早稲田大学審査学位論文

博士（スポーツ科学）

Association of daily walking time with the perceived benefit of energy conservation due to walking for health promotion

ウォーキングによる省エネルギー効果の認知と日常歩行時間との関連

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I miss you. I wish you were here.

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Garam Hong

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CHAPTER 1.

INTRODUCTION

I. Background of this study

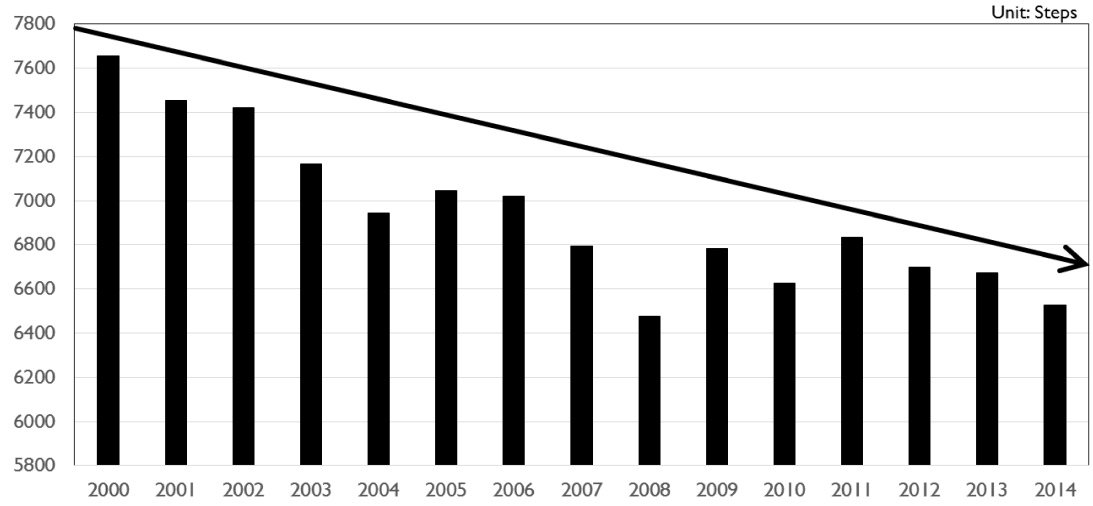
1. Physical activity and public health

1) Epidemic of physical inactivity

With advanced society, technology and economic incentives tend to discourage activity of daily living (Haskell, et. al., 2007). According to Owen et. al. (2010), the changes such as in transportation, communications, workplace and domestic-entertainment technologies have been associated with significantly reduced demands for physical activity. The physical, economic and social environments in which modern humans sit or move within the contests of their daily lives have been changing rapidly since the middle of the last century (Owen et. al., 2010). Socio-environment is one of the reason why our lifestyle became less active.

The phenomena of decreased total amount of physical activity around the world have reported. According to national and global surveys (Adabonyan et al., 2007; Hallal et al., 2012; Sisson & Katzmarzyk, 2008), the majority of people do not meet recommended physical activity level-150 min of moderate to vigorous intensity physical activity every week (Haskell et al., 2007; HHS, 2008; WHO, 2010). What we have also observed in Japan is that people who walk less than 4000 steps per day has increased (Inoue et al., 2011-b). Moreover, about 1000 steps of individuals mean steps per day has been gradually decreased during last decade according to National Health and Nutrition Survey (2012, 2013, 2014) in Figure 1.

Figure 1. Decreased individuals' mean steps in a day



2) Physical Activity and Health

Physical activity is related to the prevention of premature death from any cause, cardiovascular disease, diabetes, some cancers and osteoporosis (Warburton et al., 2006). Moreover, physical activity is recognized as being important for reducing the overall burden of disease including physical and mental (Bauman, 2004). On the other hand, physical inactivity increases the risk of major non-communicable diseases and causes 9% of premature mortality (Lee et al., 2012).

3) Health benefits from physical activity

There are several domains of physical activity which may effects on one's health. Participation in regular, moderate-intensity physical activity has significant health benefits (Lee et al., 2012). Epidemiological studies have revealed that engagements in walking behavior can reduce the risks of major non-communicable diseases such as cardiovascular diseases, type 2 diabetes, hypertension, obesity, some cancers, and clinical depression (Heath et al., 2012;

Lee, & Hung, 2012; Robertson et al., 2012; Yates et al., 2009; Yates et al., 2014).

4) Walking and Health

With advanced society, the significant changes have been associated with significantly reduced demands for physical activity (Haskell et al., 2007; Owen et al., 2010). Combining with the phenomena of physical inactivity, the features of walking have recognized for increasing daily routine physical activity. Among other exercise, walking is a common, accessible, inexpensive form, of physical activity and is an important component of total physical activity in adult populations (Hallal et al., 2012). Epidemiological studies have revealed that engagements in walking behavior can reduce the risks of major non-communicable diseases such as cardiovascular diseases, type 2 diabetes, hypertension, obesity, some cancers, and clinical depression (Heath et al., 2012; Lee, & Hung, 2012; Robertson et al., 2012; Yates et al., 2009; Yates et al., 2014). Therefore, development of effective strategies to promote walking behavior is necessary.

2. Older adults and Health

1) Epidemic of Aging

According to Word Population Prospects, the percentage of the global population above 65 years is predicted to increase by 188% by 2050. While increasing the population of older adults (USDHHS, 2012; 2013; WHO, 2010), successful aging has become one of public health goal (Pahor et al., 2014). More specifically, with the increased life expectancy, the preservation of the capacity to live independently and function well during late life became one of major concerns (McLeod et al., 2016; Pahor et al., 2014).

2) Aging and health

About aging and health, there are abundant previous studies which explain what will happen with aging. Approximately 30% of an individual's peak muscle mass is lost by the age of 80 (Topinkova, 2008). The maximal oxygen consumption also decline approximately 1% per year post 25 years (Lambert & Evans, 2005). Moreover, physical inactivity cause rapid decline of muscle mass.

While it is now well established from a variety of studies that the effects of physical activity on health benefits in adults, recent evidence suggests that more effective health benefits of physical activity for older adults. With advancing age, promotion of physical activity can be a method to maintain their physical fitness and general health. In this study, we are advancing the understanding of physical activity promotion for elders.

3) Aerobic fitness in older adults

The measurement of maximal oxygen uptake (VO_2max) has been available for more than half century and provides useful information about an individuals' maximal cardiorespiratory fitness and level of physical performance (Edvardsen et al., 2014). The purpose of this study was to determine the association between the VO_2max and the biological age.

The association between age and VO_2max were determined in this study. Without any limitation to do the test and willing to participate, 162 people were recruited for assessing aerobic capacity test in Korea in 2014. Mean value and

standard deviation (SD) were calculated by using descriptive analyses. One-way analysis of variance (ANOVA) was used to evaluate differences in variables between age groups. As post-hoc analysis, Bonferroni was used for assessing the significance among groups. Correlations between the dependent variables in age groups were assessed using Pearson's correlation coefficient. Statistical tests were conducted using SPSS version 22.0. P values of < 0.05 were considered statistically significant.

As the results, we found the group differences on VO_2max and VO_2max/kg among less than 19 years, 20-39 years, 40-59 years, and over 60 years. More specifically, the results of VO_2max in each groups with significant differences are less than19 years and 20-39 years (p=.020), 20-39 years and 40-59 years (p=.033), less than 19 years and 40-59 years (p<.001). Moreover, the results of VO_2max/kg in each groups with significant differences are less than19 years and 20-39 years (p<.001), 20-39 years and 40-59 years (p<.001), less than 19 years and 40-59 years (p<.001) which were presented in Table 1.

The result of this study shows that VO_2max (c=-.571, p<.001) and VO_2max/kg (c=-.712, p<.001) were negatively associated with age which was presented in Table 2.

The implication of these results were that the cardiovascular fitness decreases with advancing age which supports the previous study that VO2max decreases 1% every year after 25years with aging. The decreasing of cardiovascular fitness speeds up with sedentary lifestyle in older adults. The active lifestyle may be important for successful aging. Therefore we have to consider the effective method to promote physical activity in elders.

Table 1. General characteristics of subjects

	Less than 19 (n=36)	20-39 (n=68)	40-59 (n=37)	Over 60 (n=21)
Height	167.7 ± 8.7	165.6 ± 8.0	165.0 ± 7.3	154.6 ± 4.7
Weight	58.1 ± 10.9	62.9 ± 12.3	70.0 ± 11.7	57.1 ± 5.7
BMI	20.5 ± 2.5	22.9 ± 3.7	25.6 ± 2.7	23.9 ± 2.3
VO_2max	2888.81 ± 608.95	2524.91 ± 707.98	2230.65 ± 454.32	1776.00 ± 315.57
VO_2max/kg	50.34 ± 9.14	40.30 ± 8.23	32.05 ± 5.46	31.15 ± 5.09

Table 2. The correlations among age, height, weight, BMI, VO_2max, and VO_2max/kg

	Age	Height	Weight	BMI	VO_2max	VO_2max/kg
Age	1	-.451**	.082	.420**	-.571**	-.712**
Height		1	.586**	.037	.765**	.362**
Weight			1	.827**	.470**	-.267**
BMI				1	.050	-.584**
VO_2max					1	.705**
VO_2maxkg					*	1

.*p<.05, **p<.01, ***p<.001

4) Walking and health in older adults

For older adults, walking is a beneficial and relatively safe exercise alternative and most accessible form of leisure-time exercise available for senior (Rhudy et al., 2007). Engagements in walking have effect on preventing major non-communicable diseases such as cardiovascular diseases, type 2 diabetes, hypertension, obesity, cancers, and clinical depression (Heath et al., 2012; Lee, & Hung, 2012; Robertson et al., 2012; Yates et al., 2009; Yates et al., 2014). The effects of regular walking in older adults also reported as an effective method to provide not only preventing major non-communicable diseases but also, maintaining their physical fitness which may have influence on quality of life in older adults (Mobiliy, 2014; Resnick, 2000).

3. Perceived benefits of exercise and physical activity

1) Perceived benefits

According to the framework of the behavioral epidemiology (Sallis et al., 2000), identification of correlates of walking behavior is essential to develop effective strategies for promoting walking behavior. Among various factors, the perceived benefits is one of the most common psychological correlates of physical activities. Perceived benefits represents the beliefs that carrying out a specific behavior will lead to a desired benefits (Resnick et al., 2000). In major behavioral change theories, such as the social cognitive theory (Bandura,1994), the transtheoretical model (Prochaska & Diclemente, 1983), the health promotion model (Pender, 1987), and the theory of planned behavior (Ajzen, 1991), the concepts of perceived benefits are included though specific terms are different by each theory. These theories consider that perceived benefits play a role in the adoption and maintenance of the behavior. Previous studies have shown that perceived benefits are determinants of exercise behaviors and physical activities

(Bulmer et al., 2012; Gellert et al., 2012; Harada et al., 2014; Ingledew et al., 2008; Jones, 1996; Maltby et al., 2012; Sechrist, 1987; Stroud et al., 2009; White et., 2012; Williams et al., 2005).

2) Previous studies of perceived benefits

According to some physical activity studies (Bulmer et al., 2012; Dlugonski&Molt, 2014; Gellert et al., 2012; Resnick et al., 2000; White et al., 2012; Wilcox et al., 2006; Wójcicki et al., 2009), the perception of each benefit might differently influence on walking behavior. Walking behavior provide various benefits, such as disease prevention (Yates et al., 2009; Yates et al., 2014), psychological benefits (Robertson et al., 2012; Mota-Pereira et al., 2011; Lambert et al., 2013), social interaction (Bulmer et al., 2012; Nielsen et al., 2014), and energy conservation (NICE, 2008; Powerful Physical Activity-A, 2010; Bull et al., 2011). While most previous studies have not discriminated the factors of perceived benefits (Williams et al., 2005; Shin et al., 2006; Bhat et al., 2010; Ferrier et al., 2010), a few studies (Dlugonski&Molt, 2014; Wojcicki et al., 2009;

Wilcox et al., 2006; Bulmer et al., 2012; Gillert et al., 2012; Resnick et al., 2000) indicates the different relationships between factors of perceived benefits and physical activities.

Despite of the diverse benefits which we can get from physical activity, previous studies (Dlugonski&Molt, 2014; Wojcicki et al., 2009; Wilcox et al., 2006; Bulmer et al., 2012; Gillert et al., 2012; Resnick et al., 2000) have measured only 2 or 3 factors of perceived benefits (Table 3). Resnick et al. (2000) and Gellert et al. (2012) examined 2 factors (physical benefits, mental benefits) of perceived benefits with physical activity, Bulmer et al. (2012) and Wilcox et al.(2006) examined 3 factors (physical benefits, mental benefits, social benefits) of perceived benefits with physical activity. White et al. (2012), Wojcicki et al. (2009) and Dlugonski & Motl (2014), also, examined 3 factors (physical benefits, social benefits, self-evaluation benefits) of perceived benefits with physical activity. Thus, detailed discrimination of perceived benefits would be more appropriate to understand the influence of perceived benefits on physical activity behavior. If each factor of perceived benefits differently associated with walking behavior, it

indicates that walking promotion should consider the factors of the perceived benefits due to physical activity.

Table 3 Factors of perceived benefits of physical activity in advanced studies

Discriminated	Years	Authors	Factors
Not discriminated	2005	Williams et al.,	
	2006	Shin et al.,	
	2010	Bhat et al.,	
	2010	Ferrier et al.,	
2 Factors	2000	Resnick et al.,	Physical Benefits, Mental Benefits
	2012	Gellert et al.,	
3 Factors	2006	Wilcox et al.,	Physical Benefits, Mental Benefits, Social Benefits
	2012	Bulmer et al.,	
	2009	Wojcicki et al.,	Physical Benefits Social Benefits, Self-Evaluation Benefits
	2012	White et al.,	
	2014	Dlugonski & Motl	

4. Environmental Sustainability as co-benefits due to physical activity

1) Environmental sustainability

The Toronto Charter for Physical Activity (2010) stated physical activity promotes benefits such as not only wellbeing, physical and mental health, prevents disease, improves social connectedness and quality of life, but also provides economic benefits and contributes to environmental sustainability. The promotion of physical activity can also contribute to environmental sustainability (Bull et al., 2010). Although physical and mental health related factors have used for promoting physical activity, there is potential power in environmental sustainability as effective intervention method to promote physical activity (Bull., 2011). The need to alleviate traffic congestion, air pollution, environmental injustice, social inequalities, and other societal challenges is resulting in the scaling up of interventions that might promote physical activity as a co-benefit (Reis et al., 2016). Although there is the potential relationship between environmental sustainability of perceived benefit and physical activity behavior,

there is no observational or interventional previous studies about the environmental sustainability of perceived benefit on physical activity.

2) Pro-environmental attitude on behavior

Pro-environmental attitude can be defined as an individual's tendency to be concerned about the natural environment and behave for environmental sustainability (Blissing-Olson et al., 2013). Pro-environmental behavior refers to the behavior that harms the environment as little as possible, or even benefits the environment, such as reusing or recycling, refusing plastic bags or disposable products, lowering thermostat settings, using stairs instead of using escalator or elevator, and walking or bicycling instead of car using similar usage of words are pro-environmental behavior, eco-friendly behavior, green behavior (Jensen, 2002; Steg & Vlek, 2009; Steg et al., 2014). So far, however, very little attention has been paid to the role of pro-environmental attitude on physical activity behavior.

As one of the pro-environmental behavior, active commuting has discussed in previous studies (Bopp et al., 2012; Merom et al., 2008). Promoting

active commuting represents a population approach to increase daily routine physical activity (Guell et al., 2012; Tannahill, 2000). Active commuting (AC) which is the practice of walking or cycling to/from work or school (Bopp et al., 2011) has been identified as an important strategy for reducing physical inactivity and enhancing environmental protection efforts (Dora, 1999). Despite the new possibility of perceived Eco-friendly attitude such as perceived benefit of energy conservation on increasing daily routine physical activity, there remains a paucity of evidence on the relationship between perceived benefit of energy conservation and daily physical activity.

II. Purpose and Structure

1. The purpose of this dissertation

As identified above, very little is known for energy conservation on physical activity. In addition, perceived benefit of energy conservation may open the new area for promoting daily walking. Therefore, the purpose of this dissertation was to explore the association between perceived benefit of energy conservation due to walking and daily walking time in following two studies;

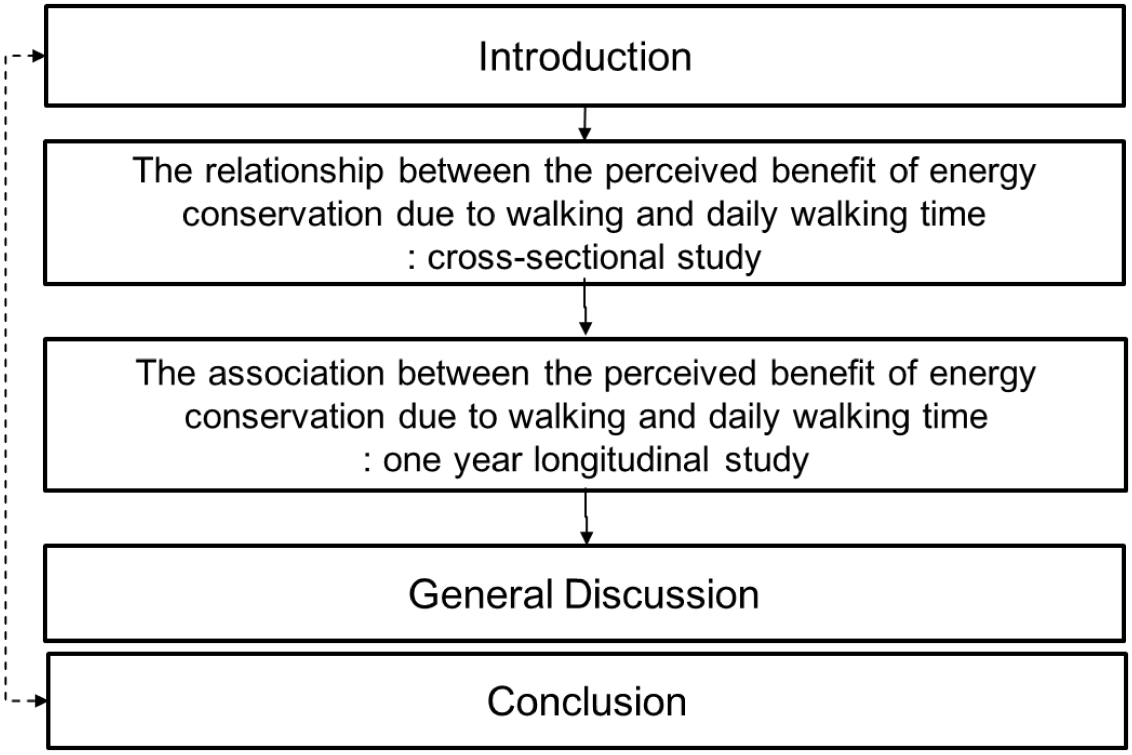
1) The relationship between the perceived benefit of energy conservation due to walking and daily walking time: cross-sectional study

2) The association between the perceived benefit of energy conservation due to walking and daily walking time: one year longitudinal study

2. The structure of this dissertation

The structure of this dissertation is in the Figure 2. The cross-sectional study for determining the relationship between perceived benefit of energy conservation due to walking and daily walking time was conducted as first research. As following, the relationship between perceived energy conservation as benefit of walking and one-year longitudinal change of daily walking time was conducted for longitudinal study as research 2.

Figure 2. The structure of this dissertation



CHAPTER 2

THE RELATIONSHIP BETWEEN PERCEIVED BENEFIT OF ENERGY CONSERVATION DUE TO WALKING AND DAILY WALKING TIME : CROSS-SECTIONAL STUDY

I. Introduction

The Toronto Charter for physical activity (2010) stated physical activity as a powerful investment not only in health, but also in the economy and environmental sustainability. Moreover, previous studies have suggested that eco-friendly attitude might be related to physical activity behavior (Bopp et al., 2011; Araki et al., 2014). Recognition of walking benefits for ecological sustainability may promote one's physical activity level in daily life. Kochi et al. (2013) developed a scale that can assess perceived benefits from walking. This scale consisted of 7 factors, one of whom focused especially on "energy conservation" (Kochi et al., 2013). Therefore, the purpose of this study was to

investigate whether the perceived benefits due to walking especially on energy conservation might be related to daily walking time.

II. Methods

1. Participants

An internet-based cross-sectional survey was conducted in August 2013 by a Japanese Internet-Research Service Company. The company was able to select specific sociodemographic groups from registered population according to requirements of each survey ordered. The present study targeted adults aged between 20 to 59 years. In all, randomly-selected 5,076 adults stratified by job status from the database were invited to participate in this survey. Of these, 1,062 individuals (40.3±10.4 years) answered the survey questions online (response rate: 20.9%). The socio-demographic characteristics of respondents are presented in Table 4.

Table 4. Socio-demographic Characteristics of Respondents (n=1,062)

	Participants of this study	
	n	%
Gender		
Male	525	49.4
Female	537	50.6
Age group		
20-29	226	21.3
30-39	296	27.9
40-49	273	25.7
50-59	267	25.1
Marital status		
Unmarried	470	44.3
Married	592	55.7
Job Status		
No full-time worker	531	50.0
Full-time worker	531	50.0
Level of education		
Junior high/high school	534	50.3
2-year college	225	21.2
4-year college/graduate school	303	28.5
Household income		
<5,000,000 yen	546	51.4
<10,000,000 yen	428	40.3
≥10,000,000 yen	88	8.3

2. Measurements

1) Perceived benefits of walking (Appendix 1.)

The scale consists of 7 factors; ‘perceived benefit of mental health due to walking’, ‘perceived benefit of physical health due to walking’, ‘perceived benefit of approval from others due to walking’, ‘perceived benefit of energy conservation due to walking’, ‘perceived benefit of social connection due to walking’, ‘perceived benefit of positive mind setting due to walking’, ‘perceived benefit of fulfil leisure interests due to walking’ (Kochi et al., 2013). Every factor was consisted of 3 times of questions. The participants were asked to rate the likelihood of these benefits expected results of walking on a Likert scale of 1 (Strongly disagree) to 5 (Strongly agree). The scale indicated the acceptable validity (GFI=0.94, AGFI=0.92, RMSEA=0.06) and the test-retest reliability ($r=0.74$, $p<0.001$). Every score of factors of perceived benefits due to walking were summed. Using tertiles as the criteria for categorizing into low, mid, and high values.

2) Daily walking time

Walking Time was measured by using short version of the International Physical Activity Questionnaire (IPAQ-SV). (Craig et al., 2003) The test-retest reliability (r=0.72-0.93), and criterion validity (r=0.39) of the Japanese version of the IPAQ-SV are good and acceptable (Murase et al., 2003). The total number of minutes per week on walking was calculated. This variable was dichotomized into <150 minutes and ≥150 minutes values, according to previous studies (Haskell et al., 2007; Inoue et al., 2009; Inoue et al., 2011-a; Tsunoda et al., 2012).

3) Socio-demographic factors

In the present study, the socio-demographic variables were obtained from the research company included sex, age (categorized as 20-29, 30-39, 40-49, and 50-59 years), marital status (classified as married and unmarried), job status (classified as full-time and not full-time employment), educational level (categorized as junior high and high school graduation, two years' college degree or equivalent, and four years' college or higher degree), and household income

(categorized as less than 5 million yen, 5-10 million yen, and over 10 million yen).

3. Statistical Analyses

The data were analyzed from 1,062 adults who provided complete information for the study variables. The descriptive statistics were used to analyze the distribution of socio-demographic factors. Multivariate logistic regression models were used to estimate multivariable-adjusted odds ratios (AOR), 95% confidence intervals (95%CI), and P for linear trend. The statistical analyses were performed using SPSS version 20.0 for Windows (SPSS Inc., Chicago, IL, USA). The statistical significance level was $p < 0.05$.

III. Results

The proportion of demographic factors and perceived benefits due to walking is shown in the Table 5. As shown in table 6, the logistic regression revealed the significant relations between factors of perceived benefits due to walking and daily walking time. In figure 3, among other factors, perceived benefit

of energy conservation due to walking was significantly related to daily walking time. Comparing 1 as reference of low perceived benefit of energy conservation due to walking on daily walking time. The adjusted odds ratio of mid perceived benefit of energy conservation due to walking on daily walking time was 2.305. Moreover, the adjusted odds ratio of high perceived benefit of energy conservation due to walking on daily walking time was 2.571. These adjusted odds ratios had linear trend of .019.

There are positive relationships between perceived benefit of mental health, physical health, and energy conservation due to walking and daily walking time. Which means that the people with higher perception of benefit on mental health, physical health, and energy conservation due to walking had higher prevalence of same or more than 150mins/week. On the other hand, the people with higher perception of benefit on approval from others due to walking had lower prevalence of the same or more than 150mins/week.

Table 5. Demographic factors and perceived benefits due to walking (n=1,062)

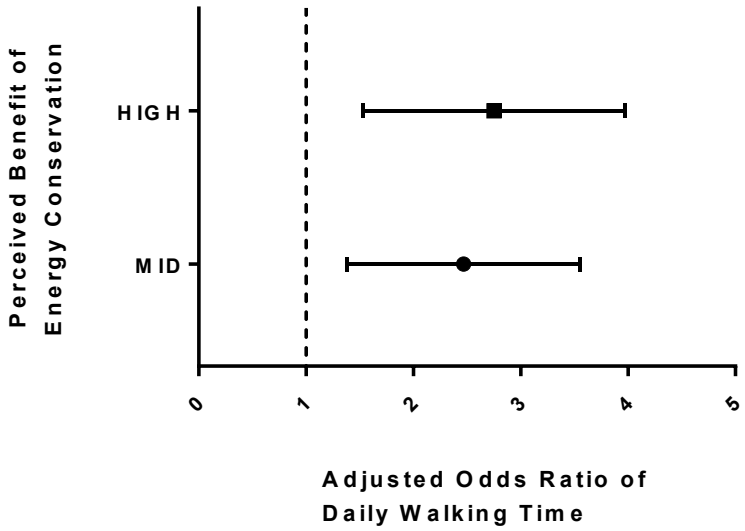
	Factors of perceived benefits due to walking																											
	Mental Health(%)				Physical Health(%)				Approval from Others(%)				Social Connection(%)				Energy Conservation(%)				Positive Mind Setting(%)				Fulfil Leisure Interests(%)			
	Low	Mid	High	p-value	Low	Mid	High	p-value	Low	Mid	High	p-value	Low	Mid	High	p-value	Low	Mid	High	p-value	Low	Mid	High	p-value	Low	Mid	High	p-value
Gender																												
Male	24.0	44.0	32.0	0.213	14.1	53.7	32.2	<0.001	21.0	34.3	44.8	0.993	20.6	29.9	19.5	0.039	33.3	16.6	50.1	0.123	32.6	6.3	61.1	0.539	33.1	36.8	30.1	<0.001
Female	22.9	40.0	37.1		13.4	42.3	44.3		21.2	34.3	44.5		16.8	36.9	46.4		27.7	16.8	55.5		29.4	6.7	63.9		32.2	27.4	40.4	
Age																												
20-29	21.7	44.7	33.6		13.3	50.9	35.8		17.3	32.7	50.0		18.6	34.5	46.9		25.7	15.0	59.3		27.0	7.5	65.5		26.5	31.4	42.0	
30-39	27.0	38.9	34.1	0.297	15.2	44.3	40.5	0.705	25.0	34.1	40.9	<0.001	20.6	33.8	45.6	0.433	31.4	17.2	51.4	0.398	33.1	7.8	59.1	0.170	37.8	30.7	31.4	0.020
40-49	25.3	39.2	35.5		14.3	49.5	36.3		21.2	34.4	44.3		20.9	32.2	46.9		32.2	18.7	49.1		34.4	6.6	59.0		37.0	31.5	31.5	
50-59	19.1	46.1	34.8		12.0	47.9	40.1		19.9	35.6	44.6		14.2	33.3	52.4		31.8	15.4	52.8		28.5	4.1	67.4		27.7	34.5	37.8	
Marital Status																												
Unmarried	25.7	44.7	29.6	0.009	15.3	53.0	31.7	<0.001	23.2	32.8	44.0	0.303	21.3	32.3	46.4	0.146	30.0	16.2	53.8	0.836	33.2	6.6	60.2	0.356	35.7	31.9	32.3	0.103
Married	21.6	39.9	38.5		12.5	43.9	43.6		19.4	35.5	45.1		16.6	34.3	49.2		30.9	17.1	52.0		29.2	6.4	64.4		30.2	32.1	37.7	
Job Status																												
No full-time worker	24.1	40.5	35.4	0.609	14.3	44.8	40.9	0.124	22.4	33.1	44.4	0.528	18.3	32.6	49.2	0.726	29.6	15.6	54.8	0.411	29.0	5.8	65.2	0.199	31.8	29.4	38.8	0.045
Full-time worker	22.8	43.5	33.7		13.2	51.0	35.8		19.8	35.4	44.8		19.0	34.3	46.7		31.5	17.7	50.8		33.0	7.2	59.9		33.5	34.7	31.8	
Level of Education																												
Junior high/ High school	24.5	44.0	31.5		13.3	50.6	36.1		20.2	33.3	46.4		18.9	28.8	52.2		30.7	15.7	53.6		29.6	4.1	66.3		30.7	35.6	33.7	
2-year college	28.4	37.3	34.2	0.012	16.4	42.2	41.3	0.258	21.8	32.0	46.2	0.452	15.6	40.9	43.6	0.009	28.9	18.7	52.4	0.875	33.8	77.1	59.1	0.006	34.7	28.4	36.9	0.177
4-year college/ Graduate school	17.8	41.9	40.3		12.5	47.5	39.9		22.1	37.6	40.3		20.5	36.0	43.6		31.4	16.8	51.8		31.4	10.2	58.4		34.7	28.4	37.0	
Household Income																												
<5,000,000yen	26.6	41.8	31.7		14.8	49.8	35.3		21.6	34.2	44.1		18.3	33.9	47.8		30.2	16.5	53.3		32.8	5.7	61.5		33.0	33.2	33.9	
<10,000,000yen	21.0	43.0	36.0	0.035	12.9	45.6	41.6	0.331	21.0	34.3	44.6	0.958	18.5	34.1	47.4	0.781	31.3	16.8	51.9	0.982	29.9	7.2	62.9	0.502	33.4	31.1	35.5	0.518
≥10,000,000yen	15.9	38.6	45.5		11.4	47.7	40.9		18.2	34.1	47.7		21.6	27.3	51.1		28.4	17.0	54.5		25.0	8.0	67.0		27.3	29.5	43.2	

Table 6. The association between perceived benefits due to walking and daily walking time

Factors of perceived benefits due to walking	Group	Daily Walking Time <150mins/week N	%	≥150mins/week N	%	AOR	95% CI	P for linear trend
Mental Health	Low	195	18.4	54	5.1	1		
	Mid	345	32.5	101	9.5	1.169	0.74-1.85	<0.001
	High	242	22.8	125	11.8	1.630	1.01-2.63	
Physical Health	Low	120	11.3	26	2.4	1		
	Mid	386	36.3	123	11.6	1.432	0.83-2.47	<0.001
	High	276	26	131	12.3	1.579	0.88-2.83	
Approval from Others	Low	154	14.5	70	6.6	1		
	Mid	265	25	99	9.3	0.686	0.44-1.08	0.025
	High	363	34.2	111	10.5	0.551	0.33-0.92	
Energy Conservation	Low	257	24.2	67	6.3	1		
	Mid	119	11.2	58	5.5	2.305	1.47-3.63	0.019
	High	406	38.2	155	14.6	2.571	1.63-4.05	
Social Connection	Low	137	12.9	61	5.7	1		
	Mid	251	23.6	104	9.8	0.784	0.49-1.25	0.070
	High	394	37.1	115	10.8	0.479	0.28-0.84	
Positive Mind Setting	Low	247	23.3	82	7.7	1		
	Mid	45	4.2	24	2.3	1.246	0.67-2.32	0.723
	High	490	46.1	174	16.4	0.990	0.60-1.63	
Fulfil Leisure Interests	Low	258	24.3	89	8.4	1		
	Mid	270	25.4	70	6.6	0.805	0.49-1.33	0.061
	High	254	23.9	121	11.4	1.124	0.71-1.79	

Adjustment variables: Sex, Age, Marital status, Job status, Education level, and Household income

Figure 3. Adjusted Odds Ratio of perceived benefit of energy conservation due to walking and daily walking time



IV. Discussion

The main finding of this research was that the positive relationship between perceived benefit of energy conservation due to walking and daily walking time. The best of our knowledge, the relationship between perceived benefit of energy conservation due to walking and daily walking time has not been reported. According to previous study (Bopp et al., 2011), individuals in the top quartile of eco-friendly attitude scores compared with those in the lower 3 quartiles, more likely to actively commute and less likely to drive. This relationship was between behavior (eco-friendly attitude) and behavior (active commuting). On the other hand, we found the perceived benefit of energy conservation due to walking which was perception on daily walking time which was behavior. This finding suggests the possibility that the perceived benefit of energy conservation due to walking might promote walking behavior.

Other findings of this study was that there were positive relationships between perceived benefit of mental health due to walking, perceived benefit of

physical health due to walking, and perceived benefit of energy conservation due to walking and daily walking time. Furthermore, there was negatively associated with perceived benefit of approval from others due to walking and daily walking time.

According to Ferrier et al. (2010) who used outcome expectancy scale which consisted of mental and physical benefits, the participants with more positive outcome expectations engaged in significantly more physical activity. Our observations on perceived benefit of mental health due to walking and perceived benefit of physical health due to walking are consistent with their hypothesis. Thus, the understanding of walking benefits for energy conservation may be useful to promote physical activity through walking mobility.

According to Dlugonski & Motl (2014), the result of social support from family and friends was not associated with physical activity. And also, Kochi et al. (2013) showed no significant relation to walking time on the approval from others factor. This can be one of the explanation for our observation in perceived benefit

of approval from others due to walking.

The limitations of this study was that the study has a limited ability to obtain representative samples, because it relies on an internet-based survey. Thus, the results in the present study may be less applicable to general population, especially those who do not have a habit of using the Internet. In the future investigation, it will be necessary to consider the objectively assessed measures on physical activity and more specific sampling for expected results. Moreover, using interventional studies to provide evidence on the directions of causality can be considered.

V. Conclusions

The finding of this study was the relationship between the perceived benefit of energy conservation due to walking, indicating that the perception on pro-environmental sustainability might be effective for promoting walking.

CHAPTER 3

THE ASSOCIATION BETWEEN PERCEIVED BENEFIT OF ENERGY CONSERVATION DUE TO WALKING AND DAILY WALKING TIME : ONE YEAR LONGITUDINAL STUDY

I. Introduction

Despite the importance of physical activity to benefit their health (WHO 2002; 2004), total steps per day has declined in Japanese population (Tanaka, 2012). Eco-friendly attitude has pointed out as possible method to increase daily life physical activity (Bopp et al., 2011). From the previous cross-sectional study, the positive relationship between perceived benefit of energy conservation due to walking and daily walking time has determined. From this cross-sectional study, we concluded that people who have higher perceived benefit of energy conservation due to walking have a characteristic of walking more than recommended time (same or more 150 mins/week). However, the longitudinal

changed perceived benefit of energy conservation due to walking may has effect on increasing daily walking time was not be able to determine by cross-sectional design. Therefore, the aim of this study was to determine the increased perceived benefit of [Energy Conservation] due to walking may increase the daily walking time between 2014 and 2015.

II. Methods

1. Procedure and participants

The study consisted of two repeated surveys with one-year interval. The internet-based surveys were conducted in February 2014 and 2015 by a Japanese Internet-Research Service Company. The present study targeted adults aged between 20 to 59 years. In all, randomly-selected adults from the database, who reviewed an e-mail, inviting them to participate. Of these, 1,196 individuals (41.6 ± 10.0 years) answered the surveys. The socio-demographic characteristics of the research was in Table 7.

Table 7. Socio-demographic characteristics of follow-up survey respondents

	Participants of this study	
	n	%
Gender		
Male	629	52.6
Female	567	47.4
Age group		
20-29	184	15.4
30-39	326	27.3
40-49	367	30.7
50-59	319	26.7
Marital status		
Unmarried	538	45.0
Married	658	55.0
Job Status		
No full-time worker	556	46.5
Full-time worker	640	53.5
Level of education		
Junior high/high school	349	29.2
2-year college	248	20.7
4-year college/graduate school	599	50.1
Household income		
<5,000,000 yen	559	46.7
<10,000,000 yen	533	44.6
≥10,000,000 yen	104	8.7

2. Measurements

1) Perceived benefits of walking

The scale consists of 21 items in 7 factors; ‘perceived benefit of mental health due to walking’, ‘perceived benefit of physical health due to walking’, ‘perceived benefit of approval from others due to walking’, ‘perceived benefit of energy conservation due to walking’, ‘perceived benefit of social connection due to walking’, ‘perceived benefit of positive mind setting due to walking’, ‘perceived benefit of fulfil leisure interests due to walking’ (Kochi et al., 2013). Every factor was consisted of 3 times of questions. The participants were asked to rate the likelihood of these benefits expected results of walking on a Likert scale of 1 (Strongly disagree) to 5 (Strongly agree). The scale indicated the acceptable validity (GFI=0.94, AGFI=0.92, RMSEA=0.06) and the test-retest reliability ($r=0.74$, $p<0.001$). Every score of factors of perceived benefits due to walking were summed. Using tertiles as the criteria for categorizing into low, mid, and high values. After categorizing, the data was calculated into changed such as

decreased, maintained, and increased perceived benefit of energy conservation due to walking between 2014 and 2015.

2) Daily walking time

Daily walking time was measured by using short version of the International Physical Activity Questionnaire (IPAQ-SV). The test-retest reliability (r=0.72-0.93), and criterion validity (r=0.39) of the Japanese version of the IPAQ-SV are good and acceptable. The total number of minutes per week on walking was calculated. This outcome variable was dichotomized into whether attaining 150 mins of recommended amount of walking. After dichotomizing, the data was calculated into changed walking time such as decreased, maintained, and increased walking time between 2014 and 2015.

3) Socio-demographic factors

In the present study, the socio-demographic variables obtained from the research company included gender, age (categorized as 20-29, 30-39, 40-49, and 50-59 years), marital status (classified as married and unmarried), job status

(classified as full-time and not full-time employment), educational level (categorized as junior high and high school graduation, two years' college degree or equivalent, and four years' college or higher degree), and household income (categorized as less than 5 million yen, 5-10 million yen, and over 10 million yen).

3. Statistical Analyses

The data were analyzed from 1,196 adults who provided complete information for the study variables. The descriptive statistics including chi-square test were used to analyze the distribution of socio-demographic factors, changed perceived benefit of energy conservation, and changed daily walking time. To compare proportions of decreased, maintained, and increased perceived benefit of energy conservation due to walking on longitudinal change of daily walking time between 2014 and 2015, Mann-Whitney U test was used. The statistical significance level was less than 0.05. SPSS version 21.0 for Windows was used for analysis.

III. Results

We found the proportion of changed walking time in same or more than 150 mins per week and less than 150 mins per week at 2014 in the Table 8. People who increased daily walking time was 15.7% (129 individuals) in the group of people who walk less than 150 mins per week. People who walk same or more than 150 mins per week at 2014 decreased into walk less than 150 mins per week at 2015 are 40.3% (151 individuals).

From the results in 2014 and 2015, we calculated the changed perceived benefit of energy conservation due to walking and changed daily walking time. We found the different proportion of longitudinal changed daily time in increased perceived benefit of energy conservation due to walking. In Figures 4, decreased, maintained, and increased perceived benefit of energy conservation due to walking and decreased, maintained, and increased daily walking time is presented. Changed perceived benefit of energy conservation due to walking was in x-axis. As it goes to the right side, it means increased perceived benefit of

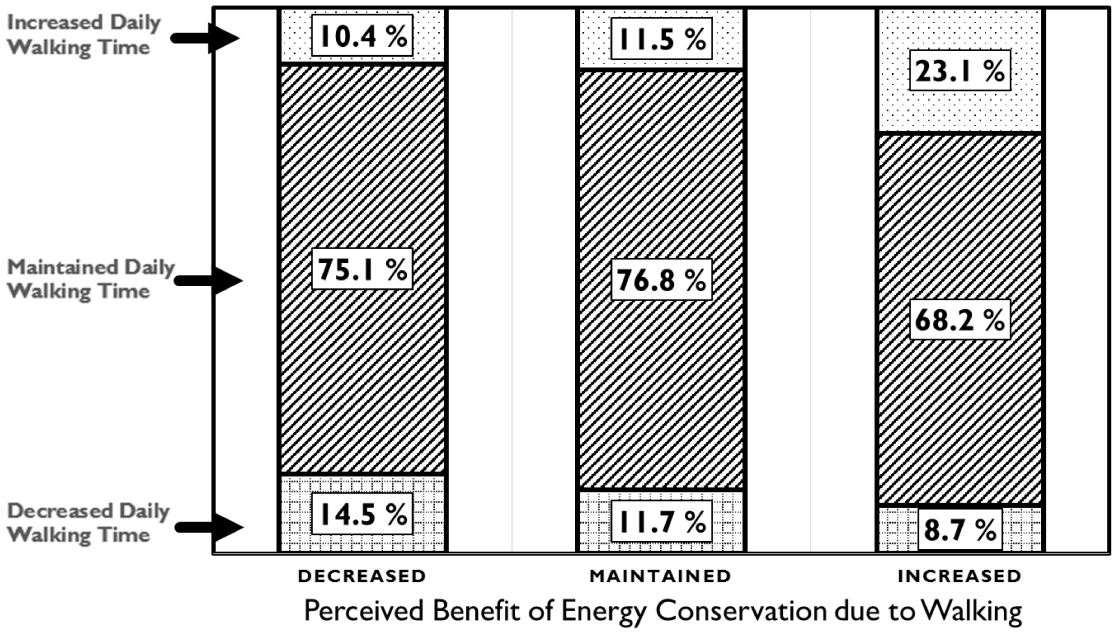
Table 8. The characteristics of walking behavior in participants

	2014-2015 changed walking level						
Walking time at 2014	Decreased		Maintained		Increased		Total
Less than 150 mins	0	0	692	84.3	129	15.7	821
Same or more than 150 mins	151	40.3	224	59.7	0	0	375

energy conservation due to walking. Moreover, Changed daily walking time was in y-axis. As it goes to the upper side, it means increased daily walking time.

The main result of research 2 was that the result of the proportion of increased perceived benefit of energy conservation due to walking and the proportion of decreased perceived benefit of energy conservation due to walking were different by Mann-Whitney U test ($p<.05$). More specifically, there was higher proportion of increased daily walking time (23.1%) and lower proportion of decreased daily walking time (8.7%) in increased perceived benefit of energy conservation due to walking.

Figure 4. Changed perceived benefit of energy conservation due to walking on changed daily walking time



IV. Discussion

The purpose of this study was to determine the effects of increased perceived benefit of energy conservation due to walking on increased walking time. We found that most of people did not change their daily walking time, only approximately 16% of individuals increased their daily walking time level (low into mid or high) in the people who have not met the recommended walking time (less than 150mins/week). On the other hand, approximately 40% of individuals decreased their daily walking time level (high into mid/low or mid into low) in the people who have met the recommended walking time (same or more than 150mins/week) in 2014. A possible explanation for these results might be that not only it is very difficult to increase individuals' daily walking time, but also even people who have met the recommended daily walking time once, they have difficulty to the adherence. The implication of this is the possibility the daily walking not only has been decreased gradually during last decade, but also will be decreased. It is why we need to promote walking.

The main result of this study was that there was higher proportion of increased daily walking time and lower proportion of decreased daily walking time in increased perceived benefit of energy conservation due to walking. The different proportion of changed daily walking time between the people who increased perceived benefit of energy conservation due to walking, and the people who decreased perceived benefit of energy conservation was determined. Although there are some studies reported the cross-sectional association between perception of pro-environment or eco-friendly attitude and physical activity such as walking and bicycling (Bopp et al., 2011; Araki et al., 2014), still the longitudinal data on the effects of perceived benefit of energy conservation due to walking has not been reported to our knowledge. The longitudinal study of the potential effects of energy conservation perception on maintaining/increasing physical activity has not been determined. These results provide the insight of potential to promote physical activity by increasing the perceived benefit of energy conservation due to walking.

Although it has limitations such as internet based survey which can cause

limited representative samples and short follow-up period, the potential of the perception of energy conservation as benefit of walking has shown from this study. In the future study, more specific sampling has to be considered for expected results. Moreover, to provide evidence, intervention studies can be considered for future study.

V. Conclusion

The finding of this study was that although most of participants in this research have maintained their daily walking time, people who increased perceived benefit of energy conservation due to walking had higher proportion of increased daily walking time. Notwithstanding limitations of this research, the study suggests the potential of perceived [energy conservation] to promote walking.

CHAPTER 4

GENERAL DISCUSSIONS

The purpose of this dissertation was to determine the association between perceived benefit of energy conservation due to walking and daily walking time which may provide a new understanding of the walking promotion. In the Research 1, there was the positive relationship between perceived benefit of energy conservation due to walking and daily walking time. Moreover, we found that increased perceived benefit of energy conservation due to walking had higher proportion of increased daily walking time between 2014 and 2015 in the Research 2. Although greater efforts needed to ensure the effects or perceived benefit of energy conservation due to walking to increase daily walking time, these results implicated the possibility of perceived benefit of energy conservation due to walking to promote daily walking time.

I. Main findings and implication

In this study, the main result we found was the positive association between perceived benefit of energy conservation due to walking and daily walking time. The first research was deigned to determine the relationship between perceived benefits of walking including energy conservation and daily walking time. We determined that people with higher perception of energy conservation as benefit of walking have more prevalence to meet recommended walking time. According to Bopp et al. (2011), individuals more likely to actively commute and less likely to drive in the top quartile of Eco-Friendly Attitude compared with those in the lower 3 quartiles. Although active commuting represents daily routine physical activity, it is not the standard measurement for physical activity. In this study, the relationship between the perceived benefit of energy conservation due to walking and daily walking time represents relationship with more general daily walking.

This was the first study to investigate the association between perceived

benefit of energy conservation due to walking and daily walking time. Perceived benefit of energy conservation due to walking is one of perceptions for pro-environmental behavior which refers to the behavior that harms the environment as little as possible, or even benefits the environment such as reusing or recycling, refusing plastic bags or disposable products, lowering thermostat settings, using stairs instead of using escalator or elevator, and walking or bicycling instead of car using (Jensen, 2002; Steg & Vlek, 2009; Steg et al., 2014). Although several environmental studies maintained the energy conservation is one of method of pro-environmental behavior, the co-benefit of energy conservation by physical activity is not defined in advanced studies of physical activity. These results provide the insight of potential to promote physical activity by increasing the perceived benefit of energy conservation due to walking. However, it may necessary to expend the base of energy conservation in environmental sustainability for the future study.

Although there are advanced studies of pro-environmental attitude on active commuting which is walking and bicycling to and from work, there was no

study that determine the longitudinal association between perceived benefit of pro-environmental and physical activity behavior. This study confirmed that the increased perceived benefit of energy conservation due to walking has the possibility to increase daily walking time in Research 2. The perceived benefits is one of factors that may promote the individuals' walking level. According to Toronto Charter for physical activity, there are the benefits of physical activity such as not only wellbeing, physical and mental health, prevents disease, improves social connectedness and quality of life, but also provides economic benefits and contributes to environmental sustainability. We found increased perceived benefit of energy conservation due to walking has more proportion of increased daily walking time. Therefore, the concept of Energy conservation due to walking could be a new approach for promoting walking.

II. Additional findings and implication

Additional findings of this study was that there were relationships between factors of perceived benefits such as not only energy conservation, but also mental health and physical health and daily walking time. Physical activity including walking is beneficial for physical and mental health (Bauman, 2004; Brown et al., 2007; Haskell et al., 2007). Although, there are several previous studies on mental and physical health of perceived benefits (Dlugonski&Molt, 2014; Wojcicki et al., 2009; Wilcox et al., 2006; Bulmer et al., 2012; Gillert et al., 2012; Resnick et al., 2000), most of studies using terms of outcome expectancies or exercise benefits and barriers scored without discrimination of the factors into physical health or mental health (Shin et al., 2006; Gellert et al., 2011 Maltby et al., 2012). On the other hand, in this study we discriminated every factors of the perceived benefits due to walking to figure out which factor may have effects on daily walking time. There were significantly positive relationships between mental health and physical health factors of perceived benefits due to walking and daily walking time in the cross-sectional study.

Another additional finding of this study was that the most of people have maintained their daily walking level over one year. With physical inactivity phenomena in Japan (Inoue et al., 2011-b; Miyachi, 2012; Sawada et al., 2013), a part of Healthy Japan 21 by Ministry of Health, Labour and Welfare is for increasing physical activity (Sawada et al., 2013). Physical Activity Guideline which introduce “Plus Ten” had presented to increase 10 minutes of physical activity in Japan (Ministry of Health, Labour and Welfare, 2013). Because amount of walking represents daily physical activity which is related to public health, there are many countries and worldwide approaches to increase walking time. The results of this study that perceived benefit of energy conservation due to walking may have effects on daily walking time opens up a new area of research and intervention for promoting physical activity.

III. Limitations

There are several limitations in this dissertation. One of the limitations was that the findings of this study were rely on self-reports, which may compromise the quality of data. Another consideration is that the study has a limited ability to obtain representative samples because it relies on an internet-based survey. The respondents of internet-based surveys might have characteristics, such as having greater access to the internet, and more likely to respond to a survey, if they are interested in its contents or are attracted by the incentives offered for participation (Rhodes et al., 2003). Thus, the results in the present study may be less applicable to the general population. In the future investigation, it will be necessary to consider the objectively assessed measures on physical activity and more specific sampling for expected results. The last consideration of the limitations in this study was that despite the fact that we used the energy conservation as one of methods for environmental sustainability, there were no concrete definition of the energy conservation and the mixed using of the terms of environmental sustainability, pro-environmental behavior, eco-

friendly attitude, and energy conservation in advanced studies of physical activity. Therefore, it is needed to be consider the usage of the words related to environmental sustainability in future studies.

IV. Conclusions

In summary, individuals who are highly perceived benefit of energy conservation due to walking have higher recommended daily walking time. Moreover, there was higher proportion of increased daily walking time in increased perceived co-benefit of energy conservation due to walking. The implication of this dissertation was the possibility of perceived benefit of energy conservation due to walking to promote the daily walking time. This may be the important message to plan public health interventions deigned to promote physical activity.

V. Future suggestions

First, future investigations on perceived benefits due to walking and daily walking, it is required to conduct the survey in person, in order to accumulate additional evidence for promoting physical activity. Because of this dissertation based on internet survey, the participants in this survey are limited to people who are able to use computer and internet which might cause selecting participants as having greater access to the internet, and more likely to respond to a survey. Especially the study for older adults, the characteristics of participants match with the characteristics which I mentioned above. Therefore, it is necessary to conduct the survey in person.

Finally, in this study what we mainly discussed was the energy conservation as perceived benefit. Perceived energy conservation is one of pro-environmental attitude for environmental sustainability. In this study we found possibility that perceived benefit of energy conservation due to walking may have effects on individuals' daily walking time. There are still many unanswered

questions about the perceived benefit of energy conservation due to walking. Although we determined the cross-sectional relationship and longitudinal association between perceived benefit of energy conservation due to walking and daily walking time, the both of studies were observational studies. Therefore, the effect size of the perceived benefit of energy conservation due to walking could not determine in this dissertation. Therefore, In the future studies, using interventional studies to provide evidence on the directions of causality can be considered.

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Appendix 1. The questionnaire of perceived benefits due to walking

Factors of perceived benefits	Items
Mental Health	When I walk, I feel released depressive feelings
	When I walk, I feel released stress
	When I walk, I am in better feelings
Physical Health	When I walk, I can prevent diseases
	When I walk, I can be better physical condition and fitness
	When I walk, I can have appetite
Approval from Others	When I walk, other people recognize me
	When I walk, other people respect me
	When I walk, other people compliment me
Energy Conservation	When I walk, it can contribute to reducing CO2 emissions
	When I walk, it can contribute to saving money
	When I walk, it can contribute to power saving
Social Connection	When I walk, the opportunity to talk with others increases
	When I walk, the opportunity to have relationship with others increases
	When I walk, the opportunity to spend time with family and friends increases
Positive Mind Setting	When I walk, I can find a new goal
	When I walk, I can enhance my everyday life
	When I walk, I can be positive to my life
Fulfil Leisure Interests	When I walk, I can spread my range of activity
	When I walk, I can find what I enjoy
	When I walk, I can increase to spend time for myself