Kazuyuki Kanosue *Editor in Chief*

Satomi Oshima
Zhen-Bo Cao
Koichiro Oka *Editors*

Physical Activity, Exercise, Sedentary Behavior and Health

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ISBN 978-4-431-55332-8 ISBN 978-4-431-55333-5 (eBook)
DOI 10.1007/978-4-431-55333-5

Library of Congress Control Number: 2015939583

Springer Tokyo Heidelberg New York Dordrecht London

Printed on acid-free paper

Springer Japan KK is part of Springer Science+Business Media (www.springer.com)

Introduction to the Series

Waseda University of Japan has a tradition of producing great athletes amongst its graduates, such as Mikio Oda, the first Japanese ever to win an Olympic gold medal. Waseda University strongly supports coaching techniques that embody a practical application of the knowledge gained from the fundamental research findings of sports science. Waseda University also takes pride in providing athletes with medical care that utilizes leading-edge sports medicine, and formulates management strategies that combine all these elements. This approach has led to a strong tradition of sports-based research—what we like to call "Waseda Sports"—which has enjoyed an unprecedented level of success. This tradition was enhanced by the Faculty of Sport Sciences in Waseda University in 2009 when they initiated the Global COE (Center of Excellence) Program, entitled "Sport Sciences for the Promotion of Active Life". The Global COE Program is under the aegis of the Japanese Ministry of Education, Culture, Sports, Science, and Technology; this Ministry supports the development of international centers of education and research excellence.

While life expectancy in Japan is the highest in the world, large-scale societal changes here and elsewhere have led to an increase in health problems due to a decrease in activity and physical fitness. In the aging population there has been a deterioration of overall health, much of which can be attributed to inactivity and excess body weight. It is especially troubling that similar problems are increasing among children and are associated with severe physical and mental disabilities. The international scope of the above problems provided the impetus for Waseda University to form the Global COE Program. This effort involved the construction of an international hub of education and research specifically designed to develop and encourage talented researchers to create sports programs that would contribute to an active and vital lifestyle. The program emphasizes the development of specialist knowledge in conjunction with a broad understanding and awareness of the diverse world of sports. One of our goals was to focus not just on improving the individual health of mind and body, but also to develop an understanding of the conditions present in regions and societies that facilitate such improvements in the lifestyle of individuals.

The sports sciences have created and are extending an important body of knowledge. It is critical that this information be utilized to produce an active, two-way interaction between the investigators and the active participants of sporting events. In order to provide a focus for developing this reciprocal intercommunication, the Global COE program identified three strategic project themes: (1) Active Children Project, (2) Active Elderly Project, and (3) Elite Athlete Project. The COE Program was proactive in seeking out mature graduate students who were returning to higher education after a period of work, thereby facilitating a meaningful contribution to the formation of academic careers for specialists who were active in the practical domain of sports. Many graduate students from abroad, especially from Asian countries, joined the program and have contributed to our goals via both the creation of academic knowledge and direct participation in the sports relevant to their area of investigation.

The formal funding for the Global COE Program came to an end in March 2014, but the projects initiated by the program and the activities of the graduates continue unabated. The accomplishments made during the 5 years of the program have been documented in a series of four books with the overall theme of "Sports Science and an Active Life". We are proud to present this substantial body of research in the following series of books: Vol. 1: *Sports Management and Sports Humanities* (Kohei Kogiso, Daichi Oshimi, Munehiko Harada, Eds.), Vol. 2: *Physical Activity, Exercise, Sedentary Behavior, and Promoting Health* (Satomi Oshima, Zhen-Bo Cao, Koichiro Oka, Eds.), Vol. 3: *Sports Performance* (Tomoyuki Nagami, Jun Tsuchiya, Eds.), and Vol. 4: *Sports Injuries and Prevention* (Tetsuya Ogawa, Mako Fukano, Toru Fukubayashi, Eds.). The series was written by the dedicated faculty members and young graduate students and postdoctoral researchers under the guidance of investigators who took part in the Global COE program. The series was also contributed to by leading researchers around the world, most of whom belong to Waseda University's research institute or university partners. I appreciate their contributions as well as their participation in the Global COE program. During the 5 years of the program, an international network of individuals and universities doing active research in the area of sports sciences has been established. I expect this network to grow wider and stronger in the future and to contribute to the solution of many of the health problems that plague modern societies. We will all continue to work hard to involve sports activities in the solutions to these problems, and in the process, aid in advancing the sports activities themselves.

Finally, I express my appreciation to the editors of each volume, who not only did a fine job of organizing the volumes but also wrote chapters that were important scientific contributions to the overall effort. We would also like to thank the Global COE staff for their efficient work and the kind support they extended to the graduate students. Drs. Larry Crawshaw and Candace S. O'Connor are thanked for their enthusiastic editorial assistance.

Program Leader
Global COE "Sport Sciences for the
Promotion of Active Life"
Waseda University

Kazuyuki Kanosue

Preface

The aim of this book is to present current views about physical activity and the benefits of physical activity in preventing and ameliorating various health conditions that are of worldwide concern. This book was developed as a compilation of the accomplishments of the 5-year Global COE (Center of Excellence) "Sport Sciences for the Promotion of Active Life" Program at the Faculty of Sport Sciences of Waseda University, Saitama, Japan. The first part establishes the research methodology and discusses the current status of physical activity. Topics covered include the prevalence of physical inactivity and highly sedentary behavior in different populations as well as strategies that can be adopted to promote physical activity. The second part focuses on the physiological effects of physical activity. Topics covered include physiological responses to exercise by the autonomic nervous system, the endocrine system, vascular functioning, postprandial blood glucose control, and inflammatory processes. The relationship between exercise and appetite is discussed, as is the influence of exercise on food intake and weight regulation. Additionally, the influence of exercise on protein regulation and posttranslational modifications is introduced. The final part discusses the role of physical activity in preventing lifestyle-related health issues and improving the quality of life, especially for the elderly. The contents should be of interest to anyone who is concerned with the human physiologic response to exercise and the promotion of healthy lifestyles, including sports and exercise science researchers as well as those involved with medicine, public health, physiology, nutrition, and elder care.

This book was written by distinguished researchers in this field all around the world as well as by dedicated faculty members and young graduate students and researchers of Waseda University who took part in the Global COE program. We feel extremely fortunate that this group of globally renowned researchers have contributed to this book. Without their involvement the book would not exist. We are especially grateful for the contribution of the following researchers and their students or collaborators: Dr. Stuart J.H. Biddle, Victoria University, Melbourne, Australia; Dr. Takemi Sugiyama, Swinburne University of Technology, Melbourne,

Australia; Dr. Neil King, Queensland University of Technology, Australia; Dr. Todd A. Hagobian, California Polytechnic State University, San Luis Obispo, U.S.A.; and Dr. Zsolt Radák, Department Chairman of the Sports Science Department, Semmelweis University, Hungary. Japanese contributors include Dr. Toshio Moritani, Kyoto University; Dr. Kiyoshi Sanada, Ritsumeikan University; Dr. Shizue Masuki, Shinshu University; and Drs. Yoshiko Ishimi and Shigeho Tanaka, National Institute of Health and Nutrition. To organize manuscripts from the divergent fields into one book that promotes exercise physiology was no easy task. However, now the book has become a reality.

Saitama, Japan — Satomi Oshima
Shanghai, China — Zhen-Bo Cao
Saitama, Japan — Koichiro Oka

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Part I
Current Status of Physical Activity and Sedentary Behavior Research

Chapter 1
Physical Activity Levels and Physical Activity Recommendations in Japan

Zhen-Bo Cao

Abstract The significant roles that physical activities play in improving the public's health and preventing and controlling chronic diseases are now well established, and physical activity has become recognized as a major health-enhancing behavior. This chapter provides an overview of the current recommendations for physical activity in Japan and briefly summarizes current information on the status of objectively-measured physical activity in Japanese adults. Physical Activity Guideline for Health Promotion 2013 established by the Ministry of Health, Labour and Welfare of Japan recommended that adults (20–64 years) should engage in at least 60 min of moderate- to-vigorous-intensity physical activity (MVPA) per day (equivalent to 23 metabolic equivalent (MET)-h per week of MVPA) while older adults (65 years and older) should engage in at least 40 min of physical activity at any intensity per day (equivalent to 10 MET-h per week of MVPA) to maintain health and fitness. According to direct studies of step-count equivalents to the current physical activity guidelines, 10,000 steps/day represented the optimal threshold for likelihood of accumulating at least 23 MET-h per week of MVPA. The National Health and Nutrition Survey of Japan (NHNS-J 2012) showed that the majority of Japanese adults perform inadequate amounts of exercise; only 36 % of men and 28 % of women aged 20 years or older regularly exercise for at least 30 min two or more times a week. Prefectures with relatively low levels of ambulatory physical activity are concentrated in the northeast and west. According to both population-based research and national surveys, Japanese adults take between 6,200 and 9,700 steps/day which is below the recommended 10,000 steps/day. Time trends for physical activity as measured by steps has shown that mean steps/day declined from peak values in 2003–2005 to values in 2008 by 550 steps/day among men and by 817 steps/day among women.

Keywords Physical activity guideline • Physical activity status • Metabolic equivalent • Pedometer • Accelerometer

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K. Kanosue et al. (eds.), *Physical Activity, Exercise, Sedentary Behavior and Health*, DOI 10.1007/978-4-431-55333-5_1

1.1 Introduction

Physical activity refers to all movement produced by skeletal muscles that increases energy expenditure resulting in energy expenditure above the resting level (ACSM 2013). The association of regular physical activity with increased health benefits has been well documented. People who are physically inactive are at higher risk of several non-communicable diseases (NCDs) and mortality (Haskell et al. 2007; Lee et al. 2012). In 2009, the World Health Organization (WHO) highlighted the importance of physical inactivity and identified physical inactivity as the fourth leading risk factor for global mortality (WHO 2010). Lee et al. (2012) reported that 9.4 % of deaths from any cause are attributable to physical inactivity; physical inactivity causes 6 % of the burden of disease from coronary heart disease, 7 % of type 2 diabetes, 10 % of breast cancer, and 10 % of colon cancer worldwide. In Japan, physical inactivity is identified as the 3rd greatest risk factor of mortality due to NCDs, preceded only by smoking and hypertension (Ikeda et al. 2012).

During the last half of the twentieth century, physical activity became recognized as a major health-enhancing behavior. However, current global physical activity trends show that more than 30 % of adults are physically inactive (Hallal et al. 2012). Accordingly, promoting physical activity has become a public health priority worldwide (WHO 2010), and numerous physical activity guidelines have been published by government agencies, professional organizations, and associations to provide information and guidance on the types and amounts of physical activity sufficient to offer substantial health benefits (Haskell et al. 2007; WHO 2010; Tremblay et al. 2011; Department of Health, United Kingdom 2011; Australian Government Department of Health and Ageing 2013; Ministry of health and Japan 2013).

Because it is a health-enhancing behavior, it is essential to have a clear understanding of the current status of physical activity and of evaluation criteria that can be used to determine the prevalence of physical activity or inactivity. This chapter will provide an overview of the current recommendations for physical activity in Japan and briefly summarize current information on the status of physical activity, especially objectively-measured physical activity, in Japanese adults.

1.2 National Physical Activity Guidelines for Japan

Usually, physical activity guidelines are expressed in terms of time or energy expenditure (metabolic equivalent, MET). One MET is defined as the amount of oxygen consumed while sitting at rest and is equal to 3.5 ml/kg/min of O_2. A number of international and national health authorities have produced similar guidelines recommending that adults accumulate at least 150 min of weekly moderate- to vigorous-intensity physical activity (MVPA) in bouts of at least 10 min (Haskell et al. 2007; WHO 2010; Tremblay et al. 2011).

1.2.1 National Physical Activity Guidelines for the Japanese People

In 2000, the Ministry of Health, Labour and Welfare of Japan established "National Health Promotion in the twenty-first century (Health Japan 21)" which focused on primary prevention, extended healthy life expectancy, and enhanced quality of life, and set specific targets to serve as an index for national health/medical standards and to promote healthy living objectives based on assessments. 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 introduced since then. Health Japan 21 set a physical activity goal of adding 1,000 steps to one's current daily total. In spite of the efforts represented by "Health Japan 21", the average number of steps/day has failed to increase during the past 10 years. However, an increase in the percentage of people possessing awareness about the importance of physical activity and exercise was observed. The Ministry of Health, Labour and Welfare of Japan revised "Health Japan 21" in 2012 [Health Japan 21 (2nd edition)], setting a new national step count target of 8,500 and 9,000 steps/day for adult, non-elderly females and males, respectively (Table 1.1). Furthermore, the "Smart Life Project" was launched with the slogan "Firstly, physical activity and exercise. Secondly, diet and complete smoking cessation. Lastly, medication". This places further emphasis on the important role of physical activity and exercise in health promotion and the prevention of chronic disease.

In 2006, the Ministry of Health, Labour and Welfare of Japan revised its previous physical activity guidelines to provide information and guidance on the amount of physical activity recommended to maintain health and fitness and recommended that Japanese adults should engage in a minimum of 23 MET-h per week of MVPA, which is more than twice the volume of activity in the recommendation of 150 min/week of MVPA. The Ministry of Health, Labour and Welfare of Japan revised the physical activity guideline in 2013 (Physical Activity Guideline for Health

Table 1.1 National physical activity guidelines for Japan

	Physical activity guideline for health promotion 2013	Healthy Japan 21 (2nd edition)
Ages: 18–64	60 min/day of MVPA (equivalent to an activity lasting approx. 23 MET-h/week at an intensity of 3 METs), of which 60 min/week should be active exercise (equivalent to an exercise lasting approx. 4 MET-h/week at moderate- to vigorous-intensity)	9,000 steps/day for men
		8,500 steps/day for women
Ages: 65+	40 min/day of physical activity at any intensity (the equivalent to an activity lasting approx. 10 MET-h/week)	7,000 steps/day for men
		6,000 steps/day for women
Ages: 18+	Walking in 10 min increments once every day; 30 min of moderate- to vigorous-intensity exercise twice or more per week	

Promotion 2013), with slight changes to recommendations of aerobic activity for different age groups (Table 1.1). Significant additions included a physical activity recommendation that adults aged 65 years and older undertake at least 40 min of physical activity per day at any intensity (equivalent to an activity lasting approximately 10 MET-h/week). In addition, the Physical Activity Guideline for Health Promotion 2013 also recommends that Japanese people should walk in 10 min increments once a day and engage in 30 min of moderate- to vigorous-intensity exercise two or more times per week. Unlike other physical activity guidelines, the Physical Activity Guideline for Health Promotion 2013 does not refer to MVPA in bouts of at least 10 min. Recent studies found that the association of sporadic MVPA (activity in bouts of <10 min) with several cardiovascular risk factors and metabolic syndrome was similar to the association for bouts of MVPA (activity in bouts of ≥10 min) (Glazer et al. 2013; Clarke and Janssen 2014).

1.2.2 Steps/Day Translation of the National Physical Activity Guidelines for Japan

Steps/day is an increasingly popular indicator of physical activity volume. Tudor-Locke and Bassett (2004) proposed a graduated step index to classify pedometer-determined habitual physical activity in adults: (1) <5,000 steps/day ('sedentary'); (2) 5,000–7,499 steps/day ('low active'); (3) 7,500–9,999 steps/day ('somewhat active'); (4) 10,000–12,499 steps/day ('active'); and (5) ≥12,500 steps/day ('highly active'). Previous physical activity guidelines in Japan have encouraged adults to achieve 10,000 steps/day (an amount equivalent to at least 20–30 min of moderate-intensity walking or other exercise most days of the week). This steps/day recommendation can be traced to the 1960s when Japanese walking clubs embraced a pedometer manufacturer's (Yamasa Corporation, Tokyo, Japan) nickname for their product: manpo-kei (literally translated, "ten thousand steps meter") (Hatano 1993). Yoshiro Hatano (1993) reported that 10,000 steps/day is approximately equal to an energy expenditure of 300 kcal/day for an average middle-aged Japanese man. Health Japan 21 (2nd edition) set a national step count target of 8,500 and 9,000 steps/day for females and males, respectively (Ministry of Health Labour and Welfare of Japan 2013). Steps/day recommendations are also directed towards current physical activity guidelines, so as to provide further options for achieving those goals. Recent Japanese physical activity guidelines encourage at least 23 MET-h/week of MVPA and indicate that 23 MET-h/week of MVPA is approximately equivalent to 60 min of MVPA or 8,000–10,000 steps/day (Ministry of Health Labour and Welfare of Japan 2013). However, this step count recommendation is not evidence-based. It is based on an assumed daily level in Japanese adults of 2,000–4,000 steps/day of low intensity unconscious activity (<3 METs), with each additional 60 min of MVPA adding 6,000 steps. There is a need to adopt evidence-based steps/day recommendations to ensure harmony with existing physical activity guidelines.

Researchers have attempted to establish the association between current physical activity guidelines and steps/day recommendations and to translate physical activity recommendations into a pedometer-based step goal for the Japanese population. Murakami et al. (2012) performed a study to determine daily step counts corresponding to 23 MET-h/week of MVPA in a large sample of Japanese adults. They reported that 8,500–10,000 steps/day, a number similar to the recent Japanese physical activity recommendation of 8,000–10,000 steps/day, was indicated as the optimal daily step count for achieving 23 MET-h/week of MVPA. However, subjects in their study had high levels of physical activity (subjects walked an average of 9,600 steps/day, and approximately 48 % of subjects achieved ≥23 MET-h/week of MVPA) compared to the general population (men in the general population average 7,139 steps/day, and women average 6,257 steps/day). In addition, the activity monitor (Actimarker EW4800; Panasonic Electric Works, Japan) used in their study undercounted steps at slow walking speeds, and its production and sales have been suspended. Cao et al. (2014) measured steps and MVPA with the an accelerometer-based activity monitor (Kenz Lifecorder; Suzuken, Nagoya, Japan) in a large sample of Japanese adults ($n = 940$) and analyzed the data with a linear regression model and Receiver Operating Chacteristic (ROC) methodology to determine the optimal number of steps/day needed to meet the current physical activity guidelines. They reported that approximately 10,000–11,000 steps/day, corresponding to the "active" level of a graduated step index for healthy adults, are needed for Japanese adults to exert at least 23 MET-h/week of MVPA. They found that current recommended step counts of 8,000–10,000 steps/day in Japan are equivalent to only 12–19 MET-h/week, falling short of the recommended 23 MET-h/week of MVPA. They also found that the current recommended 8,000–10,000 steps/day actually overestimate the proportion of their subjects who are meeting physical activity guidelines (23 MET-h/week of MVPA) by 17–40 %. Such an overestimation could be dangerous because it could lead individuals to underestimate their own health risks. Thus, 10,000 steps/day is a reasonable daily step count for achieving 23 MET-h/week of MVPA for Japanese adults. Cao et al. (2014) also reported that subjects who accumulated 7,700–8,000 steps/day were highly likely to accumulate ≥150 min/week of MVPA.

1.3 Levels of Physical Activity in Japanese Adults

Subjective self-reporting questionnaires have served as the primary means to assess physical activity during the last 50 years (Haskell WL 2012). However, self-reported physical activity measures can suffer from vulnerability to social pressure and recall biases (Tudor-Locke et al. 2011), and perhaps their greatest limitation is their inability to accurately assess unstructured and incidental ambulatory physical activity, which may account for a greater proportion of total physical activity in sedentary people (Cao et al. 2014). Advances in electronic sensor technologies have prompted a shift away from self-reporting methods in favor of objective monitoring (e.g., accelerometers and pedometers) for physical activity assessment.

1.3.1 Research Findings of Physical Activity Levels

Several studies have objectively assessed physical activity in Japanese adults via pedometry or accelerometer (Nawata et al. 2006; Kishimoto et al. 2010; Inoue et al. 2011; Murakami et al. 2012; Oshima et al. 2012; Cao et al. 2014). The average daily step count in these studies has ranged from 6,500 to 9,669 steps/day. According to the findings in two of the six studies (Nawata et al. 2006; Oshima et al. 2012), Japanese adults would be categorized as 'low activity' on average (i.e., taking <7,500 steps/day); other studies (Kishimoto et al. 2010; Inoue et al. 2011; Murakami et al. 2012; Cao et al. 2014) would classify Japanese adults as 'somewhat active' (i.e., taking 7,500–9,669 steps/day).

Cao et al. (2014) identified the objectively-measured physical activity levels of 940 Japanese adults (480 women, 460 men) aged 20–69 years who took part in the Exercise and Physical Activity Reference and Guide for Health Promotion Study (EPARGHP) conducted in four Japanese cities (Tokyo, Chita-gun, Okayama, and Matsumoto) from 2007 to 2009. All participants wore an accelerometer (Lifecorder, SUZUKEN Co Ltd., Japan) for 7 consecutive days to record their step count data and the amount of their physical activity-related energy expenditure (PAEE) that was spent in MVPA. The results showed that minutes and PAEE spent in MVPA and number of steps averaged over 7 days were 28.2 min/day, 2.1 MET-h/day, and 8,776 steps/day, respectively, in this cohort. They reported that the amount spent in MVPA, including both minutes and PAEE, was higher in men (29.7 min/day; 15.2 MET-h/week) than in women (26.8 min/day; 13.9 MET-h/week), but no significant difference in step count per day existed between men (8,793) and women (8,760). In addition, 62.6 % of men and 54.8 % of women met the recommendation of 150 min/week of MVPA, while 18.5 % of men and 15.0 % of women met the current physical activity recommendation of 23 MET-h/week of MVPA.

Inoue et al. (2011) reported on accelerometer-measured (Lifecorder, SUZUKEN Co Ltd., Japan) step counts in Japanese adults. They analyzed data from 790 individuals (421 women, 369 men) aged 20 year or older who took part in a cross-sectional mail survey that was conducted in four Japanese cities (Koganei, Tsukuba, Shizuoka, and Kagoshima) from February 2007 to January 2008. They reported that men and women took an average of 8,763 steps/day and 8,242 steps/day, respectively, while 29.0 % of men and 27.8 % of women took 10,000 steps/day.

Kishimoto et al. (2010) studied the physical activity levels of 1,878 Japanese adults (1,111 women, 767 men) aged 20 years or older in Hisayama Town of Fukuoka Prefecture from June to August 2009. The study participants were asked to wear an accelerometer (Active Style Pro HJA-350IT, Omron Healthcare Co., Ltd, Japan) for more than 7 days to record their step count data. On average, adults in Hisayama Town took fewer than 6,500 steps/day; men took more steps/day (6,499) than women did (6,061). An age-related decline in steps/day was observed.

Murakami et al. (2012) investigated the objectively-measured physical activity levels of 1,837 Japanese adults (989 women, 848 men) aged 23–69 years who participated in the Nutrition and Exercise Intervention Study (NEXIS, $n=773$)

conducted in Tokyo and the Saku Control Obesity Program (SCOP, $n=1{,}064$) conducted in Saku, Nagano prefecture. All participants were instructed to wear an accelerometer (Actimarker EW4800, Panasonic Electric Works, Japan) for more than 14 days to record their step count data and the PAEE spent in MVPA. They found that adults took an average of 9,564 steps/day, 9,594 steps/day in men and 9,537 steps/day in women. They also reported that approximately 48 % of adults met the recommendation of ≥23 MET-h/week of MVPA; adults in NEXIS took more steps/day (10,517) than those in SCOP (8,871).

Oshima and colleagues (2012) reported objectively-measured physical activity levels of 455 Japanese adults (224 women, 231 men) living in Kyoto prefecture using a triaxial accelerometer (HJA-350IT, Active style Pro, Omron Healthcare Co., Ltd. Japan). Their findings showed that mean PAEE spent in MVPA and steps/day were 28.0 MET-h/week and 7,293 steps/day in men, 26.4 MET-h/week and 6,607 steps/day in women.

Nawata et al. (2006) examined the relationship between the number of steps measured by a Yamasa pedometer (BIG EM-285, Yamasa Co. Ltd., Tokyo, Japan) and body mass index (BMI) among 310 Japanese male workers aged 30–59 years in the Tokyo metropolitan area. They reported that male workers attained an average physical activity level (PAL) of 1.5 and took an average of 10,682 steps/day on working days and 7,135 steps/day on holidays.

Ishikawa-Takata et al. (2008) investigated total energy expenditure (TEE) and PAL determined by the doubly-labeled water (DLW) method in 150 healthy Japanese adults (76 women, 74 men) aged 20–59 years. They reported that the average TEE and PAL were 10.78 ± 1.67 MJ/day and 1.72 ± 0.22 for males, and 8.33 ± 1.31 MJ/ day and 1.72 ± 0.27 for females. The minimum of the average PAL values in sex and age groups was 1.58 ± 0.29 for females in their 20s and the maximum was 1.78 ± 0.20 for 30-year-old males. PAL for 20- to 29-year olds was lower than in the other age groups; however, there were no significant differences in TEE and PAL among age groups, sexes, and areas.

1.3.2 National Physical Activity Level Surveys

The National Health and Nutrition Survey of Japan (NHNS-J) has collected nationally-representative data on levels of physical activity measured by a spring-levered pedometer (AS-200, Yamasa Co. Ltd., Tokyo, Japan) and as reported using a questionnaire since 1989. According to the most recent NHNS-J (2012), the average steps/day taken by Japanese residents aged 20 years and older was less than 7,000 steps/day, with Japanese men taking 7,139 steps/day and Japanese women taking 6,257 steps/day. These values decreased steadily throughout the age groups until they averaged approximately 5,223 steps/day in men and 4,285 steps/day in women over 70 years of age (Fig. 1.1). This is far below the recommended 10,000 steps/day. Time trends for physical activity as measured by steps taken showed that mean steps/day declined by 550 steps/day among men and by 817 steps/day among

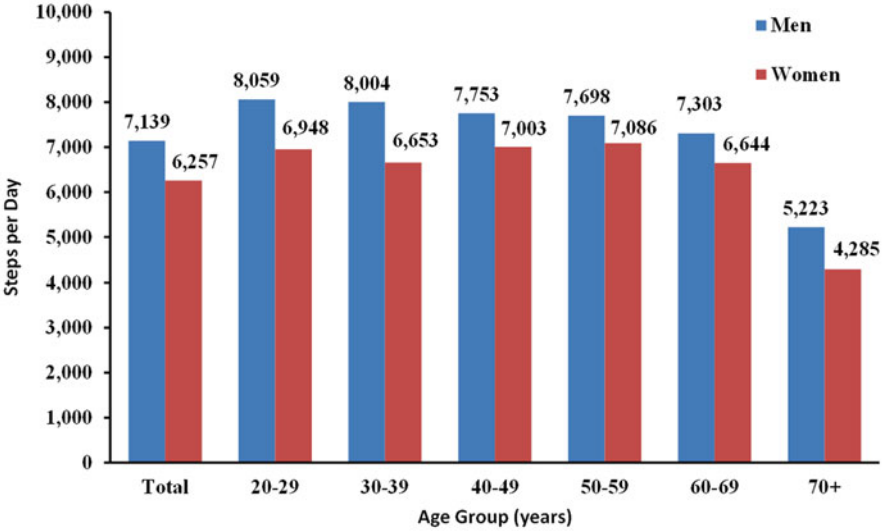

Fig. 1.1 Pedometer-determined physical activity levels (steps/day) in Japanese adults (aged 20 years or older, by gender/age categories) (The data were obtained from the National Health and Nutrition Survey Japan, 2012)

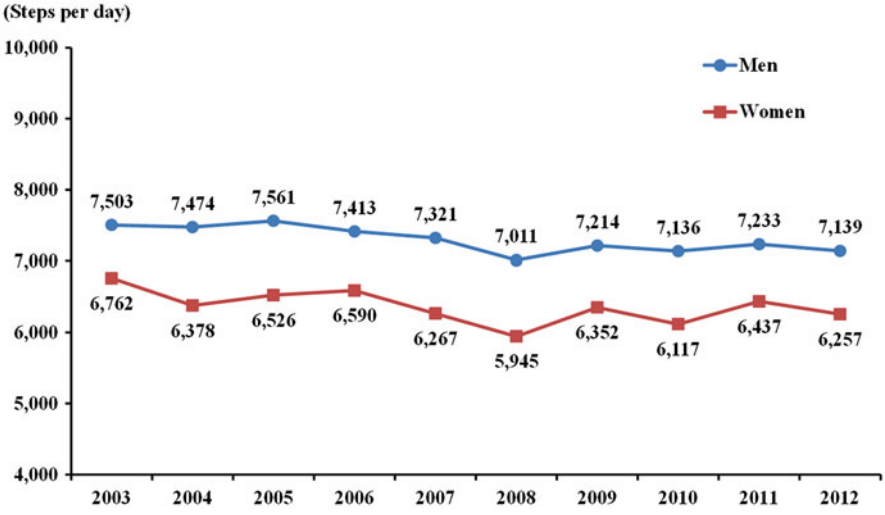

Fig. 1.2 Annual variation in the physical activity levels (steps/day) in Japanese adults (aged 20 years or older, by gender categories) (The data were obtained from the National Health and Nutrition Survey Japan, 2012)

women from peak values in 2003–2005 to values measured in 2008 (Fig. 1.2). These trends also show that the number of steps/day has remained relatively stable in Japan over the past 5 years (Fig. 1.2).

According to the NHNS-J 2012, the most active prefectures include Hyogo for men (Fig. 1.3) and Chiba for women (Fig. 1.4). The prefectures with relatively low levels of physical activity include a group of prefectures in the northeast and west, for example, Aomori, Akita, and Nagasaki (Figs. 1.3 and 1.4), in which adults fall into the "low-active" category (i.e., 5,000–7,500 steps/day) using the step index of Tudor-Locke and Bassett (2004).

Results of a subjective self-reported exercise-habits questionnaire presented in the NHNS-J (2012) also revealed that the majority of Japanese adults perform inadequate amounts of exercise, and the percentage of regular exercisers who exercise at least 2 days a week, 30 min or more each time, and have continued doing so for at least 1 year, was 36.1 % of men and 28.2 % of women aged 20 years or older. This is an approximately 1.3 % increase in men and 0.3 % decline in women from 2010 (Fig. 1.5). Even though the percentage of regular exercisers continues to rise, the exercise rate is still far less than the target rate of a 10 % increase established by Healthy Japan 21 (2nd edition). Unlike steps/day, there is an age-related increase in the percentage of regular exercisers, especially beyond 60 years of age (Fig. 1.6). Those who are over 60 years old are likely to have higher health awareness and more time than younger people heavily involved in work activities.

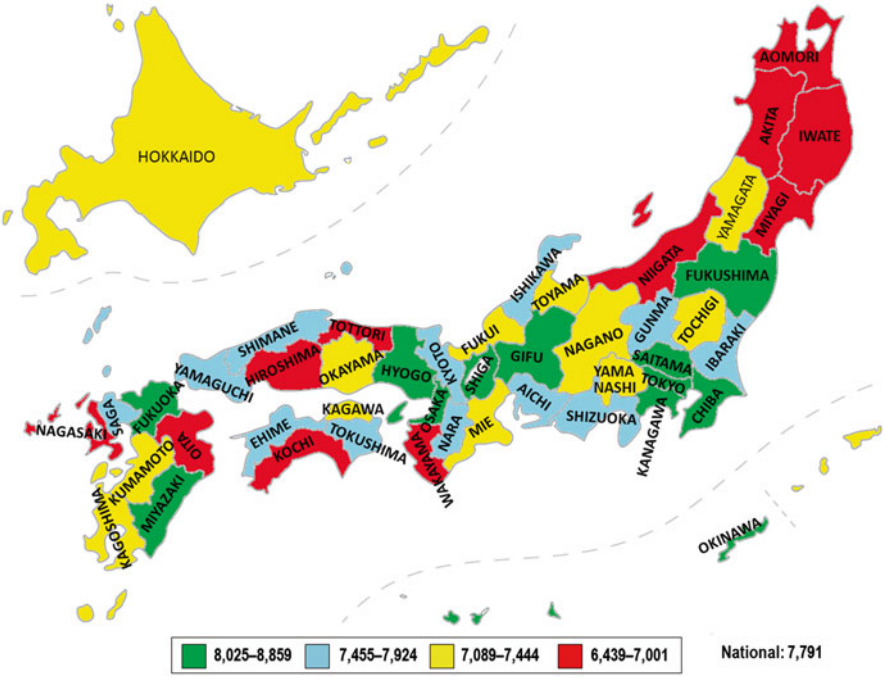

Fig. 1.3 Current physical activity levels (steps/day) of Japanese men (aged 20–64 yeras) in each prefecture (The data were obtained from the National Health and Nutrition Survey Japan, 2012)

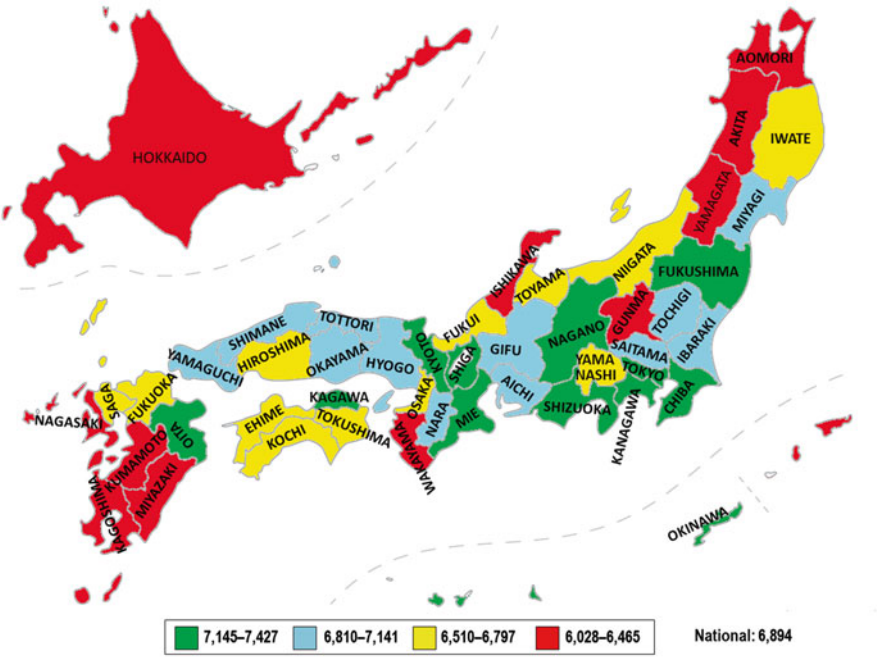

Fig. 1.4 Current physical activity levels (steps/day) of Japanese women (aged 20–64 years) in each prefecture (The data were obtained from the National Health and Nutrition Survey Japan, 2012)

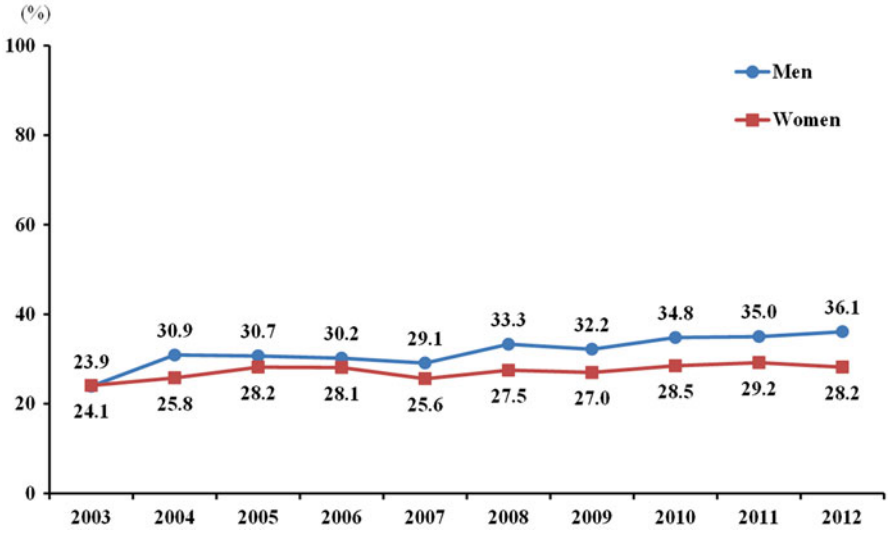

Fig. 1.5 Annual variation in the percentage of regular exercisers in Japan (aged 20 years or older, by gender categories) (The data were obtained from the National Health and Nutrition Survey Japan, 2012)

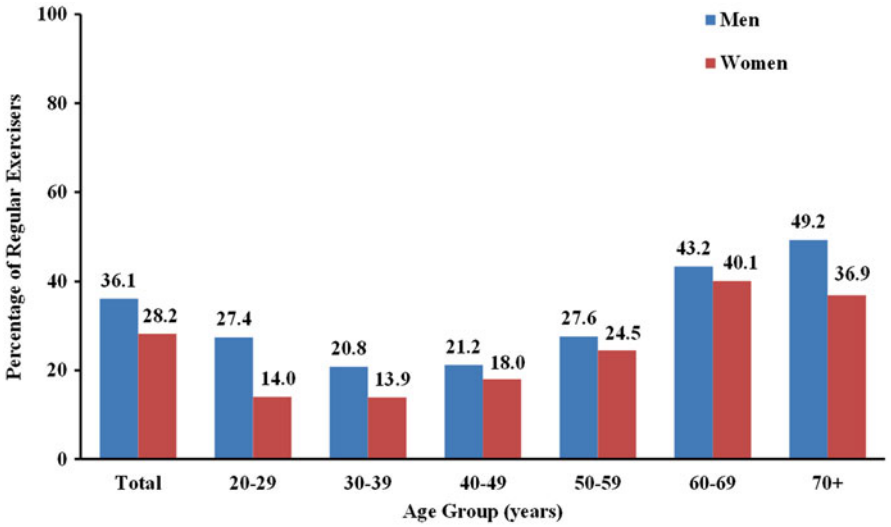

Fig. 1.6 The percentage of regular exercisers in Japan (aged 20 years or older, by gender/age categories) (The data were obtained from the National Health and Nutrition Survey Japan, 2012)

1.4 Summary

We have provided an overview of the current recommendations for physical activity in Japan and current information on the status of physical activity in Japanese adults. Some problems still exist in the physical activity guidelines and in the results of a survey on the status of physical activity in Japanese adults. The NHNS-J monitors levels of physical activity using spring-levered pedometers which are more affected by adiposity and less sensitive to low force accelerations (such as slow stepping) than accelerometer-based activity monitors, leading to underestimation of physical activity. Thus, caution should be applied when comparing NHNS-J with other cohort studies that use accelerometer-based activity monitors. The current recommendations of physical activity are mainly based on evidence in Western countries (e.g., Canada, the USA, Australia, and Europe) and on subjectively-assessed information about physical activity. Subjective measures of physical activity have been found to have several limitations, such as vulnerability to social pressure and recall bias. Technical development has offered some new, objective methods (e.g., accelerometers and pedometers) to monitor physical activity. Thus, further work is required to provide more evidence on the association between objectively-measured physical activity and health in Japan in order to improve the current physical activity guideline.

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Chapter 2
Population Strategy for Physical Activity Promotion in the Community

Takashi Arao

Abstract The importance of population-wide interventions for disease prevention and health promotion has been increasingly recognized among both researchers and health professionals. To stimulate and accelerate research on community-wide intervention for physical activity promotion, the strategies used for and scientific evidence of community-wide intervention program effectiveness were reviewed and the profile of our research, which is intended to promote physical activity in the whole population, of the community was described.

Keywords Population strategy • Physical activity • Community intervention • Health promotion

2.1 Introduction

The importance of health promotion has been growing in Japan as the society ages. In particular, the expectation of social benefits from reducing medical, health care, and long-term care expenses has been increasing, in addition to the personal benefits of disease prevention and health promotion. A number of recent reviews have suggested that a population strategy for community intervention seems to be the most successful way to achieve these public health benefits (Baker et al. 2011; Heath et al. 2012; Kahn et al. 2002; Sallis et al. 1998). This intervention strategy utilizes a multi-component approach, including educational, informational, political, and environmental aspects. Therefore, the population strategy for health promotion is complex; different sectors will be required to participate and collaborate if it is to be successful. In the past two decades, physical inactivity or a sedentary lifestyle has been recognised as a significant public health issue that needs to be addressed (Blair and Brodney 1999; Booth et al. 2012; Lancet 2012). Political approaches to promote physical activity at the national, regional, and local levels have been tried in Japan and in many other developed countries (Belanger and

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K. Kanosue et al. (eds.), *Physical Activity, Exercise, Sedentary Behavior and Health*, DOI 10.1007/978-4-431-55333-5_2

Foster 2011; Kohl et al. 2012; Rutten et al. 2013). However, the effect of community-wide intervention upon physical activity has not been clearly identified.

In this chapter, to encourage research on community-wide intervention to promote physical activity, the strategies used for and scientific evidence underlying community-wide interventions are reviewed and our research, which was intended to promote physical activity at the level of the whole population of the community, is described.

2.2 Review of a Population Strategy for Physical Activity Promotion

It is well recognised that physical activity behaviors are affected by personal, social, and environmental factors (Baker et al. 2011; Kahn et al. 2002; Sallis et al. 1998). Therefore, a population strategy to promote increased physical activity should be implemented using diverse approaches, including community-based informational, behavioural, social, political, and environmental approaches. A model that incorporates comprehensive factors associated with the promotion of physical activity was used to implement an intervention and to asses the effectiveness of the population strategy.

2.2.1 Model of the Population Strategy for Physical Activity Promotion

Since the US Surgeon General's report on physical activity in 1996, public health agencies have focused on how to promote physical activity in communities, particularly in sedentary groups. In 1996, the Premier of New South Whales (NSW) in Australia established the NSW Physical Activity Task Force to develop a comprehensive strategic plan for promoting physical activity in NSW. This Task Force developed an integrated intersectoral strategic framework for physical activity promotion and a joint action plan for achieving the targets (New South Wales Physical Activity Task Force 1997). This framework for physical activity promotion consisted of three strategic goals:

- to increase safe and ongoing participation in physical activity, particularly among less active people;
- to develop quality infrastructure, opportunities, programs, and services to support participation;
- to realise the social, health, environmental, and economic benefits of participation.

These goals accompanied four strategic themes (program development and implementation, education and information, policy and guideline development, and monitoring and evaluation) and three focus areas (people, organizations, and environments).

Sallis et al. (1998) proposed a conceptual model for developing and implementing environmental and policy interventions to promote physical activity based on a ecological model of behavior. This model was adapted from the work of the NSW Physical Activity Task Force and emphasized the creation of supportive policies and environments. In this model, complex programs are planned and implemented by interdisciplinary teams such as advocacy or planning groups which include representatives of several agencies or organizations within a community. Sallis et al. (1998) also proposed identifying potential environmental and policy influences on four domains of active living: recreation, transportation, occupation, and household activities.

In 2011, the Cochrane Public Health Group published a review of community-wide interventions for increasing physical activity. In this review, (Baker et al. 2011) developed a logic model to evaluate the effects of community-wide interventions upon population levels of physical activity. The framework of this model divides actions into two phases, a community strategy development phase and an implementation phase. The community strategy development phase consists of community intervention actions to identify target groups, populations, the delivery setting, stakeholders, and intervention options. The implementation phase consists of actions taken to promote physical activity behavior change. Actions include mass media campaigns, community participation or educational events, advocacy, and environmental changes. In this model, variables that could be used to assess impacts and outcomes from short- to long-term were proposed. Short-term impacts include awareness of the physical activity message, improvements in physical activity-related knowledge, improvements to infrastructure that supports physical activity, legislation, and fiscal and policy changes. Medium-term impacts include improvement of physical-activity-related attitudes and beliefs, intention by the members of the targeted community to increase physical activity, increased levels of physical activity/decreased sedentary behaviour or physical inactivity, and improved access to physical activity opportunities. Long-term outcomes include reduced morbidity and mortality due to increased physical activity.

2.2.2 Intervention Components and Theoretical Approaches of a Population Strategy for Promoting Physical Activity

Baker et al. (2011) systematically reviewed community-wide intervention studies of physical activity promotion (Baker et al. 2011). They used a multi-level screening process to narrow the field to 25 papers for their review, and reported the intervention components used in the included studies. In almost all (22) of these studies,

partnerships were first built with local governments or non-governmental organizations. The next most common strategy was individual counseling by health professionals (19 studies), followed by communication strategies using posters, flyers, information booklets, web sites, and maps (18 studies), social marketing through local mass media such as television, radio, newspaper (15 studies), working with specific setting such as workplace, school, community (11 studies), and environmental change strategies (7 studies). Baker et al. (2011) also reported the theoretical perspectives used for developing the intervention strategies in the included studies. Six studies developed an intervention strategy using an ecological approach, 4 studies used a stage-of-change model for choosing the intervention framework, 4 studies based their approach on the social learning model, and 2 studies were founded on the community empowerment model. Other theoretical approaches such as behavioral change due to individual self efficacy, persuasive communications theory, and community organisation principles were used.

2.2.3 Effects of a Population Intervention Strategy for Promoting Physical Activity

Baker et al. (2011) reported the effects of a community-wide intervention strategy on physical activity at a population level as quantified by dichotomous and continuous numbers (Baker et al. 2011).

Eight studies out of 25 included in the review reported the change in physical activity using the proportion of participants who attained a level of recommended physical activity or who were physically inactive. Among these eight studies, only one study showed a significant regular physical activity increase in areas where an intervention took place (Jiang et al. 2008). Intervention in this study was conducted in multiple regions of Beijing, China, using strong regional government intervention strategies such as quarterly 'door-to-door' distribution of handouts, counselling by health practitioners, and identifying people with high risk factors through an intensive individual screening campaign. As a result, the percentage of active people in the intervention areas significantly increased as compared to non-intervention areas. The relative risk (RR) of the percentage of active people adjusted for the difference in baseline values was 1.20 (95 % CI:1.09 ~ 1.31). In other studies, however, no significant effects of community-wide intervention on physical activity at the population level were reported. Although no significant increase in the percentage of active people in the whole population was observed, the subgroup analysis of gender showed a significant increase in the percentage of active men (Lupton 2003) and women (Brown et al. 2006) at the population level. (Lupton et al. 2003) conducted a community intervention based on community empowerment for 6 years in a fishing area in Norway. Men in the intervention area showed an 8.6 % increase over pre-intervention baseline in moderate physical activity for a minimum of four hours per week during the last year of the study; no significant change (0.6 %) was