnsdorf MF, et al. Exercise capacity and the risk of death in women: the St James Women Take Heart Project. Circulation 2003;108:1554-9.
26. Kurl S, Laukkanen JA, Rauramaa R, Lakka TA, Sivenius J, Salonen JT. Cardiorespiratory fitness and the risk for stroke in men. Arch Intern Med 2003;163:1682-8.
27. Mora S, Redberg RF, Cui Y, et al. Ability of exercise testing to predict cardiovascular and all-cause death in asymptomatic women: a 20-year follow-up of the lipid research clinics prevalence study. JAMA 2003;290:1600-7.
28. Sawada SS, Lee IM, Muto T, Matuszaki K, Blair SN. Cardiorespiratory fitness and the incidence of type 2 diabetes: prospective study of Japanese men. Diabetes Care 2003;26:2918-22.
29. Church TS, Cheng YJ, Earnest CP, et al. Exercise capacity and body composition as predictors of mortality among men with diabetes. Diabetes Care 2004;27:83-8.
30. Katzmarzyk PT, Church TS, Blair SN. Cardiorespiratory fitness attenuates the effects of the metabolic syndrome on all-cause and cardiovascular disease mortality in men. Arch Intern Med 2004;164:1092-7.
31. Stevens J, Evenson KR, Thomas O, Cai J, Thomas R. Associations of fitness and fatness with mortality in Russian and American men in the lipids research clinics study. Int J Obes Relat Metab Disord 2004;28:1463-70.

3) Literature referred to in determining physical fitness (muscular strength and others) required in maintaining and promoting health.

1. Fujita Y, Nakamura Y, Hiraoka J, et al. Physical-strength tests and mortality among visitors to health-promotion centers in Japan. J Clin Epidemiol 1995;48:1349-59.
2. Nguyen TV, Eisman JA, Kelly PJ, Sambrook PN. Risk factors for osteoporotic fractures in elderly men. Am J Epidemiol 1996;144:255-63.
3. Seeley DG, Kelsey J, Jergas M, Nevitt MC. Predictors of ankle and foot fractures in older women. The Study of Osteoporotic Fractures Research Group. J Bone Miner Res 1996;11:1347-55.

4. Schroll M, Avlund K, Davidsen M. Predictors of five-year functional ability in a longitudinal survey of men and women aged 75 to 80. The 1914-population in Glostrup, Denmark. Aging (Milano) 1997;9:143-52.
5. Rantanen T, Masaki K, Foley D, Izmirlian G, White L, Guralnik JM. Grip strength changes over 27 yr in Japanese-American men. J Appl Physiol 1998;85:2047-53.
6. Anstey KJ, Luszcz MA, Giles LC, Andrews GR. Demographic, health, cognitive, and sensory variables as predictors of mortality in very old adults. Psychol Aging 2001;16:3-11.
7. Al Snih S, Markides KS, Ray L, Ostir GV, Goodwin JS. Handgrip strength and mortality in older Mexican Americans. J Am Geriatr Soc 2002;50:1250-6.
8. Katzmarzyk PT, Craig CL. Musculoskeletal fitness and risk of mortality. Med Sci Sports Exerc 2002;34:740-4.
9. Lee SH, Dargent-Molina P, Breart G. Risk factors for fractures of the proximal humerus: results from the EPIDOS prospective study. J Bone Miner Res 2002;17:817-25.
10. Metter EJ, Talbot LA, Schrager M, Conwit R. Skeletal muscle strength as a predictor of all-cause mortality in healthy men. J Gerontol A Biol Sci Med Sci 2002;57:B359-65.
11. Albrand G, Munoz F, Sornay-Rendu E, DuBoeuf F, Delmas PD. Independent predictors of all osteoporosis-related fractures in healthy postmenopausal women: the OFELY study. Bone 2003;32:78-85.
12. Rantanen T, Volpato S, Ferrucci L, Heikkinen E, Fried LP, Guralnik JM. Handgrip strength and cause-specific and total mortality in older disabled women: exploring the mechanism. J Am Geriatr Soc 2003;51:636-41.
13. Stel VS, Smit JH, Pluijm SM, Lips P. Balance and mobility performance as treatable risk factors for recurrent falling in older persons. J Clin Epidemiol 2003;56:659-68.
14. Metter EJ, Talbot LA, Schrager M, Conwit RA. Arm-cranking muscle power and arm isometric muscle strength are independent predictors of all-cause mortality in men. J Appl Physiol 2004;96:814-21.