Doctoral Dissertation

Associations of various exercise types with self-rated health status and health-related physical fitness in Japanese adults

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Abbreviations

ACSM: American College of Sports Medicine

APA: American Psychological Association

BMI: body mass index

CDC: Centers for Disease Control and Prevention

FMS: fundamental motor skills

HRQoL: health-related quality of life

HRPF: health-related physical fitness

LTPA: leisure time physical activity

PA: physical activity

PFA: physical fitness age

PFS: physical fitness score

RPE: rating of perceived exertion

SRH: self-rated health

$\dot{V}O_{2max}$: maximal oxygen uptake

$\dot{V}O_{2AT}$: oxygen uptake at the anaerobic threshold

$\dot{V}E/\dot{V}O_2$: ventilation equivalent for oxygen

WHO: World Health Organization

Chapter 1 General Introduction

Participation in regular physical activity or exercise benefits many parts of the body: heart, skeletal muscles, bones, blood, the immune system and the nervous system, and reduces many of the risk factors for non-communicable diseases including reducing blood pressure, improving blood cholesterol levels, and lowering body mass index (BMI) (Haskell et al., 2007). In addition to the above benefits on improving health status and reducing risk factors for chronic disease, it has been confirmed to be effective in improving mental health: improved mood, reducing symptoms of stress, anger and depression, alleviating anxiety, and slowing cognitive decline (Babyak et al., 2000; Pate et al., 1995; Penedo & Dahn, 2005; Taylor et al., 1985; Warburton et al., 2006).

Since more than 20 years ago, the American College of Sports Medicine (ACSM) in conjunction with the Centers for Disease Control and Prevention (CDC) (Pate et al., 1995), the U.S. Surgeon General (Hootman, 2009), and the National Institutes of Health (1996) issued landmark publications on physical activity (PA) and health. An important goal of these reports was to clarify for exercise professionals and the public the amount and intensity of PA needed to improve health status. The ACSM and American Heart Association (AHA) (Haskell et al., 2007) issued updated recommendations for PA and health in 2007 as follows:

1) All healthy adults aged 18–65 years should participate in moderate intensity aerobic PA for a minimum of 30 min on 5 $d \cdot wk^{-1}$ or vigorous intensity aerobic activity for a minimum of 20 min on 3 $d \cdot wk^{-1}$.
2) Combinations of moderate and vigorous intensity exercise can be performed to meet this recommendation.
3) Moderate intensity aerobic activity can be accumulated to total the 30 min minimum by performing bouts each lasting ≥10 min.
4) Every adult should perform activities that maintain or increase muscular strength and endurance for a minimum of 2 $d \cdot wk^{-1}$.
5) Because of the dose-response relationship between PA and health, individuals who wish to further improve their fitness, reduce their risk for chronic diseases and disabilities, and/or prevent unhealthy weight gain may benefit by exceeding the minimum recommended amounts of PA.

Due to the importance of the amount of PA, most previous studies have focused primarily on the optimal “volume” (frequency, time and intensity of PA or exercise) and the minimum volume for health benefits, in particular the effects of intensity (e.g., moderate vs. vigorous) on health status (Warburton et al., 2006).

Although the health benefits of PA or exercise are widely confirmed, worldwide, 31.1% (95% CI: 30.9–31.2) of adults (aged 15 years or older) did not reach public health guidelines for recommended levels of physical activity (Hallal et al., 2012). Regular leisure time physical activity (LTPA) was undertaken by only 22.2% (95% CI, 21.8%-22.6%) among adults in the United States (Reeves & Rafferty, 2005). According to the China national survey on the status of physical activities, the percentage of people who regularly participated in physical exercise was 33.9% (General Administration of Sport of China, 2015). In Japan, the proportion of habitual exercisers was 35.9% for men and 28.6% for women, and there had been no significant increase or decrease in both men and women over the last 10 years (Ministry of Health Labour and Welfare, 2018). It seems that only understanding the health benefits of physical activity or exercise does not effectively increase people's daily physical activities and habitual exercise.

Apart from the amount of exercise, mode or type has been considered as another unique characteristic of exercise or sports. American College of Sports Medicine (2009) emphasized that an assortment of exercise modalities is recommended to avoid the potential for overuse syndromes; a variety of exercises to improve the components of physical fitness is recommended for all adults.

Exercise continuance requires a feeling of enjoyment during the activity (Ito et al., 2019). “Pleasure” and “physical competence” are considered as important factors for affecting the adherence volition of physical exercise (Nakamura & Furukawa, 2004). With different exercise types or modes, exercise practitioners are capable of learning unique exercise skills that could affect exercise motivation (Schunk, 1989). There are differences in the preferences of exercise type among people of different ages and genders (Nakamura & Furukawa, 2004), and personal motivation and preferences are likely gradually changed with aging, lower physical strength and motor function.

A few studies have reported that exercise types are associated with various health conditions. Walking, as one of the most common type of exercise, is often included in studies of exercise in relation to disease (Morris & Hardman, 1997). Edwards et al. (2005) found that hockey (a team sport) players perceived themselves as having more positive relations and sport competence with resistance trainers and runners by compared psychological wellbeing and physical self-perception. Duncan et al. (2002) confirmed that runners had significantly higher total body, femoral neck, and leg bone mineral density than swimmers, and greater leg bone mineral density than cyclists. King et al. (2003) proved that compared to non-exercisers with respect to a specific exercise type, people who regularly engaged in jogging and aerobic dancing were significantly less likely to have elevated cardiovascular markers but not those who engaged in gardening swimming, cycling, calisthenics, and weight lifting were not, after controlling for age, race, sex, body mass index, smoking, and health status.

In the studies of the association between exercise type and health, Tsujimoto et al. (2017) found that participation in multiple exercises showed better self-reported health (SRH) and self-assessment of physical fitness than those participation in single exercise. Among numerous health related indicators, SRH is simple, easy to administer measure of general health. It is a valid and reliable measure among those without cognitive impairment. Initially, it replaced clinical assessments in survey research (Strawbridge & Wallhagen, 1999). It is commonly used in psychological research, clinical settings, and in general population surveys (Bombak, 2013). Early studies using SRH involved assessing the relationship between SRH with sociodemographic, physical health, and psychosocial variables (Garrity et al., 1978; Maddox, 1962). Additional uses of SRH involved investigating relationships between health constructs, sociodemographic, physical, and psychosocial variables, clarifying measurement issues, attempting to explain health and illness behavior, or describing populations' health (Ware et al., 1980). SRH was found to be at least moderately associated with physicians' assessments of health (Idler et al., 1999).

With commonly being treated as a more accurate measure of physical activity than self-report, physical fitness is often used in large epidemiologic investigations (Williams, 2001). A high level of physical fitness usually is associated with good health. Health-related physical fitness involves the components of physical fitness related to health status, including cardiovascular fitness, musculoskeletal fitness, body composition and metabolism (Williams, 2001) . The health-related components of physical fitness are more important for public health than are the components related to athletic ability (Caspersen et al., 1985).

Health benefits are associated with physical activity and regular exercise or sports, not only with the volume (frequency, time and intensity), but also with the exercise mode or type. It is certainly not easy to classify all exercise or sports, as there are over 3,000 sport disciplines and sporting games and more than 8,000 indigenous sports worldwide (Lipoński et al., 2003). Classification of exercise or sports is considered important. In order to clear the general characteristics of exercise or sports, it is considered important to study the exercise type by means of classification. As far as the author knows, there has been no systematic study on the association of health with exercise type.

Therefore, the purposes of this thesis were to explore the associations of various exercise types with both subjective (self-rated health) and objective health indicators (health-related physical fitness).

Chapter 2 Review of Related Literature

2.1 Definition

Health

Health is the level of functional and metabolic efficiency of a living organism. In humans it is the ability of individuals or communities to adapt and self-manage when facing physical, mental, psychological and social changes with environment (Huber et al., 2011). The World Health Organization (2006a) defined health in its 1948 constitution as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity."

Physical activity and exercise

Perceptions about the meaning of physical activity might vary among countries, sexes, and age groups (Sjøl et al., 2003).

Physical activity is defined as any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in energy requirements over resting energy expenditure (Caspersen et al., 1985; Rochmis & Blackburn, 1971).

Exercise is a type of physical activity consisting of planned, structured, and repetitive bodily movement done to improve and/or maintain one or more components of physical fitness (Caspersen et al., 1985).

Exercise characteristics

This article employs the frequency (how often), intensity (how hard), time (duration or how long), type (mode or what kind) to describe the characteristics of exercise.

Physical fitness

Physical fitness has been defined in several ways, but the generally accepted definition is the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and meet unforeseen emergencies (Physical Activity Guidelines Advisory Committee, 2008) . Physical fitness is composed of various elements that can be further grouped into health-related and skill-related components (Caspersen et al., 1985) (Figure 2-1).

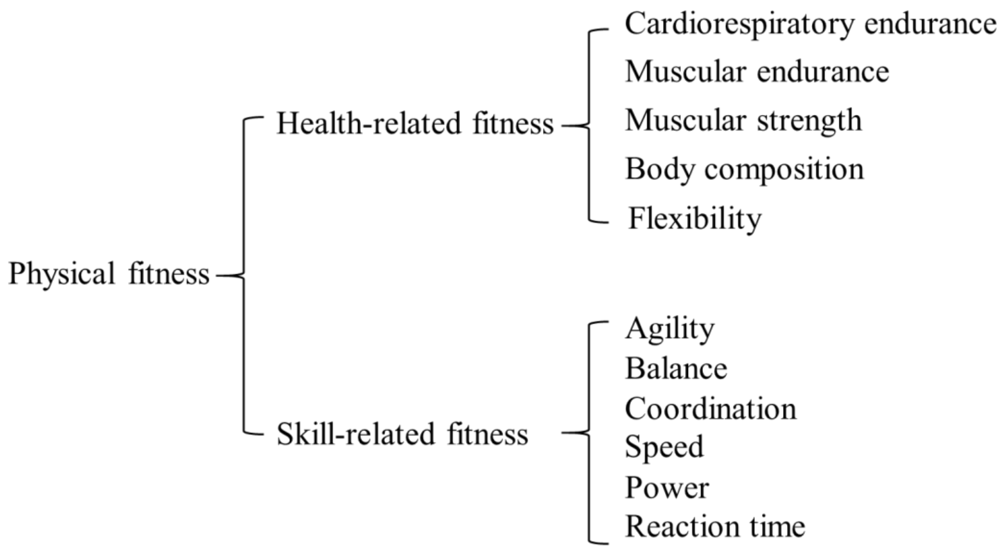

Figure 2-1 Health-Related and Skill-Related Components of Physical Fitness

2.2 Motor skills-based classification of exercise

Exercises or sports are classified using different perspectives such as energy consumption (aerobic exercise or anaerobic exercise), playing fields (indoor or outdoor), and number of participants (personal or group sports). Among numerous classification theories, Udo (1977) classified exercises or sports into five categories: simple movement without exercise equipment, complex movement without exercise equipment, non-confrontational movement with exercise equipment, confrontational movement with exercise equipment, and synchronous movement with exercise equipment.

Except the factor of genetics, fitness and health status are both influenced by many other confounding factors, including not only the social and physical environment, but also personal lifestyle of the individual such as routine exercise, healthy diet, leisure participation, spiritual growth, interpersonal relationships, stress management, and health responsibility (Walker et al., 1987). Personal characteristics also influence the impact of physical activity upon health status. Because of age, gender, and health-related differences in physical fitness, a given pattern of physical activity imposes a widely differing level of relative stress upon different individuals (Bouchard et al., 1990). Uto's classification, based on both motor skills and relationship between exercise subject (exercise participant) and exercise object (exercise equipment), includes special personal characteristics.

Udo's classification was selected as it focuses on motor skills that play a significant role in fitness levels and physical activity outcomes (Faught et al., 2005; Hands, 2008; Schott et al., 2007). Specific motor skills are needed for the development of fitness components such as strength, power, or endurance, and they are also used as health-related indexes. Better motor skills were proved to be associated with a lower body fat percentage (Cantell & Crawford, 2008). Progressive deterioration of motor skills was considered to be one of the criteria for clinical diagnosis of probable Alzheimer's disease (McKhann et al., 1984).

2.3 Motor skills, motor competence and health status

Motor skills are learned abilities to cause predetermined movement outcomes with maximum certainty. There is a large range of exercise or sporting activities each requiring a set of motor skills (Coker, 2017). Motor skills are considered playing a highly significant yet varying role in supporting physical activity behaviors thereby associated with health-related physical fitness and obesity (Stodden et al., 2008). Evidence indicates that motor skill competence is positively associated with perceived competence and multiple aspects of health status (i.e., physical activity, cardiorespiratory fitness, muscular strength, muscular endurance, and a healthy body weight status) (Cattuzzo et al., 2016; Robinson et al., 2015).

Fundamental motor skills (FMS) are the abilities to perform complex muscle-and-nerve acts that produce various movements such as locomotion (e.g. running and walking), manipulation or object control (e.g. catching and throwing) and stabilization (e.g. balancing and twisting) (Table 2-1). FMSs are defined as goal-directed movement patterns that directly and indirectly impact an individual's capability to be physically active and that can continue to be developed to enhance physical activity participation and promote health across the lifespan (Hulteen et al., 2018).

Table 2-1 Fundamental motor skills

FMS	Characteristics	Examples
Locomotor skill	Body moves from one place to another.	Walking, running, jumping
Non-locomotor skill	Individual perform while remaining stationary.	Bending, swaying, pushing
Manipulative skill	Require control of body and object beyond it.	Throwing, catching, kicking

(Stodden et al., 2008)

FMSs are the foundation of motor competence (i.e., the degree to which an individual can perform goal-directed human movement) (Robinson et al., 2015) and physical fitness (i.e., agility, balance, coordination, power, and reaction time) (Stodden et al., 2008; Stricker, 2006). Participants with efficient performance in locomotor skills have greater perceived competence in athletic abilities. The level of performance of FMS is associated with perceived competence in athletic abilities in adults (Jimenez-Diaz et al., 2018). People with high levels of motor skill competence and correspondingly more physical activity demonstrate greater health-related fitness and higher performance scores (Luz et al., 2017; Stodden et al., 2014).

Various exercises are associated with markedly different improvements in life expectancy (Schnohr et al., 2018). Skillful performance or progress in skill acquisition could also enhance or maintain self-efficacy, which is considered as an important volitional variable for the maintenance of physical exercise (Schunk, 1989; Sniehotta et al., 2005).

2.4 Self-rated health status and exercise

Regular exercise has positive health effects on individual subjective health indicators: self-rated health status (SRH), quality of life (QoL), life satisfaction, subjective well-being, etc. (Diener et al., 1999; Mroczek & Spiro III, 2005; Orfila et al., 2000). Self-rated health is a measure of participants' perception of their overall health status which is based on asking individuals to evaluate their health status on a four- or five-point scale. In the question that is most widely used in the US, responses are set out on a scale from excellent through very good, good and fair to poor, while the options recommended by the World Health Organization (1996) and the EURO-REVES 2 group (Robine et al., 2003) are very good, good, fair, bad and very bad. Although the levels and distributions are not directly comparable among the measures, they represent parallel assessments of the same phenomenon, and show basically concordant answers (Jürges & Avendano, 2007).

SRH has been well documented as a reliable predictor of functional disability, cardiovascular disease, mortality, and life prognosis (Burström & Fredlund, 2001; Idler & Benyamini, 1997; Møller et al., 1996; Mossey & Shapiro, 1982). SRH has been broadly used as an indicator in psychosocial and gerontological research, as well as in epidemiologic surveys. Many studies have demonstrated that SRH is a powerful predictor of subsequent illness and mortality (Idler & Benyamini, 1997; Idler & Kasl, 1991). The factors associated with SRH have been broadly studied (Kelleher et al., 2003). Gender, age, and socioeconomic, occupational or environment factors, access to healthcare and other variables (Kelleher et al., 2003; Rahkonen et al., 2006) can influence SRH.

In particular, the associations between physical activity and SRH has been studied in various populations. SRH was found to worsen with advancing age and to correlate with socioeconomic status, physical activity, alcohol consumption, chronic disease, and functional status (Kawada, 2003). Participation in physical activity or regular exercise was associated with a better SRH status (Phillips et al., 2005; Sun et al., 2007). An ability to go out alone to distant places was also found to correlate strongly with SRH (Phillips et al., 2005; Sun et al., 2007).

According to a study about the association between physical activity and SRH in the USA, the likelihood of fair or poor health was significantly lower among adults meeting recommended levels of physical activity or having insufficient levels of activity compared to physically inactive adults (Browning et al., 2003). In Europe, subjects who were sufficiently or highly active were more likely to report a good SRH status than those who were insufficiently active, regardless of household income and educational status (Abu-Omar et al., 2004). Another population-based study in Sweden also showed that both exercise and total physical activity were independently associated with good SRH (Södergren et al., 2008). Misra et al. (1996) studied 43 older women who had participated in an exercise class in an urban setting indicated a significant positive relationship among self-esteem, exercise, and self-rated health in older women. Older adult women who exercised, perceived themselves to be healthy had higher self-esteem in general.

2.5 Health-related physical fitness and exercise

Physical fitness is a general state of health and well-being or specifically the ability to perform aspects of sports or occupations. Physical fitness is generally achieved through correct nutrition, exercise, hygiene and rest. It is a set of attributes or characteristics that people have or achieve the ability to perform physical activity (Blair, 1996). Health-related physical fitness is defined as fitness related to some aspect of health. This type of physical fitness is primarily influenced by an individual's exercise habit; thus, it is a dynamic state and may change. Physical characteristics that constitute health-related physical fitness include strength and endurance of skeletal muscles, joint flexibility, body composition, and cardiorespiratory endurance. All these attributes change in response to appropriate physical conditioning programs, and all are related to health status (Blair, 1996).

Developing a healthy lifestyle includes maintaining appropriate levels of health-related physical fitness and exercise habituation (Reeves & Rafferty, 2005). Health-related physical fitness is a physiological state of well-being and the ability to carry out daily tasks with vigor (Caspersen et al., 1985). Improvements in health-related physical fitness are frequently equated with improvements in health status or disease prevention (Haskell et al., 1985). Exercise habituation is tightly associated with cardiovascular fitness, muscle strength, and functional capacity (Fiuza-Luces et al., 2018). Exercise habituation can help maintain functional independence in older people and prevents or markedly attenuates the age-related increase in risk factors for coronary heart disease (Nelson et al., 2007; Seals et al., 2001). Available research also indicates that participation in habitual exercise could effectively reduce and prevent a number of functional and health-associated impairments that occur with advancing age effectively (H. Tanaka, 2009).

With different exercise types, exercise practitioners were capable of learning unique exercise skills that could affect exercise motivation (Schunk, 1989). Skillful performance or progress in skill acquisition could also enhance or maintain self-efficacy, which is considered as an important volitional variable for the maintenance of physical exercise (Schunk, 1989; Sniehotta et al., 2005). Multifaceted exercises, such as tai chi, Chinese qigong, and yoga, are beneficial as part of a comprehensive exercise program for older individuals, especially to improve balance, agility, muscle strength, and reduce the risk of falls (Bird et al., 2011; Witvrouw et al., 2007). Tanasescu et al. (2002) found that running, jogging, rowing, and racquet sports (tennis and racquetball) were associated with reduced coronary heart disease risk in age-adjusted analyses in men

(40–75 years old) compared to men (40–75 years old) who did not engage in these activities, while cycling and swimming were not associated with the aforementioned reduction in risk.

2.6 Summary

The health benefits of regular exercise have been widely confirmed. Both subjective (self-rated health status) and objective health indicators (health-related physical fitness) are associated with physical activity or exercise. Apart from the amount of exercise, type or mode has been considered as other unique characteristic of exercise or sports and associated with various health conditions. The SRH and health-related physical fitness of habitual exercisers who perform different types of exercise has not been adequately described.

Motor skills play an important role in supporting physical activity behaviors and associate with health thereby motor skills-based classification of exercise may associate with the health outcomes. Although motor skills are important health-related indicators, associations of SRH and health-related physical fitness with exercise types classified according to motor skills have not been adequately studied.

Chapter 3 Hypothesis，Purpose and Significance

Hypothesis

Through the previous research on health, exercise, and physical fitness, exercise type, as one of the exercise characteristic factor, was verified resulting in different assessments on health indicators. Therefore, there may be associations of exercise type with health indicators. Developing habitual exercise with appropriate exercise types may result in different health benefits.

Purpose

The purposes of this study were to explore the associations of various exercise types with both self-rated health status and health-related physical fitness.

Significance

It is possible to know the health status of exercise participants of various exercise types through this study. Exercise instructors who provide health-supporting or health-promotion programs could provide more options for multiple exercise types in order to prompt participants to engage in more exercises or sports for a better health status.

Chapter 4 Main Studies of Dissertation

In order to fulfill the purposes, this dissertation was divided into two parts as follows:

Study 1 Associations of various exercise types with self-rated health status: A secondary analysis of Sports-Life Data 2012

This study aims to investigate the associations of various exercise types with self-rated health (SRH) among a representative sample of Japanese adults based on Udo's classification.

Study 2 Health-related physical fitness of habitual exercisers with different exercise types: A cross-sectional study

This study aims to describe health-related physical fitness status in habitual exercisers who participate in different types of exercise.

Chapter 5 (Study 1) Associations of various exercise types with self-rated health status: A secondary analysis of Sports-Life Data 2012

5.1 Purpose

This study aims to investigate the association of various exercise types with SRH among a representative sample of Japanese adults based on Udo's classification.

5.2 Materials and Methods

5.2.1 Data

The author used data from the 2012 National Sports-Life Survey conducted by the Sasakawa Sports Foundation (Ebihara et al., 2012). The National Sports-Life Survey has been conducted every two years since 1992 to describe the current exercise or sports situation of Japanese adults (20 years old or above). The 2012 survey was conducted from June 22 to July 22 and covered 210 areas (190 urban areas and 20 rural areas) nationwide by two-stage stratified random sampling with 9-10 samples in each area and a set sample size of 2,000 individuals, based on the national population census for 2011 (or 2010 for 22 areas without 2011 national population census data due to the 2011 northeast region [Tōhoku] earthquake and tsunami). The questionnaire was administered and collected by survey staff using a placement method. The recovery rate of the questionnaire was 100%. Following the Personal Information Protection Law

(Japan) and the guidelines of the Japan Marketing Research Association, the data were anonymous, and no personal information, such as name, address, date of birth, was recorded. Through these procedures, 2,000 responses were obtained. Data without missing values were considered valid for primary data analysis. The Sasakawa Sports Foundation approved the data usage for this secondary analysis.

5.2.2 Surveyed items

Participation in exercise or sports

Participants were asked to choose the exercises they had practiced in the past year from a list of 60 exercise or sports. They were also asked to list up to five exercises or sports that they practiced most frequently. If the exercises or sports that they practiced were not included in the given list, they were instructed to indicate them in the "Other" section. Information about the exercise frequency and average duration for each exercise or sports session was also obtained.

According to the official survey report (Ebihara et al., 2012), the activity levels of exercise practitioners (i.e. exercise practice level) were classified into five levels (Levels 0 to 4) by exercise frequency, time, and subjective exercise intensity (rating of perceived exertion [RPE]). Level 0 referred to no exercises or sports in the past year. Level 1 was defined as exercises or sports practiced ≥ 1 time/year, but < 2 times/week (i.e., 1-103 times/year). Level 2 was defined as ≥ 2 times/week (≥ 104 times/year). Level 3 was defined as ≥ 2 times/week and an exercise duration of ≥ 30 minutes/time. Finally, Level 4 referred to ≥ 2 times/week, exercise duration of ≥ 30 minutes/time, and an RPE of “somewhat hard” or “moderately hard.” (Table 5-1).

Table 5-1 Exercise practice level

Exercise practice level		Description
Level 0	Inactive	Did not participate in any exercise or sports in past year
Level 1	Inadequately active	≥ 1 time/year, < 2 times/week (1-103 times/year)
Level 2		≥ 2 times/week (≥ 104 times/year)
Level 3		≥ 2 times/week, ≥ 30 min/time
Level 4	Active	≥ 2 times/week, ≥ 30 min/time, somewhat hard or moderately hard

(Ebihara et al., 2012)

Classification of exercise types

The most frequently practiced exercise types were classified into five categories based on Udo (1977) ’s classification (Table 5-2).

Self-rated health (SRH)

Participants were asked to rate their own health using a single question: “How would you describe your general health?” with four possible options: (1) excellent, (2) good, (3) fair, and (4) poor. SRH was categorized as “good” in cases of “excellent” or "good" responses and as "poor" in cases of "fair" or "poor" responses.

Sociodemographic and lifestyle variables

Sociodemographic information included age, gender, height, weight, body mass index (BMI), family composition (live alone or do not live alone), and job (full-time, part-time, or no job). Lifestyle information included status of alcohol consumption (current alcohol drinker or non-alcohol drinker) and tobacco smoking (current smoker or non-smoker).

BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2). The participants were divided into the following three classes according to their BMI: underweight (BMI $\leq$ 18.5 kg/m^2), normal weight (BMI 18.5-24.9 kg/m^2), and overweight (BMI $\geq$25 kg/m^2) (World Health Organization, 2006b).

5.2.3 Statistical analysis

Statistical analyses were performed using the statistical package IBM SPSS Statistics 18.0. The distributions of the characteristics of participants were computed using the chi-squared test for categorical variables (gender, family composition, employment status, tobacco smoking, alcohol drinking, exercise practice level, and poor SRH), which were expressed by number and percentage. Continuous variables (age and

BMI) were computed using a one-way analysis of variance and expressed by mean and standard deviation. *P* values < 0.05 were considered to be statistically significant.

The primary analysis assessed the association between poor SRH and exercise type using a logistic regression analysis considering the exercise type category as the independent variable, poor SRH as the dependent variable, and sociodemographic and lifestyle variables as confounding factors. The sub-analysis examined the association between poor SRH and different exercise type categories by gender, age, and exercise frequency group. To compare poor SRH among exercisers, the author used simple movement without exercise equipment as the reference category for the logistic regression analysis in this study.

5.3 Results

Data from 46 participants (2.3%) with missing values were deleted, and data from the remaining 1,954 participants were analyzed. No difference was observed between individuals with complete and incomplete data in terms of gender, age, height, weight, BMI, family composition, and job.

A total of 181 exercises or sports (including sports games) were reported by participants. Among the 1,954 participants, 1,459 (74.7%) reported having enjoyed an exercise or sport in the past year. These 1,459 participants were classified into five categories based on the motional characteristic of the exercise type of their most-frequently-practiced exercise or sport in the past year. Major exercises or sports in each category and their distributions are presented in Table 5-2.

Table 5-2 Classification of exercise type, its characteristics, and representative examples of exercises or sports for each exercise type (n=1,459)

Category	Characteristics	Exercise type	n (%)
Simple movement without exercise equipment (n=707)	Simple physical exercise, evaluation for speed or distance.	Walking (including strolling)	591 (83.6%)
		Jogging/running	61 (8.6%)
		Swimming	32 (4.5 %)
Complex movement without exercise equipment (n=303)	Moving by directional stepping, body stretch and tilt, etc. mostly with rhythm of music.	Calisthenics (including light, radio calisthenics)	146 (48.2%)
		Dance (any form)	51 (16.8%)
		Yoga	29 (9.6%)
Non-confrontational movement with exercise equipment (n=188)	Playing by operating exercise equipment, most of the environment is predictable and response can be planned.	Golf (including golf course and golf practice range)	95 (50.5%)
		Fishing	32 (17.0%)
		Bowling	19 (10.1%)
Confrontational movement with exercise equipment (n=206)	Playing with one or more battle opponents by using exercise equipment, conditions are variable and unpredictable.	Soccer	47 (22.8%)
		Volleyball	33 (16.0%)
		Baseball	26 (12.6%)
		Tennis	26 (12.6%)
Synchronous movement with exercise equipment (n=55)	Controlling and operating exercise equipment is key point of completing the movement.	Cycling	38 (69.1%)
		Surfing	8 (14.5%)

Table 5-3 Basic information of participants by different exercise type categories (n=1,954)

	No exercise (n = 495)	I [a] (n = 707)	II [a] (n = 303)	III [a] (n = 188)	IV [a] (n = 206)	V [a] (n = 55)	*P* value
Gender, n / %							< 0.001
Male	221 / 44.6	330 / 46.7	116 / 38.3	140 / 74.5	135 / 65.5	37 / 67.3	
Female	274 / 55.4	377 / 53.3	187 / 61.7	48 / 25.5	71 / 34.5	18 / 32.7	
Age, year	51.8 ± 17.6	52.5 ± 15.6	46.9 ± 17.2	49.9 ± 16.1	40.0 ± 14.0	42.1 ± 13.1	< 0.001
20-44 years old, n / %	185 / 37.4	240 / 33.9	142 / 46.9	82 / 43.6	139 / 67.5	36 / 65.5	< 0.001
45-64 years old, n / %	166 / 33.5	282 / 39.9	102 / 33.7	62 / 33.0	53 / 25.7	16 / 29.1	
65 years or older, n / %	144 / 29.1	185 / 26.2	59 / 19.5	44 / 23.4	14 / 6.8	3 / 5.5	
BMI, kg/m^2	22.5 ± 3.5	22.7 ± 3.0	22.1 ± 3.1	22.7 ± 3.1	22.9 ± 3.4	22.0 ± 2.9	0.102
< 18.4k, n / %	42 / 8.5	39 / 5.5	23 / 7.6	12 / 6.4	9 / 4.4	3 / 5.5	0.029
18.5-24.9, n / %	340 / 68.7	521 / 73.7	231 / 76.2	134 / 71.3	153 / 74.3	46 / 83.6	
> 25.0, n / %	113 / 22.8	147 / 20.8	49 / 16.2	42 / 22.3	44 / 21.4	6 / 10.9	
Family composition (live alone), n / %	39 / 7.9	43 / 6.1	16 / 5.3	13 / 6.9	14 / 6.8	4 / 7.3	0.269
Job (unemployed), n / %	93 / 18.8	112 / 15.8	36 / 11.9	28 / 14.9	10 / 4.9	4 / 7.3	< 0.001
Current smoker, n / %	150 / 30.3	117 / 16.5	48 / 15.8	70 / 37.2	68 / 33.0	11 / 20.0	< 0.001
Current alcohol drinker, n / %	264 / 53.3	455 / 64.4	197 / 65.0	134 / 71.3	162 / 78.7	42 / 76.3	< 0.001
Exercise practice level							
Level 0, n / %	495 / 100.0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	< 0.001
Level 1, n / %	0 / 0	158 / 22.3	68 / 22.4	131 / 69.7	112 / 54.4	26 / 47.3	
Level 2, n / %	0 / 0	75 / 10.6	82 / 27.2	8 / 4.3	6 / 2.9	7 / 12.7	
Level 3, n / %	0 / 0	282 / 39.9	52 / 17.2	30 / 16.0	20 / 9.7	10 / 18.2	
Level 4 (active), n / %	0 / 0	192 / 27.2	101 / 33.3	19 / 10.1	68 / 33.0	12 / 21.8	
SRH (poor), n / %	163 / 32.9	169 / 23.9	56 / 18.5	39 / 20.7	33 / 16.0	9 / 16.4	< 0.001

P values were from Chi-squared test (categorical variable) and one-way Analysis of Variance (continuous variables).

[a] I-V: Simple movement without exercise equipment; Complex movement without exercise equipment; Non-confrontational movement with exercise equipment; Confrontational movement with exercise equipment; Synchronous movement with exercise equipment.

BMI: body mass index.

The characteristics of participants stratified by exercise or sports classification are presented in Table 5-3. Gender, age, BMI, employment status, tobacco smoking state, alcohol drinking state, and exercise practice level significantly differed according to the classification categories. Overall, 469 (24.0%) participants, 32.9% non-exercisers vs. 21.0% exercisers, rated their health as fair or poor (considered as poor SRH). The lowest prevalence of poor SRH (16.0%) was observed among participants who practiced confrontational movement with exercise equipment.

Compared to simple movement without exercise equipment, the odds ratio (OR) for poor SRH was significantly higher for no exercise group both before (Figure 5-1) and after Figure 5-2) adjusting for confounding factors. The OR for poor SRH was significantly lower for exercisers participating in confrontational movement with exercise equipment. The sub-analysis examined the association between poor SRH and different exercise type categories while SRH was categorized as “good” in cases of “excellent” responses (n=171) and as “poor” in cases of “poor” responses (n=75). The author observed similar results (Table 5-4). However, confrontational movement with exercise equipment showed no significance compared to no exercisers after adjusted influencing factors for the possible reason as decreasing sample size caused the 95% CI width increased.

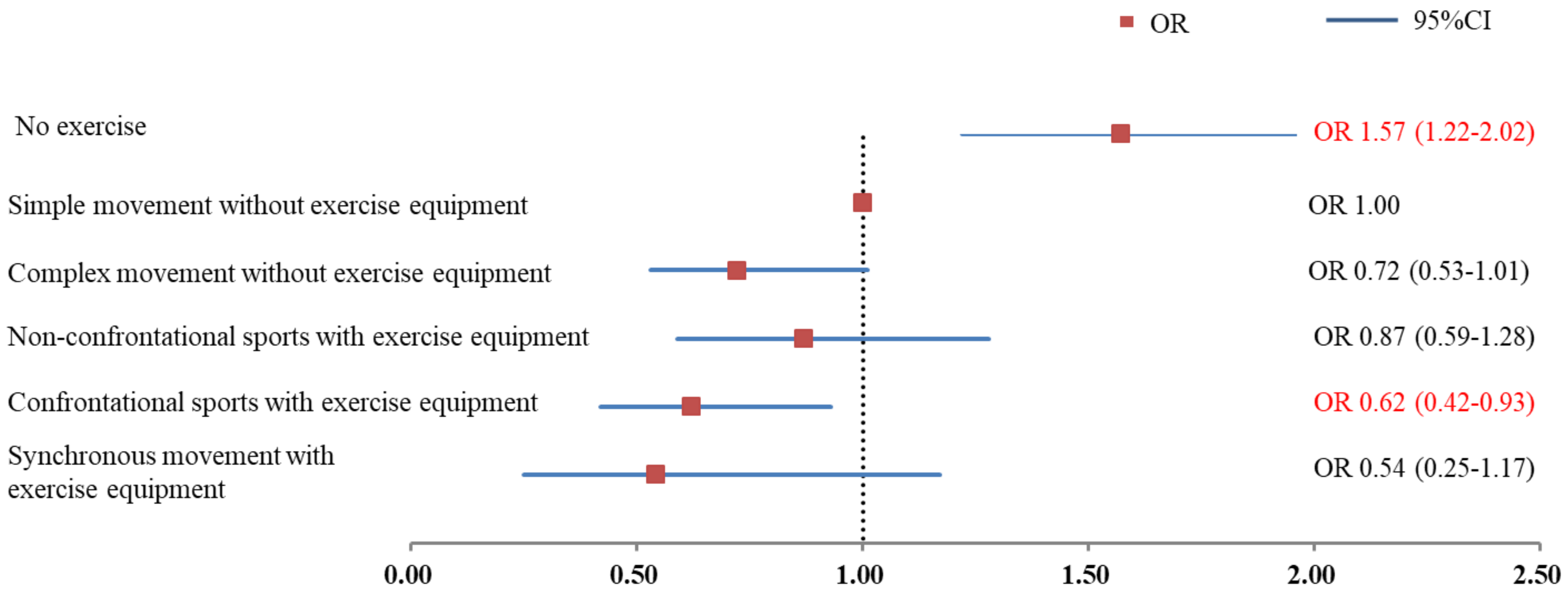

Figure 5-1 Odds ratios (95% confidence interval) of bad SRH before adjusted for confounding factors (n=1,954)

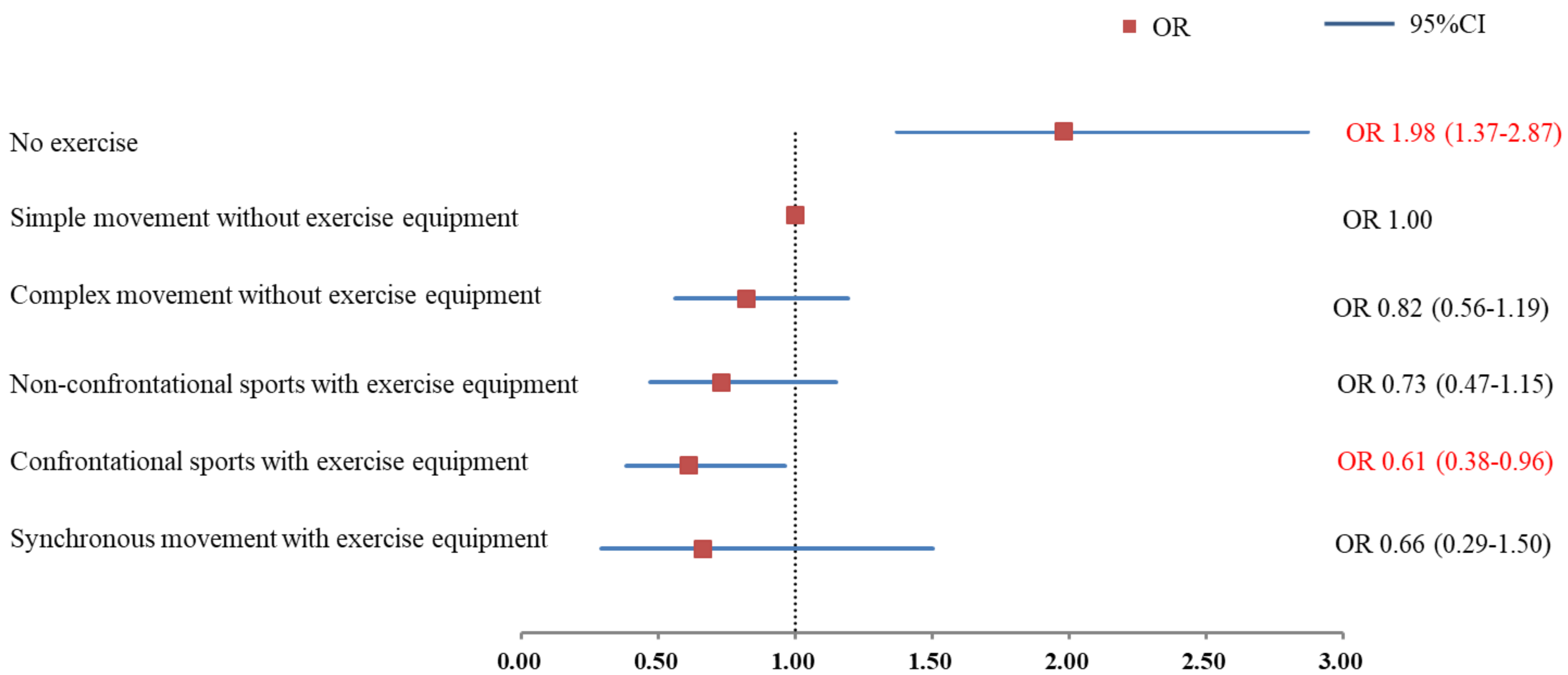

Figure 5-2 Odds ratios (95% confidence interval) of bad SRH after adjusted for confounding factors (age, sex, body mass index level, job, tobacco smoking, alcohol drinking, and exercise practice level) (n=1,954)

Table 5-4 Associations of exercise types with poor self-rated health (sub-analysis) (n=246)

Category	Crude OR	95% CI	Multiple-adjusted OR[a]	95% CI
No exercise	2.94	1.45-5.99	3.43	1.02-11.51
Simple movement without exercise equipment	1.00	ref.	1.00	ref.
Complex movement without exercise equipment	0.43	0.18-1.06	0.50	0.20-1.25
Non-confrontational movement with exercise equipment	0.26	0.06-1.24	0.29	0.05-1.46
Confrontational movement with exercise equipment	0.34	0.12-0.98	0.49	0.17-1.08
Synchronous movement with exercise equipment	0.60	0.12-3.11	0.72	0.13-3.89

OR: odds ratio; CI: confidence interval.

[a] Adjusted for age, gender, body mass index, job, tobacco smoking, alcohol consumption, and exercise practice level.

The OR for poor SRH by genders (Figure 5-3 and 5-4) and ages (Figure 5-5, 5-6, and 5-7) was analyzed. The OR for poor SRH was significantly lower for the exercise type of confrontational movement with exercise equipment in male, young (age 20-44 years), and old (age ≥ 65) participants, and in habitual exercisers (exercise frequency ≥ 1 time/week). It was also significantly lower for the exercise type of non-confrontational movement with exercise equipment in older participants compared to simple movement without exercise equipment.

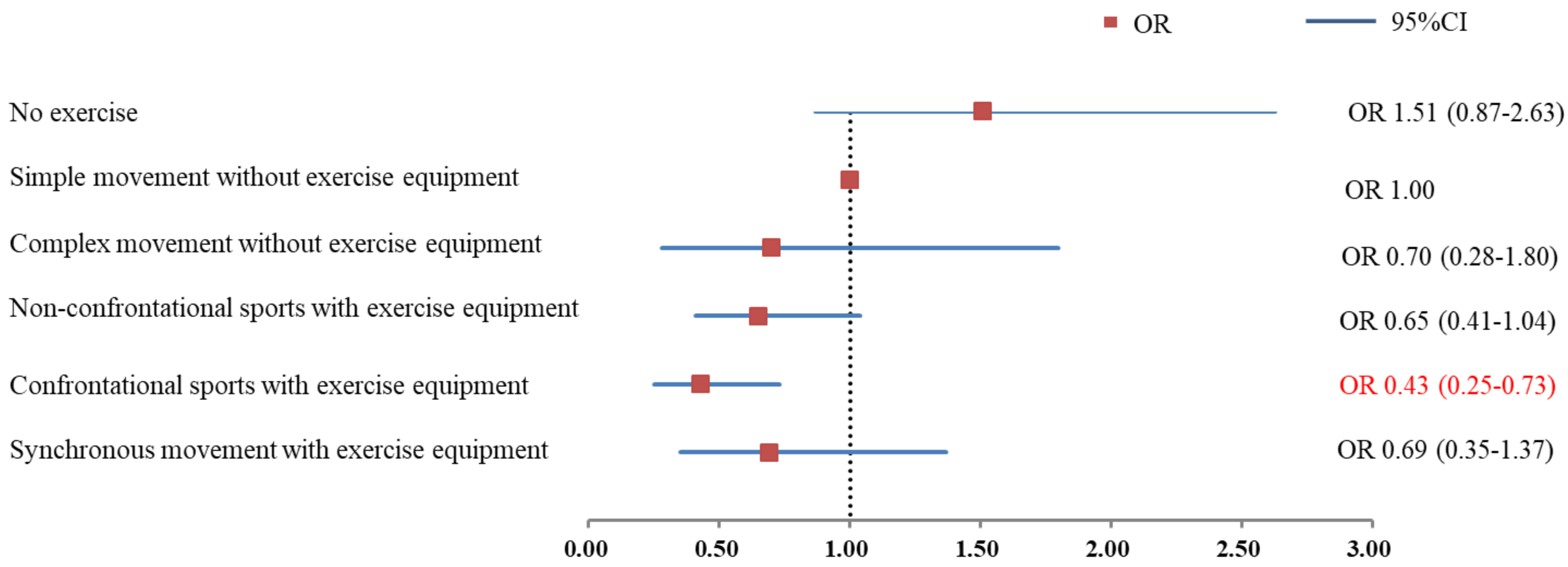

Figure 5-3 Odds ratios (95% confidence interval) of bad SRH by gender (male) (adjusted for age, gender, body mass index, job, tobacco smoking, alcohol consumption, and exercise practice level) (n=979)

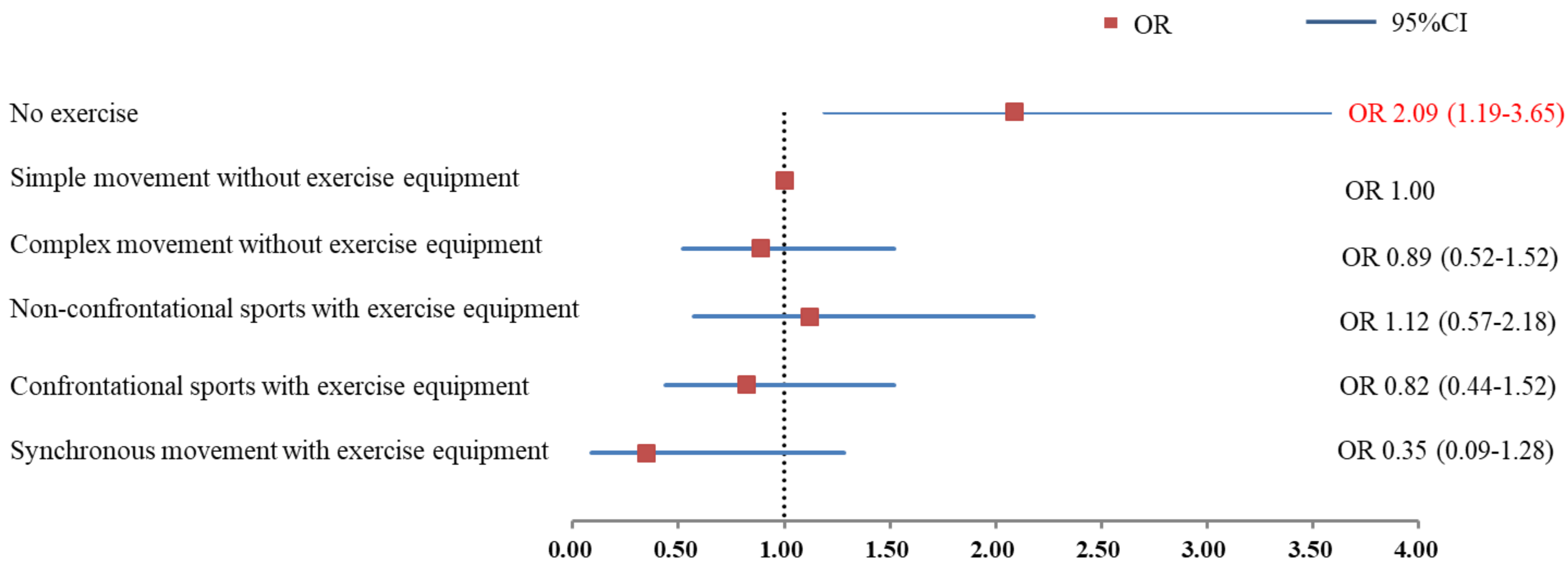

Figure 5-4 Odds ratios (95% confidence interval) of bad SRH by gender (female) (adjusted for age, gender, body mass index, job, tobacco smoking, alcohol consumption, and exercise practice level) (n=975)

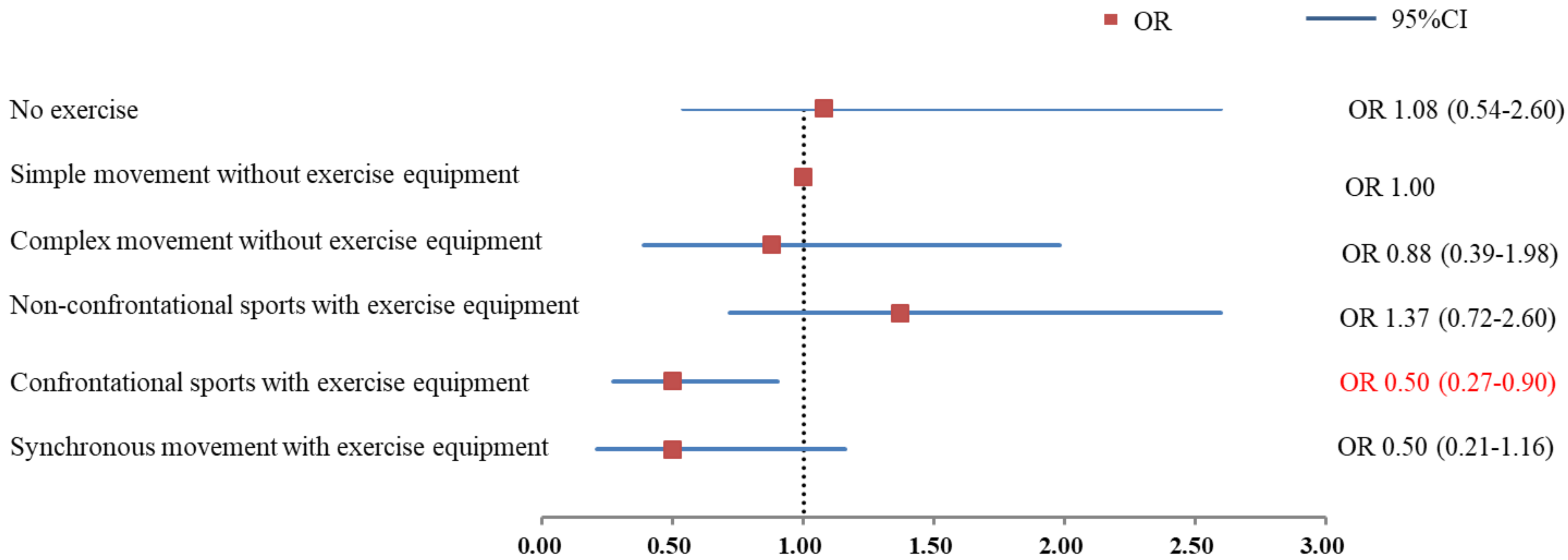

Figure 5-5 Odds ratios (95% confidence interval) of bad SRH by ages (20-44 years old) (adjusted for age, gender, body mass index, job, tobacco smoking, alcohol consumption, and exercise practice level) (n=824)

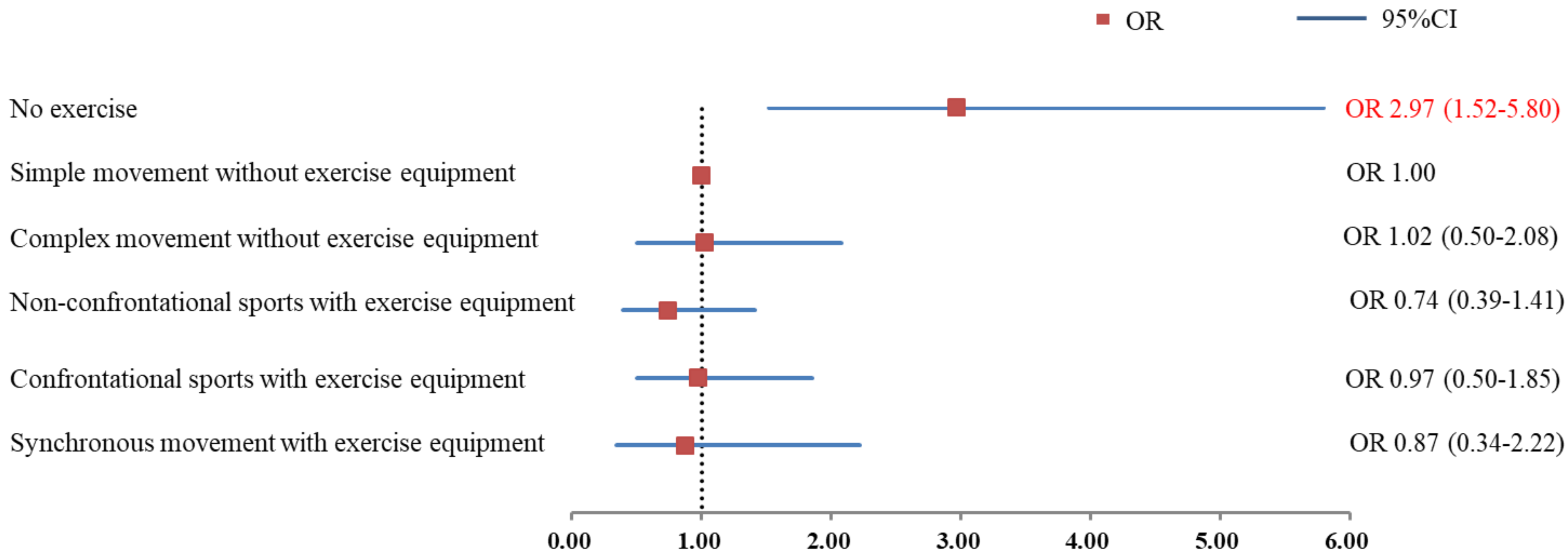

Figure 5-6 Odds ratios (95% confidence interval) of bad SRH by ages (45-64 years old) (adjusted for age, gender, body mass index, job, tobacco smoking, alcohol consumption, and exercise practice level) (n=681)

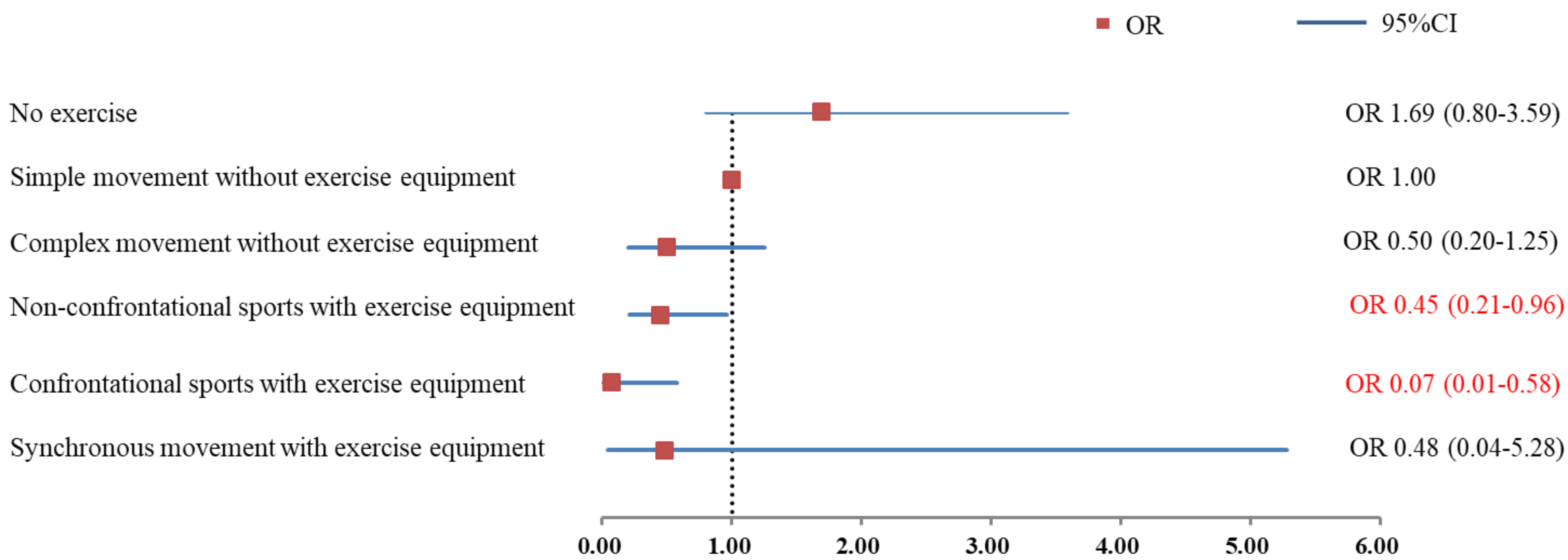

Figure 5-7 Odds ratios (95% confidence interval) of bad SRH by ages (≥ 65 years old) (adjusted for age, gender, body mass index, job, tobacco smoking, alcohol consumption, and exercise practice level) (n=449)

5.4 Discussion

The main purpose of this cross-sectional study was to explore the association between exercise type and self-rated health status in a randomly selected population of 2,000 Japanese adults aged 20 years or above. The author found that, compared to simple movement without exercise equipment, no exercise group were associated with poor SRH. The author also found that exercisers who participated in confrontational movement with exercise equipment were inversely associated with poor SRH.

The most striking finding was the significant negative association between poor SRH and confrontational movement with exercise equipment. Compared to the exercise type of simple movement without exercise equipment (e.g., walking, jogging, and swimming), the OR for poor SRH was significantly lower for confrontational movement with exercise equipment (e.g., soccer, volleyball, and tennis). Confrontational movement with exercise equipment always results in wins or loses involving one or more opponents. Competitive behavior may also affect mental states. A survey of adolescent ice hockey players showed that the players emphasized the importance of being aggressive, which they defined as being powerful, and at times fearless, in the use of their bodies (Theberge, 2003). Similarly, in another study, participants expressed their enjoyment of the physical activity of wrestling and the sense it gave them of being “in control” and able “to manage” their bodies (Sisjord, 1997). Therefore, the author believes that exercisers engaged in confrontational movement with exercise equipment should develop methods for self-assessment in order to report better SRH.

The author examined the association between poor SRH and different exercise type categories stratified by gender, age group, and exercise frequency. The results of the sub-analysis revealed a significantly inverse association between confrontational movement with exercise equipment and poor SRH, particularly in males, young participants, and habitual exercisers. This tendency may relate to the purposes and cognitions of exercise in different participants. Confrontational movement with exercise equipment always results in wins or losses. Reis and Jelsma (1978) discovered that male exercise practitioners might enjoy this type of exercise more than their female counterparts, as male athletes often mentioned winning as an important reason for athletic participation, while female athletes rated opportunities for socializing as important. The trend of younger people participating in sports was more evident in confrontational games such as soccer, baseball, and basketball (Cameron et al., 2002). With regard to the characteristics of these exercise types, males participate in confrontational movement more than females, particularly younger males (Sisjord, 1997). Exercise frequency was confirmed to be associated with health risk factors and diseases (Kemmler & von Stengel, 2013). The exercise frequency of confrontational movement with exercise equipment may impact a poor SRH.

The author also found that the old age group indicated a significantly lower OR for poor SRH for non-confrontational movement with exercise equipment. For older adults, exercise partners and communication were reported as important factors for exercise adherence. A survey in North America has shown that participation in golf has risen considerably, particularly amongst senior players (50 years or older) (Cann et al., 2005). "Playing time with partners" proved to be a factor influencing golfer enjoyment (Miyamoto, 2007) and "communication" was cited as an initial motivating factor for taking up golf (Yamamoto et al., 1998). Group exercise has been proven to have beneficial effects on physiological and cognitive functioning and well-being in older people (P. Williams & Lord, 1997). Diehl et al. (2001) confirmed that the number of exercise partners was an important issue for females with high social physique anxiety, and an exercise partner should help moderate their anxiety, increasing the acceptability of the exercise setting. As a form of social integration and social support, the existence of exercise partners is expected to facilitate the adoption and maintenance of physical activity (Gellert et al., 2011). Of course, the existence of exercise partners occurs not only in group exercises or confrontational exercises, but also in single-person exercises. However, through the use or control of exercise equipment, exercise practitioners were capable of learning or gaining unique motor skills that could affect exercise motivation, and skillful performance or progress in skill acquisition could also enhance self-efficacy (Schunk, 1989), which is associated with good SRH (Grembowski et al., 1993). For elders with physical weakness, skill exercises that do not rely on a high level of physical fitness may make them enjoy the fun of exercise more. Another characteristic of non-confrontational movement with exercise equipment is that, even if there is no competition with other players, exercisers can also enjoy the pleasure of breaking their own records (e.g. bowling score, golf score). Challenges for higher goals could promote motivation and a sense of achievement (Elliott & Dweck, 1988)，which were associated with affecting participation in exercise and with mental health (Crone & Guy, 2008). Therefore, the author has reason to believe that exercisers would obtain greater communication and self-challenges by participating in non-confrontational movement with exercise equipment that may help improve their mental health.

Although not significant, synchronous movement with exercise equipment showed a lower proportion (16.4%) of poor SRH that was close to that of confrontational movement with exercise equipment (16.0%). A representative example of this exercise type was cycling. Cycling can be practiced not only for leisure or recreation, but also for basic transportation (Saelens et al., 2003). Of course, cycling is a form of physical activity that effectively taxes the cardiorespiratory and metabolic functions of the whole body in a wide range of intensities and thus lends itself to many potential health benefits (Oja et al., 2011).

5.5 Conclusions

Exercise type was associated with SRH. Exercisers participating in confrontational movement with exercise equipment indicated better SRH status, and non-confrontational movement with exercise equipment was negatively associated with poor SRH, particularly in older adults. Developing habitual exercises with appropriate exercise types is likely to result in more health benefits.

Chapter 6 (Study 2) Associations of various exercise types with health-related physical fitness: Focus on physical fitness age

6.1 Purpose

The purpose of this study was to describe health-related physical fitness status in habitual exercisers who participate in different types of exercise.

6.2 Materials and Methods

6.2.1 Participants

One hundred and sixty-four Japanese male participants (age: 45–80 years, mean ± standard deviation: 63.7 ± 9.9 years) living in Ibaraki Prefecture were enrolled through fliers or information magazines. The inclusion criteria were that the participants had to be without a history of cardiovascular and cerebrovascular diseases and without restriction from exercising by a physician. The investigation was carried out from November 2015 to August 2016. Twenty-five participants were excluded from 189 initial entry for the reasons below: (1) do not participate in study for personal reasons (n = 11); (2) unable to complete the physical fitness test (n = 2); (3) underrepresented: age < 45 years old (n = 7); limited numbers (n = 5): handball (n =1), golf (n = 1), soccer (n = 1), baseball (n = 2). The participants were classified into seven groups according to their most frequently practiced exercise: no exercise (n = 48), walking (simple movement without exercise equipment) (n = 38), jogging (simple movement without exercise equipment) (n = 23), rhythm calisthenics (complex movement without exercise equipment) (n = 13), bowling (non-confrontational movement with exercise equipment) (n = 20), tennis (confrontational movement with exercise equipment) (n = 13), and cycling (synchronous movement with exercise equipment) (n = 9). The procedures, purpose, and risks associated with the study were fully explained and written consent was obtained before study. This study was approved by the ethics committee of the University of Tsukuba, Japan (approval number: TAI 27-68).

6.2.2 Measured variables

The participants were made to undergo the physical fitness tests mentioned below. All the testers were master or doctoral students in sports medicine of the University of Tsukuba. All the testers received special training in advance. The test items were administered and completed within 2 hours for each participant.

Anthropometry and body composition

The participants were instructed neither to engage in any vigorous physical activity nor to consume alcohol for 24 hours prior to the measurements. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer (YG-200; Yagami, Nagoya, Japan) and weight and body fat was measured using a bioelectrical impedance analyzer (InBody 770; InBody Japan, Tokyo, Japan), to the nearest 0.05 kg (weight) and 0.1% (body fat). Body mass index (BMI) was calculated as the weight divided by the height squared (kg/m^2). Waist circumference was measured horizontally around the waist at the level of the navel twice and the result was recorded as the average value if the two measured values did not differ by more than 1 cm. If the two measured values differed by more than 1 cm, the tester took a third measurement.

Physical fitness measures

Forced expiratory volume for one second

The forced expiratory volume was measured by a Spiro Analyzer (SP-310, Fukuda Denshi) and expressed as liters. The test was performed twice, and the greater result of the two was recorded as the $FEV_{1.0}$ s measurement.

Hand-grip strength

Participants were asked to grip a dynamometer (Grip-D, TKK5401; Takei Scientific Instruments, Tokyo, Japan) in each hand alternately with maximum effort while lowering the arm naturally to the side of the body (Shinkai et al., 2003). The measurement was performed twice for each hand, and the greater result of the two was recorded as the hand-grip strength for each hand.

Trunk flexion

Trunk flexion was measured by using a standing trunk flexion meter (measuring range: -20.0–35.0 cm) (T.K.K.5003 Flexion-A; Takei Scientific Instruments, Tokyo, Japan) for measuring the flexibility of the leg, hip, and trunk. The participants needed to stand with the heels kept together and big toes 5 cm apart, put the fingertips on the cursor of the instrument, and bend the body gradually forward without bending the knees, so that the cursor was pushed downwards. The value at the point on the scale corresponding to the upper surface of the cursor was read and recorded (Aye et al., 2017).

Trunk extension

The participants were asked to lie face down with hands on the back of waist and slowly raise their upper body off the floor and hold for a specified period for the staff to measure the distance between the floor and the participant's chin. The test was performed twice and the result was recorded as the greater one (Welk & Meredith, 2008).

One-legged stand with eyes closed

The participants were asked to stand on their preferred leg for a maximum of 60 seconds, raising gradually from the floor to a height of 10–20 cm, maintain balance if possible, with their hands on the waist and with the eyes closed. Timing was stopped if the participant moved his foot from the given position, opened his eyes during the trials, or reached the maximum balance time of 60 seconds. The test was performed twice. The greater score, in seconds, was used in the statistical analysis (Rogers et al., 2003).

Vertical jump

Vertical jump was conducted to measure the lower-limb strength. The test was performed as follows: The participants placed their feet on the circular board of a jump meter (Jump-MD, T.K.K.5106, Takei Scientific Instruments, Tokyo, Japan). The participants leaped vertically as high as possible using knee countermovement and landing on the circular board of the dynamometer. The jump was performed twice per participant and the highest score was recorded. The score was recorded in centimeter (cm) with one decimal point (Kim et al., 2015).

Side-to-side stepping

The side-to-side stepping test was measured on a flat floor of 3 parallel lines. Participants stood at a center line, then jumped 1 meter to one side and touched or crossed a line with the closest foot and jumped back to the center then jumped 1 meter to the other side, and back to the center again. Touching or crossing a line was counted for one time. The subjects were asked to try to complete as many times as possible within 20 seconds. The measurement was performed only once and the result was expressed as reps（Tanaka et al., 2004).

Maximal oxygen uptake ($\dot{V}O_{2}max$) and oxygen uptake at the anaerobic threshold ($\dot{V}O_{2AT}$)

The participants performed an incremental exercise test using a cycling ergometer (Aerobike 75XLⅢ, Combi Wellness Co., Tokyo, Japan) to determine their $\dot{V}O_{2}max$ and $\dot{V}O_{2AT}$. Following a 2-min warm-up at 15 W or 30 W, the workload increased every minute by 15 W until volitional exhaustion. Participants cycled at a cadence of 60 rpm. During the test, ventilation and expiratory gases were measured using an indirect calorimeter (Aeromonitor AE-310s; Minato Medical Science, Osaka, Japan). The highest oxygen uptake achieved over 30 s was determined as the $\dot{V}O_2max$. $\dot{V}O_2max$ was achieved when at least two of the following criteria (Tanaka et al., 1990) were met: (1) leveling-off of $\dot{V}O_2max$; (2) respiratory exchange ratio (RER) greater than 1.1; and (3) heart rate higher than 90% of predicted maximal heart rate. The point of $\dot{V}O_{2AT}$ was detected using v-slope technique (Beaver et al., 1986) which ventilation equivalent for oxygen ($\dot{V}E/\dot{V}O_2$) was computed, and the point where $\dot{V}E/\dot{V}O_2$ started rising was automatically detected by the computer software.

Physical fitness age (PFA) assessment procedures

In addition to the specific indicators of physical fitness, such as cardio-respiratory endurance, muscular endurance, muscular strength, flexibility, and body composition, Lee, Matsuura, et al. (1993) developed the concept of physical fitness age (PFA) for assessing physical fitness level and functional status in middle-aged and older adults. PFA is associated with exercise habituation and can be used to evaluate the overall physical fitness status (Lee, Tanaka, et al., 1993). PFA is computed from 8 independent variables measured during exercise with different motor skills. The PFA of each participant was estimated from the following equation, which was developed for use with Japanese male adults by Lee, Matsuura, et al. (1993)

$$PFA = -15.3\ PFS + 48.0 + Z$$

$$PFS\ (\text{physical fitness score}) = 0.021\ X_1 + 0.037\ X_2 + 0.020\ X_3 + 0.024\ X_4 + 0.017\ X_5 + 0.017 X_6 + 0.008\ X_7 + 0.016\ X_8 - 4.92$$

$$Z = 0.12\ \text{Age} - 5.8$$

X_1 = $\dot{V}O_2max$ (mL/kg/min), X_2 = $\dot{V}O_{2AT}$ (mL/kg/min), X_3 = hand-grip strength (kg), X_4 = side-to-side stepping (reps/20 s), X_5 = trunk extension (cm), X_6 = trunk flexion (cm), X_7 = one-legged stand with eyes closed (s), and X_8 = vertical jump (cm)

Participation in exercise or sports and lifestyle variables

Participants were asked to answer the most frequently practiced exercise if they practiced at usual. Participants were instructed to mention the habitual exercise (practiced at least twice a week, 30 minutes per time and lasting over a year [Ministry of Health, Labour and Welfare, Japan]) as the answer when they participated in sport activities more than one. The exercise frequency, time, and subjective exercise intensity (rating of perceived exertion [RPE]) were also asked (Table 6-2). Participants were asked to choose from the following RPE options that best described their level of exertion during exercise: very hard, hard, somewhat hard, and light.

The status of alcohol consumption (current alcohol drinker or not) and tobacco smoking (current smoker or not) were also asked.

6.2.3 Statistical analysis

The measurement values were expressed as means ± standard deviations. The exercise information of habitual exercisers was expressed as n/% obtained by the chi-squared test. One-way analysis of variance (ANOVA) was performed to analyze the differences in basic information among the seven groups. The RPE was used to calculate the amount of weekly exercise, with the intensity of daily exercise rated as vigorous (RPE: very hard) = 3, moderate (RPE: hard or somewhat hard) = 2, and light (RPE: light) = 1. One-way analysis of covariance (ANCOVA), with the amount of weekly exercise (frequency/week × time × intensity) and duration as covariates, was utilized to test for the significance of PFA and the difference between chronological age and PFA (CA-PFA) among the seven groups. The Bonferroni post hoc test was used when the ANOVA and ANCOVA results exhibited significant differences ($P < 0.05$). Statistical analyses were performed using statistical package for SPSS software, version 18.0 (IBM, Inc., Armonk, NY, USA).

6.3 Results

The overall study sample consisted of 164 adult males aged 45–80 years. Table

6-1 shows the basic information for participants in the present investigation. The ANOVA results demonstrated that weight, BMI, and waist circumference differed significantly among the seven groups. Mean values of BMI and waist circumference were lowest in the joggers compared to the no exercise group.

Table 6-1 Basic information of study participants (n=164)

	No exercise (n=48)	Walking (n=38)	Jogging (n=23)	Rhythm calisthenics (n=13)	Bowling (n=20)	Tennis (n=13)	Cycling (n=9)	*P* value
Height, cm	167.4 ± 6.2	166.2 ± 7.1	168.6 ± 6.7	166.9 ± 4.4	166.5 ± 6.7	162.2 ± 5.3	167.7 ± 4.6	0.153
Weight, kg	68.0 ± 10.4	64.1 ± 10.0	60.5 ± 6.7*	62.3 ± 6.2	64.0 ± 8.7	59.3 ± 6.9*	67.8 ± 14.7	0.016
BMI, kg/m²	24.2 ± 3.5	23.2 ± 2.9	21.3 ± 1.4*	22.4 ± 2.0	23.0 ± 2.4	22.5 ± 1.9	24.1 ± 4.3	0.003
WC, cm	88.0 ± 9.0	86.2 ± 8.1	76.4 ± 4.3*	82.3 ± 4.8	84.1 ± 5.6	81.0 ± 8.7	87.5 ± 10.8	< 0.001
Body fat, %	24.6 ± 7.1	23.1 ± 5.0	20.8 ± 5.1	24.3 ± 3.2	22.1 ± 3.8	21.7 ± 4.0	23.1 ± 3.5	0.172

P values were from one-way analysis of variance.
WC: waist circumference; BMI: body mass index.
* Significant group differences by post hoc test (compared to no exercise)

Table 6-2 shows the exercise information of 116 habitual exercisers. The exercise frequency (4-7 d/week or 1-3 d/week), subjective exercise intensity (vigorous, moderate, or light), and duration (10 years or more, 5-9 years, or 1-4 years) showed significant differences ($P < 0.05$) among the 6 exercise types. There were no significant differences in the exercise time (2 hours or more, 1-2 hours, or less than 1 hour).

Table 6-2 Exercise information of study participants with exercise habituation (n=116)

	Walking (n=38)	Jogging (n=23)	Rhythm calisthenics (n=13)	Bowling (n=20)	Tennis (n=13)	Cycling (n=9)	*P* value
Frequency							0.025
4-7 days/week, n / %	32 / 84.2	19 / 82.6	7 / 53.8	4 / 20.0	4 / 30.8	7 / 77.8	
1-3 days/week, n / %	6 / 15.8	4 / 17.4	6 / 46.2	16 / 80.0	9 / 69.2	2 / 22.2	
Intensity							0.026
Vigorous, n / %	3 / 7.9	15 / 65.2	2 / 15.4	3 / 15.0	7 / 53.8	3 / 33.3	
Moderate, n / %	23 / 60.5	4 / 17.4	6 / 46.1	9 / 45.0	3 / 23.1	5 / 55.6	
Light, n / %	12 / 31.6	4 / 17.4	5 / 38.5	8 / 40.0	3 / 23.1	1 / 11.1	
Time							0.673
> 2 hours, n / %	9 / 23.7	7 / 30.4	2 / 15.4	7 / 35.0	4 / 30.8	4 / 44.4	
1-2 hours, n / %	20 / 52.6	12 / 52.2	8 / 61.5	13 / 65.0	7 / 53.8	5 / 55.6	
< 1 hour, n / %	9 / 23.7	4 / 17.4	3 / 23.1	0 / 0.0	2 / 15.4	0 / 0.0	
Duration							0.006
> 10 years, n / %	15 / 39.5	15 / 65.2	2 / 15.4	7 / 35.0	12 / 92.3	5 / 55.6	
5-9 years, n / %	15 / 39.5	4 / 17.4	2 / 15.4	4 / 20.0	1 / 7.7	1 / 11.1	
1-4 years, n / %	8 / 21.0	4 / 17.4	9 / 69.2	9 / 45.0	0 / 0.0	3 / 33.3	

P values were from chi-squared test.

Table 6-3 shows the results of the physical fitness test. To avoid the influence of age on the results, ANCOVA was performed with chronological age as a covariate. The post hoc tests demonstrated significant differences among groups for all the variables. The maximal oxygen uptake of the joggers (45.5 ± 1.1 mL/kg/min) was significantly higher ($P < 0.05$) than those of the other six groups. Compared to no exercise group, tennis players' trunk flexion (6.8 ± 2.5 cm), one-legged stand with eyes closed (24.9 ±

3.3 sec.), vertical jump (38.9 ± 1.6 cm), and side-to-side stepping (39.8 ± 1.6 reps/20 sec.) were higher (*P* < 0.05). The joggers' vertical jump (37.8 ± 1.2 cm) and rhythm calisthenics practitioners' side-to-side stepping (36.3 ± 1.6 reps/20 sec.) were better (*P* < 0.05) than those for no exercise group.

The joggers' PFS (0.21 ± 0.68) were significantly higher (1.14 ± 0.16) than those of the no exercise group (-0.93 ± 0.66). The joggers' PFA (46.1 ± 11.2) was also significantly younger (-17.6 ± 2.7) than that of the no exercise group (63.7 ± 11.0). The difference between chronological age and PFA in no exercise group (-3.4 ± 7.7) was 16.4 ± 1.8 years smaller than that in joggers (13.0 ± 7.5), 13.7 ± 2.2 years smaller than that in tennis players (10.4 ± 5.8), and 7.9 ± 2.2 years smaller than that in rhythm calisthenics practitioners (4.6 ± 8.7) (Table 6-4). The difference between chronological age and PFA in joggers was 12.8 ± 1.8 years larger than that for walking (0.2 ± 6.4), 12.2 ± 2.1 years larger than that for bowling (0.8 ± 5.1), 10.4 ± 2.7 years larger than that for cycling (3.5 ± 6.5), and 8.4 ± 2.4 years larger than that for the rhythm calisthenics groups (Figure 6-1). All statistical-significance levels were *P* < 0.05.

Table 6-3 Health-related physical fitness of study participants (n=164)

	No exercise (n=48)	Walking (n=38)	Jogging (n=23)	Rhythm calisthenics (n=13)	Bowling (n=20)	Tennis (n=13)	Cycling (n=9)	*P* value
FEV $_{1.0}$s, L	3.21 ± 0.72	3.05 ± 0.68	3.15 ± 0.50	2.89 ± 0.24	3.08 ± 0.77	2.95 ± 0.58	3.35 ± 0.44	0.518
Grip_right, kg	38.0 ± 0.9	38.4 ± 1.1	40.1 ± 1.4	40.7 ± 1.8	39.7 ± 1.4	37.4 ± 1.8	40.1 ± 2.1	0.400
Grip_left, kg	37.1 ± 0.9	37.0 ± 1.0	38.3 ± 1.3	38.0 ± 1.7	37.7 ± 1.3	37.3 ± 1.7	40.1 ± 2.0	0.696
Trunk flexion, cm	-3.2 ± 1.3	3.3 ± 1.5	2.4 ± 1.9	2.1 ± 2.5	2.0 ± 2.0	6.8 ± 2.5*	3.4 ± 3.0	0.003
Trunk extension, cm	33.4 ± 1.3	34.2 ± 1.4	35.4 ± 1.8	35.0 ± 2.4	35.4 ± 1.9	35.3 ± 2.4	40.0 ± 2.8	0.069
One-legged stand with eyes closed, s	9.8 ± 1.8	12.3 ± 2.0	11.5 ± 2.5	12.0 ± 3.4	10.1 ± 2.7	24.9 ± 3.3*	16.5 ± 4.0	0.021
$\dot{V}O_{2}max$ mL/kg/min	26.6 ± 0.8	27.8 ± 0.9	45.5 ± 1.1*	30.3 ± 1.5	27.5 ± 1.2	32.5 ± 1.5	28.7 ± 1.8	< 0.001
$\dot{V}O_{2AT}$ mL/kg/min	18.2 ± 2.2	18.9 ± 2.4	27.2 ± 5.4*	17.4 ± 3.4	19.1 ± 2.9	20.4 ± 1.8	20.7 ± 2.0	< 0.001
Vertical jump, cm	32.9 ± 0.9	34.0 ± 0.9	37.8 ± 1.2*	36.3 ± 1.6	36.0 ± 1.3	38.9 ± 1.6*	37.4 ± 1.8	0.003
Side-to side stepping, reps	31.5 ± 1.0	32.7 ± 0.9	35.2 ± 1.2	36.3 ± 1.6*	33.5 ± 1.3	39.8 ± 1.6*	31.4 ± 1.9	0.002

P values were from one-way analysis of covariance.

FEV$_{1.0}$s: forced expiratory volume for one second; $\dot{V}O_2max$: maximal oxygen uptake; $\dot{V}O_{2AT}$: oxygen uptake at the anaerobic threshold.

* Significant group differences by post hoc test (compared to no exercise).

Table 6-4 Physical fitness score and physical fitness age of participants (n=164)

	No exercise (n=48)	Walking (n=38)	Jogging (n=23)	Rhythm calisthenics (n=13)	Bowling (n=20)	Tennis (n=13)	Cycling (n=9)	*P* value
Chronological age, years	60.3 ± 9.8	66.7 ± 9.1*	59.1 ± 9.9	69.5 ± 4.3*	65.3 ± 11.7	67.3 ± 6.7*	62.0 ± 9.6	< 0.05
PFS	-0.93 ± 0.66	-1.07 ± 0.57	0.21 ± 0.68*	-0.94 ± 0.53	-0.95 ± 0.72	-0.44 ± 0.54	-0.48 ± 0.61	< 0.001
PFA, year	63.7 ± 11.0	66.5 ± 9.6	46.1 ± 11.2*	64.9 ± 8.2	64.5 ± 12.3	57.0 ± 8.8	58.5 ± 9.4	< 0.001
PFA#, year	63.7 ± 11.0	68.2 ± 1.7	45.3 ± 2.0*	65.6 ± 2.9	64.9 ± 2.2	56.1 ± 3.4	57.8 ± 2.9	< 0.001
CA-PFA, year	-3.4 ± 7.7	0.2 ± 6.4	13.0 ± 7.5*	4.6 ± 8.7*	0.8 ± 5.1	10.4 ± 5.8*	3.5 ± 6.5	< 0.001
CA-PFA #, year	-3.4 ± 7.7	0.05 ± 6.69	12.5 ± 7.6*	5.4 ± 8.5*	0.7 ± 5.3	10.1 ± 6.0*	1.3 ± 5.3	< 0.001

P values were from one-way analysis of covariance.

PFS: physical fitness score; PFA: physical fitness age; CA: chronological age.

Adjusted for amount of weekly exercise (frequency/week × time × intensity) and duration

* Significant group differences by post hoc test (compared to no exercise).

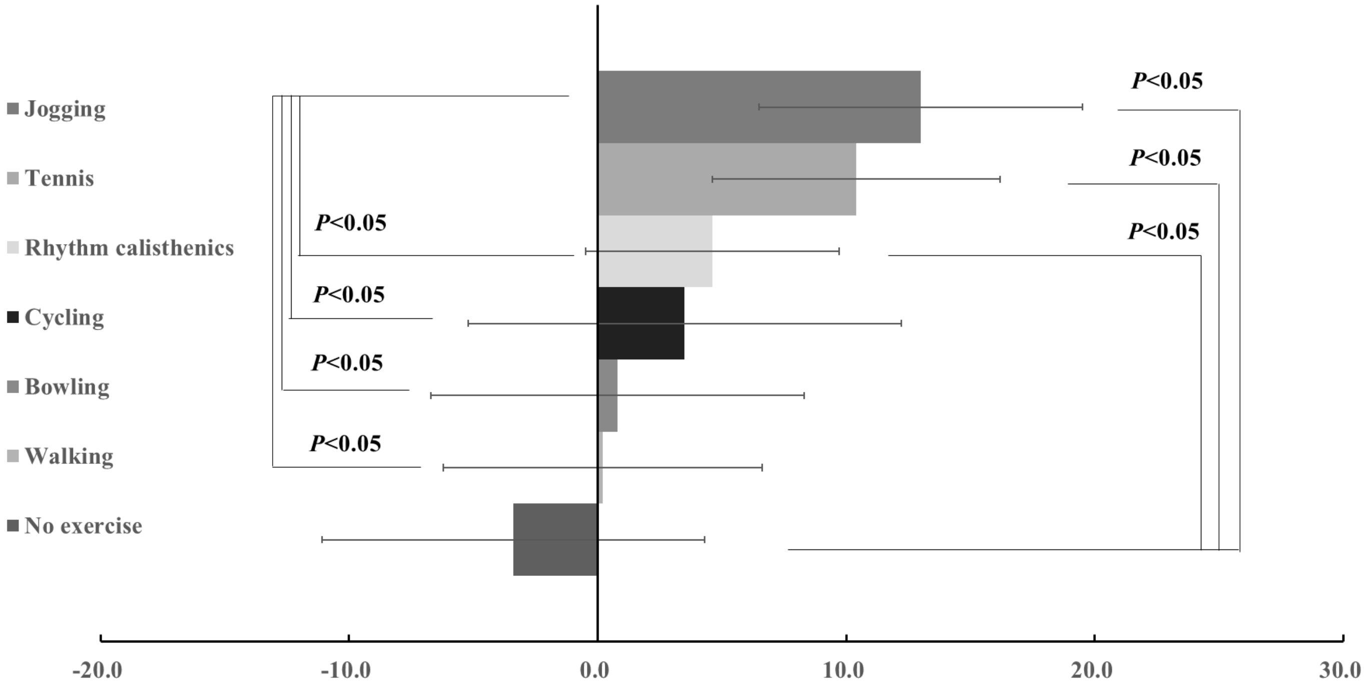

Figure 6-1 Differences in chronological age and physical fitness age in seven groups

6.4 Discussion

The purpose of this study was to assess the health-related physical fitness of habitual exercisers with various exercise types in 164 Japanese male adults aged 45-80 years. The author's most striking finding was that PFS and PFA were different in practitioners of different exercise types. Joggers showed higher PFS and younger PFA than no exercise group. The difference between the chronological age and PFA in joggers, tennis players, and rhythm calisthenics practitioners was significantly larger than that in no exercise group.

In eight physical fitness test items, the joggers' $\dot{V}O_2max$ was significantly higher than those for the other six groups in this study. Joggers showed the obvious advantage of cardiorespiratory endurance. For this result, the author first considered the effect of exercise time and intensity (i.e., volume or amount) on cardiopulmonary function. A randomized interventions study (Suter et al., 1994) of endurance training on nonsmoking, sedentary men conducted at a high- (jogging) and a low- (walking) exercise intensity level showed that after a 6-month endurance training period, joggers (90 ± 41 min/week) and walkers (121 ± 72 min/week) showed a similar statistically significant increase in $\dot{V}O_2max$. It seems that higher intensity and/or longer duration of exercise results in better body function and physical fitness. In this study, the joggers showed the highest proportion of vigorous intensity (65.2%) (Table 6-2) and the best $\dot{V}O_2max$ (45.5 ± 1.1 mL/kg/min) among the seven groups ($P < 0.001$) (Table 6-3). Vigorous-intensity exercise resulted in greater increase in aerobic capacity than moderate-intensity exercise (Gormley et al., 2008). Seals et al. (1984) studied the effects of prolonged endurance training on $\dot{V}O_2max$ in older individuals and showed that $\dot{V}O_2max$ was increased from 25.4 ± 4.6 mL/kg/min to 28.2 ± 5.2 mL/kg/min after 6 months of low intensity training ($P < 0.05$), and to 32.9 ± 7.6 mL/kg/min after an additional 6 months of higher-intensity training ($P < 0.01$). In this study, the author observed a similar result that the participants with the highest exercise intensity showed the greatest $\dot{V}O_2max$, which may be the cause of the better PFS and PFA in joggers.

Tennis has evolved from a sport in which exercise skill is the primary prerequisite for successful performance into a sport that also requires complex interaction of several physical components (i.e., strength and agility) (Fernandez-Fernandez et al., 2014). In many sports, such as tennis and soccer, sport-specific technical skills are predominant factors (Fernandez-Fernandez et al., 2009; Rebelo et al., 2013). In this study, tennis players showed better flexibility (trunk flexion: 6.8 ± 2.5 cm), agility (side stepping: 39.8 ± 1.6 reps/20 sec.), balance (one-legged stance with eyes closed: 24.9 ± 3.3 sec.), and lower-limb strength (vertical jump: 38.9 ± 1.6 cm) than no exercise group (Table 6-3). Therefore, in addition to better cardiopulmonary function, various technical skills are also the possible reasons for the difference between chronological age (CA) and PFA in tennis players.

When compared to no exercise group (-3.4 ± 7.7 years), the difference in chronological age and PFA of the rhythm calisthenics group (4.6 ± 8.7 years) was significant and remarkably better. A series of investigations have shown that individuals who maintain a physically active life-style in middle and old age are significantly less likely to experience age-related decrements in their ability to perform activities of daily living compared to less active individuals of the same chronological age (Chodzko-Zajko, 1996; Tanaka et al., 1990). (Chodzko-Zajko, 1996; K. Tanaka et al., 1990). Rhythm exercise is a kind of performance form consisting of purposefully selected sequences of human movement, generally performed with the accompaniment of music. Rhythm exercise probably improves the stability and flexibility with the skill of stepping, bending, swaying, and stretching (Iida et al., 2017). The rhythm calisthenics practitioners in this study showed better side-to-side stepping (36.3 ± 1.6 reps/20 sec.) than no exercise group. The author noticed that even though each group of exercisers showed better health-related physical fitness levels than no exercise group, participants in different exercise types showed different advantages on physical fitness. Therefore, the author believes that in addition to exercise intensity and duration, skillful exercise types also have a positive effect on enhancing physical fitness.

The author also obtained similar results for PFA and CA-PFA after adjusting for the amount of weekly exercise and duration (Table 6-4). Obviously, the author cannot ignore the effect of exercise intensity, time, and duration on health-related physical fitness. Joggers in this study showed the best PFA and CA-PFA with a high percentage of frequently vigorous intensity practice (Table 6-2), which caused joggers having the highest $\dot{V}O_2max$. As an evaluation index of cardiopulmonary function, $\dot{V}O_2max$ has a greater influence on the calculation of PFS and PFA. The improvement of cardiopulmonary function requires the participants to maintain a certain intensity and time of daily exercise, such as jogging (Garber et al., 2011). Although $\dot{V}O_2max$ of tennis players was lower than that of joggers, as skillful exercise participants, tennis players showed better flexibility, agility, and balance, and lower-limb strength, which resulted in better CA-PFA. Moreover, the participants of rhythm calisthenics also showed better results for CA-PFA with even light or moderate intensity (Table 6-2).

6.5 Conclusions

Various exercises appeared to confer different advantages on health-related physical fitness status. Exercise type with different skills was considered as a factor to maintain or promote physical fitness for habitual exercisers, especially older individual.

Chapter 7 General Discussion and Summary

Motor skills-based exercise type positively affects habitual exercise participation and health status (Figure 7-1). It was found in this dissertation that various exercise types with different motor skills were associated with both SRH and health-related physical fitness.

Health-related fitness has been hypothesized as a mediator of the relationship between physical activity and motor competence (Stodden et al., 2008). Low motor competence showed to lead to lower motivation and opportunities for physical activity (Hulteen et al., 2018). In addition to physiological factors, psychological factors, such as self-efficacy (i.e., belief in ability to be successful) and perceived competence (i.e., perceptions of actual capability) contribute to the broader 'self-concept' construct and are critical factors linked to physical activity participation (Hulteen et al., 2018; Robinson et al., 2015; Schunk, 1989).

The author found in Study 1 that male exercisers participating in confrontational movement with exercise equipment were about double those in female exercisers (Table 5-3), which confirmed that people of different genders showed obvious differences in their choice of exercise type. This tendency may relate to the purposes and cognitions of

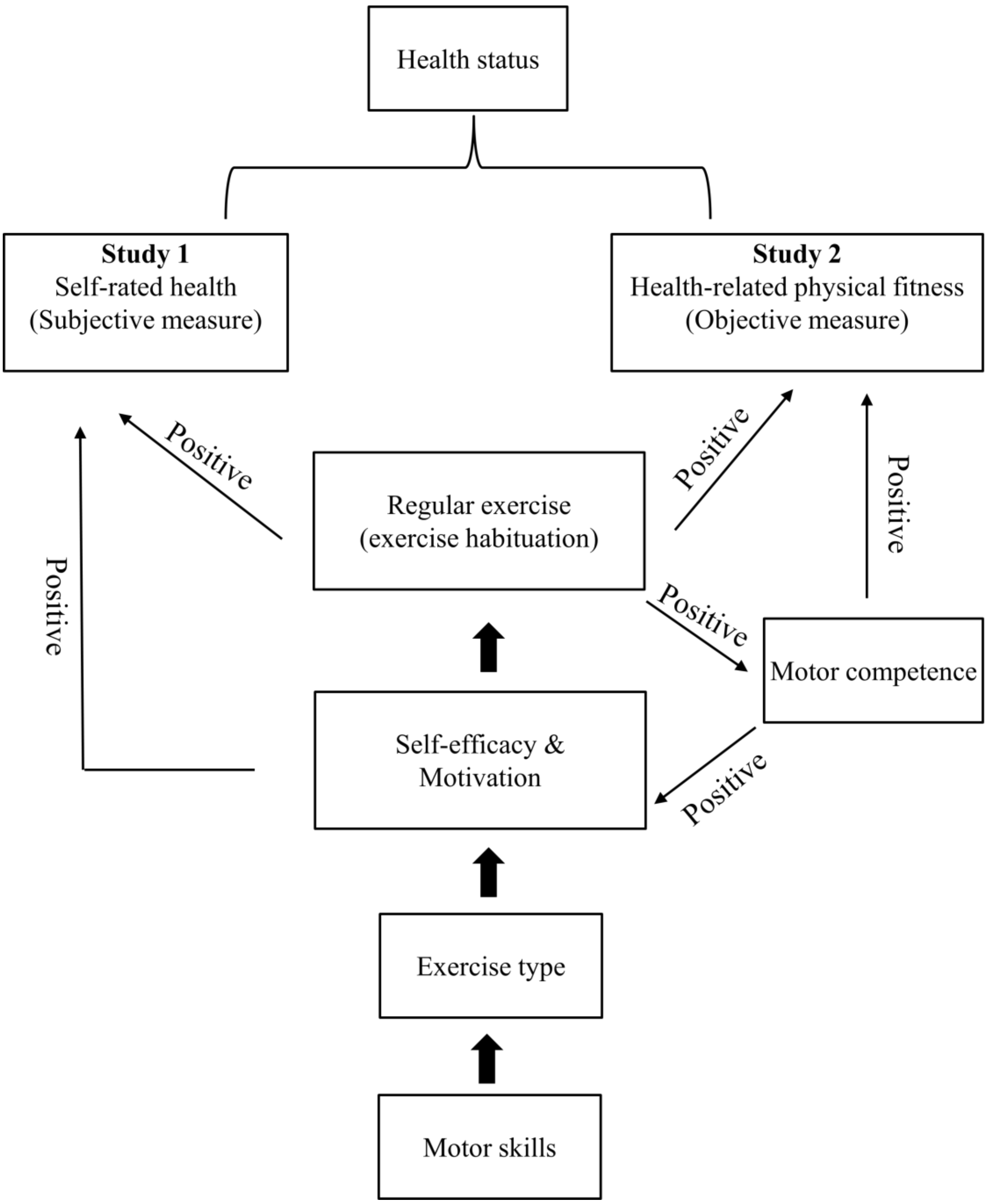

Figure 7-1 Relationship between Study 1 and 2

exercise in different participants. Confrontational movement with exercise equipment always results in wins or losses. Male exercise practitioners might enjoy this type of exercise more than their female counterparts, as male athletes often mentioned winning as an important reason for athletic participation, while female athletes rated opportunities for socializing as important (Reis & Jelsma, 1978).

Participants in Study 2 were asked to firstly answer this question in questionnaire (Appendix 1): “For health or enjoyment, do you exercise in a daily basis?” for distinguishing physical activity in other situations, such as housework or physical job. Subjective motivation affects the choice and the effect of exercise. Exercise is recognized as one of the effective ways improving health status for the well-known health benefits. “Pleasure”, “enjoyment”, “for likes”, etc. are considered as important factors for affecting the adherence volition of physical exercise (Hamari & Koivisto, 2015; Nakamura & Furukawa, 2004). In both Studies 1 and 2, the author observed similar results that exercisers participating in confrontational movement with exercise equipment indicated better SRH status (Study 1), and tennis players (Study 2) showed better flexibility, agility, balance, and lower-limb strength, all of which resulted in younger PFA.

In this dissertation, the author chose the most frequently practiced exercise types for analysis. However, people may participate in not only one single exercise, but two or more exercises in daily life. Tsujimoto et al. (2017) confirmed that compared to single exercise participants, SRH and self-reported physical strength of multiple exercises participants were higher, but not significant while exercise time was added as an interaction factor. It was confirmed that the health evaluation of multiple exercises participants was affected by exercise time and exercise volume. To avoid these influencing factors, exercise time, frequency, intensity, and exercise amount were adjusted in sub-analysis in both Studies 1 and 2 in this dissertation. Participating in multiple exercises could increase exercise time and exercise amount, but also could possibly obtain specific motor skills, which has a positive effect on overall health evaluation.

Considering the health benefits of various exercise types on both the subjective and objective indicators, exercise instructors who provide health-supporting or health-promotion programs should probably consider including exercise types in exercise instruction to engage in more exercises or sports for a better health status.

Chapter 8 Limitation and Future Tasks

Study 1 has high external validity as the National Sports-Life Survey is a national-scale social survey based on well-designed research with a sufficient sample size. The present classification according to exercise type, however, has a significant limitation. The author classified exercises or sports based on motional characteristics. However, specific exercises have differences in exercise intensity (e.g. walking vs. running) and exercise time (e.g. golf vs. bowling), even in the same category. Physical fitness condition and exercise participation were documented on a self-reported basis that may have affected information accuracy and strengthened or weakened the effect of exercise on SRH.

Study 2 grasps the relationship between exercise type and health-related physical fitness which based on not only subjective indicators but also physical indicators. There are also limitations in Study 2. The author only evaluated male participants in present study, the female habitual exercisers will be discussed in future study.

In this dissertation, the author chose the most frequently practiced exercise type (single exercise) for evaluation and lacked discussion on the effects of multiple exercise types. Further studies are needed to grasp the relationship between multiple exercise types and health status. Both Studies 1 and 2 are cross-sectional studies which do not allow for making inferences about causality. Longitudinal studies are needed to further explore these associations.

Appendix 1: Questionnaire on exercise habits (in Japanese)

運　動　習　慣　質　問　調　査　票

問１　今、“健康のため”または“楽しむため”の 運動をしていますか。

※　　１ 回の運動時間は 30 分以上とします。

※　　家事労働（炊事、洗濯、掃除、ふとんの上げ下ろしなど）や身体を使った職業（農作業、漁業、大工など）は、<u>運動に含めません</u>。

１．している　　　　　２．していない

＜運動を「している」と答えた方のみ、お答えください。＞

問２　１週間の中で運動する日数は何日ですか。

１．６～７日　　２．４～５日　　３．２～３日　　４．１日

５．１日未満（月に　　　日）

問３　運動する日の平均運動時間はどのくらいですか。

１．３時間以上　　２．２～３時間　　３．１～２時間

４．１時間くらい　　５．４５分くらい　　６．３０分くらい

問４　運動の強さは平均してどのくらいですか。

１．かなりきつくて息が乱れる程度

２．ややきつくて少し息が乱れる程度

３．楽であまり息が乱れない程度

４．非常に楽でまったく息が乱れない程度

問５　運動の強さは最高でどのくらいですか。

１．かなりきつくて息が乱れる程度

２．ややきつくて少し息が乱れる程度

３．楽であまり息が乱れない程度

４．非常に楽でまったく息が乱れない程度

問６　運動はどのくらい継続していますか。

１．１０年以上　　２．５～９年　　３．３～４年

４．１～２年　　５．１年未満

問７　どのような運動をしていますか。(番号に○をつけて下さい、○はいくつでも可)

１．散歩　　　　　　２．速歩（ウォーキング）　　３．水中ウォーキング

４．ジョギング　　　５．ストレッチ　　　　　　　６．太極拳

７．健康体操　　　　８．社交ダンス　　　　　　９．エアロビックダンス

１０．アクアエクササイズ　１１．サイクリング　　１２．ゲートボール

１３．グランドゴルフ　　　１４．ゴルフ　　　　　１５．卓球

１６．テニス　　　　　　　１７．野球　　　　　　１８．ソフトボール

１９．バレーボール　　　２０．バスケットボール　２１．サッカー

２２．登山　　　　　　　２３．柔道　　　　　　　２４．剣道

２５.ボウリング　　　２６.その他(具体的に　　　　　　　　　　　　)

「その他」を選択した方が具体的な種目を書いてください。複数の種目を選択場合、あなたにとって一番大切な運動に○をおつけください（例 :テニス ）。

問 8　運動することを楽しいと思いますか。あなたの考えに最もあてはまる線上に、○印をつけてください。

まったく楽しくない　　　どちらともいえない　　　かなり楽しい

↓　　　　　　　　　　　↓　　　　　　　　　　　↓

ご協力ありがとうございました。

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