Abstract Japan is one of the most rapidly aging countries in the world. “Healthy Japan 21” is a Japanese government initiative promoting lifestyle-related disease prevention, health promotion, and successful aging. Increasing physical activity participation among older Japanese, the least physically active of any age group, is especially important for preventing frailty and chronic disease, and the associated health care expenditure. Informed by the research we have to date, the following evidence-based conclusions can be drawn relative to exercise and physical activity for the obese population. A combination of aerobic exercise, resistance exercise and physical activities, in addition to proper diet (mostly caloric restriction: 1200 kcal for women and 1680 kcal for men for a certain period of time), is more effective than either form of intervention alone for reducing body weight, visceral fat, blood pressure, and many other negative health-related variables. Exercise habituation in conjunction with proper diet is also most effective for improving vital age. Incorporating and adhering to these lifestyle factors, coupled with adherence to other known health modifiers (reduced stress, improved sleep, etc) will help reduce individual and population obesity and improve national health.

Keywords: obesity, weight reduction, exercise, diet, visceral fat, vital age
responds with the World Health Organization (WHO) suggested prevalence for Japan\textsuperscript{18}. While this 5 kg/m\textsuperscript{2} difference in BMI corresponds to an approximate 13 kg and 16 kg change in body weight when height is 160 cm and 178 cm, respectively, if an obesity marker of 25 kg/m\textsuperscript{2} were adopted by the United States (US), rates would escalate to as much as 66\% of the total population\textsuperscript{15}. This indicates the current obesity situation in Japan and the US is significantly different. Nevertheless, the prevalence of metabolic disorders, specifically individuals with mild obesity as classified by a BMI of 25 - 30 kg/m\textsuperscript{2}, is still high in Japan\textsuperscript{17,18}.

Although those with a BMI greater than 25 kg/m\textsuperscript{2} and less than 30 kg/m\textsuperscript{2} are classified as overweight, for a Japanese, distinguishing between being overweight and obese is not as important as acknowledging their elevated risk of obesity-related morbidity. In this article, overweight and obesity are used synonymously. Of importance, however, is the need to acknowledge that the severity of obesity and the risk of developing metabolic disorders morbidity varies largely among individuals and depends upon, but is not limited to, ethnicity, gender, age, genetic factors, physical activity, diet, and quality of medical treatment. The criteria for selecting individuals with metabolic syndrome need to be revised; otherwise, the percentage of people who can be erroneously discriminated as having metabolic disorders will increase. If Japan is aiming for a healthier population, improving diagnostic techniques and public and health professional awareness, of the precursors to obesity-related morbidity and mortality, should be a national priority.

### Prevalence of obesity in Japan and its relationship with morbidity and mortality

It seems logical to assume that obesity, and in particular morbid obesity (BMI $\geq$ 35 kg/m\textsuperscript{2}), is a very serious health concern associated with increased morbidity and mortality. Obesity in Japan, regardless of the degree of fatness, is increasing year by year, particularly among men. This has a potential relationship with overeating (i.e., an increase in fat consumption) and/or poor dietary choices, and a lack of physical activity due to the development of various laborsaving devices and increased sedentary behavior. The most recent data from the Japanese National Health and Nutrition Survey reported that, based on a BMI of 25 kg/m\textsuperscript{2} and above, the prevalence of obesity is 29.6\% in men aged 20 - 60 yrs and 21.7 \% in women aged 40 - 60 yrs. Among Japanese men, and using the BMI marker of 30 kg/m\textsuperscript{2}, obesity rates increased from 0.84\% in the 1976 - 80 period to 2.01\% in 1991 - 95\textsuperscript{19}. During the same period, obesity rates in women remained stable at 2.33\%. This is supported by the Organization for Economic Co-operation and Development (OECD) Health Data 2011 Report that shows the same serial trends in increased prevalence of overweight and obesity in Japanese individuals aged 15 yrs or older (Fig. 1). However, these rates are minor (3.9\%) in contrast to the prevalence of obesity in the US (33.8\%) (Fig. 2). As with other countries, close relationships between obesity and various metabolic disorders have been observed among different Japanese population groups (based on BMI, age, gender, etc.). Concerning a precursor to diabetes type II, Sasai et al.\textsuperscript{20} reported that among individuals whose BMI

![Fig. 1: Obesity prevalence from 1978-2009, as a percentage of the total Japanese population (individuals aged 15 years and older). Obesity is defined as a BMI $\geq$ 25 kg/m\textsuperscript{2} or $\geq$ 30 kg/m\textsuperscript{2} [OECD Health Data 2011].](image-url)
was greater than 30 kg/m², the rate of metabolic disorders was significantly higher than among those whose BMI was lower than 25 kg/m². In addition, average systolic blood pressure was higher for men (143 ± 17 mmHg versus 135 ± 17 mmHg) and for women (141 ± 17 mmHg versus 129 ± 17 mmHg) who had a greater BMI, as was total cholesterol, HDL cholesterol, triglycerides, and fasting blood glucose. Ishikawa-Takata et al. demonstrated that an increase in BMI beyond 22 kg/m² was associated with an increased risk for developing hypertension, even after data were adjusted for age, smoking status, alcohol intake, family history and baseline value of systolic blood pressure. In addition, Ishikawa-Takata et al. reported that the risk of hypertension significantly increased for subjects with a BMI greater than 27 kg/m²; and increased risk of diabetes and hypercholesterolemia was observed for subjects with a BMI greater than 29 kg/m².

There is also a relationship between coronary heart disease (CHD) incidents and obesity, particularly among men. As part of the Japan Public Health Center-based (JPHC) prospective study, Chei et al. collected data from 43,235 Japanese men and 47,444 Japanese women, aged 40-69 years, who were community-dwelling. Over a 10-yr follow-up period, men with a BMI ≥ 30 kg/m² at baseline had a multivariable relative risk increase of 1.8 (1.1 - 3.0) and 1.9 (1.1 - 3.2) for CHD and myocardial infarction, respectively, when compared to those with a BMI of 23.0 - 24.9 kg/m². This relationship was not observed for women. These data support earlier work done by Cui et al. in the Japan Collaborative Cohort Study (JACC Study) that found a multivariate relative risk of death from CHD in Japanese men and women of 2.05 (1.35 to 3.0) and 1.58 (0.95 to 2.62), respectively, when compared to those with a BMI of 23.0 - 24.9 kg/m². Moreover, the risk levels remained unchanged when those who died within 5 years of baseline were excluded or when smoking status was taken into account.

Matsuo et al. reported that, for age and gender, the relationship between all-cause mortality and BMI could be illustrated by a U-shaped curve, where those with an unhealthy low or high BMI show an increased level of risk. While data are somewhat mixed, the multivariate-adjusted relative risk for all-cause mortality has been shown to increase with BMI.
to be 2.05 and 1.54 for Japanese men with a BMI less than 18.5 kg/m² and greater than 30.0 kg/m², respectively. In the same study, and using the same BMI markers, the multivariate-adjusted relative risk of all-cause mortality in women was 1.77 and 2.23, respectively. This is supported by Hozawa et al.²³ who demonstrated a relative risk of approximately 1.42 for men with a BMI less than 18.5 kg/m² or greater than 27.0 kg/m². Again, women displayed similar relative risk for the same BMI markers (1.99 and 1.78, respectively).

Exercise- and/or diet-induced weight loss

While research has shown that exercise is a powerful stimulus to reduce adipose tissue and reduce BMI, in our laboratory, studies have shown that diet alone is a more powerful mediator. This was demonstrated by the −8.2 kg, −7.1 kg, and −1.7 kg weight loss achieved when female participants followed a diet + exercise, diet only or exercise only regime, respectively, for 12 weeks²⁴. Similar results were found in males (Table 1)²⁴. This may be related to exercise-related energy expenditure being generally low among these study participants. Take the example of a 60-kg male who expends 240-300 kcal during 60 minutes of walking. If he engages in this exercise at least 3 times per week for 12 weeks, and maintains a balanced diet, he could expect a total body weight loss of up to 1.5 kg. This is supported by exercise-only research interventions that have demonstrated total body weight losses of 0.7 – 2.6 kg in up to 12 months using mainly aerobic activities²⁵-²⁷. In contrast, our work has demonstrated that calorie-restricted diets and calorie-restricted diets plus exercise are more effective in reducing total body weight²⁸. This is also acknowledged in the Curioni and Lourenço (2005)²⁸ systematic review of 33 randomized trials investigating weight loss in overweight and obese adults 18 years or older with a BMI greater than 25 kg/m². The authors concluded diet plus exercise results in significant and clinically meaningful weight loss that could be partially sustained for up to one year. Using these methods, the general agreement, in terms of the quantity of weight loss to avoid an excessive neurohormonal reaction and a disturbance in homeostatic balance among Western populations, is approximately 10% of an individual’s current weight over a period of 6 to 12 months, or up to one-half kg per week²⁹. For the typical Japanese adult (height 160 cm and weight 72 kg), with a BMI of 28.1 kg/m², a 10% weight loss would be 7.2 kg, which at a rate of one-half kg per week, could be safely lost in approximately 16 weeks and lower the individual’s BMI to a more appropriate 25.3 kg/m².

Table 1. Effects of 12-week diet plus exercise intervention versus 12-week exercise only on body weight, visceral adipose tissue and CHD risk factors in obese men²⁴.

<table>
<thead>
<tr>
<th>Items</th>
<th>Diet + Exercise (n=35)</th>
<th>Exercise (n=37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight, kg</td>
<td>-8.2</td>
<td>-1.8</td>
</tr>
<tr>
<td>Visceral adipose tissue mass, kg</td>
<td>-1.1</td>
<td>-0.4</td>
</tr>
<tr>
<td>Visceral adipose tissue area, cm²</td>
<td>-44</td>
<td>-13</td>
</tr>
<tr>
<td>Systolic blood pressure, mmHg</td>
<td>-13</td>
<td>-3</td>
</tr>
<tr>
<td>Diastolic blood pressure, mmHg</td>
<td>-11</td>
<td>-4</td>
</tr>
<tr>
<td>Total cholesterol, mg/dl</td>
<td>-30</td>
<td>-5</td>
</tr>
<tr>
<td>Low-density lipoprotein cholesterol, mg/dl</td>
<td>-20</td>
<td>-2</td>
</tr>
<tr>
<td>High-density lipoprotein cholesterol, mg/dl</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td>Triglycerides, mg/dl</td>
<td>-83</td>
<td>-47</td>
</tr>
<tr>
<td>Glucose, mg/dl</td>
<td>-11</td>
<td>-6</td>
</tr>
</tbody>
</table>

While a reduction in risk factors appears to be specific to each individual, and is dependent on, among other things, the amount and location of weight loss, positive weight loss is known to reduce CHD risk³⁰. In addition, Katsukawa³¹ showed a relationship between relative changes in total body fat and visceral fat following a diet or exercise, or diet plus exercise intervention, with larger reductions in the total body fat associated to greater losses in visceral fat, regardless of which type of intervention was undertaken. Although an independent effect of exercise on visceral fat has been reported in several studies³², the exercise mechanisms that act to induce the additional loss of visceral fat are unclear.

Exercise and visceral fat

Abdominal obesity is assessed by measuring the visceral fat (VF) area either by computed tomography (CT) or by magnetic resonance imaging (MRI). With weight gain, the associated enlargement of visceral fat deposits becomes metabolically active and further facilitates the
pro-inflammatory catabolic state of insulin resistance. In general, a VF area of 100 cm² or greater indicates an increased risk of obesity-related disorders (Examination Committee of Criteria for ‘Obesity Disease’ in Japan; Japan Society for the Study of Obesity, 2002)\(^{14}\).

Several cross-sectional studies have shown the inverse association between physical activity and degree of abdominal obesity\(^{34-36}\), while several randomized trials have demonstrated the positive impact of regular exercise on VF levels\(^{3,12,37}\). Hougham & Ross (2011)\(^{38}\) investigated the effects of a 700-kcal energy deficit induced by daily exercise on MRI-determined VF volume. Among those who exercised regularly, intra-abdominal fat decreased significantly when compared to a control group. In addition, three review articles on the topic of exercise-induced VF loss have been published\(^{39-41}\). Ross and Janssen (2001)\(^{40}\) determined that, in response to short-term, structured physical activity expressed as energy expended per week, total adiposity was significantly reduced. However, they further concluded that, although physical activity was associated with VF reduction, there was insufficient evidence to determine the dose-response relationship. More recently, Ohkawara et al. (2007)\(^{41}\) observed a dose-response relationship between exercise and VF reduction in obese subjects without metabolic-related disorders. Although numerous investigations have been conducted to determine the effects of regular aerobic exercise on VF levels\(^{39}\), results vary considerably with outcomes dependent on the exercise (intensity, frequency, continuous or accumulated bouts, etc.) and the characteristics of the participants at baseline\(^{42}\). Moreover, despite the international accumulation of evidence, little work has been done on the effects of increased physical activity on VF reduction among Japanese. Addressing this shortcoming is important given the greater VF levels displayed among Japanese adults when compared to Caucasians of the same age, BMI, and waist circumference\(^{15}\).

Based on a series of weight loss studies conducted in our laboratory\(^{31,13,43-45}\), Sasai et al. (2008)\(^{46}\) found a proportionally greater loss in VF following exercise alone when compared to diet alone. More recently, we reported that physical activity (PA) intensities modulate the exercise-induced reduction in intra-abdominal fat\(^{45}\). In this study, 37 obese men were divided into a low-volume vigorous PA (n = 19) or high-volume vigorous PA group (n = 18) and data was collected over 12 weeks. PA was assessed by a single-axis accelerometer before and during each exercise regimen, and VF levels were measured before and after each regimen by CT scan. Following the intervention, we observed reductions in VF levels by 18 ± 38 cm² for those in the low-volume group and 30 ± 23 cm² for those in the high-volume group. In addition, we found that time spent in vigorous PA was positively related to VF reduction. This relationship remained after data were adjusting for initial level of VF, time spent in vigorous PA, and for weight change (r = -0.42, P = 0.02). This study showed that the greater the volume, and the more vigorous the PA, the greater the reduction in VF levels in obese Japanese men.

Exercise and metabolic syndrome

Metabolic syndrome (MS) is characterized by inter-related risk factors that increase susceptibility to cardiovascular diseases, diabetes type 2 and all-cause mortality\(^{46}\). In relation to physical fitness, Farrell et al. (2004)\(^{47}\) demonstrated that among 7,104 women, in the Aerobics Center Longitudinal Study, prevalence of MS decreased from 19% among those in the lowest-fitness quintile to 6.0% and 2.3% among those in the intermediate- and highest-fitness quintile, respectively. Weight loss by caloric restriction combined with exercise is commonly employed for management of MS. Recent systematic reviews have reported that a moderate weight loss of 5 - 10% of the baseline body weight is associated with improvement in obesity-related cardiovascular and metabolic abnormalities\(^{48}\), and a reduction in all-cause mortality risk\(^{49-52}\). However, only a few studies have explored the degree of weight loss that is most effective to reverse MS.

It should be noted that the definition of MS, in Japan, differs from that of the World Health Organization (WHO)\(^{53}\), National Cholesterol Education Program (NCEP, 2002)\(^{54}\), and International Diabetes Federation (IDF, 2012)\(^{55}\). In Japan, the Examination Committee for Criteria for Metabolic Syndrome (2005)\(^{56}\) defines MS as abdominal obesity accompanying any two or more of the following: dyslipidemia (triglycerides > 150 mg/dl, and/or high-density lipoprotein cholesterol < 40 mg/dl), hypertension (systolic blood pressure >/= 130 mmHg, and/or diastolic blood pressure >/= 85 mmHg), and/or hyperglycemia (fasting plasma glucose > 110 mg/dl).

Nakata et al. (2009)\(^{51}\) studied the impact of a weight-loss program, incorporating a low-calorie diet with or without exercise, on 323 Japanese women aged 24-67 yrs, with a BMI of 25 - 40 kg/m², and the presence of at least one MS factor. Following the 3-month intervention period, participants showed a moderate weight loss of 8% - 13% and improvement in MS factors. Complementing this work, another study from our laboratory showed that when Japanese women participated in a diet-only or diet plus exercise intervention, the adjusted odds ratio was 1.00 or 3.68 for body weight loss (95%CI, 1.02-17.6) (P = 0.04), respectively\(^{51}\). These studies demonstrate that, for obese Japanese adults with MS prevalence, aerobic exercise or physical activity plus diet intervention is more effective than diet alone at reducing body weight and MS associated factors.

Exercise and body mineral density

Due to reduced nutritional intake, changes in protein turnover and reduced bone loading, dietary-induced
weight loss may be a precursor to bone loss. Therefore, a combination of exercise and diet, which includes the recommended daily intakes of calcium, is suggested for the prevention of bone loss during dieting. In our laboratory, the effects of diet-only or diet plus resistance training on weight loss, whole-body and selected regional bone mineral density (BMD) in 42 obese premenopausal Japanese women was investigated. Following a 14 week intervention period, individuals in the diet group lost $6.2 \pm 3.5$ kg, while those in the diet plus exercise group lost $8.6 \pm 3.6$ kg. However, no statistical differences between groups were found. In addition, no gains in whole-BMD, lumbar spine BMD or 1/3 radial BMD were observed. However, importantly for postmenopausal women, no further losses emerged. While this indicates no additional effect of resistance training, it could be suggested the intervention period was insufficient to observed significant bone remodeling change.

Exercise and overall health status “vital age”

It is not adequate to judge the effectiveness of weight loss programs by the margin of weight loss. The impact of weight loss on other important factors such as physical fitness, blood pressure, lipid profiles, etc. should be included. With this in mind, Tanaka et al. (1990) developed the concept of “vital age” and defined it as “level of biological vitality”, which is computed from a variety of 9 to 11 variables such as physical fitness, blood lipid variables, blood pressure, pulmonary function and body composition. A younger vital age compared with the individual’s actual chronological age means the individual is in good health and well-conditioned; it factors well for prolonging independence, and resisting disease and disability. A series of vital age studies among obese Japanese women suggests that both weight loss by diet plus exercise, or by exercise alone, significantly improves vital age. And, in obese Japanese men, improvements in vital age were similar following a 12-week diet-only (-7.1 yrs) or exercise-only (-6.7 yrs) intervention. In the study by Nakata et al. (2008), vital age became significantly younger, by approximately 5 years, following a diet-only intervention, by 8 years following exercise-only, and by 10 years following a combined exercise plus diet intervention. Large changes in coronary risk factors and physical fitness variables during the intervention contributed substantially to the improvement of vital age in the three groups. In addition, weight reduction yielded an improvement in vital age, which was further enhanced by aerobic exercise adherence.

Healthy lifespan and exercise

In the Americas and Europe, the following six major factors are the primary contributors to the decrease in a healthy lifespan: 1. tobacco use; 2. high blood pressure; 3. increased blood cholesterol; 4. obesity; 5. low levels of physical activity; 6. limited fruit and vegetable consumption. It is very clear that the prevention of obesity and encouragement of exercise are crucial, particularly for pre-obese individuals. Worldwide we have an emergence of data supporting the use of physical activity throughout the lifespan to prolong wellbeing and reduce the risk of later-life disability and morbidity; yet few populations are embracing the international guidelines recommending 30 minutes of physical activity, every day of the week, that incorporate aerobic, strengthening, balance and flexibility components.

Many gerontologists claim that research on aging should not focus on increasing total lifespan, but rather on extending a healthy lifespan, defined as the total number of years a person remains in good health. Given the negative health outcomes associated with obesity, reductions in weight among older adults is an important key to prolonged health. For older adults, regular physical activity (including exercise), that is important in the prevention and management of various chronic diseases, can reduce physical decline and prolong functional capacity in the activities of daily living, and, in addition, reduce the risk of falls and cognitive decline.

Conclusions

Research data, from our laboratory, clearly indicate that a proper diet that incorporates caloric restriction is more effective at reducing the risk factors of metabolic syndrome, compared to any form of exercise alone. Specifically, from our research it is apparent that exercise has less influence than proper diet on reducing visceral adipose tissue, blood pressure, lipid profiles, and liver and kidney function. Our physical activity and all-cause

![Fig. 3](image-url) Changes in vital age in Diet (D) and Exercise (E) groups following 12 weeks of training. *Significant changes within group by paired t-test (P < 0.05). Data are group mean ± standard deviations.
mortality research has struggled to demonstrate the cause-and-effect of exercise with factors such as quantity, speed of walking, physical fitness and energy expended on morbidity and mortality. We acknowledge that exercise is a significant stimulus, and that a combination of diet and exercise has the greatest effect on reducing body weight (Fig. 4) and improving health. However, there is not much longitudinal data examining the effect of diet when compared to that of physical activity. We therefore suggest that more stringent research is needed in this area to answer which is best in preventing chronic disease: diet, physical activity or a combination of the two.

Besides caloric restriction and exercise, other factors such as nutritional education, stress management, and wellness behaviors such as sleeping, regular bathing, regular bowel movements, relaxation and hydration, are also effective mechanisms to promote and maintain weight loss, and play an important role in healthy aging. Consequently, encouraging individuals to adhere to these healthy behaviors is important for wellbeing; but it is also an acknowledged challenge for health professionals. In line with international dietary and nutritional guidelines, it is strongly recommended that allied health professionals, including exercise physiologists, general practitioners, nurses, and physiotherapists, become better educated about the benefits of a healthy lifestyle, so they can communicate, if even in part, these benefits to their clients to increase awareness. It is acknowledged that communicating and implementing professional and behavior change in the population remains a significant challenge; and it might require a government campaign, or similar measures, to catalyze such a paradigm shift. However such a behavioral change is paramount if individuals wish to experience long-term physical independence, health and wellbeing.

References


38) Hougham KA, Ross R. 2011. Evidence that the association...


