Master's thesis

Walking speed and the prevalence of hypertension, diabetes, and dyslipidemia in Japanese middle-aged and older adults: a cross-sectional study

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1. Introduction

1-1. Background

Non-communicable diseases (NCDs) are a group of conditions that result in long term health consequences and have become an emerging pandemic globally, with higher rates and increasing trends in developing countries. These conditions include cancers, cardiovascular disease (CVD), diabetes and chronic lung illnesses (*Noncommunicable Diseases - PAHO/WHO | Pan American Health Organization*, 2022).Diabetes, dyslipidemia and arterial hypertension are major modifiable risk factors for CVD and can be reduced through dietary, behavioural and pharmacological interventions (Hiligsmann et al., 2017). Despite the overwhelming evidence that physical inactivity is one of the leading risk factors of NCDs worldwide, a considerable percentage of the world's population do not meet the recommended levels of physical activity (PA) (*World Health Organization*, 2022; *WHO Highlights High Cost of Physical Inactivity in First-Ever Global Report - PAHO/WHO | Pan American Health Organization*, 2022). To meet PA and public health guidelines, there is clear evidence that walking is one of the most accessible forms of PA and has substantial benefits for health. Walking is the most common type of leisure time PA among adults and has strong potential to improve public health. Walking at a slightly faster pace than your usual may present an opportunity for reducing the risk of NCD as walking plays an important role for cardiovascular health, by increasing physical fitness, heart rate, reducing blood pressure (BP) and subsequently reducing adverse health outcomes that come with aging. Walking speed (WS), also frequently termed as gait speed, may accurately predict mortality, disability and hospitalizations worldwide (Hardy et al., 2007; Purser et al., 2005).WS has been shown to be associated with survival among older adults and has been proposed as a potentially useful and appealing way of screening the functional status of older people in epidemiological cohort studies and clinical settings (Studenski et al., 2011; Syddall et al., 2015).WS has been shown to reflect both functional and physiological changes and has the potential to assess and monitor functional status and overall health, as well as predicting future health status (Middleton et al., 2015). It is possible however, that healthy, more fit individuals walk faster than those who are ailing such as those living with pre-existing conditions and other disabilities such as musculoskeletal disorders or lower back pain (LBP). However current literature reflects more of a relationship with WS and mortality risk independent of total PA, possibly due to the increased exercise intensity of walking at faster speeds. There is currently no literature that can definitively say that walking faster causes better health or having better health leads to faster WS. Furthermore, WS may have the potential to serve as a simple pragmatic screening tool to identify those at risk or in need of interventions to prevent adverse health outcomes.

1-2. The burden of cardiometabolic diseases

NCDs have become an emerging pandemic globally, with higher rates and increasing trends in developing countries. NCDs are attributable to 71% of all deaths and are currently the leading cause of mortality worldwide, posing significant threat and burden to governments and healthcare systems (Chand et al., 2020; Islam et al., 2014; Vandenberghe & Albrecht, 2020). Behavioral risk factors such as elevated BP, blood glucose, blood lipids, and overweight/obesity can be detected in individuals (*Hypertension*, 2023). In Japan, CVD accounts for one of the top contributors to disease burden and accounts for over 20% of total medical expenditures (Mo et al., 2019). Hypertension, diabetes and dyslipidemia are amongst the main chronic NCDs that can lead to pre-mature morbidity and mortality and are major modifiable risk factors for CVD. The promotion of healthier lifestyles and equitable healthcare is therefore imperative in order to reduce the risk of premature mortality and reducing risk factors associated with NCDs (Arena et al., 2015).

1-2-1. Cardiometabolic disease

Cardiometabolic disease (CMD) and cardiometabolic risk factors encompass a combination of metabolic abnormalities and include a group of conditions and interrelated risk factors, primarily hypertension, dyslipidemia, abdominal obesity and elevated triglycerides (Hiligsmann et al., 2017; Kim et al., 2022). CMD is one of the leading causes of death worldwide and contributes to an increase in health expenditures with significant effect on morality in Japan (Ikeda et al., 2012). Pathophysiology of CMD includes changes in insulin resistance (diabetes mellitus), hyperglycemia, dyslipidemia, abdominal obesity and hypertension (Kirk & Klein, 2009). Furthermore, CMD is a multidimensional disease that involves genetic, behavioural, and environmental factors, with major risk factors being physical inactivity, smoking and an unhealthy diet (Sattar et al., 2020). CMD is strongly associated with an increased risk of developing CVD. When coupled with increasing economic burden and the rise of disability and mortality, preventative methods such as early detection and management of individuals at risk is essential in order to prevent a further rise in CMD and related health care burden (Chand et al., 2020; de Waard et al., 2019).

Prevention of risk factors for CMD and public health programs designed to reduce a populations exposure to modifiable risk factors is an urgent public health issue worldwide, as over two thirds of deaths are caused by ischemic heart disease (IHD) and stroke (GBD 2017 Causes of Death Collaborators, 2018). Stroke/cerebrovascular disease is the fourth leading cause of death in Japan after Cancer, heart disease, and pneumonia, in first, second, and third place respectively (*Japan | The Institute for Health Metrics and Evaluation*, 2023). Japan has a unique cardiovascular profile with higher mortality rates from cerebral stroke than coronary heart disease (CHD). Traditionally, the prevalence of stroke is higher for Japanese than for Western populations by about 20-30%. These differences in vascular pathology and CVD, although genetic contributions may exist, are likely due to major differences in lifestyles and diet, such as high sodium intake, low calcium, low animal protein intake, smoking habits, alcohol consumption, long time spent sitting and low levels of PA (Iso, 2011). However, Japan experienced a significant decline in hemorrhagic stroke occurrence since the 1970s until around the 1990s (Iso et al., 2021). This trend is presumed to be largely due to a steady decrease in the mean BP of the entire population as well as a more recent decline in smoking. This is likely due to the contribution of improved preventative measures and emergency medical care such as a reduced intake of salts as well as a population-wide screening of BP (Iso et al., 2021). However, this declining trend slowed down in the 1980s and 1990s possibly due to an increase in the westernization of Japanese lifestyle. Although this is a shift in a more positive direction than before, the increase in the westernization of Japanese lifestyle may cause further issues such as an increase in CMD in the future.

1-2-2. Diabetes Mellitus

Diabetes mellitus (DM) is a metabolic disease involving elevated blood glucose levels and is one of the most common metabolic diseases in older adults (Longo et al., 2019). Pathophysiology of this disease includes insulin insensitivity as a result of resistance and a decrease in insulin production leading up to eventual pancreatic β-cell failure (Olokoba et al., 2012). The health consequences of diabetes are numerous and involve macrovascular and microvascular complications, liver disease, cognitive decline, increased susceptibility to infection, damage to the heart, blood vessels, eyes and nerves (World Health Organization, 2023). According to the World Health Organization (WHO), Diabetes was the direct cause of 1.5 million deaths annually and 48% of these deaths occurred before the age of 70 (World Health Organization, 2023). The increasing prevalence and incidence of Type 2 Diabetes Mellitus (T2DM) are recognized as a pressing public health concern, placing a considerable burden on health expenditures and quality of life, with developing countries bearing the highest burden (Khan et al., 2020). Although the prevalence of diabetes is increasing globally, the situation is particularly alarming in Asian countries as they contribute to more than 60% of the world's diabetic population. These numbers are predicted to steadily and rapidly increase due to socio-economic growth, industrialization and population aging (Ramachandran et al., 2012).

The increasing number of people with DM in Japan is an evident problem and has placed substantial burden on the Japanese healthcare system. DM is one of the most common aging-associated diseases and the prevalence of diabetes in Japan is expected to substantially increase over the next two decades, mainly as a result of Japan's rapidly aging population and an increase in the westernization of Japanese lifestyle (Akter et al., 2017; Charvat et al., 2015). In Western countries, increased consumption of unhealthy diets and sedentary lifestyles resulting in elevated body mass index (BMI), fasting plasma glucose and insulin resistance can be attributed to high rates of disease. However, a relatively larger burden of diabetes in Asian than in Western countries cannot fully be explained by obesity (Hayama-Terada et al., 2016). Asians tend to develop T2DM with a much lower mean BMI compared to Caucasians. DM in Japanese is characterized primarily by reduced insulin secretion along with lower insulin resistance and early β-cell dysfunction, suggesting that Japanese easily accumulate visceral fats (Akter et al., 2017; Kohsaka et al., 2021; Yabe et al., 2015). The vast difference in etiology of diabetes in Japanese compared with that in Western or European populations also highlight that lifestyle changes such as higher fat intake and less PA are greater risk factors for disease than obesity. Due to the much lower prevalence of obesity/overweight compared with other high and middle-income countries, a significant proportion of those at high risk of DM may be missed under nationwide screening. Thus, preventative strategies that target weight loss may not be as effective in Japan and other Asian countries as it is in Western countries. Early detection and facilitating early diagnosis for middle aged adults in Japan is especially critical as diabetes develops at a younger age in this population.

1-2-3. Hypertension

Systemic arterial hypertension (HTN) is characterized by a persistently high BP in the systemic arteries at 140/90mmHg or higher (World Health Organization, 2023; Oparil et al., 2018). The development of HTN is determined by several parameters of the cardiovascular system and there are various mechanisms described for the development of HTN (Iqbal & Jamal, 2022). HTN is one of the greatest modifiable risk factors for CVD and is one of the leading contributors to all-cause mortality and disability worldwide (Oparil et al., 2018). It is estimated that 46% of adults with HTN are unaware of their condition and uncontrolled/undiagnosed HTN is responsible for 7.5 million deaths per year, worldwide (World Health Organization, 2023., Delacroix et al., 2014). With that said, the prevalence of HTN is rising globally, concomitantly with population aging and increases in exposure to lifestyle risk factors such as excessive sodium consumption, insufficient intake of dietary potassium, overweight/obesity, alcohol consumption, smoking and physical inactivity (Mills, Stefanescu & He., 2021., Oparil et al., 2018). Although the prevalence of HTN has increased globally, over the past two decades, high-income countries have experienced a modest decrease in HTN prevalence, which may be attributable to changes in lifestyle, education and dietary habits (Mills et al., 2021). Given the adverse health consequences associated with HTN, successful prevention of the occurrence and the identification of modifiable risk factors is still a pressing public health concern.

Compared to Western countries, Japanese experience higher rates of stroke morbidity and mortality, with stroke being the most prevalent CVD in Japan and other East Asian countries. High sodium, low calcium, low animal protein intake, physical inactivity and for middle-aged men, high alcohol consumption and smoking, may have contributed to the high prevalence of HTN and high mortality rates from stroke among Japanese populations (Okui & Park, 2022). However, Japan has experienced a significant decrease in mean BP levels over the past 50 years, with this trend presumed to be due to implementation of primary and secondary preventative community public health measures and population wide screening of BP (Ikeda et al., 2011). However, adverse BP levels remain the most preventable risk factors for stroke and it is estimated that 43 million people in Japan are hypertensive with approximately 50% of cases left untreated (Umemura et al., 2019). In a comparative assessment of preventable risk factor in Japan, high BP was found to be second only to tobacco smoking as a leading contributor of adult mortality from NCDs (Miura et al., 2013). Recent increases in the morbidity of coronary artery disease (CAD) and the prevalence of obesity in Japan also suggest, increasing prevalence of HTN should be of public health concern (Miura et al., 2013). Although Japan has made progress in reducing HTN and improving management of the condition, poor control rate and the large prevalence of HTN in this population suggest that preventing the occurrence and the earliest possible detection must be a high priority (Okui & Park, 2022).

1-2-4. Dyslipidemia

Dyslipidemia (DL) is the result of an imbalance of lipids such as plasma cholesterol, triglycerides (TGs), low-density lipoprotein cholesterol (LDL), and high-density lipoproteins (HDL). Elevated lipids or fats in your blood contributes to the development of atherosclerosis and arteriosclerosis which may lead to CVD (Pappan & Rehman, 2023). Abnormally high total cholesterol levels, which are attributable to a diet high in saturated fats such as meat, diabetes, smoking and HTN may accelerate this type of pathology. Sociodemographic factors associated with DL include age, sex, ethnicity and living in urban areas. DL and DM frequently occur together due to significant enzyme and lipid metabolism pathways being affected, which aggravates the development of atherosclerosis (Kobayashi et al., 2022). People with DL are at two-times escalated risk of CVD compared to those with healthy lipid levels (Bereda, 2022.). Etiology of DL include intrinsic, extrinsic, or a combination of genetic predisposition and external factors. Primary DL refers to abnormal lipid levels caused by familial disorders and are less common. Secondary dyslipidemia, which are more common, occurs due to a variety of lifestyle factors such as tobacco exposure, physical inactivity and diet. Dyslipidemias can also be determined by secondary predisposing factors such as DM and overweight/obesity (Bereda, 2022). Due to rapid economic growth, changes in dietary habits and the adoption of unhealthy lifestyles, the prevalence of DL has increased over the past three decades and is considered an important public health issue globally (Pirillo et al., 2021). National guidelines and interventions aimed at the screening and identification of DL and associated risk factors are important steps in preventing further progression and incidence of DL (Ali et al., 2023)

According to the 2017 patient survey conducted every 3 years by the Ministry of Health, Labour and Welfare, the total number of patients with DL in Japan was 2.2 million. Incidence and mortality rates of CAD in Japan are much lower than in western countries, presumably due to differences in dietary patterns as well as the remarkable difference in cardiovascular profiles between Japan and the North American and European countries (Iso, 2008). Due to the relatively low rates of CAD, which are strongly associated with dyslipidemia, fewer epidemiological studies have been available in Japan compared with other lifestyle related diseases such as HTN and DM (Okamura, 2010; Okui, 2021). The lower rates of CAD make it difficult to perform epidemiological studies of DL in Japan, and thus it is challenging to produce articles of interest on DL using Japanese datasets. However, recent increases in total blood cholesterol in Japanese people may reflect an increased intake of saturated fat from meat and dairy products as well as high alcohol consumption, high smoking rates and physical inactivity. These lifestyle changes are mainly attributable to the industrialization of Japan due to the large economic development during the 1960s and 1990s and rapid westernization of lifestyle, and there is concern that CAD prevalence will rise throughout Japan (Okamura, 2010). Although effective pharmacological treatments for DL exist, non-pharmaceutical remedies or lifestyle interventions to prevent and control the prevalence of DL, as well as further high-quality cohort studies are necessary to ascertain the public health burden of DL in Japan.

1-3. Physical activity, exercise, physical fitness and cardiometabolic disease

Over the past 5 decades, several observational studies and numerous scientific reports support the relationship between PA, physical fitness (PF) and lower risk of CVD and mortality. PA can be defined as any bodily movement produced by the skeletal muscles that requires energy expenditure. This includes any motion that you do throughout the day including during leisure time, such as for commuting to and from places, taking the stairs and doing household tasks (World Health Organization ,2022). Exercise is a subset of PA that is planned, structured, repetitive and purposeful with the intention of improving or maintaining components of PF (Caspersen et al., 1985). PF is a set of attributes that are health or skill related and includes the ability to execute daily activity with optimal performance, strength and endurance (Caspersen et al., 1985). PF is an important predicator of mortality and is associated with the management of disease, fatigue, stress and reduced sedentary behaviour with higher rates of cardiovascular events and higher mortality seen in those with low PF (Campbell et al., 2013). The specific adaptations our bodies make to keep all systems involved and working efficiently in their respective roles allow us to become more resilient to the wear and tear that comes with increased demand. Due to this, the body becomes more resilient to environmental stresses, injuries and disease. Regular and frequent PA provides substantial health benefits and is one of the most important lifestyle behaviours people can do to improve and maintain their physical and mental health. Regular exercise is the most effective way of improving one's PF which is a measure of one's cardiovascular, pulmonary and metabolic health and has strong potential to predict future health risk (Lee & Buchner, 2008).

There is compelling evidence suggesting that engaging in 30-60 minutes a day of moderate-vigorous intensity PA improves health and reduces the prevalence of NCDs (World Health Organization, 2022). Current PA guidelines recommend that adults should engage in at least 150 to 300 minutes of moderate intensity aerobic PA or at least 75-150 minutes of vigorous intensity PA per week (World Health Organization, 2022). The current Japanese PA guidelines recommend that adults engage in at least 60 minutes of moderate-to-vigorous intensity PA per day which is equivalent to 23 metabolic equivalent (MET) hours per week. An intensity of 3 METs or greater is recommended to see benefits (Jetté et al., 1990., Ministry of Health, Labour and Welfare of Japan., 2013).

Physical inactivity is an established risk factor for NCDs and the protective effects of PA, specifically for CMD, have been well established (Myers, 2003). Compared to physically inactive individuals, those who engage in regular PA have lower BP, higher insulin sensitivity and a more favorable plasma lipoprotein profile (Nystoriak & Bhatnagar, 2018). Physical inactivity contributes to unhealthy weight gain, higher levels of cholesterol, elevated blood glucose levels and an elevated BP which contribute significantly to CMD (World Health Organization, 2022). It is estimated that almost 500 million people will develop heart disease, obesity, diabetes or other NCDs attributable to physical inactivity in the next two decades, placing an enormous burden on healthcare systems and governments worldwide (WHO Highlights High Cost of Physical Inactivity in First-Ever

Global Report - PAHO/WHO | Pan American Health Organization, 2022). National policies put in to place to tackle NCDs and physical inactivity need to be established, as worldwide, 23% of the adult population is insufficiently active, with these trends increasing concomitantly with economic development (Bull et al., 2017).

Physical inactivity significantly contributes to the pathogenesis of T2DM and is one of the greatest risk factors for DM in addition to age, family history and obesity. Participation in regular PA has beneficial effects on the reduction of anthropometric parameters such as body weight and BMI, improves blood glucose control, positively affects lipids, BP, cardiovascular events, mortality and increases quality of life (Colberg et al., 2010). Regular exercise has been shown to reduce elevated hemoglobin (HbA1c) levels, which are a sign of vascular complications in patients with diabetes. Increased PA also enables muscle cells to use insulin and glucose more efficiently, in turn, lowering diabetes risk. Lack of exercise or physical inactivity can cause muscle cells to lose their sensitivity to insulin, increasing the risk of developing diabetes (Kirwan et al., 2017). It is important to consider that the impact of exercise on insulin is transient, thus PA should be frequent and performed regularly to optimize the exercise-induced benefits of insulin sensitivity. Furthermore, it is well established that habitual PA levels contribute significantly to the primary prevention of DM (LaMonte et al., 2005). T2DM also frequently occurs with other factors related to insulin resistance such as HTN or DL (Colberg et al., 2010).

The mechanism in which PA aids in the prevention of HTN remain ambiguous as the etiology of HTN is multifactorial and involves a complex interplay of environmental and pathophysiological factors as well as genetic predisposition (Oparil et al., 2018). Possible mechanisms underlying the protective effect of PA on HTN and BP may include the reduction in cardiac output, sympathetic nerve activity, plasma norepinephrine levels and total peripheral resistance which in turn improves endothelial function. In addition, PA may decrease plasma viscosity which can contribute to the peripheral vascular resistance influencing blood flow. Other mechanisms include changes in oxidative stress, inflammation, arterial compliance, body mass, renin-angiotensin system activity, parasympathetic activity, renal function and insulin sensitivity. PA may also decrease the risk of HTN by improving balance and reducing adiposity (Hegde & Solomon, 2015; Liu et al., 2016). The anti-hypertensive response to PA is highly variable and depends on differences in the intensity and frequency of exercise, environmental factors and genetic factors. Furthermore, there is compelling evidence proving that PA serves as a single or additive treatment for HTN and is a major protective factor for incidence of HTN (Liu et al., 2016). Regular PA can decrease systolic and diastolic BP with evidence supporting that the benefits can be achieved from moderate-intensity activities *as simple and as accessible as walking.*

Leading risk factors for DL include age, central obesity, smoking, insufficient exercise, BMI and waist circumference. It is recommended that regular exercise, avoiding smoking and adhering to a healthy diet can reduce the risk of DL. Although pharmacological treatments for DL exist, long term use of medication may cause side effects alongside increasing economic burden, and compared to medications, exercise is easier to carry out and has fewer side effects (Wang & Xu, 2017). PA is one way of improving the imbalance of lipid levels and previous studies have noted the benefits of regular exercise on lipid and lipoprotein levels (Igarashi et al., 2019). Exercise improves serum lipids by lowering serum triglyceride levels, total cholesterol (TC) and LDL levels while simultaneously increasing HDL (Wang & Xu, 2017). It is notable that in a recent meta-analysis looking specifically at East Asians, regular aerobic exercise improved HDL-C, TC and TG levels. This study suggests that improvements in lipid and lipoprotein levels depend on the intensity or volume of exercise, and accumulating ≥150 minutes of moderate to vigorous PA per week has the potential to improve lipid and lipoproteins levels (Igarashi et al., 2019)

1-4. Walking speed and cardiometabolic disease

Current Japanese PA guidelines recommended increasing the time spent walking, and in particular, reaching daily step count goals, however relatively little emphasis has been put on walking at a faster pace. The notion that we should take 10,000 steps a day has been included and adopted in broader public health recommendations and was derived from the name of the Japanese-made pedometer sold in the 1960s called Manpo-kei. Measuring daily steps counts through PA trackers such as smart phones and smart watches have become an easy and accessible way to monitor and set PA goals, such as reaching a goal of 10,000 steps per day (*ACSM Blog*, n.d.). In a large-scale prospective cohort study of 78,500 adults, using accelerometry data, significant associations were found between higher number of daily steps and intensity of walking with all-cause mortality, cancer and CVD morbidity and mortality. This study suggests that up to 10,000 steps may be associated with lower risk of mortality, cancer and CVD incidence, however, notably, steps performed at a higher cadence were associated with additional benefits such as risk reduction for disease incidence (del Pozo Cruz et al., 2022). Considering the associations between higher accelerometry data on walking with NCDs and mortality, WS has emerged as an interesting candidate in various chronic diseases. Methods for predicting WS can range from simple approaches that combine step length with frequency such as the use of accelerometers (Schimpl et al., 2011). However, subjective measurements such as self-reported WS have not yet been established as useful measures to quantify and establish WS as a useful outcome parameter in epidemiological studies. Current literature suggests that self-report PA measures may be less accurate in assessing moderate-intensity activities. However, due to the simplicity and convenience of self-rated WS, it may present as a way to be more attentive to reduced walking speed or complaints about difficulty walking as there is a possibility these parameters reflect health decline. In addition, self-reported WS may present an opportunity to increase population levels of moderate-intensity PA.

To meet PA and public health guidelines, there is clear evidence that walking is the one of the most commonly reported PA in healthy adults. Walking is recommended to many individuals as it confers multiple benefits with minimal adverse effects. It is also one of the easiest ways for adults to get active as it demands little skill, facility or equipment, is low cost and can be commonly performed on a day-to-day basis such as for commuting, recreational or occupational activities (Morris & Hardman, 1997). Walking plays an important role in physical, mental and social wellbeing (Stamatakis et al., 2018). However, the benefits of walking, may in part, depend on the intensity of the activity. PA may be rated using METs to indicate the intensity of activity. One MET is defined as the amount of oxygen consumed while sitting at rest and is equal to 3.5 ml O2 per kg body weight x min, this concept represents a simple and practical procedure for expressing the energy cost of PA (Jetté et al., 1990). The Japanese PA guidelines suggest that normal intensity of walking is equivalent to roughly 3 METs, and walking for at least 60 minutes daily is equivalent to 23 METs hr/week. Walking fast, such as taking a brisk walk and walking for exercise is roughly 3.5-6.0 METS which roughly equates to moderate intensity activity. According to the updated 2011 adult compendium of PA walking at a slow pace is equivalent to 2.8 METS and walking for pleasure at a relative pace is roughly 3.5 METS (Ainsworth et al., 2011). Walking at a faster pace, may confer additional risk reduction particularly for incidence disease and has been shown to be a strong prognostic marker for all-cause or cardiovascular mortality, than other measures of PA volume or physical function (del Pozo Cruz et al., 2022).

Several studies have demonstrated that WS can predict important aspects of health status reflect various underlying physiology. WS is the fundamental walking measure that defines a person's walking ability and is defined as the time required for an individual to reach a particular distance (*Walking Speed - an Overview | ScienceDirect Topics*, 2020). The ability to walk and WS depend on the complex interactions of various body systems including musculoskeletal, visual, central nervous, cardiovascular, and reflects both functional and physiological changes (Middleton et al., 2015; *Walking Speed - an Overview | ScienceDirect Topics*, 2020). For example, WS is influenced by motor control, muscle performance, endurance and energy levels, motivation and mental health, as well as the characteristics of the environment that walking is performed such as local area walkability (Middleton et al., 2015). Walking at a faster pace or a higher relative intensity provides a greater physiological response though increased relative exercise intensity (Stamatakis et al., 2018). Although increasing population level walking is an important public health imperative, increasing walking pace could be linked with lower risk for CVD mortality and should be emphasized in public health messages (Stamatakis et al., 2018).

The health benefits of walking and the predictive capacity of WS have become a widely recognized marker of health in middle aged and older adults. Epidemiological studies have reported WS to be associated with survival among older adults and slow WS has been associated with increased risk of disease, disability, mobility limitation, and mortality (Hardy et al., 2007; Imran et al., 2019; Purser et al., 2005). In a meta-analysis of randomized controlled trials Murphy and colleagues found that healthy but sedentary individuals who engage in regular brisk walking will improve several CVD risk factors (Murphy et al., 2007). Timmins et al. performed a genome-wide association study of self-reported walking pace and found genetic associations of walking pace with a range of health outcomes. They found significant genetic correlations with cardiometabolic traits, CMD and their risk factors, presumably due to causal associations between self-reported walking pace. These finding suggest that self-reported walking pace is a pragmatic target intervention aiming for general benefits on health (Timmins et al., 2020). Recent evidence suggests self-reported WS as one of the strongest predictors of all cause mortality even when adjusting for other established risk factors such as BMI and lifestyle behaviours such as smoking (*ACSM Blog*, n.d.;

Timmins et al., 2020). Studies have observed that a brisk walking pace, self-reported through questionnaire or interview, to be associated with a reduced risk of cardiorespiratory and cancer outcomes as well as all-cause mortality (Stamatakis et al., 2018). Studenski and colleagues pooled individual data from 9 selected cohorts and found that gait speed was associated with survival in older adults and also suggest that self-report is an alternative to WS for reflecting function when direct measurement is not feasible (Studenski et al., 2011). In a prospective pooled analysis of 50,225 walkers from 11 population based British cohorts, Stamatakis and colleagues found that a higher self-rated WS was associated with a 24% and 21% risk reduction in all-cause mortality and CVD mortality (Stamatakis et al., 2018). When measured objectively, slowest walkers compared with fastest walkers have a higher risk of all-cause mortality, with similar findings in both middle-aged and older adults (Yates et al., 2017). Similar associations have been found when investigating the association between self-reported WS and cardiovascular events. In a recent analysis of 420,000 UK Biobank participants, Yates and colleagues found that self-reported walking pace was a strong predictor of cardiovascular mortality in both men and women, even after adjusting for covariates such as smoking habits and other lifestyle measurements. Furthermore, they found that self-reported health and walking pace were the strongest predictors in both sexes with the strongest associations seen in those with low BMI (Yates et al., 2017). A study comparing self-reported WS with measured WS found that self-reported WS was strongly associated with measured WS among both men and women and that both self-rated and objectively measured WS were associated with clinical characteristics and mortality. The findings of Syddall et al. suggest that self-reported WS is a good marker of measured WS and could serve as a useful marker in physical performance (Syddall et al., 2015).

Using data from the National Runners and Walkers Health study cohort, Williams and Thompson examined the effect of differences in exercise mode on cardiometabolic diseases such as HTN, DM and hypercholesterolemia. They found that equivalent energy expenditures of running (a vigorous exercise) and walking (a moderate exercise) are associated with equivalent risk reductions for HTN, hypercholesterolemia and diabetes. The results of this large prospective cohort study suggest that walking and running, though different intensities, produce similar health benefits and may lower the risk of CMD (Williams & Thompson, 2013). Engagement in light intensity PA is independently associated with favourable HDL and total cholesterol levels in adults with multiple chronic conditions, suggesting that PA has favourable effects on cardiometabolic profile. A prospective observational study examining the association between walking and HTN incidence in 83,435 postmenopausal women without history of CVD found that faster WS were associated with lower HTN risk and observed stronger associations with HTN for WS than walking volume. The results of this study indicate that walking at a casual speed to meet or exceed PA guidelines is associated with lower risk of HTN in later life. Furthermore, suggesting that WS could be a marker of cardiorespiratory fitness, which is inversely associated with HTN incidence in women (Miller et al., 2020). A similar study by Hayashi et al., followed-up 6017 middle-aged Japanese men with no history of HTN or diabetes at baseline and found a 29% lower HTN risk associated with walking >21 minutes to work compared to >10 minutes a day, suggesting that regular exercise such as walking to work is associated with a reduction in the risk for incident HTN (Hayashi et al., 1999). A national health survey conducted in a Chilean population examined associations of self-reported walking pace and diabetes incidence. They found that compared to slow walkers, brisk walking pace was associated with lower blood glucose and HbA1c and a reduced risk of T2DM (Cigarroa et al., 2020).

Furthermore, evidence has established WS as a predictor of current and future health status and if causal, assessment of walking pace could be a predictor of CMD risk in young, middle-aged and older adults. This study could potentially help determine the public health utility of self-reported WS for cardiometabolic outcomes measures such as CMD and the need to establish further epidemiological studies and clinical trials with self-reported WS as a measure to quantify WS. WS (if causal) could be a useful tool to identify those at high risk for CMD and could be used as a screening question in primary care settings to identify individuals at high risk and those who may benefit from further metabolic screening or PA interventions.

1-5. Rationale and purpose of the study

This cross-sectional study examined the associations between self-reported WS with CMD and subsequent CVD risk among young, middle-aged and older adults in Japan. Subjective WS or self-rated WS is known to reflect functional capacity as well as objective WS, however, the predictive capacity of self-report WS and CMD is limited, as there are few epidemiological data regarding the relationship between subjective WS and younger or middle-aged adults as much of the literature and evidence regarding WS and CMD come from older adult cohorts (Ueno et al., 2022). Younger and middle-aged adults are primary targets for CVD prevention as the promotion of positive health behaviours early in life are the foundation for preserving ideal cardiovascular health and preventing adverse cardiovascular outcomes. Previous studies have reported gender differences between WS and chronic disease. A study by Izawa and colleagues aimed to determine the differences in maximum gait speed and daily measured PA based on sex. They found that maximum gait speed was slower and PA was lower in their female inpatients versus male inpatients (Izawa et al., 2015). To my knowledge this is the first cross-sectional study observing the associations between subjective or self-reported WS and CMD in young, middle-aged and older adults in Japan. Our aim was to examine the associations between self-reported WS with cardiometabolic disease, specifically, T2DM, HTN and DL in Japanese adults. A secondary aim was to better understand the role of sex as potential moderators of these associations.

2. Methods

2-1. Study Design and Participants

This was an observational, cross-sectional and population-based study with participants (1,339 women, 1216 men) living in Japan. This study was conducted by using an internet survey targeting Japanese residents. Data were collected from 3,110 young, middle-aged and older adults (49.84 ±15.829) living in various regions in Japan.

2-2 Internet Survey

Data was collected through an internet research company (My Voice.com, Inc.) and began on September 30, 2022 and ended on October 3, 2022. An internet survey is a survey method that asks people to answer web-based questionnaires and extracting target people who meet the sampling conditions and request them to answer the WEB questionnaire by email. The survey company builds a “panel” or monitor, that cooperates with the survey and the target respondents are selected according to the survey theme by their registered attributes. MyVoice started around 1998 and has rapidly spread to become a major survey method, accounting for more than 50% of Ad Hoc surveys (individual surveys), due to its ability to collect a large amount of data quickly and inexpensively. My Voice has clear and careful measures for monitoring and data quality control to provide reliable data and has over 20 years of experience with over 1.7 million registered survey respondents in Japan. Monitors from this internet research company participated in this survey on the research company's website after reviewing the contents of the survey requested by email and sent by the research company.

2-2-1. Self-administered Questionnaire Data

All participant data including WS, cardiometabolic disease, sociodemographic and lifestyle variables were obtained through self-administered questionnaires (internet survey). The online self-reporting questionnaire covered a wide range of domains and consisted of 45 questions investigating the respondent's current status of CMD.

2-2-2. Walking Speed

Self-reported WS was determined through asking the following questions "How would you describe your usual walking pace compared to those around you?" participants were asked to select one of the following WS categories to answer the question: slow, slightly slow, average, slightly fast, fast.

2-2-3. Cardiometabolic Disease Ascertainment

The outcome of interest for the present study was incident CMD. In this study, CMD was defined by the presence or absence of one or more of the following: HTN, DM, DL Prevalence of CMD was identified based on self-reported medical history. Respondents were identified as having CMD if they responded yes to the question "have you ever been diagnosed by a doctor from any of the following diseases?": hypertension, diabetes, dyslipidemia.

2-2-4. Sociodemographic Variables

The sociodemographic variables age, sex (male or female), age group (39 and under, 40-49, 50-64, 65 and over), educational attainment (graduate school, university, junior college or technical college, vocational school, high school, junior high school, other), marital status (never married, separated, married), occupation (company employee or officer, self-employed, professional job, civil servant, student, housewife/househusband, part time job, unemployed or retired, other), household income (under 3,000,000 yen, 2,000,000 to 5,000,000 yen, 5,00,000 to 7,000,000 yen, 7,000,000 to 10,000,000 yen, 10,000,000 to 15,000,000 yen, Over 15,000,000 yen) were determined using self-reported questionnaire (internet survey).

2-2-5. Lifestyle variables

This questionnaire also ascertained lifestyle factors such as smoking habits (smoker, former smoker, non-smoker), alcohol consumption (rarely drink, former drinker, 1-3 days/month, 1-2 days/week, 3-4 days/week, 5-6 days/week, every day. Other variables such as green tea, coffee (rarely drink, 1-3 days/month, 1-2 days/week, 3-4 days/week, 5-6 days/week, almost every day) and chocolate consumption (rarely eat, 1-3 days/month, 1-2 days/week, 3-4 days/week, 5-6 days/week, almost every day), BMI groups (underweight, normal, overweight, obese), sleep duration(less than 4 hours, 4-5 hours, 5-6 hours, 6-7 hours, 7-8 hours, ≥8 hours) and LBP (some pain, almost no pain, no pain) were included in sex-specific and additional analysis.

2-2-6. Covariates other covariates included for sex-specific and additional analysis

Covariates in the present study were in line with previous similar research (Sawada et al., 2019) and included age, sex, marital status, educational attainment, occupation, household income, smoking habits and alcohol consumption. Additional social and health-related variables utilized in further analyses were green tea, coffee, chocolate consumption, sleep duration, LBP and BMI. BMI was calculated as weight (in kilograms) divided by height (in meters) squared. Furthermore, we categorized BMI into four groups according to the Asian-Pacific cutoff points; underweight (≤18 kg/m2), normal (18.5-22.9 kg/m2), overweight (23-24.9 kg/m2) and obese (≥25 kg/m2) (WHO Expert Consultation, 2004).

2-3. Ethical statement

The data received from the internet research company was anonymous and no personally identifiable information was received. Participation in this study was voluntary, and consent to participate in the study was obtained by responding to this survey. This study has been approved by the research ethics committee of Waseda University (approval number: 2022-288).

2-4. Statistical analysis

All statistical analyses were performed with SPSS version 28.0.0.0 (IBM SPSS Statistics, IBM Corporation, Chicago, IL). Means and standard deviations were computed for all descriptive characteristics. WS was originally entered in its original five-category format but the low number of events in the “slow” and “fast” category resulted in unstable estimates and broad 95% CIs and for this reason all main analyses were carried out with collapsing the categories “slow” and “slightly slow” into one group and “fast” and “slightly fast” into one group, leaving the categories to “slow”, “average” and “fast”. Multiple logistic regression models were used to calculate the OR of WS with CMD. All analyses were incrementally adjusted according to different confounding factors. Model 1 was adjusted for factors age, Model 2 was adjusted according to age and sex and Model 3 was adjusted to age, sex, occupation, marital status, household income, educational attainment, smoking status and drinking habits. Those who reported “slow” as their WS were the reference group and Data were presented as odds ratios (OR) and their 95% CIs. In age-specific and additional analysis, we analyzed according to age, sex, occupation, marital status, household income, educational attainment, smoking status and drinking habits, green tea, coffee, chocolate consumption, BMI, sleep duration and LBP.

3. Results

Table 1. shows the characteristics of participants by sex. A total of 2,555 (1,339 women, 1,216 men) participants aged 20-79 (49.8 ± 15.8) years of age were eligible for analyses.

30.8 % of participants were 39 and younger and 22.6% were over the age of 65. Almost half of participants (45.7%) were university educated and were from middle socioeconomic status strata (2,000,000 to 5,000,000 yen). Prevalence of current smoking was 20.9% for men and 9% for women. The characteristics of the participants by gender and by each disease are shown in the table (Table 2−5). The mean age of participants in the walking pace category was 49.2 ± 16.0, 50.8 ± 15.4, and 51.9 ± 16.3 for women and 51.9 ± 16.6, 48.8 ± 15.6, and 47.5 ± 15.4 for men in the slow, average, and fast pace categories, respectively (Table 6).

Table 1. Characteristics of participants according to sex.

	Total (n = 2,555)	Women (n = 1,339)	Men (n = 1,216)
Age (y), mean ± SD	49.8 ± 15.8	50.8 ± 15.8	48.8 ± 15.8
Height (cm), mean ± SD	163.3 ± 8.8	157.0 ± 5.6	170.1 ± 6.2
Weight (kg), mean ± SD	59.1±13.0	52.1 ± 9.0	66.89 (±12.22)
BMI (kg/m²), mean ± SD	22.1 ± 3.8	21.1 ± 3.5	23.1 ± 3.9
Smoking, *n* (%)			
Non-smoker	1,817 (71.1)	1,122 (83.8)	695 (57.2)
Previous smoker	386 (15.1)	119 (8.9)	267 (22.0)
Smoker	352 (13.8)	98 (7.3)	254 0.9%)
Drinking, *n* (%)			
Rarely drink	1,199 (46.9)	744 (55.6)	455 (37.4)
Former drinker	64 (2.5)	32 (2.4)	32(2.6)
1 to 3 day a month	308 (12.1)	173 (12.9)	135 (11.1)
1 to 2 days a week	318 (12.4)	146 (10.9)	172 (14.1)
3 to 4 days a week	165 (6.5)	67 (5.0%)	98 (8.1)
5 to 6 days a week	162 (6.3)	59 (4.4%)	103 (8.5)
Every day	339 (13.3)	118 (8.8%)	221 (18.2)
Occupation, *n* (%)			581 (47.8)
Company employee or	897 (35.1)	316 (23.6)	114 (9.4)
officer	150 (5.9)	36 (2.7)	40 (3.3)
Self-employed	85 (3.3)	45 (3.4)	59 (4.9)
Professional job	78 (3.1)	19 (1.4)	23 (1.9)
Civil servant	44 (1.7	21 (1.6)	4 (0.3)
Student	452 (17.7)	448 (33.5)	103 (8.5)
Housewife or Househusband	389 (15.2)	286 (21.4)	259 (21.3)
Part-time job	400 (15.7)	141 (10.5)	33 (2.7)
Unemployed or retired	60 (2.3)	27 (2.0)	
Other			
Marital status, *n* (%)			
Unmarried	1,046 (40.9)	462 (34.5)	584 (48.0)
Married	1,456 (57.0)	843 (63)	613 (50.4)
Other	53 (2.1)	34 (2.5)	19 (1.6)
House income, *n* (%)			
Under 3,000,000 yen	601 (23.5)	324 (24.2)	277 (22.8)
2,000,000 to 5,000,000 yen	728 (28.5)	371 (27.7)	357 (29.4)
5,00,000 to 7,000,000 yen	531 (20.8)	277 (20.7)	254 (20.9)
7,000,000 to 10,000,000 yen	416 (16.3)	213 (15.9)	203 (16.7)
10,000,000 to 15,000,000 yen	197 (7.7)	111 (8.3)	86 (7.1)
Over 15,000,000 yen	82 (3.2)	43 (3.2)	39 (3.2)
Education, *n* (%)			
Graduate School	136 (5.3)	30 (2.2)	106 (8.7)
University	1167 (45.7)	476 (35.5)	691 (56.8)
Junior college or technical	309 (12.1)	271 (20.2)	38 (3.1)
Vocational school	243 (9.5)	149 (11.1)	94 (7.7)
High school	630 (24.7)	384 (28.7)	246 (20.2)
Junior high school	61 (2.4)	25 (1.9)	36 (3.0)
Other	9 (0.4)	4 (0.3)	5 (0.4)
Walking speed, n (%)			
Slow	481 (18.8)	297 (22.2)	184(15.1)
Average	1184 (46.3)	634 (47.3)	550 (45.2)
Fast	890 (34.8)	408 (30.5)	482 (39.6)
Sleep, n (%)			
Less than 4 hours	42 (1.6)	21 (1.6)	21 (1.7)
4-5 hours	251 (9.8)	130 (9.7)	121 (10.0)
5-6 hours	699 (27.4)	383 (28.6)	316 (26.0)
6-7 hours	935 (36.6)	480 (35.8)	455 (37.4)
7-8 hours	471 (18.4)	248 (18.5)	223 (18.3)
More than 8 hours	157 (6.1)	77 (5.8)	80 (6.6)
Low back pain, n (%)			

some pain	789 (30.9)	414 (30.9)	375 (30.8)
almost no pain	990 (38.7)	525 (39.2)	465 (38.2)
no pain	776 (30.4)	400 (29.9)	376 (30.9)
Age group, *n* (%)			
39 and under	787 (30.8)	380 (28.4)	407 (33.5)
40 to 49	520 (20.4)	271 (20.2)	249 (20.5)
50 to 64	671 (26.3)	352 (26.3)	319 (26.2)
65 and over	577 (22.6)	336 (25.1)	241 (19.8)
Green tea, n (%)			
Rarely	597 (23.4)	320 (23.9)	277 (22.8)
1-3 day a month	360 (14.1)	198 (14.8)	162 (13.3)
1-2 days a week	330 (12.9)	164 (12.2)	166 (13.7)
3-4 days a week	272 (10.6)	130 (9.7)	142 (11.7)
5-6 days a week	174 (6.8)	88 (6.6)	86 (7.1)
Almost every day	822 (32.2)	439 (32.8)	383 (31.5)
Coffee, n (%)			
Rarely	486 (19.0)	252 (18.8)	234 (19.2)
1-3 day a month	148 (5.8)	87 (6.5)	61 (5.0)
1-2 days a week	183 (7.2)	88 (6.6)	95 (7.8)
3-4 days a week	157 (6.1)	66 (4.9)	91 (7.5)
5-6 days a week	199 (7.8)	93 (6.9)	106 (8.7)
Almost every day	1382 (54.1)	753 (56.2)	629 (51.7)
Chocolate, n (%)			
Rarely	548 (21.4)	233 (17.4)	315 (25.9)
1-3 day a month	673 (26.3)	308 (23.0)	365 (30.0)
1-2 days a week	649 (25.4)	345 (25.8)	304 (25.0)
3-4 days a week	317 (12.4)	202 (15.1)	115 (9.5)
5-6 days a week	132 (5.2)	89 (6.6)	43 (3.5)
Almost every day	236 (9.2)	162 (12.1)	74 (6.1)
BMI categories			
Underweight <18.5	360 (14.3)	263 (19.9)	97 (8.2)
Normal 18.5-22.9	1332 (53.1)	776 (58.7)	556 (46.8)
Overweight 23-24.9	366 (14.4)	134 (10.1)	232 (19.5)
Obese ≥ 25	451 (18.0)	149 (11.3)	302 (25.4)

SD: standard deviation, BMI: body mass index

Table 2. Characteristics of study participants according to cardiometabolic disease status and sex.

	Women		Men	
	With CMD	Without CMD	With CMD	Without CMD
n	286	1053	325	891
Age (y), mean ± SD	62.9 ± 11.6	47.5 ± 15.2	60.4 ± 12.3	44.5 ± 14.7
Height (cm), mean ± SD	155.8 ± 5.8	157.4 ± 5.4	169.1 ± 6.4	170.5 ± 6.1
Weight (kg), mean ± SD	54.3 ± 10.1	51.5 ± 8.6	70.1 ± 12.5	65.7 ± 11.9
BMI (kg/m2), mean ± SD,	22.3 ± 3.8	20.8 ± 3.3	24.5 ± 3.8	22.6 ± 3.8
Smoking, *n* (%)				
Non-smoker	21 (21.4)	77 (78.6)	68 (26.8)	186 (73.2)
Previous smoker	40 (33.6)	79 (66.4)	113 (42.3)	154 (57.7)
Smoker	225 (20.1)	897 (79.9)	144 (20.7)	551 (79.3)
Drinking, *n* (%)				
Rarely drink	162 (21.8)	582 (78.2)	91 (20.0)	364 (80.0)
Former drinker	6 (18.8)	26 (81.3)	8 (25.0)	24 (75.0)
1-3 day a month	32 (18.5)	141 (81.5)	36 (26.7)	99 (73.3)
1-2 days a week	24 (16.4)	122 (83.6)	44 (25.6)	128 (74.4)
3-4 days a week	14 (20.9)	53 (79.1)	30 (30.6)	68 (69.4)
5-6 days a week	18 (30.5)	41 (69.5)	35 (34.0)	68 (66.0)
Every day	30 (25.4)	88 (74.6)	81 (36.7)	140 (63.3)
Occupation, n (%)				
Company employee or officer	37 (11.7)	279 (88.3)	123 (21.2)	458 (78.8)
Self-employed	8 (22.2)	28 (77.8)	24 (21.1)	90 (78.9)
Professional job	10 (22.2)	35 (77.8)	14 (35.0)	26 (65.0)
Civil servant	3 (15.8)	16 (84.2)	17 (28.8)	42 (71.2)
Student	0 (0.0)	21 (100.0)	2 (8.7)	21 (91.3)
Housewife or Househusband	132 (29.5)	316 (70.5)	4 (100.0)	0 (0.0)
Part-time job	52 (18.2)	234 (81.8)	28 (27.2)	75 (72.8)
Unemployed or retired	40 (28.4)	101 (71.6)	102 (39.4)	157 (60.6)
Other	4 (14.8)	23 (85.2)	11 (33.3)	22 (66.7)
Marital status, n (%)				
Unmarried, n (%)	57 (12.3)	405 (87.7)	78 (13.49	506 (86.6)
Married	217 (25.7)	626 (74.3)	241 (39.3)	372 (60.7)
Other	12 (35.3)	22 (64.7)	6 (31.6)	13 (68.4)
House income, n (%)				
Under 3,000,000 yen	76 (23.5)	248 (76.5)	64 (23.1)	213 (76.9)
2,000,000 to 5,000,000 yen	92 (24.8)	279 (75.2)	101 (28.3)	256 (71.7)
5,00,000 to 7,000,000 yen	53 (19.1)	224 (80.9)	77 (30.3)	177 (69.7)
7,000,000 to 10,000,000 yen	35 (16.4)	178 (83.6)	47 (23.2)	156 (76.8)
10,000,000 to 15,000,000 yen	23 (20.7)	88 (79.3)	31 (36.0)	55 (64.0)
Over 15,000,000 yen	7 (16.3)	36 (83.7)	5 (12.8)	34 (87.2)
Education, n (%)				
Graduate School	5 (16.7)	25 (83.3)	24 (22.6)	82 (77.4)
University	84 (17.6)	392 (82.4)	200 (28.9)	491 (71.1)
Junior college or technical	61 (22.5)	210 (77.5)	13 (34.2)	25 (65.8)
Vocational school	25 (16.8)	124 (83.2)	20 (21.3)	74 (78.7)
High school	106 (27.6)	278 (72.4)	62 (25.2)	184 (74.8)
Junior high school	5 (20.0)	20 (80.0)	5 (13.9)	31 (86.1)
Other	0 (0.0)	4 (100.0)	1 (20.0)	4 (80.0)
Walking speed, n (%)				
Slow	68 (22.9)	229 (77.1)	76 (41.3)	108 (58.7)
Average	135 (21.3)	499 (78.7)	144 (26.2)	406 (73.8)
Fast	83 (20.3)	325 (79.7)	105 (21.8)	377 (78.2)
Sleep, n (%)				
Less than 4 hours	4 (19.0)	17 (81.0)	5 (23.8)	16 (76.2)
4-5 hours	32 (24.6)	98 (75.4)	31 (25.6)	90 (74.4)
5-6 hours	84 (21.9)	299 (78.1)	92 (29.1)	224 (70.9)
6-7 hours	105 (21.9)	375 (78.1)	121 (26.6)	334 (73.4)
7-8 hours	49 (19.8)	199 (80.2)	59 (26.5)	164 (73.5)
More than 8 hours	12 (15.6)	65 (84.4)	17 (21.3)	63 (78.8)

Low back pain, n (%)				
some pain	102 (24.6)	312 (75.4)	312 (75.4)	242 (64.5)
almost no pain	119 (22.7)	406 (77.3)	406 (77.3)	348 (74.8)
no pain	65 (16.3)	335 (83.8)	335 (83.8)	301 (80.1)
Age group, n (%)				
39 and under	16 (4.2)	364 (95.8)	23 (5.7)	384 (94.3)
40-49	24 (8.9)	247 (91.1)	38 (15.3)	211 (84.7)
50-64	97 (27.6)	255 (72.4)	125 (39.2)	194 (60.8)
65 and over	149 (44.3)	187 (55.7)	139 (57.7)	102 (42.3)
Green tea, n (%)				
Rarely	45 (15.7)	275 (26.1)	48 (14.8)	229 (25.7)
1-3 day a month	37 (12.9)	161 (15.39	41 (12.6)	121 (13.6)
1-2 days a week	30 (10.5)	134 (12.7)	37 (11.4)	129 (14.4)
3-4 days a week	29 (10.1)	101 (9.6)	40 (12.3)	102 (11.4)
5-6 days a week	26 (9.1)	62 (5.9)	25 (7.7)	61 (6.8)
Almost every day	119 (41.6)	320 (30.4)	134 (41.2)	249 (27.9)
Coffee, n (%)				
Rarely	27 (9.4)	225 (21.4)	38 (11.7)	196 (22.0)
1-3 day a month	14 (4.9)	73 (6.9)	13 (4.0)	48 (5.4)
1-2 days a week	17 (5.9)	71 (6.7)	21 (6.5)	74 (8.3)
3-4 days a week	8 (2.8)	58 (5.5)	25 (7.7)	66 (7.4)
5-6 days a week	28 (9.8)	65 (6.2)	30 (9.2)	76 (8.5)
Almost every day	192 (67.1)	561 (53.3)	198 (60.9)	431 (48.4)
Chocolate, n (%)				
Rarely	55 (19.2)	178 (16.9)	80 (24.6)	235 (26.4)
1-3 day a month	78 (27.3)	230 (21.8)	100 (30.8)	265 (29.7)
1-2 days a week	86 (30.1)	259 (24.6)	77 (23.7)	227 (25.5)
3-4 days a week	27 (9.4)	175 (16.6)	30 (9.2)	85 (9.5)
5-6 days a week	10 (3.5)	79 (7.5)	13 (4.0)	30 (3.4)
Almost every day	30 (10.5)	132 (12.5)	25 (7.7)	49 (5.5)
BMI categories, n (%)				
Underweight <18.5	33 (11.7)	230 (22.1)	9 (2.9)	88 (10.1)
Normal 18.5-22.9	142 (50.5)	634 (60.9)	108 (34.3)	448 (51.4)
Overweight 23-24.9	51 (18.1)	83 (8.0)	80 (25.4)	152 (17.4)
Obese ≥ 25	55 (19.6)	94(9.0)	118 (37.5)	184 (21.1)

CMD: cardio metabolic disease, SD: standard deviation, BMI: body mass index

Table 3. Characteristics of participants according to hypertension status and sex.

	Women		Men	
	With hypertension	Without hypertension	With hypertension	Without hypertension
n	153	1,186	224	992
Age (y), mean ± SD	65.5 ± 9.4	48.9 ± 15.5	61.42 ± 12.1	45.9 ± 15.1
Height (cm), mean ± SD	155.6 ± 5.6	157.2 ± 5.5	169.1 ± 6.2	170.3 ± 6.2
Weight (kg), mean ± SD	55.1 ± 10.5	51.7 ± 8.7	71.3 ± 13	65.9 ± 11.8
BMI, (kg/m^2), mean ± SD	22.6 ± 3.9	20.9 ± 3.4	24.8 ± 3.9	22.7 ± 3.8
Smoking, n (%)				
Smoker	10 (10.2)	88 (89.8)	48 (18.9)	206 (81.1)
Former smoker	21 (17.6)	98 (82.4)	85 (31.8)	182 (68.2)
Non-smoker	122 (10.9)	1000 (89.1)	91 (13.1)	604 (86.9)
Drinking, n (%)				
Rarely drink	663 (89.1)	81 (10.9)	56 (12.3)	399 (87.7)
Former drinker	28 (87.5)	4 (12.5)	5 (15.6)	27 (84.4)
1-3 day a month	157 (90.)8	16 (9.2)	21 (15.6)	114 (84.4)
1-2 days a week	133 (91.1)	13 (8.9)	26 (15.1)	146 (84.9)
3-4 days a week	58 (86.6)	9 (13.4)	23 (23.5)	75 (76.5)
5-6 days a week	48 (81.4)	11 (18.6)	29 (28.2)	74 (71.8)
Every day	99 (83.9)	19 (16.1)	64 (29.0)	157 (71.0)
Chocolate, n (%)				
Rarely	35 (15.0)	198 (85.0)	54 (17.1)	261 (82.9)
1-3 day a month	47 (15.3)	261 (84.7)	74 (20.3)	291 (79.7)
1-2 days a week	42 (12.2)	303 (87.8)	50 (16.4)	254 (83.6)
3-4 days a week	10 (5.0)	192 (95.0)	20 (17.4)	95 (82.6)
5-6 days a week	4 (4.5)	85 (95.5)	9 (20.9)	34 (79.1)
Almost every day	15 (9.3)	147 (90.7)	17 (23.0)	57 (77.0)
Coffee, n (%)				
Rarely drink	10 (4.0)	242 (96.0)	25 (10.7)	209 (89.3)
1-3 day a month	7 (8.0)	80 (92.0)	8 (13.1)	53 (86.9)
1-2 days a week	10 (11.4)	78 (88.6)	14 (14.7)	81 (85.3)
3-4 days a week	3 (4.5)	63 (95.5)	16 (17.6)	75 (82.4)
5-6 days a week	16 (17.2)	77 (82.8)	23 (21.7)	83 (78.3)
Almost every day	107 (14.2)	646 (85.8)	138 (21.9)	491 (78.1)
Green tea, n (%)				
Rarely drink	25 (7.8)	295 (92.2)	33 (11.9)	244 (88.1)
1-3 day a month	15 (7.6)	183 (92.4)	27 (16.7)	135 (83.3)
1-2 days a week	19 (11.6)	145 (88.4)	24 (14.5)	142 (85.5)
3-4 days a week	11 (8.5)	119 (91.5)	28 (19.7)	114 (80.3)
5-6 days a week	15 (17.0)	73 (83.0)	18 (20.9)	68 (79.1)
Almost every day	68 (15.5)	371 (84.5)	94 (24.5)	289 (75.5)
Walking speed, n (%)				
Slow	35 (11.8)	262 (88.2)	60 (32.6)	124 (67.4)
Average	70 (11.0)	564 (89.0)	101 (18.4)	449 (81.6)
Fast	48 (11.8)	360 (88.2)	63 (13.1)	419 (86.9)
Occupation, n (%)				
Company employee or	20 (6.3)	296 (93.7)	78 (13.4)	503 (86.6)
officer	6 (16.7)	30 (83.3)	18 (15.8)	96 (84.2)
Self-employed	2 (4.4)	43(95.6)	12 (30.0)	28 (70.0)
Professional job	1 (5.3)	18 (94.7)	14 (23.7)	45 (76.3)
Civil servant	0 (0.0)	21 (100.0)	2 (8.7)	21 (91.3)
Student	79 (17.6)	369 (82.4)	3 (75.0)	1 (25.0)
Housewife or Househusband	24 (8.4)	262 (91.6)	19 (18.4)	84 (81.6)
Part-time job	20 (14.2)	121 (85.8)	70 (27.0)	189 (73.0)
Unemployed or retired	1 (3.7)	26 (96.3)	8 (24.2)	25 (75.8)
Other				
Marital status, n (%)				
Unmarried, n (%)	26 (5.6)	436 (94.4)	58 (9.9)	526 (90.1)
Married	120 (14.2)	723 (85.8)	162 (26.4)	451 (73.6)

Other	7 (20.6)	27 (79.4)	4 (21.1)	15 (78.9)
House income, n (%)				
Under 3,000,000 yen	42 (13.0)	282 (87.0)	43 (15.5)	234 (84.5)
2,000,000 to 5,000,000 yen	56 (15.1)	315 (84.9)	72 (20.2)	285 (79.8)
5,00,000 to 7,000,000 yen	27 (9.7)	250 (90.3)	53 (20.9)	201 (79.1)
7,000,000 to 10,000,000 yen	12 (5.6)	201 (94.4)	34 (16.7)	169 (83.3)
10,000,000 to 15,000,000 yen	10 (9.0)	101 (91.0)	19 (22.1)	67 (77.9)
Over 15,000,000 yen	6 (14.0)	37 (86.0)	3 (7.7)	36 (92.3)
Education, n (%)				
Graduate School	2 (6.7)	28 (93.3)	14 (13.2)	92 (86.8)
University	42 (8.8)	434 (91.2)	138 (20.0)	553 (80.0)
Junior college or technical	33 (12.2)	238 (87.8)	10 (26.3)	28 (73.7)
Vocational school	12 (8.1)	137 (91.9)	16 (17.0)	78 (83.0)
High school	60 (15.6)	324 (84.4)	42 (17.1)	204 (82.9)
Junior high school	4 (16.0)	21 (84.0)	4 (11.1)	32 (88.9)
Other	0 (0.0)	4 (100.0)	0 (0.0)	5 (100.0)
Age group, n (%)				
39 and under	1(0.3)	379 (99.7)	13 (3.2)	394 (96.8)
40-49	10 (3.7)	261 (96.3)	24 (9.6)	225 (90.4)
50-64	50 (14.2)	302 (85.8)	85 (26.6)	234 (73.4)
65 and over	92 (27.4)	244 (72.6)	102 (42.3)	139 (57.7)
Sleep, n (%)				
Less than 4 hours	4 (19.0)	17 (81.0)	3 (14.3)	18 (85.7)
4-5 hours	17 (13.1)	113 (86.9)	21 (17.4)	100 (82.6)
5-6 hours	39 (10.2)	344 (89.8)	59 (18.7)	257 (81.3)
6-7 hours	56 (11.7)	424 (88.3)	83 (18.2)	372 (81.8)
7-8 hours	29 (11.7)	219 (88.3)	46 (20.6)	177 (79.4)
More than 8 hours	8 (10.4)	69 (89.6)	12 (15.0)	68 (85.0)

SD: standard deviation, BMI: body mass index

Table 4. Characteristics of participants according to type 2 diabetes status and sex.

	Women		Men	
	With T2DM	Without T2DM	With T2DM	Without T2DM
n	49	1290	94	1122
Age (y), mean ± SD	59.6 ± 14.2	50.5 ± 15.8	61 ± 10.9	47.7 ± 15.6
Height (cm), mean ± SD	155.8 ±6.1	157.1 ± 5.5	169.3 ± 5.8	170.2 ± 6.2
Weight (kg), mean ± SD	58.3 ± 10	51.8 ± 8.9	68.6 ±11.3	66.7 ± 12.3
BMI, (kg/m^2), mean ± SD	24 ± 3.6	21 ±3.4	23.9 ± 3.6	23 ± 3.9
Smoking, n (%)				
Smoker	5 (5.1)	93 (94.9)	26 (10.2)	228 (89.8)
Former smoker	11 (9.2)	108 (90.8)	27 (10.1)	240 (89.9)
Non-smoker	33 (2.9)	1089 (97.1)	41 (5.9)	654 (94.1)
Drinking, n (%)				
Rarely drink	27 (3.6)	717 (96.4)	33 (7.3)	422 (92.7)
Former drinker	1 (3.1)	31 (96.9)	4 (12.5)	28 (87.5)
1-3 day a month	5 (2.9)	168 (97.1)	13 (9.6)	122 (90.4)
1-2 days a week	4 (2.7)	142 (97.3)	11 (6.4)	161 (93.6)
3-4 days a week	1 (1.5)	66 (98.5)	6 (6.1)	92 (93.9)
5-6 days a week	4 (6.8)	55 (93.2)	7 (6.8)	96 (93.2)
Every day	7 (5.9)	111 (94.1)	20 (9.0)	201 (91.0)
Chocolate, n (%)				
Rarely	10 (4.3)	223 (95.7)	25 (7.9)	290 (92.1)
1-3 day a month	12 (3.9)	296 (96.1)	26 (7.1)	339 (92.9)
1-2 days a week	13 (3.8)	332 (96.2)	19 (6.3)	285 (93.8)
3-4 days a week	5 (2.5)	197 (97.5)	11 (9.6)	104 (90.4)
5-6 days a week	3 (3.4)	86 (96.6)	5 (11.6)	38 (88.4)
Almost every day	6 (3.7)	156 (96.3)	8 (10.8)	66 (89.2)
Coffee, n (%)				
Rarely drink	0 (0.0)	252 (100.0)	10 (4.3)	224 (95.7)
1-3 day a month	3 (3.4)	84 (96.6)	3 (4.9)	58 (95.1)
1-2 days a week	4 (4.5)	84 (95.5)	6 (6.3)	89 (93.7)
3-4 days a week	1 (1.5)	65 (98.5)	8 (8.8)	83 (91.2)
5-6 days a week	6 (6.5)	87 (93.5)	6 (5.7)	100 (94.3)
Almost every day	35 (4.6)	718 (95.4)	61 (9.7)	568 (90.3)
Green tea, n (%)				
Rarely drink	6 (1.9)	314 (98.1)	14 (5.1)	263 (94.9)
1-3 day a month	4 (2.0)	194 (98.0)	16 (9.9)	146 (90.1)
1-2 days a week	6 (3.7)	158 (96.3)	9 (5.4)	157 (94.6)
3-4 days a week	7 (5.4)	123 (94.6)	8 (5.6)	134 (94.4)
5-6 days a week	5 (5.7)	83 (94.3)	5 (5.8)	81 (94.2)
Almost every day	21 (4.8)	418 (95.2)	42 (11.0)	341 (89.0)
Walking speed, n (%)				
Slow	18 (6.1)	279 (93.9)	22 (12.0)	162 (88.0)
Average	22 (3.5)	612 (96.5)	42 (7.6)	508 (92.4)
Fast	9 (2.2)	399 (97.8)	30 (6.2)	452 (93.8)
Occupation, n (%)				
Company employee or officer	4 (1.3)	312 (98.7)	36 (6.2)	545 (93.8)
Self-employed	1 (2.8)	35 (97.2)	3 (2.6)	111 (97.4)
Professional job	2 (4.4)	43 (95.6)	1 (2.5)	39 (97.5)
Civil servant	0 (0.0)	19 (100.0)	4 (6.8)	55 (93.2)
Student	0 (0.0)	21 (100.0)	0 (0.0)	23 (100.0)
Housewife or	23 (5.1)	425 (94.9)	2 (50.0)	2 (50.0)
Househusband	9 (3.1)	277 (96.9)	4 (3.9)	99 (96.1)
Part-time job	9 (6.4)	132 (93.6)	38 (14.7)	221 (85.3)
Unemployed or retired	1 (3.7)	26 (96.3)	6 (18.2)	27 (81.8)
Other				
Marital status, n (%)				
Unmarried	8 (1.7)	454 (98.3)	27 (4.6)	557 (95.4)
Married	40 (4.7)	803 (95.3)	65 (10.6)	548 (89.4)
Other	1 (2.9)	33 (97.1)	2 (10.5)	17 (89.5)

House income, n (%)				
Under 3,000,000 yen	11 (3.4)	313 (96.6)	21 (7.6)	256 (92.4)
2,000,000 to 5,000,000 yen	12 (3.2)	359 (96.8)	36 (10.1)	321 (89.9)
5,00,000 to 7,000,000 yen	12 (4.3)	265 (95.7)	19 (7.5)	235 (92.5)
7,000,000 to 10,000,000 yen	10 (4.7)	203 (95.3)	10 (4.9)	193 (95.1)
10,000,000 to 15,000,000 yen	4 (3.6)	107 (96.4)	7 (8.1)	79 (91.9)
Over 15,000,000 yen	0 (0.0)	43 (100.0)	1 (2.6)	38 (97.4)
Education, n (%)				
Graduate School	0 (0.0)	30 (100.0)	6 (5.7)	100 (94.3)
University	12 (2.5)	464 (97.5)	53 (7.7)	638 (92.3)
Junior college or technical	10 (3.7)	261 (96.3)	6 (15.8)	32 (84.2)
Vocational school	7 (4.7)	142 (95.3)	5 (5.3)	89 (94.7)
High school	18 (4.7)	366 (95.3)	21 (8.5)	225 (91.5)
Junior high school	2 (8.0)	23 (92.0)	2 (5.6)	34 (94.4)
Other	0 (0.0)	4 (100.0)	1 (20.0)	4 (80.0)
Age group				
39 and under	7(1.8)	373 (98.2)	7 (1.7)	400 (98.3)
40-49	7 (2.6)	264 (97.4)	7 (2.8)	242 (97.2)
50-64	12 (3.4)	340 (96.6)	43 (13.5)	276 (86.5)
65 and over	23 (6.8)	313 (93.2)	37 (15.4)	204 (84.6)
Sleep, n (%)				
Less than 4 hours	1 (4.8)	20 (95.2)	2 (9.5)	19 (90.5)
4-5 hours	9 (6.9)	121 (93.1)	14 (11.6)	107 (88.4)
5-6 hours	17 (4.4)	366 (95.6)	25 (7.9)	291 (92.1)
6-7 hours	14 (2.9)	466 (97.1)	34 (7.5)	421 (92.5)
7-8 hours	4 (1.6)	244 (98.4)	14 (6.3)	209 (93.7)
More than 8 hours	4 (5.2)	73 (94.8)	5 (6.3)	75 (93.8)

T2DM: type 2 diabetes, SD: standard deviation, BMI: body mass index

Table 5. Characteristics of participants according to dyslipidemia status and sex.

	Women		Men	
	With dyslipidemia	Without dyslipidemia	With dyslipidemia	Without dyslipidemia
n	149	1190	114	1102
Age,(y), mean ± SD	62.5 ± 11.5	49.3 ± 15.7	60.2 ± 13	47.6 ± 15.5
Height (cm), mean ± SD	156.1 ± 5.8	157.2 ± 5.5	168.2 ± 6.7	170.3 ± 6.1
Weight (kg), mean ± SD	53.7 ± 9.8	51.9 ± 8.9	70.2 ± 11.9	66.5 ± 12.2
BMI, (kg/m^2), mean ± SD	22 ± 3.6	21 ± 3.4	24.8 ±3.3	22.9 ± 3.9
Smoking, n (%)				
Smoker	8 (8.2)	90 (91.8)	21 (8.3)	233 (91.7)
Former smoker	22 (18.5)	97 (81.5)	37 (13.9)	230 (86.1)
Non-smoker	119 (10.6)	1003 (89.4)	56 (8.1)	639 (91.9)
Drinking, n (%)				
Rarely drink	88 (11.8)	656 (88.2)	31 (6.8)	424 (93.2)
Former drinker	2 (6.3)	30 (93.8)	2 (6.3)	30 (93.8)
1-3 day a month	18 (10.4)	155 (89.6)	14 (10.4)	121 (89.6)
1-2 days a week	15 (10.3)	131 (89.7)	16 (9.3)	156 (90.7)
3-4 days a week	6 (9.0)	61 (91.0)	13 (13.3)	85 (86.7)
5-6 days a week	8 (13.6)	51 (86.4)	13 (12.6)	90 (87.4)
Every day	12 (10.2)	106 (89.8)	25 (11.3)	196 (88.7)
Chocolate, n (%)				
Rarely	22 (9.4)	211 (90.6)	22 (7.0)	293 (93.0)
1-3 day a month	38 (12.3)	270 (87.7)	38 (10.4)	327 (89.6)
1-2 days a week	49 (14.2)	296 (85.8)	27 (8.9)	277 (91.1)
3-4 days a week	18 (8.9)	184 (91.1)	9 (7.8)	106 (92.2)
5-6 days a week	5 (5.6)	84 (94.4)	7 (16.3)	36 (83.7)
Almost every day	17 (10.5)	145 (89.5)	11 (14.9)	63 (85.1)
Coffee, n (%)				
Rarely drink	20 (7.9)	232 (92.1)	10 (4.3)	224 (95.7)
1-3 day a month	7 (8.0)	80 (92.0)	8 (13.1)	53 (86.9)
1-2 days a week	6 (6.8)	82 (93.2)	7 (7.4)	88 (92.6)
3-4 days a week	4 (6.1)	62 (93.9)	8 (8.8)	83 (91.2)
5-6 days a week	13 (14.0)	80 (86.0)	9 (8.5)	97 (91.5)
Almost every day	99 (13.1)	654 (86.9)	72 (11.4)	557 (88.6)
Green tea, n (%)				
Rarely drink	23 (7.2)	297 (92.8)	19 (6.9)	258 (93.1)
1-3 day a month	23 (11.6)	175 (88.4)	13 (8.0)	149 (92.0)
1-2 days a week	12 (7.3)	152 (92.7)	17 (10.2)	149 (89.8)
3-4 days a week	19 (14.6)	111 (85.4)	16 (11.3)	126 (88.7)
5-6 days a week	10 (11.4)	78 (88.6)	10 (11.6)	76 (88.4)
Almost every day	62 (14.1)	377 (85.9)	39 (10.2)	344 (89.8)
Walking speed, n (%)				
Slow	30 (10.1)	267 (89.9)	19 (10.3)	165 (89.7)
Average	75 (11.8)	559 (88.2)	49 (8.9)	501 (91.1)
Fast	44 (10.8)	364 (89.2)	46 (9.5)	436 (90.5)
Occupation, n (%)				
Company employee or officer	20 (6.3)	296 (93.7)	41 (7.1)	540 (92.9)
Self-employed	2 (5.6)	34 (94.4)	6 (5.3)	108 (94.7)
Professional job	8 (17.8)	37 (82.2)	7 (17.5)	33 (82.5)
Civil servant	3 (15.8)	16 (84.2)	5 (8.5)	54 (91.5)
Student	0 (0.0)	21 (100.0)	1 (4.3)	22 (95.7)
Housewife or Househusband	64 (14.3)	384 (85.7)	1 (25.0)	3 (75.0)
Part-time job	27 (9.4)	259 (90.6)	10 (9.7)	93 (90.3)
Unemployed or retired	23 (16.3)	118 (83.7)	39 (15.1)	220 (84.9)
Other	2 (7.4)	25 (92.6)	4 (12.1)	29 (87.9)
Marital status, n (%)				
Unmarried	30 (6.5)	432 (93.5)	21 (3.6)	563 (96.4)
Married	112 (13.3)	731 (86.7)	90 (14.7)	523 (85.3)
Other	7 (20.6)	27 (79.4)	3 (15.8)	16 (84.2)
House income, n (%)				

Under 3,000,000 yen	39 (12.0)	285 (88.0)	21 (7.6)	256 (92.4)
2,000,000 to 5,000,000 yen	45 (12.1)	326 (87.9)	35 (9.8)	322 (90.2)
5,00,000 to 7,000,000 yen	27 (9.7)	250 (90.3)	27 (10.6)	227 (89.4)
7,000,000 to 10,000,000 yen	24 (11.3)	189 (88.7)	19 (9.4)	184 (90.6)
10,000,000 to 15,000,000 yen	12 (10.8)	99 (89.2)	11 (12.8)	75 (87.2)
Over 15,000,000 yen	2 (4.7)	41 (95.3)	1 (2.6)	38 (97.4)
Education, n (%)				
Graduate School	4 (13.3)	26 (86.7)	11 (10.4)	95 (89.6)
University	51 (10.7)	425 (89.3)	72 (10.4)	619 (89.6)
Junior college or technical	32 (11.8)	239 (88.2)	4 (10.59	34 (89.5)
Vocational school	9 (6.0)	140 (94.0)	4 (4.3)	90 (95.7)
High school	53 (13.8)	331 (86.2)	21 (8.5)	225 (91.5)
Junior high school	0 (0.0)	25 (100.0)	2 (5.6)	34 (94.4)
Other	0 (0.0)	4 (100.0)	0 (0.0)	5 (100.0)
Age group, n (%)				
39 and under	10 (2.6)	370 (97.4)	9 (2.2)	398 (97.8)
40-49	11 (4.1)	260 (95.9)	13 (5.2)	236 (94.8)
50-64	52 (14.8)	300 (85.2)	39 (12.2)	280 (87.8)
65 and over	76 (22.6)	260 (77.4)	53 (22.0)	188 (78.0)
Sleep, n (%)				
Less than 4 hours	1 (4.8)	20 (95.2)	0 (0.0)	21 (100.0)
4-5 hours	11 (8.5)	119 (91.5)	10 (8.3)	111 (91.7)
5-6 hours	51 (13.3)	332 (86.7)	36 (11.4)	280 (88.6)
6-7 hours	61 (12.7)	419 (87.3)	45 (9.9)	410 (90.1)
7-8 hours	23 (9.3)	225 (90.7)	17 (7.6)	206 (92.4)
More than 8 hours	2 (2.6)	75 (97.4)	6 (7.5)	74 (92.5)

Table 6. Characteristics of study participants according to walking speed and sex.

	Women (n = 1,339)			Men (n = 1,216)		
	Slow	**Average**	**Fast**	**Slow**	**Average**	**Fast**
Age (y), mean ± SD	49.2 ± 16.0	50.8 ± 15.4	51.9 ± 16.3	51.9 ± 16.6	48.8 ± 15.6	47.5 ± 15.4
Height (cm), mean ± SD	156.5 ± 5.9	156.9 ± 5.4	157.7 ± 5.5	168.5 ± 5.9	169.8 ± 6.0	171.1 ± 6.3
Weight (kg), mean ± SD	53.5 ± 10.9	52.2 ± 8.9	50.9 ± 7.4	68.4 ± 15.9	66.7 ± 12	66.5 ± 10.8
BMI (kg/m2), mean ± SD	21.8 ± 4.1	21.2 ± 3.5	20.5 ± 2.7	24.0 ± 5.3	23.1 ± 3.8	22.7 ± 3.4
Smoking, *n* (%)						
Smoker	26 (26.5)	37(37.8)	35 (35.7)	42 (16.5)	119 (46.9)	93 (36.6)
Former smoker	27 (22.7)	55(46.2)	37 (31.1)	49 (18.4)	127 (47.6)	91 (34.1)
Non-smoker	244 (21.7)	542(48.3)	336 (29.9)	93 (13.4)	304 (43.7)	298 (42.9)
Drinking, *n* (%)						
Rarely drink	176 (23.7)	354 (47.6)	214 (28.8)	73 (16.0)	219 (48.1)	163 (35.8)
Former drinker	7 (21.9	18 (56.3)	7 (21.9)	13 (40.6)	8 (25.0)	11 (34.4)
1-3 day a month	36 (20.8)	83 (48.0)	54 (31.2)	16 (11.9)	68 (50.4)	51 (37.8)
1-2 days a week	31 (21.2)	65 (44.5)	50 (34.2)	22 (12.8)	75 (43.6)	75 (43.6)
3-4 days a week	16 (23.9)	30 (44.8)	21 (31.3)	9 (9.2)	35 (35.7)	54 (55.1)
5-6 days a week	2 (20.3)	27 (45.8)	20 (33.9)	20 (19.49	38 (36.9)	45 (43.7)
Every day	19 (16.1)	57 (48.3)	42 (35.6)	31 (14.0)	107 (48.4)	83 (37.6)
Occupation, n (%)						
Company employee or officer	62 (19.6)	142 (44.9)	112 (35.4)	71 (12.2)	257 (44.29	253 (43.5)
Self-employed	11 (30.6)	17 (47.2)	8 (22.2)	15 (13.2)	49 (43.09	50 (43.9)
Professional job	9 (20.0)	20 (44.4)	16 (35.6)	7 (17.5)	15 (37.59	18 (45.0)
Civil servant	3 (15.8)	7 (36.8)	9 (47.4)	3 (5.1)	24 (40.7)	32 (54.2)
Student	5 (23.8)	2 (9.5)	14 (66.7)	1 (25.0)	8 (34.8)	14 (60.9)
Housewife or Househusband	96 (21.4)	230 (51.3)	122 (27.2)	1 (25.0)	3 (75)	0 (0.0)
Part-time job	65 (22.7)	138 (48.3)	83 (29.0)	13 (12.6)	45 (43.7)	45 (43.7)
Unemployed or retired	41 (29.1)	64 (45.4)	36 (25.5)	66 (25.5)	135 (52.1)	58 (22.4)
Other	5 (18.5)	14 (51.9)	8 (29.6)	7 (21.2)	14 (42.4)	12 (36.4)
Marital status, n (%)						
Unmarried, n (%)	118 (25.5)	205 (44.4)	139 (30.1)	94 (16.1)	266 (45.5)	224 (38.4)
Married	170 (20.2)	412 (48.9)	261 (31.0)	89 (14.5)	274 (44.7)	250 (40.8)
Other	9 (26.5)	17 (50.0)	8 (23.5)	1 (5.3)	10 (52.6)	8 (42.1)
House income, n (%)						
Under 3,000,000 yen	79 (24.4)	148 (45.7)	97 (29.9)	51 (18.4)	139 (50.2	87 (31.4)
2,000,000 to 5,000,000 yen	86 (23.2)	172 (46.4)	113 (30.5)	60 (16.8)	169 (47.3)	128 (35.9)
5,00,000 to 7,000,000 yen	64 (23.1	134 (48.4)	79 (28.5)	40 (15.7)	113 844.5)	101 (39.8)
7,000,000 to 10,000,000 yen	38 (17.8)	106 (49.8)	69 (32.4)	24 (11.8)	75 (36.9)	104 (51.2)
10,000,000 to 15,000,000 yen	24 (21.6)	55 (49.5)	32 (28.8)	8 (9.3)	40 (46.5)	38 (44.2)
Over 15,000,000 yen	6 (14.0)	19 (44.2)	18 (41.9)	1 (2.6)	14 (35.9)	24 (61.5)
Education, n (%)						
Graduate School	4 (13.3)	14 (46.7)	12 (40.0)	9 (8.5)	34 (32.1)	63 (69.4)
University	94 (19.7)	225 (47.3)	157 (33.0)	103 (14.9)	298 (43.1)	290 (42.0)
Junior college or technical	65 (24.0)	124 (45.8)	82 (30.3)	11 (28.9)	15 (39.5)	12 (31.6)
Vocational school	36 (24.2)	63 (42.3)	50 (33.6)	10 (10.6)	53 (56.49	31 (33.0)
High school	89 (23.2)	193 (50.3)	102 (26.6)	40 (16.3)	125 (50.8)	81 (32.9)
Junior high school	9 (36.0)	13 (52.0)	3 (12.0)	9 (25.0)	24 (66.7)	3 (8.3)
Other	0	2 (50.0)	2 (50.0)	2 (40.0)	1 (20.0)	2 (40.0)
Sleep, n (%)						
Less than 4 hours	6 (28.6)	6 (49.2)	9 (42.9)	4 (19.0)	10 (47.6)	7 (33.3)
4-5 hours	37 (28.59	64 (49.2)	29 (22.3)	23 (19.0)	50 (41.3)	48 (39.7)

5-6 hours	80 (20.9)	189 (49.3)	114 (29.8)	43 (13.6)	136 (43.0)	137 (43.4)
6-7 hours	104 (21.7)	222 (46.3)	154 (32.1)	61 (13.4)	218 (47.9)	176 (38.7)
7-8 hours	50 (20.2)	119 (48.0)	79 (31.9)	31 (13.9)	103 (46.2)	89 (39.9)
More than 8 hours	20 (26.0)	34 (44.2)	23 (29.9)	22 (27.5)	33 (41.3)	25 (31.3)
Low back pain, n (%)						
some pain	109 (26.3)	188 (45.4)	117 (28.3)	70 (18.7)	172 (45.9)	133 (35.5)
almost no pain	106 (20.2)	267 (50.9)	152 (29.0)	65 (14.0)	212 (45.6)	188 (40.4)
no pain	82 (20.5)	179 (44.8)	139 (34.8)	49 (13.0)	166 (44.1)	161 (42.8)
Age group, n (%)						
39 and under	103 (27.1)	167 (43.9)	110 (28.9)	53 (13.0)	176 (43.2)	178 (43.7)
40-49	58 (21.4)	137 (50.6)	76 (28.0)	36 (14.5)	116 (46.6)	97 (39.0)
50-64	69 (19.6)	182 (51.7)	101 (28.7)	40 (12.5)	157 (49.2)	122 (38.2)
65 and over	67 (19.9)	148 (44.0)	121 (36.0)	55 (22.8)	101 (41.9)	85 (35.3)
Green tea, n (%)						
Rarely	80 (26.9)	141 (22.2)	99 (24.3)	50 (27.2)	127 (23.1)	100 (20.7)
1-3 day a month	40 (13.5)	92 (14.5)	66 (16.2)	26 (14.1)	75 (13.6)	61 (12.7)
1-2 days a week	39 (13.1)	87 (13.7)	38 (9.3)	25 (13.6)	74 (13.5)	67 (13.9)
3-4 days a week	31 (10.4)	54 (8.5)	45 (11.0)	26 (14.1)	61 (11.1)	55 (11.4)
5-6 days a week	14 (4.7)	45 (7.1)	29 (7.1)	9 (4.9)	46 (8.4)	31 (6.4)
Almost every day	93 (31.3)	215 (33.9)	131 (32.1)	48 (26.1)	167 (30.4)	168 (32.9)
Coffee, n (%)						
Rarely	62 (20.9)	119 (18.8)	71 (17.4)	49 (26.6)	112 (20.4)	73 (15.1)
1-3 day a month	23 (7.7)	37 (5.8)	27 (6.6)	6 (3.3)	26 (4.7)	29 (6.0)
1-2 days a week	15 (5.1)	52 (8.2)	21 (5.1)	13 (7.1)	47 (8.5)	35 (7.3)
3-4 days a week	13 (4.4)	37 (5.8)	16 (3.9)	14 (7.6)	40 (7.3)	37 (7.7)
5-6 days a week	13 (4.4)	47 (7.4)	33 (8.1)	12 (6.5)	61 (11.1)	33 (6.8)
Almost every day	171 (57.6)	342 (53.9)	240 (58.8)	90 (48.9)	264 (48.0)	275 (57.1)
Chocolate, n (%)						
Rarely	50 (16.8)	110 (17.4)	73 (17.9)	49 (26.6)	164 (29.8)	102 (21.2)
1-3 day a month	70 (23.6)	149 (23.5)	89 (21.8)	64 (34.8)	163 (29.6)	138 (28.6)
1-2 days a week	85 (28.6)	151 (23.8)	109 (26.7)	37 (20.1)	126 (22.9)	141 (29.3)
3-4 days a week	35 (11.8)	101 (15.9)	66 (16.2)	18 (9.8)	49 (8.9)	48 (10.0)
5-6 days a week	19 (6.4)	46 (7.3)	24 (5.9)	6 (3.3)	20 (3.6)	17 (3.5)
Almost every day	38 (12.8)	77 (12.1)	47 (11.5)	10 (5.4)	28 (5.1)	36 (7.5)
BMI categories, n (%)						
Underweight <18.5	52 (17.7)	115 (18.4)	96 (23.8)	13 (7.1)	45 (8.4)	39 (8.3)
Normal 18.5-22.9	150 (51.2)	380 (60.7)	246 (61.0)	72 (39.6)	245 (45.6)	239 (51.1)
Overweight 23-24.9	40 (13.7)	60 (9.6)	34 (8.4)	36 (19.8	109 (20.3)	87 (18.6)
Obese ≥ 25	51 (17.4)	71 (11.3)	27 (6.7)	61 (33.5)	138 (25.7)	103 (22.0)

A total of 481 (18.8%) of participants self-reported a slow walking pace whereas 890 (34.8%) self-reported fast WS, and almost half of participants 1,184 (46.3%) reported average WS (Table 7). A total of 611 (325 men and 286 women) participants reported having CMD and out of those who reported slow, average, and fast WS, 144, 279, 188 reported that they were currently diagnosed with CMD, respectively. Prevalence of CMD (23.9%), HTN (14.8%), DM (5.6%), DL (10.3%) was relatively low. Mean BMI were 22.7 ±4.7, 22.1 ±3.7, 21.7 ± 3.3, for slow, average and fast pace WS categories, respectively. Slower self-reported WS and prevalence of CMD was associated with higher BMI in both men and women.

The associations of WS with CMD are shown in table 7. CMD prevalence rate (per 1,000 persons) was 299 for slow walkers, 236 for average and 211 for fast walkers. Multiple logistic regression models were used to calculate the OR of WS with CMD under adjustment for other covariates. Statistical analyses were incrementally adjusted Model 1 was adjusted for age: model 2 was adjusted for age and sex; model 3 was adjusted for age, sex, occupation, marital status, household income, educational attainment, smoking status and drinking habits.

Table 7. Adjusted odds ratios for prevalence of cardiometabolic diseases, hypertension, type 2 diabetes, and dyslipidemia according to walking speed.

	Slow (n = 481)	Average (n = 1,184)	Fast (n = 890)	P for trend
Cardiometabolic diseases				
Number of cases	144	279	188	
Cases per 1,000 persons	299	236	211	
Age adjusted OR (95%CI)	1.00 (Reference)	0.70 (0.54-0.92)	0.59 (0.45-0.79)	< 0.001
Age and sex-adjusted OR (95%CI)	1.00 (Reference)	0.67 (0.52-0.89)	0.55 (0.42-0.74)	< 0.001
Multivariable-adjusted OR (95%CI) *	1.00 (Reference)	0.65 (0.49-0.86)	0.52 (0.38-0.70)	< 0.001
Hypertension				
Number of cases	95	171	111	
Cases per 1,000 persons	198	144	125	
Age adjusted OR (95% CI)	1.00 (Reference)	0.69 (0.51-0.93)	0.57 (0.41-0.79)	< 0.001
Age and sex-adjusted OR (95%CI) *	1.00 (Reference)	0.66 (0.48-0.90)	0.52 (0.37-0.72)	< 0.001
Multivariable-adjusted OR (95%CI)	1.00 (Reference)	0.62 (0.45-0.85)	0.47 (0.33-0.66)	< 0.001
Type 2 diabetes				
Number of cases	40	64	39	
Cases per 1,000 persons	83	54	44	
Age adjusted OR (95% CI)	1.00 (Reference)	0.65 (0.43-0.99)	0.52 (0.33-0.82)	< 0.001
Age and sex-adjusted OR (95%CI)	1.00 (Reference)	0.62 (0.41-0.95)	0.47 (0.30-0.76)	
Multivariable-adjusted OR (95%CI) *	1.00 (Reference)	0.66 (0.42-1.02)	0.55 (0.34-0.90)	
Dyslipidemia				
Number of cases	49	124	90	
Cases per 1,000 persons	102	105	101	
Age adjusted OR (95% CI)	1.00 (Reference)	1.10 (0.76-1.58)	1.051 (0.72-1.54)	1.02
Age and sex-adjusted OR (95%CI)	1.00 (Reference)	1.10 (0.77-1.60)	1.06 (0.72-1.55)	0.84
Multivariable-adjusted OR (95%CI) *	1.00 (Reference)	1.09 (0.75-1.58)	1.01 (0.68-1.5)	0.94

OR: odds ratio, CI: confidence interval

*Adjusting for confounders: age (continuous variable), gender (male/female), occupation (9 groups), marital status（2 groups）, household income（6 groups), educational background (6 groups), tobacco use (3 groups), alcohol consumption (3 groups).

There was evidence for an inverse association between self-reported WS and prevalence of CMD in all models (Table 7). Using the “slow” WS group as reference, model 1 adjusted ORs (95% Cis) for the “average” and “fast” groups were 0.70 (0.54-0.92) and 0.59 (0.45-0.79), respectively (P for trend = 0.001). The OR and 95% CI for model 2 for the “average” group was 0.67 (0.52-0.89) and for “fast” WS group was 0.55 (0.42-0.74). The multivariable-adjusted, model 3 OR and (95% Cis) for the “average” and “fast” groups were 0.65 (0.49-0.86) and 0.52 (0.38−0.70), respectively, (P for trend = 0.001). For the multivariate adjusted model there those who reported “fast” WS had a 48% risk reduction with significant protective effect on CMD.

There was a clear inverse association with self-reported WS and prevalence of HTN. Multivariable-adjusted OR and 95% CI s were 0.62 (0.45-0.85) for “average” WS and 0.47 (0.33-0.66) compared to the reference group “slow” WS category. This shows a 53% lower OR for prevalence of HTN for those who report faster WS. The association for T2DM and WS showed a 45% lower OR for prevalence of disease with those who reported fast WS. However multivariable-adjusted OR and 95% CI s for average WS compared to the reference group of “slow” was 0.66 (0.41-1.02) suggesting that walking at a “average” pace is possibly protective but not significant for T2DM. In contrast there was no association between WS and prevalence of dyslipidemia. Multivariable adjusted OR and 95% CI s for “average” and “fast” WS categories using “slow” WS group as a reference was 1.09 (0.75-1.58) and 1.01 (0.68-1.5), respectively, suggesting that there was no possible protective effect of faster self-reported WS and prevalence of dyslipidemia.

Table 8. Sex-specific adjusted odds ratios for prevalence of cardiometabolic diseases, hypertension, type 2 diabetes, and dyslipidemia according to walking speed.

			Men			Women		
Variable	n	n of cases	Age-sex adjusted OR (95% CI)	*Multivariable-adjusted OR (95% CI)	**Adjusted for further lifestyle and health variables	Age-sex adjusted OR (95% CI)	*Multivariable-adjusted OR (95% CI)	**Adjusted for further lifestyle and health variables
CMD								
Slow	481	144	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Average	1184	279	0.54 (0.36-0.80)	0.48 (0.31-0.73)	0.46 (0.30-0.73)	0.81 (0.56-1.17)	0.80 (0.55-1.17)	0.87 (0.58-1.3)
fast	890	188	0.44 (0.29-0.67)	0.38 (0.24-0.59)	0.39 (0.24-0.62)	0.67 (0.45-1.0)	0.64 (0.41-0.97)	0.74 (0.48-1.16)
Hypertension								
Slow	481	95	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Average	1184	171	0.51 (0.340.78)	0.45 (0.28-0.70)	0.94 (0.55-1.5)	0.86 (0.54-1.35)	0.85 (0.52-1.37)	0.45 (0.28-0.72)
fast	890	111	0.35 (0.23-0.55)	0.29 (0.17-0.47)	0.98 (0.56-1.72)	0.81 (0.49-1.34)	0.77 (0.45-1.37)	0.31 (0.19-0.53)
T2DM								
Slow	481	40	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Average	1184	64	0.73 (0.41-1.29)	0.81 (0.44-1.13)	0.51 (0.24-1.06)	0.53 (0.28-1.01)	0.53 (0.27-1.01)	0.86 (0.45-1.62)
fast	890	39	0.62 (0.34-1.14)	0.80 (0.42-1.54)	0.38 (0.15-0.98)	0.31 (0.14-0.71)	0.31 (0.13-0.73)	0.84 (0.42-1.68)
Dyslipidemia								
Slow	481	49	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Average	1184	124	1.03 (0.58-1.84)	1.02 (0.56-1.88)	1.24 (0.75-2.04)	1.14 (0.72-1.82)	1.13 (0.69-1.83)	0.89 (0.48-1.67)
fast	890	890	1.20 (0.67-2.17)	1.15 (0.61-2.16)	0.94 (0.54-1.64)	0.93 (0.56-1.54)	0.86 (0.50-1.46)	1.07 (0.55-2.07)

CMD: cardiometabolic diseases, T2DM: type 2 diabetes, OR: odds ratio, CI: confidence interval

*Multivariable-adjusted OR (95% CI: adjusted for age (continuous variable), gender (male/female), occupation (9 groups), marital status（2 groups）, household income（6 groups), educational background (6 groups), tobacco use (3 groups), alcohol consumption (3 groups)

**Adjusted for addition variables: adjusted for age, gender, occupation, marital status, household income, education attainment, smoking habits, alcohol consumption, coffee consumption (6 groups), green tea consumption (6 groups), chocolate consumption (6 groups), BMI groups (4 groups), sleep duration (6 groups) and LBP (3 groups).

The sex-specific association between WS and CMD is presented in table 8. In the sex-specific analysis for association between WS and CMD showed that there was a significantly low OR for “fast” WS categories in women compared to participants in the “slow” WS group. In the multivariable-adjusted model there was a 36% lower OR of CMD with faster reported WS in women. In comparison to the “slow” WS category, OR and 95% CI for women who reported “average” and “fast” WS had a 0.81 (0.56-1.17) and 0.67 (0.45-1.0), respectively for age adjusted model and 0.80 (0.55-1.17) and 0.64 (0.41-0.97), respectively, for multivariable-adjusted model. This suggests that there was a possible protective effect of faster WS but no significant association for WS and prevalence of CMD in women. For men, in comparison to the “slow” WS category, OR and 95% CI for age adjusted model was 0.54 (0.36-0.80) and 0.44 (0.29-0.67) for “average” and “fast” WS categories, respectively. For multivariable-adjusted OR and 95% CI there was a 0.48 (0.31-0.73) risk reduction for “average” WS and 0.38 (0.24-0.59) for “fast” WS, indicating a significant association between average and fast WS and prevalence of CMD in men. In sex-specific analyses for WS and prevalence of HTN there was significant associations in men for “average” and “fast” WS categories with a 62% possible risk reduction for “fast” WS in the multivariable-adjusted model. For women there were a possible protective effect but no significant association in age-adjusted and multivariable-adjusted models. In sex-specific analyses for associations between WS and prevalence of T2DM there was a possible protective effect of “average” and “fast” WS but non-significant associations in men. For women, there was significant associations in “fast” WS and prevalence of T2DM in both age and multivariable-adjusted models, OR and 95% CI for “fast” WS categories in reference to “slow” WS were 0.31 (0.14-0.71) for age-adjusted and 0.31 (0.13-0.73) for multivariable-adjusted model. In sex-specific analyses for prevalence of DL and WS there was no significant association for women. For men there was a possibly protective effect for “fast” WS but a non-significant association. OR and 95% CI for WS and prevalence of DL in men for “fast” WS categories were 0.93 (0.56-1.54) for age-adjusted model and 0.86 (0.50-1.46), suggesting a 7% and 14% possible risk reduction, respectively.

Table 9. Associations of walking speed with prevalence of CMD adjusted for further lifestyle and health variables.

	n of cases	Age-sex adjusted OR (95% CI)	*Multivariable-adjusted OR (95% CI)	**Adjusted for further lifestyle and health variables
Walking speed				
Slow		1.00 (reference)	1.00 (reference)	1.00 (reference)
Average		0.68 (0.52-0.89)	0.67 (0.50-0.90)	0.68 (0.51-0.91)
Fast		0.55 (0.42-0.74)	0.57 (0.41-0.77)	0.59 (0.43-0.80)

CMD: cardiometabolic diseases, OR: odds ratio, CI: confidence interval

*Multivariable-adjusted OR (95% CI: adjusted for age (continuous variable), gender (male/female), occupation (9 groups), marital status（2 groups）, household income（6 groups), educational background (6 groups), tobacco use (3 groups), alcohol consumption (3 groups)

**Adjusted for addition variables: adjusted for age, gender, occupation, marital status, household income, education attainment, smoking habits, alcohol consumption, coffee consumption (6 groups), green tea consumption (6 groups), chocolate consumption (6 groups), BMI groups (4 groups), sleep duration (6 groups) and LBP (3 groups).

In additional analysis we investigated the relationship between CMD and potential moderators such as BMI (underweight, normal, overweight, obese), green tea (rarely drink, 1-3 days/month, 1-2 days/week, 3-4 days/week, 5-6 days/week, almost every day), coffee (rarely drink, 1-3 days/month, 1-2 days/week, 3-4 days/week, 5-6 days/week, almost every day) chocolate consumption (rarely eat, 1-3 days/month, 1-2 days/week, 3-4 days/week, 5-6 days/week, almost every day), sleep duration (less than 4 hours, 4-5 hours, 5-6 hours, 6-7 hours, 7-8 hours, ≥8 hours) and LBP(some pain, almost no pain, no pain) (Table 9).When adjusting for coffee, green tea, chocolate consumption and BMI, WS was significantly associated with prevalence of CMD. OR and 95% CI for “average” and “fast” WS categories, when in reference to “slow” WS were 0.71 (0.55-0.91) and 0.61 (0.46-0.80) for “average” and “fast” WS, respectively. Being overweight or obese was associated with 3.6 and 4.3 times increase in experiencing CMD, respectively, compared to individuals who were underweight. Consuming chocolate 5-6 days/week were associated with 47% risk reduction of CMD with an OR and 95% CI of 0.53 (0.31-0.88). Green tea and coffee consumption did not have any significant potential protective effect on prevalence of CMD. When adjusting for age, sex, occupation, marital status, household income, educational attainment, smoking status, drinking habits, green tea consumption, coffee consumption, chocolate consumption, BMI categories, sleep duration and LBP “average” and “fast” WS had significant association with prevalence of CMD. In comparison to “slow” WS, “average” and “fast” WS had OR and 95% CI of 0.67 (0.50-0.90) and 0.57 (0.41-0.77), respectively. Consuming chocolate had potential protective and significant associations on CMD only in the 5-6 days/week category, with an estimated OR was 0.54, with an 95% CI of 0.30 to 0.97.

4. Discussion

In this cross-sectional study, we aimed to investigate the association between self-reported WS and CMD in younger, middle aged and older adults in Japan. Increasing age is an important risk factor for CMD, and our study showed that those with CMD were older. We found that those who self-reported average and fast WS had significantly lower risk of CMD compared with those who reported slower self-reported WS despite controlling for additional covariates. After controlling for sociodemographic and lifestyle factors, we observed a significantly lower HTN and T2DM risk of 53% and 45% (Table 7) in younger, middle-aged and older adults. Interestingly, there was no evidence that fast WS were associated with prevalence of dyslipidemia. This could likely be due to the large variability and the gender differences that exist in dyslipidemias between men and women.

Due to sex differences in CMD and its risk factors in Japan and other Asian populations we systematically stratified prevalence of CMD according to WS by sex. Though many studies on sex differences in CMD concentrate on established risk factors, the main purpose of our study was to determine the effect of sex on self-reported WS and prevalence of CMD. We found that when observing the sex-specific associations of WS with CMD, WS was significantly associated with CMD in men but not in women. In women there was a possible protective but non-significant effect suggesting that the variation is less in women or that women report less accurately than men. Possible explanations for the sex differences in this study could be in part, due to differences in lifestyle and psychological factors. The inherent differences in the pathophysiology of CMD and

CVD and its underlying mechanisms as well as sex differences in treatment and diagnoses rates could be factors to consider. Differences in lifestyle variables could contribute to the sex differences in cardiovascular risk factors. For example, unhealthy lifestyle factors such as smoking, drinking and BMI were higher in men than women in this study. For dyslipidemias, women tend to have more favourable lipid profiles than men at a younger age, but these levels rise after the menopausal transition, and cholesterol rises to levels higher than in men, which is associated with an increase in CVD risk factors such as higher prevalence of DL in postmenopausal women. There is clear evidence that women with heart disease are less likely to reach treatment targets than males and the discrepancies in the presentation and outcomes between the sexes often lead to disparities in the detection, referral and management of CVD (Keteepe-Arachi & Sharma, 2017; Peters et al., 2019). The control of CMD; HTN, DM and DL are suboptimal in both sexes with lower prevalence of controlled DL in women and lower prevalence of controlled HTN and DM in men. Furthermore, knowledge gaps remain for sex differences in CMD and further public health efforts are required to reduce the persistent sex differences in the control of CMD (Peters et al., 2019). Regarding WS, more women reported slow WS than men in this study. In a systematic review and meta-analysis, Whipple and colleagues demonstrated that female patients with diabetes were less likely than male patients in meeting PA guidelines and performed less moderate-to-vigorous physical activity. Walking is a popular moderate-to-vigorous PA and can enhance body composition and insulin sensitivity and lower systematic inflammation. Therefore, it is possible that those who report slower WS may also have lower PA, which is a plausible mechanism for prevalence of CMD. Furthermore, significant sex differences between WS and prevalence of CMD were identified in this study. These results suggest a need for a more comprehensive and sex-specific approach for PA promotion and management of CMD risk factors as well as lifestyle factors to reduce the risk of CVD.

We also adjusted for additional lifestyle variables such as green tea, coffee, chocolate consumption, sleep duration, LBP and BMI (Table 8, 9). Scientific evidence suggests that Asian populations have different associations and cut off points for BMI and percentage of body fat compared to western and European populations, however it is important to note that the cut off points for observed risk for CVD varies in different Asian populations (WHO Expert Consultation, 2004). Asian populations such as Japanese have a higher risk of developing weight-related diseases and comorbidities such as CVD at lower BMIs (≤ 25kg/m2). In this study we found that BMI was higher among men than in women, with 25% of men having a BMI ≥ 25. In this study, being overweight or obese were associated with a 2.83 and 4.40 increase in the odds of experiencing CMD, in reference to individuals who are underweight. BMI could also have significant effect on WS which in turn may lead to negative outcomes such as CMD. For example, older adults experience loss of muscle mass and lower aerobic capacity over time. These changes lead to a decrease in muscle strength which is associated with slower gait speeds. Thus, higher and lower BMI may constitute a risk factor for being a slow walker (Tabue-Teguo et al., 2020). When adjusting for chocolate, green tea, and coffee consumption, only chocolate consumption of 5-6 days a week had associations with CMD. This is consistent with evidence that higher levels of chocolate consumption are associated with reduced risk of cardiometabolic disorders. Possible explanations for the protective effect of chocolate against CMD are the high content of polyphenols present in cocoa produced. This subsequently may lead to improvements in endothelial functions, reductions in platelet function and additional beneficial effects on BP, insulin resistance and blood lipids (Buitrago-Lopez et al., 2011). For the associations between LBP and CMD, when comparing to individuals who reported pain/slight pain, not surprisingly, having almost no pain or no pain at all were significantly associated with reduced risk of CMD. Walking may have important protective effects on LBP as it can engage your core and lower back muscles, subsequently reducing muscular fatigue and may alleviate LBP.

4-1. Comparison with the previous study

Previous studies have shown that WS is a strong predictor of cancer, premature morality as well as CVD events and risk of death in older adults (Yates, 2017). WS has also been found to be associated with predicting disability and hospitalizations, mobility limitations as well as other important aspects of health status(Hardy et al., 2007; Imran et al., 2019; Purser et al., 2005). In a meta-analysis of randomized controlled trials on walking intervention studies Murphy and colleagues sought to quantify the magnitude of walking induced changes on CVD risk factors in sedentary individuals. They found that healthy but sedentary individuals who take up a program of regular brisk walking improves several known risk factors for CVD (Murphy et al., 2007). In a prospective pooled analysis of 11 population-based baseline surveys in British cohorts Stamatakis and colleagues examined the associations between self-reported walking pace with all-cause, CVD and cancer mortality. In this cohort, walking at an average or brisk pace was associated with reduced risk of al cause and CVD morality compared to walking at a slow pace(Stamatakis et al., 2018). These findings are important for public health as it emphasizes the importance of faster WS on CVD risk factors, and targeted interventions such as brisk walking programs should implemented in communities and public health messages to increase moderate intensity physical activities.

Miller et al prospectively examined the association between walking and HTN incidence in the Women's Health Initiative Study. They observed a stronger association with HTN for WS than for walking volume. For women who did not meet recommendations on volume or duration, walking faster was associated with lower HTN risk. A study investigating the association between WS and CVD risk among community-dwelling middle-aged and older adults in Taiwan found that slower measured WS, through a 6-meter WS test was associated with increased risk of CVD in middle-aged people (Shih et al., 2020). In a study of 290 female outpatients with CVD, Grazzi and colleagues found that WS at baseline was inversely associated with the risk of all-cause hospitalization or death, independent of age, clinical history and established risk factors. They observed a 26% lower rate of all-cause hospitalization or death with every 1km/h increase in WS. These results support the notion that in women with CVD, faster WS has protective effects on hospitalization and death rates (Grazzi et al., 2020). Furthermore, walking at an average or faster pace (3.5-6.0 METS) can help achieve moderate intensity PA which can increase levels of PA and decrease risk of CMD, when meeting PA guidelines such as 23 MET hr/week are not feasible (Miller et al., 2020).

Self-reported WS has been identified as a global measure of physical health status with potential for risk stratification in comparison to other lifestyle factors. In a prognostic study using data from 502,621 volunteers within UK biobank between the ages of 38-73, Argyridou et al. found that amongst several easily measured dietary, PA and physical function measures, self-reported walking pace were the most notable measure in predictive capacity for all-cause and cardiovascular mortality. For all-cause mortality, smoking status and WS provided the greatest risk discrimination in both men and women with these results more notable in men. In this study, self-reported walking pace was the only lifestyle variable found to improve risk prediction for all-cause and CVD mortality when added to established CVD risk factors (Argyridou et al., 2020).

The associations found between self-reported walking pace and CMD in our study are consistent with existing international literature. Cigarroa and colleagues investigated the association between self-reported walking pace and T2DM in the Chilean adult population (ages 15-90). They found that brisk walking pace was associated with lower blood glucose and HbA1c compared to those who reported slower walking pace. There was a significant risk reduction in those who reported average and brisk walking pace for T2DM in comparison to slower walkers, independent of age, sex, BMI and other lifestyle behaviours (Cigarroa et al., 2020). A study by Chen et al., investigated the causal relationship between self-reported WS and several CVD outcomes such as stroke and heart failure using two-sample mendelian randomization analyses. They found significant inverse associations of self-reported walking pace with risk of CVD (Chen et al., 2022). Using data from 93,709 UK Biobank participants, Rowlands and colleagues investigated the associations between self-reported walking pace and device-based measures of PA volume and intensity as well as associations between self-reported walking pace and all-cause mortality. In this large population-based cohort of middle-aged adults, they found that the volume and intensity of accelerometer-assessed PA was lowest in people who reported being slow walkers and highest in brisk walkers. They concluded that self-reported walking pace and accelerometer assessed PA are measuring distinct construct and the combination of the two measurements will provide more information than either measure alone. They also concluded that it is likely that self-reported walking pace reflects comparisons relative to perceived “similar people” such as same sex and age groups. If causal, the results of this study suggest that the use of self-reported WS should be used as a fast and pragmatic screening tool for risk stratification at a population level (Rowlands et al., 2023). Ueno and colleagues sought to clarify the clinical utility of self-reported gait speed in primary CVD prevention settings in Japan. In their comprehensive analysis of nationwide epidemiological database of 2.6 million individuals with no prior history of CVD, they found that fast self-reported gait was independently associated with heart failure and other CVD related events. This study highlighted the potential clinical utility of subjective or self-reported WS as a simple predictive tool for primary CVD prevention (Ueno et al., 2022). These findings suggest self-reported WS is a beneficial target for health interventions and increasing population WS is a simple way to increase moderate intensity exercise which can reduce the risk for CMD. Given the ease of self-reported measurements, it may be entirely feasible to develop pragmatic interventions on WS and CMD.

4-2. Possible mechanisms.

There are many variables that contribute to and influence WS such as individual health status, motor control, muscle performance, musculoskeletal condition, sensory and perceptual function, endurance and habitual activity, cognitive status, motivational and mental health as well as environmental conditions (Middleton et al., 2015). It is important to note that CMD involves complex interactions between multiple organs and organ systems and there are a large number of phenotypes associated with CMD risk (Zhernakova et al., 2022). Major causal risk factors for CMD are total cholesterol, LDL cholesterol, triglyceride levels, BP, BMI, smoking, alcohol consumption and physical inactivity. Some evidence of causality has been identified for certain lifestyle factors such as diet quality, PA or stress.

The association between WS and CMD may be explained by the increased relative exercise intensity and METs by a faster WS, in turn, providing a greater stimulus for physiological adaptations known to influence CMD risk factors. Faster WS may promote the use of glucose utilization and enhanced insulin sensitivity in skeletal muscle, which may lead to beneficial changes in body composition and adiposity, thus reducing CMD and associated risk factors (Stamatakis et al., 2018).

WS is strongly related to cardiorespiratory fitness and thus it is not surprising that in this study, faster WS was associated with additional risk reduction for prevalence of CMD. Possible mechanisms could be that those who report faster walking pace could also have higher levels of fitness and physical activity. Self-reported WS may also reflect variables such as physical self-perception, physical health and cultural norms (Rowlands et al., 2023). It is known that regular PA favorably influences numerous established risk factors for CMD and CVD (Grazzi et al., 2020). WS requires the complex integration of multiple organ systems including the cardiovascular, pulmonary, nervous and musculoskeletal systems in addition to support and balance (Imran et al., 2019; Studenski et al., 2011). Slower WS may reflect poorer efficiency of these systems which may affect health outcomes and survival. Slower WS may reflect reduced activity or deconditioning of the musculosketal system and in turn can contribute significantly to CMD risk factors such as unhealthy weight gain, high cholesterol, elevated BP and blood glucose levels.

It is also likely that fast WS may increase healthy muscle tissues and skeletal muscle mass. Several observational studies have shown that low muscular strength is a strong prognostic factor for CVD. It is known that skeletal muscle mass and muscle strength are the main determinants of WS (Ueno et al., 2022). A study by Santos et al., found that improvements in WS are associated with increases in lower limb muscular strength and muscle quality (Santos et al., 2017).Healthy muscle tissues and skeletal muscles are inversely associated with cardiometabolic health (Tyrovolas et al., 2020).Skeletal muscle mass has been shown to be related to various health outcomes in middle-aged and older adults and is inversely related to CVD health and outcomes such as cardiometabolic health, insulin secretion and resistance, metabolic syndrome and diabetes (Tyrovolas et al., 2020). Faster WS may increase cardiorespiratory fitness, increase who muscle mass, muscle quality and improve functional activities while attenuating age-related decreases in strength. Physical inactivity is one of the key factors affecting muscle aging and can lead to harmful muscular adaptations (Distefano & Goodpaster, 2018). It is known that moderate intensity exercise, specifically walking, can improve basal myofibrillar protein synthesis and capillarization which promotes skeletal muscle hypertrophy and increased strength (Brightwell et al., 2019). Furthermore, walking fast could modulate the aging-associated loss of muscle mass and strength and subsequently reduce the risk of CMD and CVD risk.

In our questionnaire we ascertained WS by asking the question “compared to those around you how would you rate your WS”. Self-reported WS could therefore be gauged relative to others who an individual perceives as “similar to them” such as same sex or same age group. It is also likely that self-reported WS likely reflects relative intensity of a person’s PA and thus their cardiorespiratory fitness (Rowlands et al., 2023). We must consider that WS as an indicator of PA varies across groups with differing levels of PA or PF. Thus, it is possible that self-reported WS may reflect relative or perceived intensity of PA rather than the absolute intensity of the activity.

It is important for disease prevention and diagnosis purposes to know which risk factors are causal, however, inferring causality is difficult and the list of causal risk factors are constantly changing over time with the emergence of new research and evidence. If causal, the early assessment of WS through measures such as self-report could aid in CMD and CVD risk assessment in younger, middle-aged and older adults in Japan.

4-3. Features and advantages

With an emphasis on NCD, sound and up-to-date evidence on trends at the national and global level is essential to reflect the effects of public health policy and medical care delivery (GBD 2017 Causes of Death Collaborators, 2018; Islam et al., 2014). CVD is the leading cause of morbidity and mortality in developing counties and in Japan, CVD accounts for one of the top contributors to disease burden (Ueno et al., 2022). Cardiometabolic diseases such as HTN, T2DM and DL are major modifiable risk factors for CVD and thus primary CVD prevention is of critical foci in reducing burden of disease.

WS is a fundamental parameter of human motion and has increasingly become considered an important indicator of individual health status (Middleton et al., 2015; Studenski et al., 2011). The results of our study showed that walking at a faster pace may reduce the risk of CMD independent of age, suggesting the need for preventative strategies as early as young adulthood. However, it is likely that many young adults may not be aware of their cardiometabolic risk status and believe they are less susceptible to CMD due to their age; further emphasizing the importance of early assessment for CVD risk factors. Early assessment of WS could serve as a marker of cardiometabolic and cardiovascular risk in younger, middle-aged and older adults. Furthermore, WS should be emphasized in public health and PA guidelines as a target for health interventions.

Walking is a simple, safe, and highly accessible PA that is highly promotable to adult populations. Encouraging population walking, specifically walking at a faster pace, may be a viable approach to deliver health benefits related to PA at the population level. Objective measurements of WS are an established indicator for risk stratification in CVD prevention settings. Although WS is quick, safe, inexpensive and is a highly reliable objective measurement, it may not be feasible in primary CVD prevention settings, as it necessitates measurements with attendance of a large number of patients, primarily in laboratory settings, involving numerous medical professionals and may be time consuming. Thus, self-reported WS may represent a better option as it can easily be obtained using questionnaire.

The additional protective effects for CMD demonstrated from higher self-reported WS may have important implications for public health and may have meaningful use for the prediction of future health outcomes (Yates et al., 2017). Increasing population walking, and emphasizing WS could be a feasible way of increasing population levels of moderate-intensity activity PA which in turn has many beneficial and protective effects on CMD. Furthermore, self-reported walking pace could function as a pragmatic measure of PF. However, in order to have clinical and public health relevance, research is needed to examine the extent to which pragmatic self-reported measures of WS are associated with cardiorespiratory fitness and whether the associations with CMD are maintained after adjustment for potential confounding variables or vary across potential effect modifiers such as age, sex, smoking status, alcohol consumption, physical activity, BMI and other behavioural and lifestyle factors.

A faster walking pace may have tremendous implications for public health and assessment of individuals WS could be used to guide clinical decision making. Walking faster speeds should be emphasized in public health messages, especially when increases in walking frequency and volume as well as PA are less feasible.

4-4. Strengths and limitations

Most studies on WS and health outcomes have been conducted on samples of older adults however this study included younger, middle-aged and older adults. This study, to our knowledge is the first study to report associations between self-reported WS and CMD in young, middle-aged and older adults throughout Japan.

We acknowledge several limitations of our study. Firstly, this study is a cross-sectional study and not designed to refer to any causal relationship. Secondly, we were unable to include some important covariates such as history of metabolic conditions, salt intake, medication use, duration of disease, physical activity, sedentary behaviour and other potential confounders that may interfere with the effect of WS on CMD risk. We also did not account for any physical challenges related to aging that are potential factor's affecting WS, such as locomotive syndrome, arthritis and musculoskeletal diseases which could have significant impact on WS, especially in older adults. Thirdly, the measures of WS and CMD status were self-reported. The data via internet survey can lead to response bias and misclassification bias if some participants do not accurately report their pace. For example, response bias of WS could have to do with a misunderstanding of what a proper measurement is due to the nature of the question. It is likely that individuals report their WS gauged relative to others who are “similar” to them such as same age and sex. However, previous evidence supports that self-reported WS is strongly associated with measured WS (Syddall et al., 2015). Syddall and colleagues found significant associations between self-reported and measured WS using data from a large cohort of community-dwelling older adults including the potential impact of a large range of socio-demographic, lifestyle and clinical characteristics. Self-reported WS is not only associated with objectively measured gait speed, but has also been found to be associated with physical functions regarding skeletal muscle function such as grip strength and Short Physical Performance Battery (Ueno et al., 2022). Self-reported CMD may not accurately reflect objective measures of CMD, however previous studies in Japan have also assessed CMDs based on self-administered questionnaire (Sawada et al., 2019). For example, Goto et al., evaluated the validity of self-reported diabetes among Japanese adults who underwent a health checkup. They found that of the adults who underwent a health checkup, the validity of self-reported diabetes was reasonably high. These findings are similar to those of previous validation on self-reported CMD in Japan (Goto et al., 2013). The results of these studies suggest that the use of self-reported diseases such as HTN diabetes and DL in epidemiological studies performed under similar settings in Japan can be useful for identifying individuals when laboratory findings or other biomarker-based measurements are difficult to obtain.

Due to the nature of study design, these findings were based on a one-time point assessment and therefore it is unclear whether the positive effects of average and fast WS are due to accumulation of long-term PA or whether self-reported WS have a relationship with perceived PF (i.e., those who think they have higher fitness levels may report faster WS). We did not look at volume of PA or the impact of PA and perceived PF as potential moderators of self-reported WS.

It is also possible that higher oxidative stress and inflammation from CMD can be another mechanism of slower WS. Oxidative stress may cause musculoskeletal system damage which can facilitate the development of frailty and slower gait speeds. Furthermore, we suspect that the relationship between WS and CMD is bi-directional with the slower self-reported WS increasing the risk of CMDs (Liu et al., 2016). However, our study design was cross-sectional which limits our ability to determine temporality of this association. For example, it is possible that the prevalence of CMD can lead to slower gait speeds due to biological and pathophysiological mechanisms.

Finally, these results are limited to Japanese adults and may not be generalizable to other countries or populations due to vast differences in pathophysiology and etiology of CMD in East Asians compared to other ethnic groups. For example, BMI, which is a strong risk factor for CMD in Western and European populations, is relatively low in Japanese. Furthermore, the lack of ethnic diversity in our study sample may limit the generalizability of these findings to other populations.

5. Conclusions

The results obtained from this cross-sectional study provide essential information when considering WS as a tool for assessing CMD and risk in Japanese adults. Our findings suggest that self-reported WS is inversely associated with CMD in Japanese men. Furthermore, men who reported fast WS in this study had lower risk of HTN and T2DM. Due to the results of our study caution is recommended when interpreting self-reported WS in women. Self-reported WS adds predictive information when added to established risk factors and may be used as a simple, non-invasive measure with potential to improve the performance of established risk prediction tools.

Increasing population level walking remains a key focus of PA promotion. Regular walking is known to confer many physical, mental and social health benefits. WS could potentially entail the identification of individuals who are at high risk of CMD followed by interventions to reduce their level of risk, with increasing evidence that lifestyle changes such as faster WS and patient education can significantly reduce the risk of disease. Developing further screening programs for the early detection of CMD is a top priority. The results obtained from this cross-sectional study provide essential information when considering WS as a tool for assessing CMD and CVD risk in Japanese adults.

In conclusion, self-reported walking pace is a practical measure because it is simple to evaluate, can be performed in a timely fashion, in various settings, with minimal to no additional cost. Thus, it may have significant public health utility and can be used as a pragmatic screening tool for risk stratification and intervention at a population level. Future studies investigating the association of self-reported WS in comparison to accelerometer or smart phone assessed PA (such as objectively measured WS) should be carried out. Consequently, further longitudinal studies that prospectively examine peoples WS from a young age are required to establish a causal effect of WS on CMD. If our results are confirmed, it seems reasonable to contemplate a design of a randomized controlled trials evaluating self-reported WS for the primary prevention of CMD in Japanese adults. Future studies in ethnically diverse populations are needed to validate the role of self-reported WS on top of other established risk assessment tools.

6. Nonstandard abbreviations and acronyms

Blood pressure (BP)
Body Mass Index (BMI)
Cardiometabolic disease (CMD)
Cardiovascular disease (CVD)
Coronary artery disease (CAD)
Coronary heart disease (CHD)
Diabetes mellitus (DM)
Dyslipidemia (DL)
High-density lipoproteins (HDL)
Hypertension (HTN)
Ischemic heart disease (IHD)
Low-density lipoprotein cholesterol (LDL)
Metabolic equivalents (METs)
Non-communicable diseases (NCDS)
Physical activity (PA)
Physical fitness (PF)
Triglycerides (TGs)
Type 2 Diabetes mellitus (T2DM)
Walking speed (WS)
World Health Organization (WHO)

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