EÖTVÖS LORÁND UNIVERSITY
FACULTY OF EDUCATION AND PSYCHOLOGY

DOCTORAL SCHOOL OF EDUCATION

FEIFEI WANG

THE INTERACTION BETWEEN PHYSICAL ACTIVITY AND SLEEP QUALITY, STRESS AND LIFE SATISFACTION AMONG ADULTS

------Aerobic Walking Intervention

DOCTORAL (PhD) DISSERTATION

BUDAPEST

2021

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------Aerobic Walking Intervention

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Budapest, 2021

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Acknowledgements

Life is a journey, and doing a PhD is an extortionary experience in my life journey. Pursuing a PhD degree brings me a feeling of gains and gratefulness. Obtaining a PhD degree is more than learning new knowledge but an enrichment of my life. Achieving a goal, which may be perceived as high maintenance, makes me satisfied and the feeling of success is amazing. Besides, the process of pursuing a PhD degree may influence personality. For me, dedication is only a word to my country, but now, it is also a word to science. Completing a PhD degree is the end of journey as a student, but the start of journey as a scientist.

Life is splendid when there are like-minded people around you. I am lucky enough to encounter such brilliant people, who are my supervisors, friends, colleagues and families. Without their love and support, the dissertation would not be accomplished and the PhD journey would be dim. With highest sincerity, I would like to thank Dr. Szilvia Boros, my supervisor, a nice lady who is always supportive and helpful. Time means a lot during PhD journey, efficiency is always essential for me, Dr. Szilvia Boros devoted her full kindness and warmness to me. I think, there is a psychological effect when a person is warmly treated, he/she would also like to spread the warmness. I will always keep a positive attitude in my life and cherish the memory of cooperating with Dr. Szilvia Boros. Special thanks to Dr. Attila Szabó, from whom I learned how to behave professionally in an academic position. The professionality of Dr. Attila Szabó impressed me and motivated me in science. I would also like to thank lovely Dr. György Bárdos, my programme director. The word “lovely” came to my mind when I first met Dr. György Bárdos, whose face is always full of amity and gentleness.

There are many external professors who I think occupy non-removable seats in my heart. They all impacted on my personality and expertise. Dr. Krisztina Károly, whose morality I admire so much, left me a deep impression because of her elegance and responsibility. I would definitely thank my ex-supervisor in Debrecen University (Hungary), Dr. Éva Bíró, who owes high morality and professionality that influenced me a lot. Many thanks to Dr. Gábor Halász, who is the dean of the Doctoral School of Education (PPK) and the director of the EDiTE programme. Dr. Gábor Halász is among the most easy-going deans that I have ever met. I appreciate the manifestation of leadership. They are all my role models in my life and in my career.

Great thanks to people who contributed in my intervention study. Deep thanks to Darma Juwono (a fellow PhD student) and the 54 research volunteers who participated in the aerobic walking intervention study. Darma Juwono is a very good colleague of mine, and I appreciate

his voluntary assistance in my research. I thank the research volunteers for their passion and enthusiasm in joining the research, which inspired my endeavor. I would like to thank all my lovely friends, they were friends who brought me warmness and happiness during the year of written-up the dissertation, and friends who helped me to release stress and anxiety. I would like to express an indebted heart to my lovely family (Dad, Mum, my younger sister and her husband and my new-born nephew). Also, graceful thanks to my grandparents, who always offer kind expectations on me and encourage me to become a big girl. A family with love brought me a lot of power and energy dealing with stress and difficulties occurred in my life. I would also like to thank myself: be strong, be active, be kind, be patient.

Last but not the least, I would like to thank the staff in the Faculty of Education and Psychology (PPK), Eötvös Loránd University (ELTE). PhD journey coordinated with every sector in the faculty, including library, administration office, financial office, reception etc., I am thankful for all of the support and kindness from this faculty. Furthermore, I wish to thank the Tempus Foundation (StipendiumHungaricum Scholarship) that provided financial support for my study in Hungary. With the integrated collaboration, my PhD journey finally comes to the end. To all of the personnel, you have my sincerest gratitude.

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION OF THE RESEARCH TOPIC

The Ph.D. research investigated the relationship between physical exercise and sleep quality, stress and life satisfaction and explored the mechanism between physical exercise and sleep quality, stress as well as life satisfaction. We designed specific requirements (i.e., particular goal setting) for aerobic walking as a physical exercise intervention by considering its feasibility and the possibility of public health promotion and implementation. A multi-method research strategy was utilized, including theoretical and experimental research methods.

1.2 BACKGROUND AND RATIONALE

The benefits of physical activity have been widely addressed. The examination of different physical activity strategies including vigorous and moderate exercises indicated essential impacts on health and quality of life (Brown et al., 2003). Moreover, physical activity is emphasized in the health promotion sector and plays a role in facilitating policy makers and health professionals who are interested in health surveillance at national and international levels (Brown et al., 2003). Epidemiological research highlighted the health benefits of physical activity in reducing disease risks (Wannamethee & Shaper, 2001). Behavioral research supported the notion that continuity of physical activity may be associated with protection against disease (Kujala, Sarna, Kaprio, Tikkanen, & Koskenvuo, 2000). In young adults, there is a growing number of evidence showing that physical inactivity may be a preventive factor for multiple adverse health outcomes (Thorp, Owen, Neuhaus, & Dunstan, 2011). However, individuals' physical activity level is more likely to decrease after a certain period of time and their physical activity habits are significantly influenced by life-changing events (Dai, Wang, & Morrison, 2014). Thus, feasible leisure-time physical activities are highly recommended for global health promotion to achieve consistent health outcomes.

Physical activity is recognized to be influential on sleep health. Sleep health is associated with health implications and is regarded as a health indicator (Zee & Turek, 2006). Therefore, the relationship between physical activity and sleep quality is essential to be discussed. Previous evidence indicated that the prevalence of sleep disorder should be

concerned (Peppard et al., 2013). For instance, sleep disturbance among elderly individuals is common (Foley, Ancoli-Israel, Britz, & Walsh, 2004). Furthermore, sleep habits and disturbances were examined among 1,034 elderly individuals, which revealed that 75% of these individuals had occasional or persistent sleep disturbance and 38% were diagnosed with insomnia (Lo & Lee, 2012). Not only older people, but young adults are also suffering from sleep disorders including obstructive sleep apnea and insomnia, etc. (Gaultney, 2010). Considering the health implications and health care functionality, it is recommended that sleep disorders be prevented by health promotion strategies rather than by taking medical treatment. Consequently, given the health benefits of physical exercise, to explore the sleep benefits of physical exercise is of scientific interest to reduce health symptoms caused by disordered sleep.

Stress is another health indicator among young adults. From a diagnosis-based study, ranging from mild to extremely severe, depressive symptoms were presented in 18.5%, anxiety in 24.4%, and stress in 20% in the college population (Sahoo & Khess, 2010). Perceived stress is an important risk factor for mental health among young adults (Bovier, Chamot, & Perneger, 2004). The previous study has appealed the necessity for preventing stress levels among young adults especially college students (Sahoo & Khess, 2010). Psychology trials acknowledged physical activity to be a strategy for managing stress. However, measuring physical activity and quantifying the appropriate intensity/volume of physical activity for general young adults is still unclear. Hence, further actions are required to quantify physical exercise instruction in instructing stress release among young adults.

Improving satisfaction with life is one of the highest goals for health promotion. Physical exercise is supposed to be positively associated with life satisfaction despite the influence of mood and health status. Nevertheless, supplementary evidence demonstrating that the association between life satisfaction and health-promoting behavior seems to be bidirectional (Grant, Wardle, & Steptoe, 2009). Therefore, on the one hand, it is necessary to figure out the association between physical activity and life satisfaction; on the other hand, it is important to unfold functional interventions for improving life satisfaction. Even though physical activity is considered to be a valuable tool for enhancing life satisfaction, feasible and instructive physical activity recommendations for health strategy at a population level are under discovery. Besides, risk factors such as mood and stress levels should not be trimmed out when evaluating life satisfaction. The perceived life satisfaction may differ across the life span (Baird, Lucas, & Donnellan, 2010). Among young adults, a high level of life satisfaction is associated with more past-positive or future orientations (Gao, 2011). Hence, it is prospective to add supplementary evidence in physical intervention on life satisfaction among young adults.

Sleep quality, stress management and life satisfaction are different aspects of health promotion. The relationship between sleep quality, stress and life satisfaction should be clarified with the co-ordinance of physical exercise. Walking is an easy type of physical exercise (Stubbs et al., 2016), which does not require internal and external facilitators; thus, specified instructions for walking activities need to be addressed. Finally, examine the integrated efficacy of physical exercise, especially walking, by gathering sleep quality, stress and life satisfaction together among young adults have not been investigated.

1.3 PURPOSES AND RESEARCH QUESTIONS OF THE PH.D. STUDY

Controversial findings may emerge because potential factors such as perceived stress might also affect the sleep and exercise relationship; therefore, examining these variables in the context of physical activity and sleep quality may be warranted. Sleep quality and life satisfaction are important variables to assess life quality. Thus, in our study, we will include perceived stress and life satisfaction as additional parameters of the research. It is a three-step process including cross-sectional study, intervention study and interview study.

The doctoral research aims 1) to figure out the comprehensive relationships between sleep quality, stress and life satisfaction (cross-sectional study); 2) to examine the effectiveness of the designated aerobic walking exercise on sleep quality, stress and life satisfaction (intervention study); 3) to explore the potential cognitive interactions of physical exercise on sleep quality, stress and life satisfaction (interview study). Broadly, we will try to apply the results of this study in promoting the health status and sleep status of the overall population and encourage society to behave actively and reduce the health and economic burden caused by poor physical and sleep health.

Research questions were formulated based on the hypothesis above:

Q1. What is the relationship between sleep quality, stress and life satisfaction among general healthy adults?

Q2. How does the walking exercise associated demographic factors (e.g., gender, BMI, etc.) interact on sleep quality, stress reduction and life satisfaction in adults?

Q3. The effects of daily aerobic walking exercise on sleep quality, stress reduction and life satisfaction in adults?

Q4. What is the effect of regular aerobic walking exercise on mental & cognitive function?

1.4 JUSTIFICATION OF THE STUDY

1.4.1 Research feasibility

With the development of entertainment technology and speedy lifestyles, more and more young adults choose to stay at home and watch videos, play games, etc., it is urgent to raise attention to hazardous lifestyles (WHO). Sedentary life is regarded as one of the hazardous lifestyles (Nuviala, Gómez-López, Turpin, & Nuviala, 2011). The physiological and health implications of sedentary lifestyle should be taken into consideration by health professionals. In Europe, it is supposed that low physical activity and sedentary lifestyle may be one of the key determinants of overweight and obesity among the general adult population (Martínez-González, Martinez, Hu, Gibney, & Kearney, 1999). The regularity of physical exercise is supposed to produce positive cognitive outcomes for both sedentary and irregular exercised populations. As we know, doing physical exercise on regular basis requires time management ability, perseverance, motivation etc., of which the cognitive outcome may be different from doing spontaneous physical exercise. Therefore, for people who are in sedentary and irregular exercise life style (which are unhealthy), to maintain the regularity of physical exercise might positively influence their life habits. Thus, it would be valuable to evaluate a feasible and regulated physical exercise to promote the health status and examine the consistency of the health outcomes.

Concerning the hypothesized outcomes of regular aerobic walking and the recommended steps for avoiding sedentary lifestyles, a designated aerobic walking would be instructive and easy to follow. Previous researchers noted that walking for less than 5000steps/day can be defined as sedentary (Tudor-Locke, Craig, Thyfault, & Spence, 2013). However, total step counts for a whole day is not enough to track the regularity and continuity of walking activity. With the assistance of a pedometer, we decided to examine the effects of one-hour aerobic walking per day (with aerobic steps counts and daily steps counts). Aerobic steps are differentiated from daily step counts by walking speed and duration. It is full of the feasibility of embedding aerobic walking on a daily basis.

1.4.2 Necessity and significance

There is a need for health promotion not only in Europe but also worldwide. In order to reach the best balance between health investment, econom

ic cost and medical expenses, it is highly recommended to promote global health by using cost-effective interventions. In large scale health promotion, prevention is more than cure. There are a number of sports and physical activity instructions and suggestions from health organizations and experts, but to the general population, an easily accessible way of exercising makes much more sense. Goal setting aerobic walking enables the possibility of being implemented extensively by considering its easy-constructive and flexible management.

The study is significant from four domains: 1) it adds supplementary research evidence in walking exercise and sleep quality, stress and life satisfaction; 2) it provides future research on the relationship between physical exercise, sleep quality, stress and life satisfaction in real-life basis, where many factors (e.g., walking environment, daily life routine, life events etc.) can not be controlled; 3) it added supplemental evidence in walking exercise research in terms of walking duration, walking intensity, psychological outcomes during walking exercise etc., 4) it identifies the designated aerobic walking as a practical way of exercising with the interaction of sleep quality, stress and life satisfaction.

1.5 OUTLINE OF THE DISSERTATION

Faculty of Psychology and Education (PPK) (Eötvös Loránd University) accepts two types of dissertation: The (A) type is the traditional monographic form, while the (B) type is based on already published works and consists of those publications and an introduction and a discussion which frame the findings. According to the doctroal regulations (PPK), type B is adopted in the present dissertation. This dissertation contains seven chapters. Each chapter described a specific aspect of the related context of the research topic.

Chapter 1 presents an overview of the dissertation by introducing the research topic, presenting the research rationale, formulating the research questions and illustrating pertinent justification of the research.

Chapter 2 makes a comprehensive literature review of the selected research topic from five perspectives: definitions, categorization, assessment and recommendation of physical activity; physical activity and health promotion; adoption & maintenance of physical activity; overview of walking activity and walking research; walking and sleep quality, stress and life

satisfaction. This chapter documents the research findings and research gaps in physical intervention as well as walking intervention with the above-mentioned key research variables.

Chapter 3 presents the research paradigm of conducting the Ph.D. research and explains the methodology for conducting a multimethod research in the pragmatist paradigm. The research design in the Ph.D. research is also discussed in this chapter. A mix-method research design is adopted.

Chapter 4 includes a quantitative study (Study 1), which addressed the association between physical activity and sleep quality. A cross-sectional study was conducted with the purpose of answering research question 1 by examining the relationship between sleep quality, stress and life satisfaction and comparing the difference associated with age and gender together with lifestyle factors. The study process is elaborated and findings are explicitly discussed.

Chapter 5 presents the investigation of the designated daily aerobic walking intervention on sleep quality, stress and life satisfaction. The intervention study is a randomized controlled cross-over study. Randomized controlled cross-over study is a combination of crossover trial and randomized controlled trial. Crossover trials are generally restricted to the study of short-term outcomes. In a crossover trial subjects are randomly allocated to study arms where each arm consists of a sequence of two or more treatment/intervention given consecutively. The simplest model is the AB/BA study. Subjects allocated to the AB study arm receive treatment/intervention A first, followed by treatment/intervention B, and vice versa in the BA arm. Crossover trials allow the response of a subject to treatment/intervention A to be contrasted with the same subject's response to treatment/intervention B. This way, it makes crossover trials potentially more efficient than similar sized, parallel group trials in which each subject is exposed to only one treatment/intervention. The dissertation adopted the this model, which is the AB/BA study. Subjects allocated to the AB study arm receive treatment/intervention A first, followed by treatment/intervention B, and vice versa in the BA arm (Sibbald & Roberts, 1998). The whole intervention process lasted for 12 weeks in total, in which two groups of participants exchanged their roles for active intervention. Omron HJ-112 pedometer was used to facilitate the intervention process. The intervention study answers the research question 2 & 3. Participant selection and intervention procedures are fully interpreted to affirm the quality of the experiment. Findings are discussed by taking consideration into the state-of-art literature and acknowledging the limitations.

Chapter 6 discloses research question 4 by a qualitative study, which intended to search for the interactions between regular aerobic walking exercise and mental health construction. A semi-structured interview study was conducted with the research participants who completed

the aerobic walking intervention in Chapter 5. The findings of the interview study are not limited to the psychological outcomes of the regular aerobic walking exercise but also an overall assessment of the intervention. Clues are drawn from three angles: efficacy of the intervention, feasibility of the intervention and cognitive feedback. In general, the qualitative study summarized the aerobic walking intervention study and underlaid the potential outcomes.

Chapter 7 sums up the Ph.D. research by deliberating the findings of each study. Significant findings are highlighted and the implications of the research are explicitly stated; meanwhile, recommendations for future study are well elaborated.

CHAPTER 2: LITERATURE REVIEW

This chapter elaborates existing literature on the associations between physical exercise and health promotion correlates, methodologies, theories and approaches; plus, the intervention trials explore the effectiveness of walking exercise on sleep quality, stress and life satisfaction. In detail, this chapter also reviews the definition of physical activity, physical activity categorization, assessment and recommendations, epidemiology of physical activity and health promotion, well-being and life satisfaction, walking associated health interventions, and motivation in physical activity behavior modifications as well as maintenance of physical activity habits. Besides, the present dissertation addresses the key elements in physical activity behavior change and correlated constraints.

There are five leading sections in this chapter. The literature review is discussed from various perspectives with the understanding of physical activity and health promotion in the first four sections. The last section in this chapter highlights the implication of the dissertation based on the comprehensive literature review. Three sections (section 2.1, 2.2, 2.3) reviewed the definition, categorization, assessment and recommendations for physical activity; the correlation between physical activity and health promotion; adoption&maintainence of physical activity. To start the literature review, the definition, categorization, assessment and recommendations of physical activity are discussed (Section 2.1). And then, the retrospective overview of physical activity and health promotion strategies including history & epidemiology and physical activity behavior is represented in Section 2.2, which emphasizes the effectiveness of physical activity practices on health promotion, and addresses the potential shortages in physical activity interventions. Walking exercise, as a type of physical exercise enables the possibility of national and international implementation. Health promotion experts work with human beings and public health; in fact, there come the realistic issues for implementation when working with human beings. Existing evidence and explorations remind readers of the adoption and maintenance of physical exercise after a comprehensive assessment of physical activity interventions regarding psychosocial predictors. Psychosocial predictors encompass both the social and psychological aspects of someone's life and cover a broad range of both positive and negative factors. Social factors include quality of life, health behaviors (alcohol consumption, smoking status, drug use), physical activity level, and socioeconomic status, whereas psychological factors include depressive symptoms, perceived stress levels, anxiety, and mood etc. (Section 2.3). Two sections (section 2.4 and 2.5) reviewed the literatures on particularly

walking activity and walking research; walking research and sleep, stress and life satisfaction, which tailored to the research topic of the dissertation. In compliance with the research objectives and the research goals of the dissertation, the following section (Section 2.4) focuses on the effectiveness of walking exercise with sleep quality, stress and life satisfaction. This section presents the available evidence in walking intervention and emphasizes the need for supplementary evidence. In the end, Section 2.5 justifies and concludes the implications of the dissertation. Nevertheless, each section is summarized individually by a section summary at the end of each section.

2.1 PHYSICAL ACTIVITY: DEFINITION, CATEGORIZATION, ASSESSMENT, RECOMMENDATIONS

The benefits of physical activity are well addressed, but our knowledge is much less advanced in helping people become active enough to enjoy these benefits. Physical activity is regarded as a legitimate research topic for investigation. Accumulated evidence documented that physical inactivity increases health problems (Kohl 3rd et al., 2012). Enhancing physical activity level seems to have become an important issue in recent decades since modern life is becoming increasingly sedentary (Owen & Bauman, 1992). Increasing physical activity level at the national and international levels raised scientific interest in theoretical and empirical physical exercise research (Hagströmer & Franzén, 2017; Kallings, Leijon, Hellénius, & Ståhle, 2008). Understanding physical activity is a crucial step for physical exercise applications in public health. Promoting physical activity is one of the major public health tasks (Cavill, Foster, Oja, & Martin, 2006). However, it takes time to corroborate the implications of physical activity and bring it into effect at a populational level. Thus, it is essential to figure out how to expand and promote physical activity on a long-term basis.

Given that the term of physical activity is broad, the definition of physical activity is interpreted deliberately (Section 2.1.1). Physical activity can be grouped from multiple perspectives. For instance, in kinetical research, physical exercises can be grouped into vigorous and moderate activity (Kinetics is the study of rates of chemical reactions. Kinetics allows the chemists to predict how the speed of a reaction will change under a reaction condition. At higher concentrations a reaction will proceed more quickly.); in physiological research, physical exercises can be grouped into aerobic and non-aerobic activity. Hence, the grouping methods in physical research fields and categorizations of physical activity are discussed

(Section 2.1.2). It is not redundant to emphasize the importance of physical activity since physical activity is not only supposed to be functional in physical health but also mental health (Biddle, 2016; Paluska & Schwenk, 2000; White et al., 2017). To raise up the awareness of physical activity is of much more importance than doing the physical activity itself (Section 2.1.3). In order to make the theory of physical activity more applicable, physical activity recommendations from updated research findings are discussed (Section 2.1.4). The last sub-section identifies the key issues and summarizes relevant literature (Section 2.1.5).

2.1.1 Definition of physical activity

Traditional definitions of physical activity encompass a broad range of functional capacities. Thereinto, one of the potential reasons is that physical professions define physical activity and always refer to health outcomes (Fortier et al., 2011). However, to better acknowledge the functional capacities of physical activity to public citizens, it is needed to well-understand the theories and models of physical activity. Given the demand to actualize physical activity theories into practice, it is fundamental to enhance the concepts and understanding of physical activity with the purpose of evaluating physical effects radically. Even though a number of researches explicated the benefits of physical activity, it is rare to define physical activity in scientific researches. Below is the definition of physical activity from the world health organization (WHO, 2010).

> *"Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure – including activities undertaken while working, playing, carrying out household chores, travelling, and engaging in recreational pursuits. The term "physical activity" should not be confused with "exercise", which is a subcategory of physical activity that is planned, structured, repetitive, and aims to improve or maintain one or more components of physical fitness*." (WHO, 2010)

From the definition above, physical activity is a broad macro-concept of body movement. The definitions of "physical activity movement" have captured the attention of many physical educators and health professionals (Johnson & Turner, 2016). It is important to keep in mind that the features of the physical activity movement among young adults could be different compared with elder or youth populations (Young, 2014). Regardless of the definition of physical activity, the distinction between "physical activity" and "physical exercise" should

be labeled because people always mix them up. Physical exercise is defined as "a specific type of physical activity that is planned, structured and repeatedly done to improve or maintain physical fitness, whereas the definition of physical activity is "any bodily movement produced by skeletal muscles that result in energy expenditure" (Caspersen, Powell, & Christenson, 1985).

Through a brief etymology of the term, the notion of physical activity is described as one dimension of corporeal discourse, concerned with meaning-making in and around the body-centered on sport, physical recreation and exercise (Kirk, 1999). Kirk pointed out that physical recreation can be dominant in physical activity, which can be regarded as physical activity at leisure time. It is reported that worker class typically exhibit lower rates of enjoyable physical activity, and their participation in recreational physical activity is commonly low (da Silva et al., 2018; Gu et al., 2016; Ussery, Fulton, Galuska, Katzmarzyk, & Carlson, 2018). Based on recent investigations, sedentary occupational life has become dominant in recent years, which should be concerned. Therefore, in controversy to physical activity, there is a need to clarify the emerging concept of sedentary to better facilitate physical interventions. Any activity at the low end of the physical activity continuum can be regarded as sedentary (Pate, O'neill, & Lobelo, 2008). Sedentary behavior refers to activities that do not increase energy expenditure substantially above the resting level and includes activities such as sleeping, sitting, lying down, and watching television, and other forms of screen-based entertainment (Pate et al., 2008). Accumulated studies claimed about sedentary lifestyle nowadays, which in turn, emphasized the definition of physical activity.

Defining physical activity is not limited to virtual conceptualizations; there are also definitions that appeal to health benefits. For example, physical fitness is employed when defining operationalized physical activity. The current body of knowledge in exercise science and society's view on physical fitness indicates that physical activity should focus on the health-related aspects since physical education professions proposed that the primary concern for promotion should be health-related physical fitness (Pate, 1988).

In addition, the self-definition of physical activity also provides supplementary knowledge in defining physical activity. A physical activity self-definition model demonstrates that perceived commitment and perceived ability had direct effects on the self-definition of physical activity (Kendzierski & Morganstein, 2009). Self-definition could not be ignored due to the fact that human beings are the "engines" to perform physical activity, without concerning human being's involvement and cooperation, it is non-sense in conducting health promotion programs. In order to achieve persistent health promotion benefits by applying physical activity

programs, it is essential to design interventions to reverse the decline in physical activity participation.

The definition of "physical activity" is relatively clear, but the way of understanding physical activity is not yet clear. For example, sedentary, which is frequently mentioned in physical activity research. By simply understand the basic definition of physical activity is not enough in current dissertation, more detailed concepts should also be reviewed. Although the definition of physical activity has been clearly defined, further detailed understandings of physical activity are discoursed in scientific research. To better support the aims and goals of the present dissertation, the literature review in this section did not illustrate deeply about the grounded theories of physical activity definitions, but to focus on publicly understandable perspectives for implementation. Appropriate understanding of physical activity through substantial physical associated definitions allows health professions to make instructive and directive suggestions in the context of health promotion.

2.1.2 Categorizations of physical activity

When taking physical activity as an intervention strategy for health purposes, the particular period of life spans should always be concerned. A number of physical activities examining health outcomes are investigated in cross-life age groups. Possible mechanisms by which physical activity facilitates cognitive and kinetic performance are proposed to vary along with age groups (Voelcker-Rehage & Niemann, 2013). Identifying types of physical activity and understanding the categorizations of physical activity could improve the estimation of energy expenditure, physical activity counts and health outcomes (Bonomi, Plasqui, Goris, & Westerterp, 2009).

Physical activity of all kinds can be performed in a variety of intensities, ranging between light, moderate, and vigorous (high) intensity activity; thereof, categories are made accordingly. The definition for light intensity activity is an activity that is classified as < 3 METS. One MET, or metabolic equivalent, is the amount of oxygen consumed while sitting at rest. Sedentary behavior should be differentiated from light activity. Sedentary behavior includes activities that involve energy expenditure at the level of 1.0-1.5 metabolic equivalent units (METs). Light physical activity, which often is grouped with sedentary behavior but is in fact a distinct activity construct, involves energy expenditure at the level of 1.6-2.9 METs (Pate, O'neill, & Lobelo, 2008). Moderate intensity activities are defined as activities ranging between

3 - < 6 METS. Vigorous intensity activities are defined as activities ≥ 6 METS (Colley & Tremblay, 2011). American Heart Association Recommendations for Physical Activity (AHARPA) lists sample activities in each category. For instance, moderate-intensity activities include brisk walking (at least 2.5 miles per hour), water aerobics, dancing (ballroom or social), gardening, tennis (doubles), biking slower than 10 miles per hour, etc. Examples of vigorous-intensity activities are hiking uphill or with a heavy backpack, running, swimming laps, aerobic dancing, heavy yard work like continuous digging or hoeing, etc. (Haskell et al., 2007).

Despite the categorization by the intensity of physical activity, the degree of body movement can be another indicator for physical activity categorization. National Heart, Lung and Blood Institute in the United States[1] proposed four main types of physical activity including aerobic (e.g., walking, dancing, swimming, etc.), muscle-strengthening (e.g., resistance exercises), bone-strengthening (e.g., jumping rope, running, gymnastics, lifting weights, ball games), and stretching activities (e.g., shoulder rolls, standing hamstring stretch, chest mobilizer). Compelling evidence has shown that regular aerobic activity contributes to cardiovascular health and is able to work better (McMurray, Ainsworth, Harrell, Griggs, & Williams, 1998). The other types of physical activity mentioned above are supposed to benefit the body in other ways. For example, muscle-strengthening and bone-strengthening activities incorporate high-intensity resistance training, impact exercises and balance challenges (Hillsdon & Foster, 2018).

For global health promotion with individuals, leisure time physical activity (LTPA) should be emphasized as a particular category of physical exercise. Reports indicated that there is considerable variability in daily LTPA variability across different types of LTPA in terms of typical durations and intensities among adults (Ginis et al., 2010). To achieve the target to increase the physical activity level, it is remarkable to highlight activities that meet not only global health requirements and needs, but also meet individual abilities, needs, and desires. Given that variability in LTPA cannot be explained independently; therefore, availability in LTPA between population subgroups should be identified in order to add to our understanding of health risk profiles, and assist in the development of health promotion strategies (Burton & Turrell, 2000). It can be understood that the category of LTPA is a commonly used but a particular category of the physical activity considering real-life possibilities.

In summary, the categorizations of physical activity can be explained from different perspectives. Generally, the categorization of physical activity is not complicated. The existing

[1] https://www.nhlbi.nih.gov/health-topics/physical-activity-and-your-heart

theory in categorizing physical activity needs further scientific research. With the current understanding of physical activity categorization, it can be acknowledged that the understanding of physical activity can be intercrossed; for example, leisure time activity can either be a moderate or vigorous activity. The categorization of physical activity helps people quantify physical exercise volume, which is essential in physical activity implementation.

2.1.3 Assessment of physical activity

Measuring physical activity is not a simple task. The time and effort required to achieve consensus on physical activity assessment should be well justified. Generally, physical activity dimensions include intensity, frequency and duration, which make up the total volume of activity together (Corder, Ekelund, Steele, Wareham, & Brage, 2008). Precise measurements are essential to establish and monitor the effectiveness of interventions and to make cross-cultural comparisons more accurately. In addition, accurate measurements of physical activity are often amplified in young people due to the cognitive, physiological, and biomechanical changes that occur during natural growth as well as a more intermittent pattern of habitual physical activity (Corder et al., 2008). In addition, young adults usually maintain routine life within certain contexts including spaces such as homes, schools, and neighborhoods, thus, to advocate general schematic for investigations could be a significant issue (Cradock, Melly, Allen, Morris, & Gortmaker, 2007). Hence, unique considerations are required for measurement in young adults.

Subjective measures

Self-report instruments (e.g., questionnaires, interviews, activity diaries (logs), and direct observation, etc.) are currently the most frequently used methods in measuring physical activity. The physical activity questionnaire is the most practical self-report instrument in physical activity research given its low cost and applicability to a wide range of ages. Subjective recall instruments vary in detail, type of activity assessed, reference periods, administration, completion time, targeted population, and how respondents are classified. Due to the nature of subjective measures, these instruments are inherently limited by factors such as recall error, social desirability or gender bias, floor effects, misinterpretation of terminology, and some questionnaires fail to quantify the totality of physical activity dimensions and contexts. The accuracy of subjective instruments is influenced by the ability to accurately recall all

relevant details retrospectively, but it may also be influenced by the opinion and perception of the participant, and numerous limitations of self-reports have been discussed (Sallis & Saelens, 2000). Although there are many different direct and indirect methods of assessing physical activity participation, self-report measurement is more feasible for large-scaled populational surveys (Booth, 2000).

Objective measures

Objective measurement seems to be more valid in decreasing cognitive biases; for example, technical devices (e.g., heart rate monitoring, multisensory, etc.) have the potential of accuracy in measuring physical activity. Common objective measures include devices such as accelerometers (activity watches), pedometers (step-counters), or Global Positioning System (GPS) units. In recent decades, accelerometers have gained popularity given measure acceleration (counts) in real time. Pedometers correlate strongly with uniaxial accelerometers, yet pedometers appear to yield the most accurate data (Sylvia, Bernstein, Hubbard, Keating, & Anderson, 2014). Heart rate monitoring is a physiological indicator of PA and energy expenditure, providing real-time data on the frequency, duration, and intensity of physical activity. However, there are uncertainties in using physiological or biomechanical parameters to estimate physical activity. In small sized research, it is suggested to measure objective parameters when evaluating physical activity.

Comparison between subjective and objective measures

Five methods (i.e., behavioral observation, questionnaires, heart rate monitoring, motion sensors and doubly labeled water) measuring physical activity were tested. Table 1 shows a summary of the comparative description of the separate methods (Westerterp, 2009). The five methods described above were ranked on six parameters including subject interference, subject effort, providing information on activity context, providing information on activity structure, the objectivity of the data, and the time and cost involved in the application. Questionnaires show low reliability and validity but the doubly labeled water method has become the gold standard for assessing physical activity (Westerterp, 2009). Technical devices can better assess the effect of interventions on physical activity within individuals (Martínez-García, Ruiz-Cárdenas, & Rabinovich, 2017). Using wearable devices to assess physical activity in epidemiologic research becomes possible (Lee et al., 2018). Both objective

measurements and subjective measurements of physical activity have their function in sport and health research.

Table 1 Ranking of methods for the assessment of physical activity on six different parameters

	Subject interference	Subject effort	Contextual information	Activity structure	Objective data	Observer time/cost
Behavioral observation	5	1	1	2	4	5
Questionnaires diaries interviews	4	5	2	4	5	2
Heart rate monitoring	3	4	4	3	3	3
Motion sensors	2	3	3	1	2	1
Doubly labeled water	1	2	5	5	1	4

It is imperative to adopt multiple methods in assessing physical activity in order to overcome measurement challenges purposely. A clear understanding of the nature of the individuals being studied is a criterion when making decisions in measurement selection (Welk, Corbin, & Dale, 2000). In addition, the choice for the use of a particular method for activity assessment also depends on the design of the study (Kohl 3rd, Fulton, & Caspersen, 2000). Both advantages and disadvantages should be considered and comprehensive study evaluation should be made before selecting an instrument.

2.1.4 Physical activity: efficacy and recommendations

Given the benefits of physical activity including diagnostic diseases (Berlin & Colditz, 1990), physical health (Hallal, Wells, Reichert, Anselmi, & Victora, 2006), and mental facilitation, etc. (Paluska & Schwenk, 2000), a number of recommendations for physical activity have been released. Despite the health benefits of physical activity, the physical inactivity rate is increasing in recent decades as mentioned above, which results in deleterious consequences in exporting health benefits of physical activity (Kohl 3rd et al., 2012). In the

present Ph.D. dissertation, factors that are interacting with physical activity efficacy and recommendations will be elaborated with the consideration of developing physical activity level at a populational and individual level.

Physical intensity and public health

Observations revealed significant differences in intensity levels across gender, age, and race groups (Kaczynski, Stanis, Hastmann, & Besenyi, 2011). The evaluation of physical intensity and public health is a young field, in general, the common knowledge of physical activity intensity is classified into moderate and vigorous physical activity. Both moderate and vigorous physical activity were supposed to be associated with positive efficacy in a broad spectrum of health outcomes (Kaczynski et al., 2011). In addition, reduced body mass index (BMI) and increased cardiovascular fitness may be important mediators of this association for both intensities of activity (Rennie, McCarthy, Yazdgerdi, Marmot, & Brunner, 2003).

Moderate physical activity is more frequently used in predicting health outcomes than vigorous physical activity. Epidemiological evidence regarding physical activity provides sound evidence from different populations that moderate physical activity confers significant benefits for coronary heart disease (CHD) and cardiovascular mortality in both men and women in middle-aged and older individuals (Kachur et al., 2017; Piercy & Troiano, 2018; Wannamethee & Shaper, 2001). Furthermore, the biological effects of regular, moderate physical activity translate into a substantially reduced risk of hypertension (Larsen & Matchkov, 2016), maturity onset diabetes (Van Dijk, Tummers, Stehouwer, Hartgens, & Van Loon, 2012), overweight and obesity (Flack, Ufholz, Johnson, & Roemmich, 2019), and osteoporosis (Nikander et al., 2010). It is reasonable to emphasize that moderate physical activity elicits performance-improving and health-enhancing effects. However, how much moderate physical activity should general adults take? Physical Activity Guidelines for Americans (PAGA) helps Americans understand the types and amounts of physical activity that offer important health benefits (Piercy et al., 2018). It is recommended that adults should do at least 150 minutes (2 hours and 30 minutes) to 300 minutes (5 hours) a week of moderate-intensity, or an equivalent combination of moderate intensity aerobic activity, which is in adherence to the physical activity recommendations from WHO (2010) (see Appendix 1).

There was a debate on whether high-intensity physical training could produce enough health implications on a populational level (Gaesser & Angadi, 2011). Limited health benefits were found from the vigorous physical activity, which may be because, in most studies, the

measurement and reporting of vigorous exercise are ambiguous (Brown, Burton, & Rowan, 2007). Additionally, experts believe that high-intensity interval training interventions will have limited reach, effectiveness, and adoption, and poor implementation and maintenance (Biddle & Batterham, 2015). In contrast, scientists also proposed that high-intensity training could be a successful population strategy for producing rapid physiological adaptations benefiting public health and there is genuine potential for scalable, enjoyable high-intensity interventions to contribute to addressing areas of public health priority (Weston, Taylor, Batterham, & Hopkins, 2014).

In order to better perform the physical activity intervention at a populational level, taking the opinions of physical preferences from local citizens could be helpful. A nationally representative survey indicated that moderate activity offers greater health benefits than vigorous activity in the general population (O'Donovan & Shave, 2007). Prescribed exercise analysis revealed greater adherence in the moderate intensity condition compared with vigorous intensity (Perri et al., 2002). Scientific data supports that the current public health recommendations for physical activity should emphasize moderate intensity activity (Lee & Paffenbarger Jr, 2000). Therefore, moderate physical activity has priority in public health promotion by concerning the feasibility and efficacy.

Physical activity in young and old age

There are obviously differences in young and old populations when implementing physical activity interventions and assessing physical activity efficacy (McPherson, 1994). There has been a notable number of researches on physical activity in different age groups. Most of this research derives from the social sciences, using quantitative methods to examine the consequences of the physical effects regarding the dominant determinants in different age groups (Markula, Grant, & Denison, 2001). For adolescents, it does not seem to be programmed by physiological factors in infancy; however, genetic factors or early habit formation may be important (Hallal et al., 2006). There is a notion that physical activity declines rapidly during childhood and adolescence (Trost et al., 2002). A remarkable decline in the frequency of physical activity and sport participation was found among young adulthood (RISTO Telama & Yang, 2000). In adults, there are many factors affecting physical activity levels such as behavioral and personality characteristics, environmental circumstances and community settings (Seefeldt, Malina, & Clark, 2002). Activity levels tend to decline with increasing age

progressively, age-specific barriers and motivators unique to elderly adults need to be acknowledged (Schutzer & Graves, 2004).

To explore the activity theory of aging fulfils the praxis of physical activity interventions, the so-called activity theory of aging (Zhou, Liu, & Yu, 2018). The essence of this theory is incoherent with the categorization of physical activity. To our best knowledge, the adequate theoretical formulation and related concepts are not explicitly discoursed (Rhodes, Blanchard, & Blacklock, 2008). Nevertheless, a social-cognitive theory responding to age differences in motivational orientation towards physical activity revealed positive implications of interventions that aimed at increasing participation in physical activity (Netz & Raviv, 2004). Furthermore, emerging evidence showed a positive relationship between activity and health benefits and life satisfaction among elder people (e.g., retirement community) (Junhyoung Kim, Lee, Chun, Han, & Heo, 2017). With the best acknowledgment of existing findings among adults (25-64 years old), fairly similar levels of overall and daily levels of leisure-time physical activity are reported, but the levels differ across educational groups (Borodulin, Laatikainen, Lahti-Koski, Jousilahti, & Lakka, 2008).

Although these physical investigations have contributed significantly to our knowledge, more investigations on health benefits were established in elder populations. There is emerging evidence for significant psychological and cognitive benefits accruing from regular exercise participation by older adults (Chodzko-Zajko et al., 2009). Laboratory evidence shows that physical activity is associated with better performance in old but not in young subjects (Christensen & Mackinnon, 1993). Aging is a complex phenomenon involving multiple biological pathways at the cellular level (Kelly, 2011). There is considerable evidence showing that physical inactivity contributes to many of the adverse changes that occur with the aging process (Stewart, 2005). Figure 1 is a modification of a commonly presented graphic at an aging conference and shows the selected pathways by which changes upon aging lead to disease (Stewart, 2005).

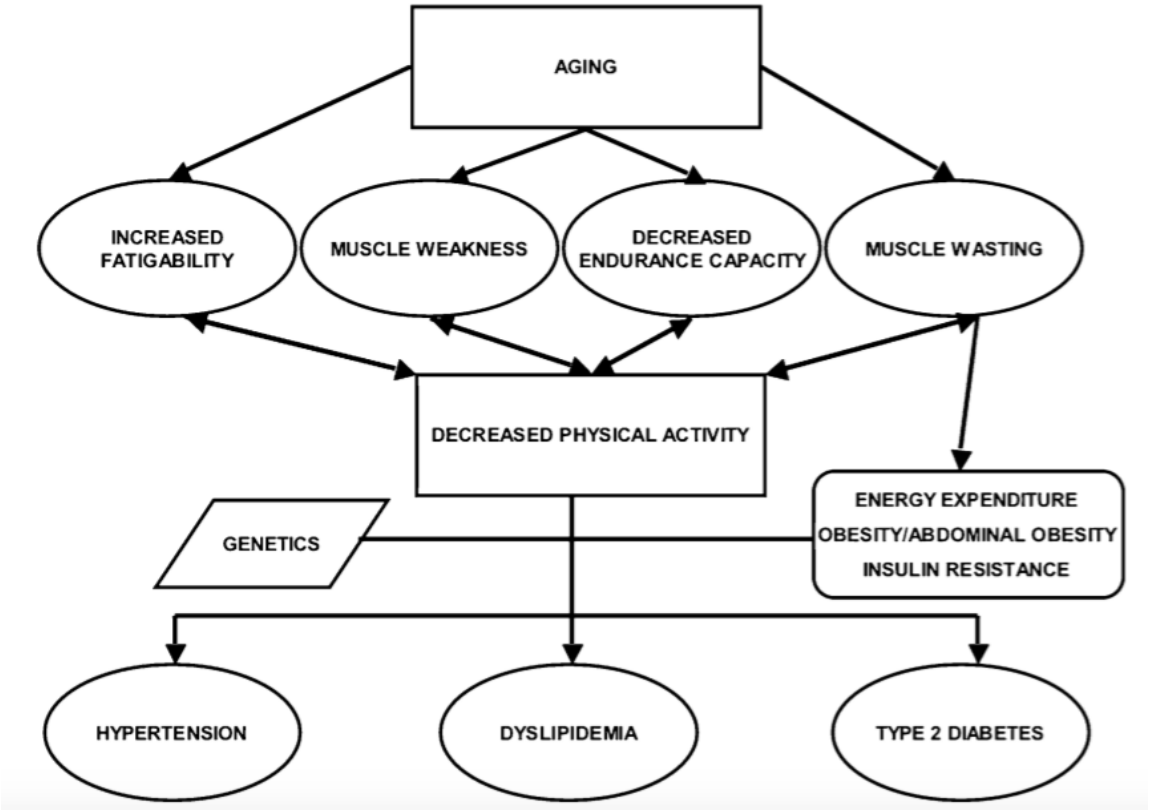

Figure 1 A commonly presented figure showing selected pathways by which changes upon aging lead to disease (Stewart, 2005)

Physical activity with aging is a life-long story. In activity-based health promotion, more emphasis should be targeted to the age-related population groups. The predictors of adherence elucidated in elder adults are unreliable in young populations. Even though the exploration of physical interventions in elderly populations has been well-documented, it is still under discovery in young adults. This dissertation highlights the physical intervention among young adults only (see section 2.2).

Regularity and continuity of physical activity

Regularity and continuity of physical activity should always draw attention from health promotion experts, health policy makers and public health professionals. Limited studies in the literature have explored how internal and psychological characteristics influence physical activity and exercise regularity. A well-accepted model is a trans-contextual model, which proposes that young people's perceived autonomy support will affect their perceived locus of causality, intentions, and physical activity behavior at leisure time (Hagger, Chatzisarantis,

Culverhouse, & Biddle, 2003). Figure 2 shows hypothesized trans-contextual model and indicates that both internal and external perceived loci of causality will influence internal and external perceived loci of causality, respectively, in a leisure-time context (Hagger et al., 2003).

The trans-contextual model outlines the processes by which autonomous motivation toward activities in a physical education context predicts autonomous motivation toward physical activity outside of school, and beliefs about, intentions toward, and actual engagement in, out-of-school physical activity (see Figure 2) (Hagger & Chatzisarantis, 2016). The model was originally developed and tested in the physical exercise context and focused on transferring of students' autonomous motivation toward activities in physical exercise lessons to motivation to engage in related activities, namely, leisure-time physical activity, outside of school. However, the model represents a generalizable framework to test the processes underpinning the transfer of motivation for in-class activities to motivation for related activities in contexts outside of school. The defining characteristic of the theory is that it differentiates between qualities or types of motivation experienced by individuals toward the activities and behaviors in which they engage rather than the quantity of motivation alone (Hagger & Chatzisarantis, 2016).

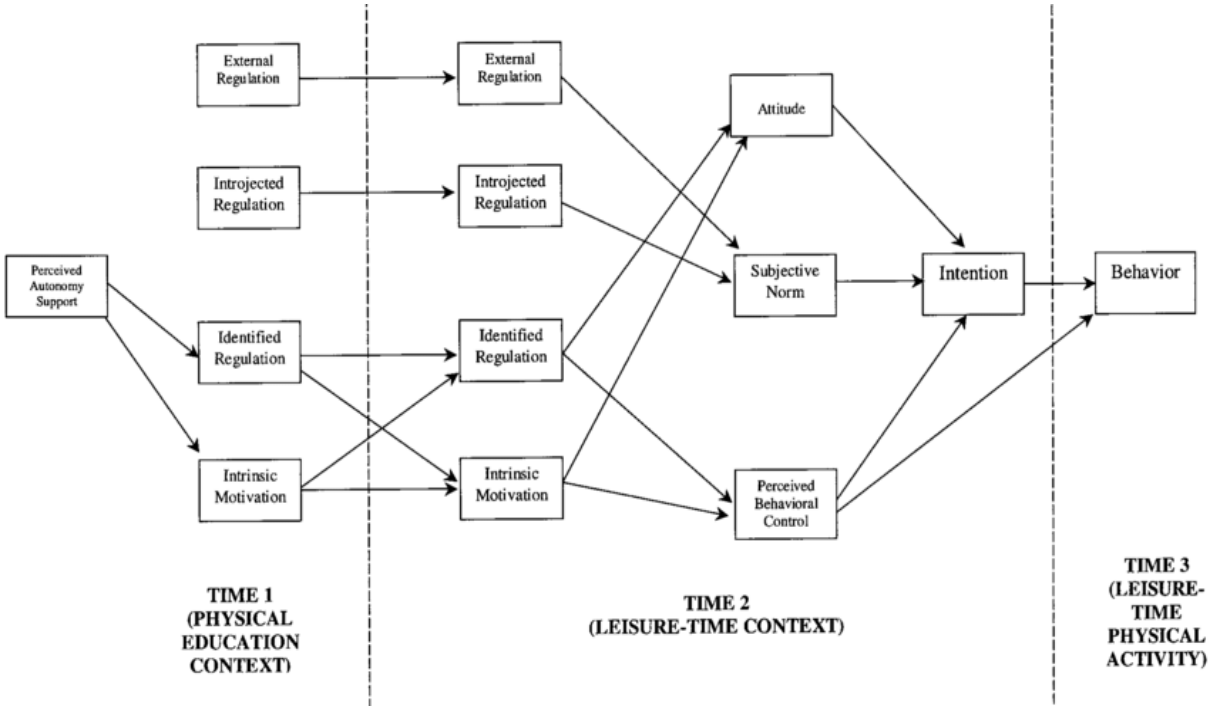

Figure 2 The hypothesized trans-contextual model (Hagger et al., 2003)

A previous study examined how individual self-efficacy impacts exercise behavior coupled with mediating factors such as health consciousness, goal progress, attitude toward

exercise should be included in order to fully explain the relationship between perceived self-efficacy and exercise regularity (Bui, Kemp, & Howlett, 2011). The regularity of exercise is associated with high positive affect and contributes to the ability of participants to attain high levels of performance (Norlander, Bood, & Archer, 2002).

Despite the regularity and motivation of physical exercise, to maintain the continuity of physical activity habits should be concerned. A recent study investigated the continuity of life-span physical activity by examining the predictors of the maintenance of physical activity through a retrospective study indicated that physical activity in adulthood is strongly connected to maintaining physical activity in later life (Hirvensalo, Lintunen, & Rantanen, 2000). Rather, persistent participation in sport in particular increases the probability of a higher level of physical activity in later life (Risto Telama, Yang, Laakso, & Viikari, 1997). For youth, although involvement in school sporting activities may protect against marked reductions in physical activity for school members, there is a need for innovative approaches after leaving school (Dovey, Reeder, & Chalmers, 1998). Parental and peer influence on continuity of involvement in sport should not be omitted. The degree to which physical activity involvement is maintained is positively related to the amount and type of influence received from social life context, which is "socializing influence" (Brown, Frankel, & Fennell, 1989).

Contextualizing the meaning and evolution of sport participation to integrate the continuity theory of physical activity is a prerequisite for successful implementation of physical exercise intervention. Persistent involvement in sport appeared to mediate past and continuing patterns of social relationships, the development of personal identity, and a general propensity for lifelong physical activity (Langley & Knight, 1999).

2.1.5 Section summary

This section provides an exploited literature review of physical activity definitions, categories, assessments, recommendations from relevant theories and models to build a conceptual basis of the physical activity context in public health promotion. The literature review of physical activity stated a clear understanding of physical activity and presented the theoretical rationales of physical intervention. Physical activity has always been linked with health since ancient times. Current literature, on one hand, addressed the importance of physical activity to health, on the other side, it emphasized the dilemmas of promoting physical activity to decrease health risks.

From the literature review, the definitions and categories of physical activity are seldom discussed in physical activity research. The categorization of physical activity is reviewed in order to provide a basic conception about physical activity, which deepened the understanding of the key issues of well-implementation of physical exercise. Also, to clarify the fundamentals of body movement at the surface level is essential for the general population to be aware of the mechanisms of health benefits and physical exercise selection.

The assessment of physical activity is an important issue in physical exercise research. This chapter is not a comprehensive account of the literature, the literature revealed the research evidence in the general population rather than in athletes or physical exercise professionals. For large population health promotion, it is important to consider the feasibility and availability of physical exercise. Hence, even though the measurements of physical activity are adequate, the accuracy and efficiency of those measurements should be well-justified. The literature review presents the pros and cons of each type of measurement.

It is always an important issue for health professionals and policy makers to assess the success (i.e., efficacy, function, etc.) of physical interventions. Research into the influential interactions of physical activity has burgeoned. At a population level, it is not unitary when evaluating the effectiveness of physical exercise. The literature reviewed popular models and theories to physical exercise intervention. For populational sized physical intervention, it is essential to take physical intensity, aging process, regularity and continuity of physical activity into consideration with the purpose of better adjusting physical activity in life-long run.

The literature review offered in this chapter presented an overview of the integration of physical activity and health. The literature review identified several concepts (e.g., definition, categorization, assessments) of physical activity. Additionally, it analyzed the context for physical intervention and correlated concerns in physical exercise practices. All of these evidence supports to understand the core aim of the present Ph.D. dissertation. The next section will review the literature on the detailed exploration of physical activity and health outcomes, which mainly focuses on the research-based approaches and methods with regard to health promotion.

2.2 PHYSICAL ACTIVITY AND HEALTH PROMOTION

Once considering physical activity, it is always related to health implications. The literature review above has manifested the interactions and connections between physical

activity and health systematically. Even though substantial knowledge confirms that physical activity has a broad health effect, results from specific studies with particular exercise types have not been exclusively described. Health consequences are diverse across samples and correlations (Steptoe et al., 1997). This section goes further into detailed explorations of physical exercises and health mechanisms, which provides theoretical and practical support in physical activity intervention.

This section starts with explaining the history & epidemiology of physical activity (Section 2.2.1), followed by describing the evolution of physical activity guidelines (Section 2.2.2.), and then reviewing the state-of-art literature underlining the physical activity psychology in health promotion (Section 2.2.3). This section also identified the risks and opportunities of physical activity (Section 2.2.4). A summary of this section is made by restating the main issues discussed through the literature review (Section 2.2.5).

2.2.1 History & epidemiology of physical activity

The knowledge of exercise science evolves over time, with the change of the society and development of the world, new information is established bit by bit. Past published findings heavily influenced the recent knowledge about the relationship between physical activity and health. Without doubts, a body of research completed in past decades pioneers the recent studies. A literature review from a historical perspective to understand the current beliefs about the effects of physical activity is essential.

The earliest record of connecting physical activity and health was from China about 3000 BC ago retrieved from Traditional Chinese Medicine (TCM) (Cai & Zhen, 2003). Ancient Chinese promoted a system of exercise to harmonize the body with the purpose to extend longevity (Engelhardt, 2000) and maintain health (Kohn, 2011). Moreover, exercise is regarded as a non-pharmacological medicine (Jette & Vertinsky, 2011). In western cultures, Hippocrates, a famous Greek physician, the “Father of Western Medicine”, prescribed that exercise can prevent ailments and hypothesized that physical activity is associated with life quality (Chadwick & Mann, 1950). The new era of physical activity research may go back to the last 30 years given the exploding publications and globalized health concerns. With the emergence and fast development of the Internet, the lifestyle of human beings changed a lot compared with old times. The epidemiological characteristics of physical activity differ with demographics (Adams-Campbell et al., 2000). It is significant to mention that sedentary life behaviors have become dominant in contemporary society (Rhodes, Mark, & Temmel, 2012).

The concept of “Physical Activity Transition” was adopted to explore the potential effects associated with the declining physical activity levels. Available evidence suggests that low levels of physical activity will attenuate the expected health gains associated with the epidemiological transition (Katzmarzyk & Mason, 2009). Evidence indicated that environmental factors might influence physical activity behaviors, the dynamic of which could help to map the relevant possibilities in public health context (Owen, Leslie, Salmon, & Fotheringham, 2000). Physical inactivity has become a pandemic nowadays (Kohl 3rd et al., 2012). To decrease physical inactivity at global level becomes a challenging task for health scientists and policy makers.

2.2.2 Evolution of physical activity guidelines

The influence of physical activity on the risk of diseases has been comprehensively discussed (Hardman & Stensel, 2009, p.59). Physical activity recommendations and guidelines at the country level initiated consequently (some details are shown below). It is reasonable to believe that developed countries implemented better actions in health promotion compared with less developed countries. In this section, the highly recognized guidelines of physical activity for adults will be evaluated. The guidelines and recommendations could, on one hand, help people to better cope with exercises, on the other hand, to emphasize the significance of the current health promotion situation.

Given the definition of physical activity includes any form of exercise or movement of the body that uses energy, hence, no theoretical explanations are needed. As a result, to provide transparent and easy-following recommendations is critical in achieving health promotion goals. In 2008, The Department of Health and Human Services (HHS, U.S.) issued the federal government's first-ever Physical Activity Guidelines for Americans, which aimed to help Americans understand the types and amounts of physical activity that offer important health benefits (Hootman, 2009). HHS has now released the second edition of the Physical Activity Guidelines for Americans, this edition provides science-based guidance to help people improve their participation in regular physical activity (Piercy et al., 2018). Below are physical recommendations for adults (18-64 years):

- Adults should move more and sit less throughout the day. Some physical activity is better than none. Adults who sit less and do any amount of moderate-to-vigorous physical activity gain some health benefits.

- For substantial health benefits, adults should do at least 150 minutes (2 hours and 30 minutes) to 300 minutes (5 hours) a week of moderate-intensity, or 75 minutes (1 hour and 15 minutes) to 150 minutes (2 hours and 30 minutes) a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity. Preferably, aerobic activity should be spread throughout the week.
- Additional health benefits are gained by engaging in physical activity beyond the equivalent of 300 minutes (5 hours) of moderate-intensity physical activity a week.
- Adults should also do muscle-strengthening activities of moderate or greater intensity and that involve all major muscle groups on 2 or more days a week, as these activities provide additional health benefits.

Canadian Society for Exercise Physiology (CSEP) also developed its newest Canadian Physical Activity Guidelines. The guidelines include a preamble to provide context and specific guidelines for each age group. This new national physical activity guideline represents the most current synthesis, interpretation, and application of the scientific evidence to date. Below are guidelines for adults (18-64 years) (Tremblay et al., 2011):

- To achieve health benefits, adults aged 18-64 years should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more.
- It is also beneficial to add muscle and bone strengthening activities 24 using major muscle groups, at least 2 days per week.
- More physical activity provides greater health benefits.

European countries such as the U.K. also developed the UK Physical Activity Guidelines to encourage people to be physically active. Below are guidelines for adults (19-64 years) (Hunter, Tully, Donnelly, Stevenson, & Kee, 2014):

- Adults should aim to be active daily. Over a week activity should add up to at least 150mins (2.5 hours) of moderate intensity activity in bouts of 10 minutes or more - one way to approach this is to do 30 minutes on at least 5 days a week.

- Alternatively, comparable benefits can be achieved through 75 minutes of vigorous intensity activity spread across the week or combinations of moderate and vigorous intensity activity.
- Adults should also undertake physical activity to improve muscle strength on at least two days a week.
- All adults should minimize the amount of time spent being sedentary (sitting) for extended periods.

Comparing the leading physical activity guidelines, similarities can be found. A basement requirement of weekly moderate-vigorous exercise for at least 150 minutes is highly recommended. These guidelines directed the future concerns for health. A call for attention to physical health rather than clinical health is emerging for global health. This section interprets the initiatives of physical activity guidelines and provides insights about exercise recommendations at the documentary side. Health intervention is a key issue in public health. The following section (Section 2.2.3) provides evidence in physical activity behavior.

2.2.3 Physical activity behavior

Theories and recommendations of physical exercises are used for supporting real-life interventions (Abdi, Eftekhar, Estebsari, & Sadeghi, 2015). Promoting physical health should not stay on the literacy level, but should be implemented in daily life. Research evidence-based theory, on the contrary, can aid in facilitating theoretical construction and guideline initiations. To explore the physical interventions, firstly, enables theory developers to adopt a more overarching approach to support physical exercise implementation. Secondly, it allows physical interventions to be fully examined for health efficacy and efficiency.

Moderate versus vigorous physical activity

Moderate-to-vigorous physical activity (MVPA) can play an important role in health promotion (Lonsdale et al., 2013). Differential reactions in moderate and vigorous physical activity vary by personality dimensions. It is recommended that in order to increase the prevalence of physical exercise, educational methods should focus on psychosocial indicators (Winters, Petosa, & Charlton, 2003). Human behaviors are always associated with

psychological processes. The theory of planned behavior (TPB) (Figure 3) (Ajzen, 2011) explains the influences of self-conscientiousness on action control regarding both moderate and vigorous physical activity (de Bruijn, de Groot, van den Putte, & Rhodes, 2009). The TPB theory was designed to predict and explain human behavior in specific contexts, and health experts explained exercise conscientiousness, extroversion and action. The theory of planned behavior shows that intention is an important mediator in behavior nurturing.

The Theory of Planned Behavior started as the Theory of Reasoned Action in 1980 to predict an individual's intention to engage in a behavior at a specific time and place. The theory was intended to explain all behaviors over which people have the ability to exert self-control. The key component to this model is behavioral intent; behavioral intentions are influenced by the attitude about the likelihood that the behavior will have the expected outcome and the subjective evaluation of the risks and benefits of that outcome. The TPB states that behavioral achievement depends on motivation (intention) and ability (behavioral control). It distinguishes between three types of beliefs - behavioral, normative, and control. The TPB comprises six constructs (i.e., attitudes, behavioral intention, subjective norms, social norms, perceived power, perceived behavioral control) that collectively represent a person's actual control over the behavior.

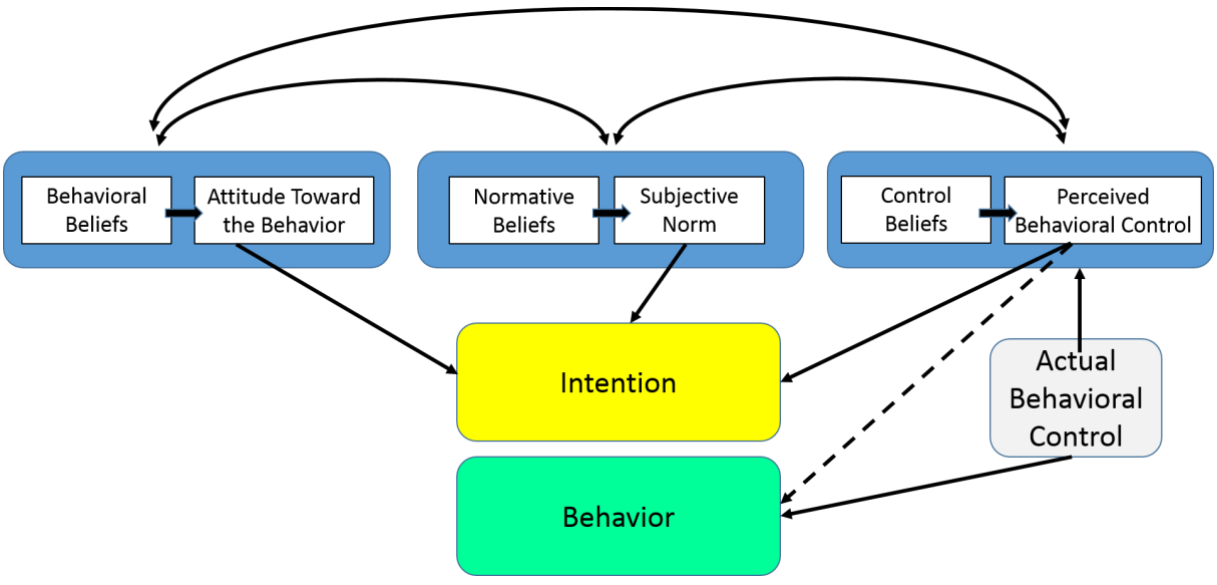

Figure 3 Theory of planned behavior (Ajzen, 2011)

By analyzing the physical activity patterns, women who are likely to engage in physical activity behavior reported that behavioral control of moderate-intensity physical activity is

demanded for investigation (Jewson, Spittle, & Casey, 2008). Intention-enhancing interventions may effectively promote vigorous physical activity, but other motivational processes may be more appropriate to target in interventions of moderate physical activity (e.g. walking) (Rebar, Maher, Doerksen, Elavsky, & Conroy, 2016). An examination on the predictive capability of a habit construct, controlling for intention and perceived behavioral control, with moderate and strenuous intensity physical activity indicated that individuals who reported high habit levels in the vigorous physical activity condition demonstrated a larger intention-behavior relationship (Rhodes & De Bruijn, 2010).

Social Cognitive Theory (SCT) (Figure 4) (Luszczynska & Schwarzer, 2005) has been used for predicting vigorous physical activity, which supports that the SCT is useful in understanding factors associated with vigorous physical activity (Petosa, Suminski, & Hortz, 2003). Self-efficacy is useful for maintaining physical activity and self-identity may relate to differences in social cognition and physical exercise behavior (Strachan, Woodgate, Brawley, & Tse, 2005). Maintenance of vigorous physical activity was predicted by self-efficacy (James F Sallis, Hovell, & Hofstetter, 1992). Nevertheless, the effect of self-efficacy on vigorous physical activity can be mediated by intention (Hamilton, Warner, & Schwarzer, 2017). Last but not the least, physical activity self-efficacy is predictive in physical activity participation but also needs to take age and gender into consideration (Pauline, 2013).

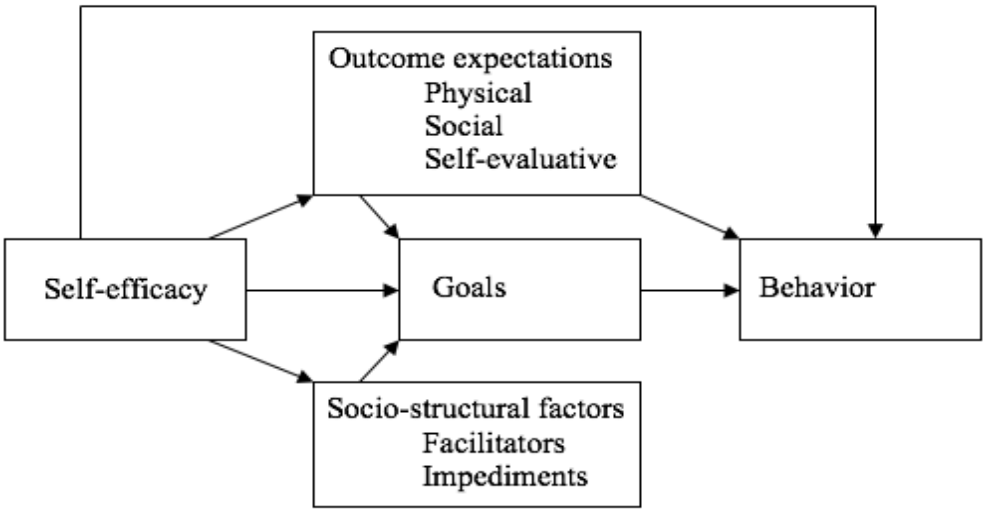

Figure 4 Flow of social cognitive theory (Luszczynska & Schwarzer, 2005)

Leisure time physical activity (LTPA)

Leisure time physical activity was inversely associated with all-cause mortality in both men and women in all age groups (Andersen, Schnohr, Schroll, & Hein, 2000). Lack of time is one of the most frequently reported barriers, which suggests it may actually represent a lack of motivation (Reichert, Barros, Domingues, & Hallal, 2007). In addition, when promoting LTPA, gender, age and socioeconomic level should be taken into account (Azevedo et al., 2007). Regardless of the demographic determinants of LTPA, it is essential to highlight the psychological determinants, which could be important indicators for health implementation.

Awareness of physical fitness provides fundamental support for the development of leisure-time physical activity participation (Lloyd & Little, 2010). Autonomy-supportive individuals reported stronger intentions to exercise during leisure time and participated more frequently in leisure-time physical activities (Chatzisarantis & Hagger, 2009). The effect of autonomous motives in LTPA intentions and behavior is mediated by theory of TPB constructs (Hagger et al., 2003). Leisure time behaviors can be influenced by behavior change techniques (BCTs), which are indicated to be associated with increases in self-efficacy and physical activity (Olander et al., 2013).

Formulation of physical activity habits

Habit formation is thought to aid the maintenance of physical activity (Gardner & Lally, 2013). Psychological theories and concepts offer a basis for health promotion. Health behavior models have tended to emphasize reasonable concepts to initiate behavior change (Armitage, 2005). As stated in the theoretical investigation, habits are behavioral patterns enacted automatically upon encountering contextual cues, acquired through repetition in the presence of those cues (Lally, Van Jaarsveld, Potts, & Wardle, 2010). Therefore, to discuss the formulation of physical activity habits makes great significance in physical activity research.

The role of habit in exercise behavior should be emphasized. A study that explored the role of habit in predicting physical activity with the TPB supported that habit is important to physical activity action control (Rhodes, de Bruijn, & Matheson, 2010). Principally, the repetitive nature of habits should not be ignored when considering the models of reasoned action and planned behavior (Aarts, Paulussen, & Schaalma, 1997). Habits are developed through repeated experience of physical activity in stable contexts and health interventions should promote self-regulatory skills that foster physical activity habits (Hagger, 2019). Habit strength seems to be the most important mediator for physical activity (Thomas & Upton, 2014).

To achieve the goal of increasing population physical activity level during a life-long period, the preliminary understanding of the physical habit formulation theory should be acknowledged.

The theory of planned behavior explained the way of strengthening exercise habits driven by intention. There is a considerable asymmetry in the intention–exercise relationship, with successful exercise intenders reporting stronger exercise habits (de Bruijn, 2011). The proposition that the psychological process is related to behavior regulation may fail to continue intended behavior due to a lack of self-determined motivation (D'Angelo, Reid & Pelletier, 2007). Attention should be paid when changing physical exercise behavior through the psychological conditions. Similarly, it is important to recognize the initiation and behavior change.

2.2.4 Physical activity: opportunities and risks

The opportunities and risks are of great importance to be reviewed in order to achieve the best outcomes of health promotion. Currently, the actions in increasing physical activity levels are not optimal. Evidence indicated that little progress has been made in increasing physical activity levels in the US and demonstrated that there is much room for improvement in achieving recommended levels of physical activity among Americans, particularly among relatively inactive subgroups (Carlson, Fulton, Schoenborn, & Loustalot, 2010). Given the fact that physical activity guidelines are poorly implemented, the opportunities and risks of physical activity are discussed below. Opportunities and risks are born at the same time, it is reasonable to believe the opposite side of the opportunity is a risk, vice versa.

Health experts concern that when untrained or previously sedentary persons undertake vigorous exertion suddenly, the undesired side effects of injuries, dehydration or cardiac arrest are amplified (Melzer, Kayser, & Pichard, 2004). Indeed, scientists worry about the risk of exposure through physical activity is outweighed by its overall benefits (Melzer et al., 2004). Thus, to understand the dose-response of physical activity helps to facilitate and optimize physical exercise interventions. When testing for a dose-response relationship between physical activity and health outcomes, exercise volume and intensity need to be considered with the change of biological response (see Figure 5) (Kesaniemi et al., 2001).

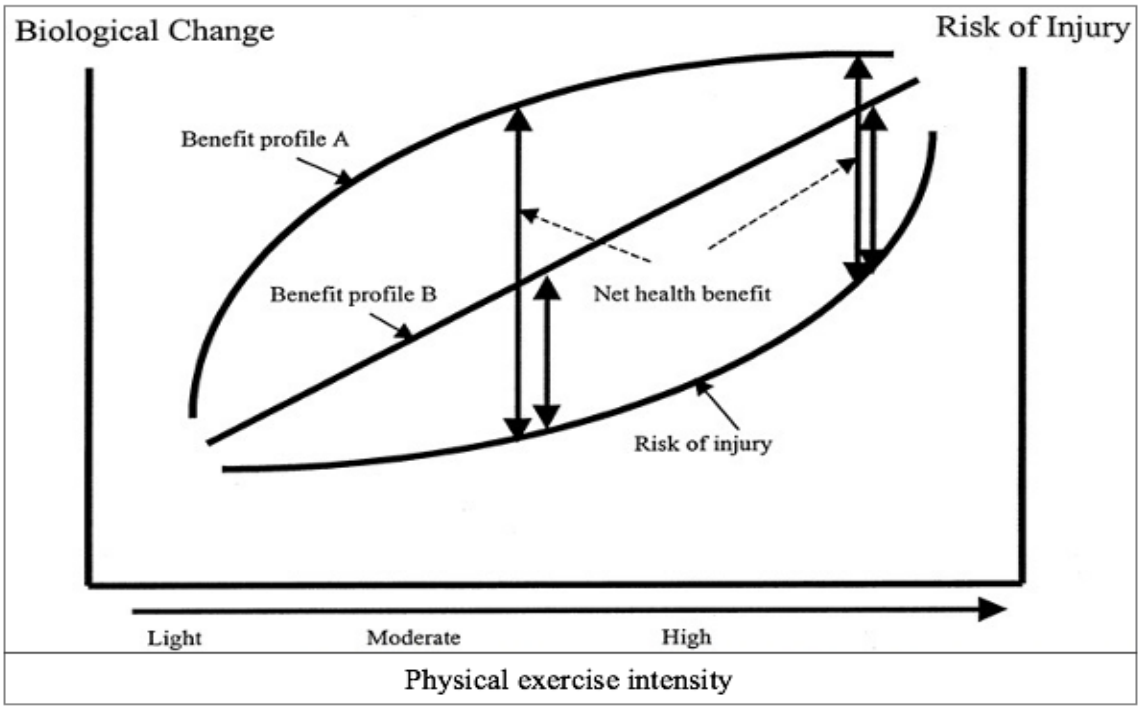

Figure 5 The relationship of exercise intensity to biological change and risk of injury (Kesaniemi et al., 2001)

Due to the two dose-response profiles, more effort is needed to put physical activity guidelines into effect and discover more possibilities in promoting exercise. Maintaining physical fitness through regular physical activity may increase the compliance of physical activity (Thompson et al., 2007).

2.2.5 Section summary

This section interpreted the elements correlated with physical activity and health promotion by illustrating the history & epidemiology of physical activity, evaluating the guidelines from developed countries, exploring the physical activity oriented psychological theories, the opportunities and risks of physical activity. This section deepened the historical perspectives of physical activity and health and enhanced the cognitive theories related to physical activity. The understanding of physical activity in health promotion has developed a lot. The exploration of the interdependent relationship between physical activity and health outcomes tends to incandesce. To have a macro view of physical activity evaluations, risks & opportunities and fully understand the physio-psychological nature of human beings enables health policy makers and health educators better spread physical intervention theories. For

individuals, it is also helpful to find out the potential relations in formulating physical exercise habits.

The historical analysis provides a solid belief of physical activity on health, further, the epidemic of physical health research. When dealing with health promotion strategies at the global level, namely, the epidemiology of physical activity, the development of technical measurements and lifestyle change should be taken into consideration. Nowadays, the monitors or detectors of body movement are much developed compared with ancient times. New challenges of physical activity emerge with the development of society. Existing evidence about the health benefits of physical exercise have been well documented, there is still space to continuously explore the intervention strategies coping with the change of life habits and living conditions. Therefore, to actualize the physical health theories into practice become a dominant issue in health promotions.

Even though guidelines and recommendations of physical activity based on age groups were released, the execution process and efficiency are not satisfying at all. Efforts of changing and reducing physical inactivity should be a cooperation between people who make policies (e.g., health authorities, governments, etc.) and people who undertake policies (e.g., citizens, schoolers, etc.). Health guidelines and recommendations are to help make a real-life effect. Without doubt, based on the data received from quantitative and qualitative researches, the implementation of physical activity guidelines in developed countries is under expectation. There is more we can do to implement the physical activity recommendations.

When implementing physical activity recommendations, it is important to reveal the inter-psychology behind the physical activity. Overall, physical activity can be regarded as a type of habit (i.e., physical activity habits). Thus, to explore the human nature of formulating habits should be acknowledged. The literature review discussed physical activity relations theories about planned behavior and social cognitive theory of behavior, which emphasized the factors that impact on the physical activity habits. Doing physical exercise is not a difficult task, the difficulty is to formulate physical activity habits, which is to organize physical activity habits regularly. To promote regular physical activity habits is a tough but rewardable goal in health promotion. Moderate physical exercise seems to have the advantage over vigorous physical activity in physical habit formulation among the general population.

Opportunities and risks are factors that should be taken into account when implementing health promotion strategies. It is understandable that opportunities and risks of physical exercise occur together. Therefore, to specify the usage and amplify the existing physical recommendations is under further emphasis. The balance between opportunities and risks, plus,

the human nature in psychology, should be well adjusted before investigating physical intervention strategies.

The overview offered in this section explicates the indispensable theories in physical activity intervention and implementation. Basic concepts are made to provide a context for health promotion with efficiency and build beliefs in health implementation. The role of health promotion should not stay on the documentary level but try to work out the health benefits, which is in the enforcement of the implementation. The next section will review the literature on determinants in physical activity promotion, which provides additional evidence and reinforces the importance of physical activity implementation.

2.3 ADOPTION & MAINTENANCE OF PHYSICAL ACTIVITY

Motivating individuals to adopt and maintain regular physical activity is a major challenge for health professionals, and facilitating physical activity via public health initiatives is considered of paramount importance. Health promotion is associated with many determinants and involves two main processes: stopping negative behaviors (such as sedentary behaviors) and starting positive behaviors (such as regular exercise) (Nahas, Goldfine, & Collins, 2003). Changing from a sedentary life to a physically positive activity life is a dynamic process and involves an array of factors obviously. To understand the determinants and sort out the predictors that may be associated with physical activity behavior adoption and/or maintenance needs to be advanced. Physical activity interventions have had varying degrees of success with adoption; however, maintenance over the long term is even more difficult to achieve, as the majority of individuals who start a physical activity program drop out or relapse (Nigg, Borrelli, Maddock, & Dishman, 2008). It is inevitable to pay attention to the adoption and maintenance of physical activity.

This section firstly explores the demographic predictors of physical activity-based health promotion (Section 2.3.1), then psychological determinants (e.g., motivation, cognition, etc.) that may be potential risks for physical activity maintenance are discussed (Section 2.3.2). A section summary is made to provide a brief reflection of the contents and knowledge (Section 2.3.3).

2.3.1 Demographic predictors

Physical activity guidelines made recommendations based on age groups. It is reasonable to put an eye on the demographic predictors of physical activity interventions. High quality prospective evidence on the determinants of these behaviors is expected to develop long-term effective interventions that increase physical activity and decrease time spent in sedentary behaviors in young people (Uijtdewilligen et al., 2011).

Age and gender

Despite that, a series of demographic issues, including age, sex, height, weight, education attained, income level, marital status, and ethnic identification might impact physical activity behavior, age and gender are believed to have consistent relation with physical activity, yet theoretical explanation for these associations is scant (Belcher et al., 2010; Shiroma & Lee, 2010). To explore gender differences in reasoning about the relationships between natural ability, effort/practice, and final skill level/performance and to foster beliefs in the efficacy of effort may be challenging to use the conception of gender-typed sports (Li, Lee, & Solmon, 2006). Different attributions made by men and women are due to the different expectations, but researchers argue that significant differences in attributions between men and women occurred when the activity was labeled as male-dominant (Deaux & Farris, 1977).

Physical beliefs have shown that age moderates the intention–behavior relationship, for instance, older individuals are more likely to implement their intentions than younger individuals (Nigg, Lippke, & Maddock, 2009), but younger people show more proactive personality than for older ones (Bertolino, Truxillo, & Fraccaroli, 2011). A measurement equivalence model across the three age sub-samples (younger (18–34 years), middle-aged (35–54 years) and older study participants (55 years and older)) was examined (Figure 6) (Nigg et al., 2009). The intercorrelations between attitude, subjective norm and behavior control are constrained to be equal across the age groups except two intercorrelations, which turned out to be age-specific: in younger people, subjective norm is less important than in persons over 35 years (Nigg et al., 2009). Figure 6 shows that intention and behavior are less related in middle-aged individuals than the older or younger group. A lower association of subjective norm and intention was observed in younger people compared to older participants; intention and behavior are more highly associated in younger persons than in middle-aged people.

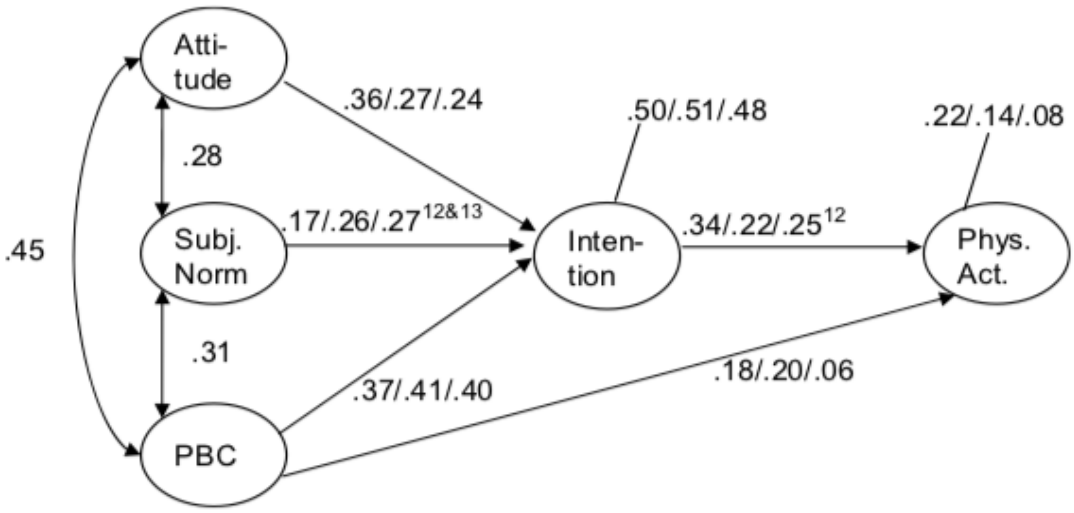

Figure 6 Standardized coefficients for the measurement equivalence model across the three age sub-samples (Nigg et al., 2009)

Note. Path coefficients are reported young/middle aged/older sample. Covariances were constrained to equal (only one path coefficient is reported). Significant differences (CR < 1.96) of the path coefficients are indicated by the truncated numbers: ‘‘12’’ means the younger and the middle-aged groups differ significantly. ‘‘13’’ stands for significant differences across the younger and the older sub-sample and ‘‘23’’ indicated significant differences across the middle aged and the older sub-sample.

Social predictors

Social networks and contacts are supposed to be influential in physical activity behavior and self-efficacy, regular participation of friends and family are significantly associated with being active (Bertera, 2003; M. L. Booth, Owen, Bauman, Clavisi, & Leslie, 2000). In addition, healthy and unhealthy individuals may perceive different physical intentions or physical needs. It is widely recognized that physical exercise could strengthen health (Sharif et al., 2018) and is highly recommended for physical exercise therapies, for public health promotion, to explain the indicators and predictors which have an effect on the maintenance of physical activity is crucial.

Positive neighborhood social life has been highlighted as a key predictor of physical activity and is associated with increases in moderate to vigorous physical activity over time (Sweeney, Wilson, & Van Horn, 2017). Social support, and the presence of trials showed positive associations with physical activity, too (Fisher et al., 2018). Social gamification

interventions, impact individuals to adjust their behaviors based on social ties or connections, are ubiquitous, but in most cases, it has no appropriately leveraged principles from theories of health behavior (Harrison et al., 2019). Social incentives and technology could provide a scalable, low-cost approach to increase engagement (such as the activity trackers installed on smartphones.), which was found to be effective and could be deployed more broadly to increase physical activity (Gal, May, van Overmeeren, Simons, & Monninkhof, 2018; Strain, Wijndaele, & Brage, 2019). In the family context, parental influence impacts students' enduring involvement in sport by normalizing the sport experience and allowing them a voice in their own participation decisions (Dixon, Warner, & Bruening, 2008). Insights regarding the roles of family members and social networks predict the interactive and contextual nature of socialization.

Geographical and environmental predictors

This sector draws a the perspective that geographical and environmental factors could be associated with physical activity. Geographical and environmental predictors of physical activity should be concerned when discovering health promotion at the global level. There is supposed to be a large variation in physical activity level by country of origin. Nurturing the international perspective of the declining physical activity levels is an alert for the importance of increasing physical activity practice. Besides, environmental predictors and environmental variables are also important correlates of physical activity (James F Sallis, King, Sirard, & Albright, 2007). The most recent data which covers a majority of countries in the world indicates that the prevalence of physical inactivity in less developed territories is higher than the other parts of the world (Figure 7) (Stewart et al., 2013).

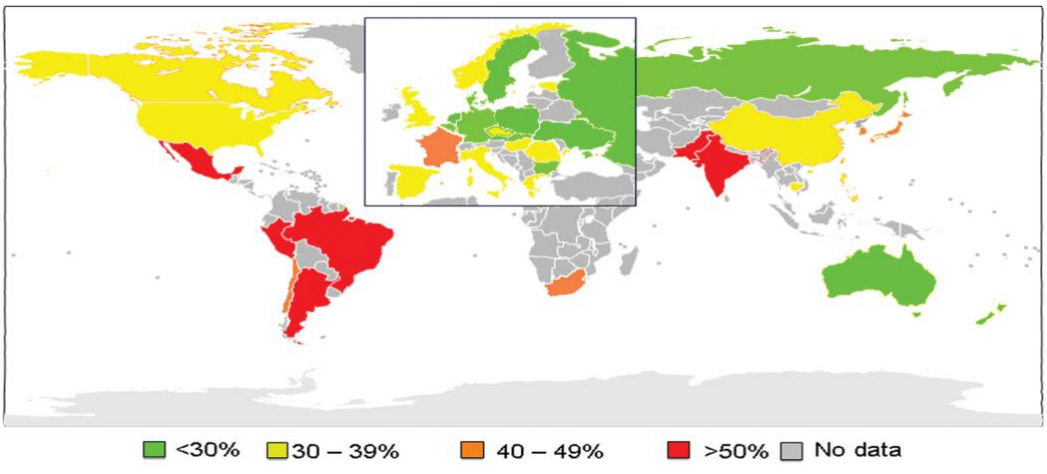

Figure 7 Proportion of study subjects who reported low levels of physical activity (<24MET.h/week) by country (Stewart et al., 2013)

There is a growing recognition that environmental factors affect individuals' physical activity choices and health behaviors. A number of theoretical models embracing environmental factors as correlates of physical activity have been proposed (Cohen, Scribner, & Farley, 2000). Researchers proposed that sedentary lifestyles are being driven, at least in part, by environmental factors (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003). Understanding and measuring the environment predictors may remain at a common conceptual framework. Despite plenty of evidence suggesting a link between the environment and physical activity, there is a conspicuous absence of a theoretical framework through which to understand how environmental correlates influence an individual's behavioral intention or change. Perceived environment and physical activity were examined to explain and promote physical activity (Table 2) (Fein, Plotnikoff, Wild, & Spence, 2004). Energy expenditure was strongly associated with self-efficacy ($\beta = .30$, $p < .01$), sex ($\beta = –.15$, $p < .01$), peers ($\beta = .18$, $p < .01$) and family ($\beta = .15$, $p < .01$). Age and teacher relationship measures were not associated with energy expenditure. Perceived importance of the school environment was the only environmental measure showing a significant association ($\beta = .14$, $p < .01$) with energy expenditure. Given that schools are key settings to promote physical activity for youth, policies and interventions to enhance perceptions that school environments are natural locations for engaging in physical activity deserve support and rigorous evaluation.

Table 2 Perceived physical environment, perceived importance of the physical environment and controlling factor scores on energy expenditure

	R^2	R^2 Change	F Change	Beta 1	Beta 2
Block 1-Model 1	.22	.22	28.62*		
Self-efficacy				.30*	/
Sex				-.15*	/
Age (Grade)				-.05	/
Physical education teacher relationships				.00	/
Peers				.18*	/
Family				.15*	/
Block 2-Model 2	.26	.04	3.951*		

Home environment	/	.02
Perceived importance of home environment	/	.09
Neighborhood environment	/	.05
Perceived importance of neighborhood environment	/	.01
Convenient facilities	/	.00
Perceived importance of convenient facilities	/	.04
School environment	/	.01
Perceived importance of school environment	/	.14*

Note: Beta 1 and Beta 2 are standardized regression coefficients for the linear equations represented by block 1 and 2 respectively. Degree of freedom for Equation 1 are (6.603) and for Equation 2 are (14.595)

* $p < .01$

2.3.2 Physical activity and psychological variables

This section focuses on the psychological theories in physical activity because psychosocial variables are strongly associated with self-reports of physical activity (Jago, Baranowski, Baranowski, Cullen, & Thompson, 2007). Psychology is supposed to differ with demographic segmentation. Whereas, previous research revealed that simple segmentation strategies such as relying on demographic variables provided little improvement over no segmentation (Boslaugh, Kreuter, Nicholson, & Naleid, 2005). The research also appealed to yield more homogeneous subgroups when psychosocial factors are combined with demographic variables. Psychological mediators of physical activity that can be applied in interventions tailored to the needs of various subgroups. As mentioned, social influences could play a role in physical activity participation and selection. Psychological factors such as self-efficacy, perceived benefits, and perceived barriers varied in importance by age and sex groups (De Bourdeaudhuij & Sallis, 2002).

Psychosocial factors and daily physical activity

Daily physical activity (DPA) is affected by psychological factors directly. The association of DPA with psychological variables such as anxiety, depression, self-efficacy and

motivation has not been investigated extensively, whereas self-efficacy has been shown to correlate positively with DPA in clinical patients (Lemmens, Nieboer, & Huijsman, 2008). Psychosocial variables may operate differently in predicting physical activity adoption versus maintenance (Williams et al., 2008). A structural equations model has been made based on the hypothesis that psychological variables might indirectly affect DPA (Altenburg et al., 2013). Figure 8 indicates a possible causal link between psychological capacity and DPA via functional capacity (Altenburg et al., 2013). Analysis of the model fit shows a $\chi 2 = 161.8$, (df = 63); $p < 0.001$ and RMSEA = 0.10. The model shows a clear, but indirect association between psychological variables and DPA. The model provides a more extensive insight in the complex relationship of DPA with functional and psychological variables. Psychology capacity (e.g., self-efficacy, anxiety, depression, motivation) indirectly affect DPA by affecting functional capacity variables (e.g., lung function, exercise capacity, activity restriction, physical functioning, etc.).

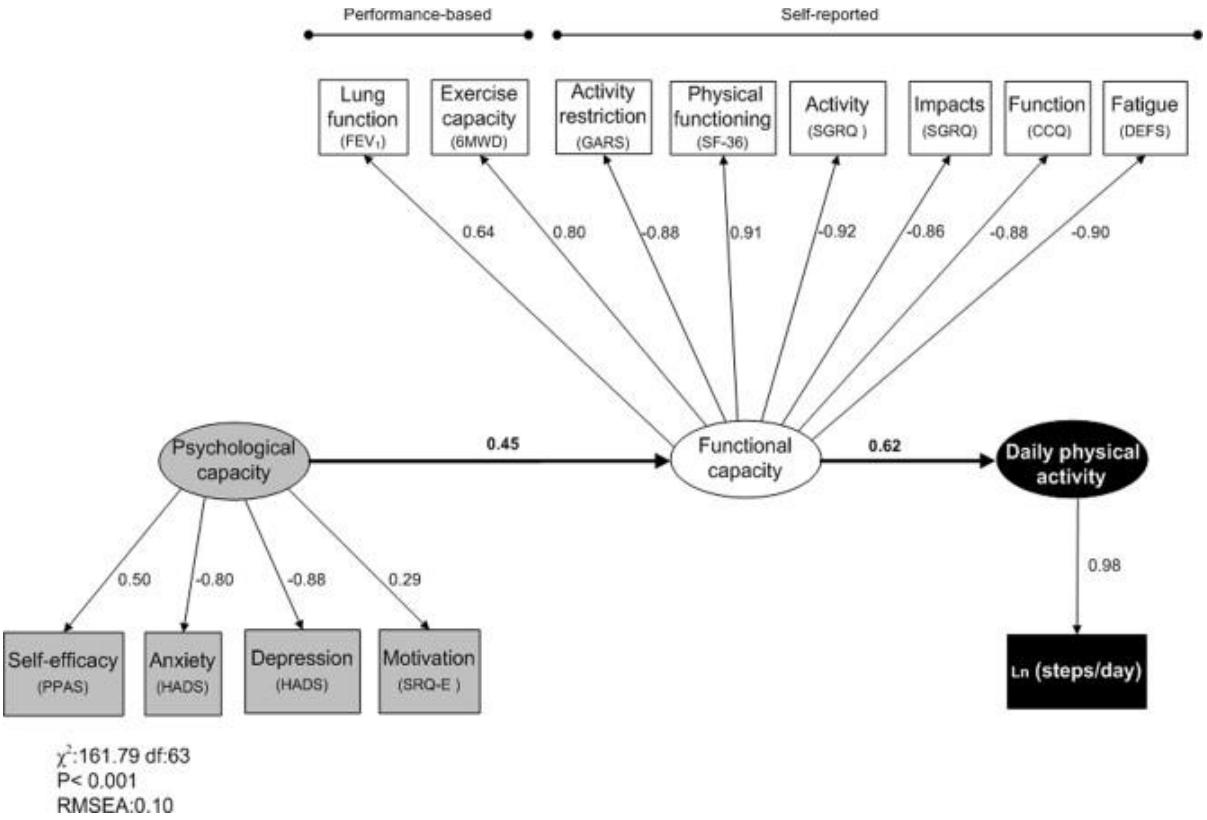

Figure 8 The path diagram shows the causal relationship (bold arrows) between psychological capacity and DPA via functional capacity (Altenburg et al., 2013)

Psychological meaning is a broad concept and it has been proposed that physical activity can be usefully characterized based on its psychological meaning (Marttila, Laitakari,

Nupponen, Miilunpalo, & Paronen, 1998). From the standpoint of physical activity promotion, broad considerations can be essential indeed. Respectively, physiologically-based characterizations of physical activity point to the type of activity required to obtain certain health or fitness outcomes. Compared to public health promotion with physical intervention, more comprehensive personal strategies and tactics of personal psychology should be emphasized. Nevertheless, the association between physical activity and psychology status declared that higher levels of physical activity were associated with improved mental health (Al-Eisa, Buragadda, & Melam, 2014). Individuals are suggested to cope with psychological symptoms through the enhancement of positive affect of physical activity on a day-to-day basis (Kishida & Elavsky, 2015), though individual variations in the way DPA need to be perceived as well (Elavsky, Molenaar, Gold, Williams, & Aronson, 2012).

Motivation, cognition and self-determination

Researchers exploring how individuals come to adopt and maintain physical activity have found some success by examining the relationship between exercise behaviors and a number of theoretical constructs derived from decision-making theory (Marcus, Eaton, Rossi, & Harlow, 1994) and motivational change models (Marcus & Simkin, 1993). These constructs include decisional balance, motivational readiness, and a number of cognitive and behavioral changes (Rhodes & Pfaeffli, 2010). It is obvious that mastery motivational climate is associated with more adaptive motivational patterns. Contemporary theorists agree on the important assumption that motivation is not an entity, but a process (Roberts, Treasure, & Conroy, 2007). Based on this prediction, cognitive processes, such as self-regulation and self-systems, processes such as personal goals and goal setting, or emotional processes are mediators that can be interacted.

There is a need to examine the effects of interventions underlying theoretical constructs and the mediating role of such constructs concerning the psychological influence of physical activity habits. Greater intensity and duration may be needed for sustained intervention effects (Pinto, Lynn, Marcus, DePue, & Goldstein, 2001). In young adults, perceived competence and goal orientations mediated the effects of motivational climate on intrinsic motivation directly predicted effort and persistence (Vallerand, 2007). An overview of self-determination theory that applied to physical activity, sports and health distinguished intrinsic and extrinsic motivations for physical activities was conducted (Ryan & Patrick, 2009). Within SDT, the

categories and subtypes of motivations can be applied to all intentional actions. Therefore, physical interventions pertaining to personal and community interests could be ponderable.

The central theme of self-determination is defining the differences in self-determined (i.e., autonomous forms of motivation) and non-self-determined (i.e., controlling types of motivation) rather than focusing on what causes motivation (Ryan & Deci, 2000). The SDT has been used to explain the conditions that influence self-determined motivation. According to SDT, motivation flows along a continuum ranging from no motivation (i.e., motivation) through four types of extrinsic forms (i.e., external, introjected, identified, integrated regulation) to intrinsic motivation (Buning, 2016). In physical exercise behavior, the SDT undermines the development of needs and motivation. The use of theory to inform and test interventions is important both for expanding basic science and for developing interventions that have real-world practical utility. Self-determination theory is a general theory of human motivation that emphasizes the extent to which behaviors are relatively autonomous (i.e., the extent to which behaviors originate from the self) versus relatively controlled (i.e., the extent to which behaviors are pressured or coerced by intrapsychic or interpersonal forces).

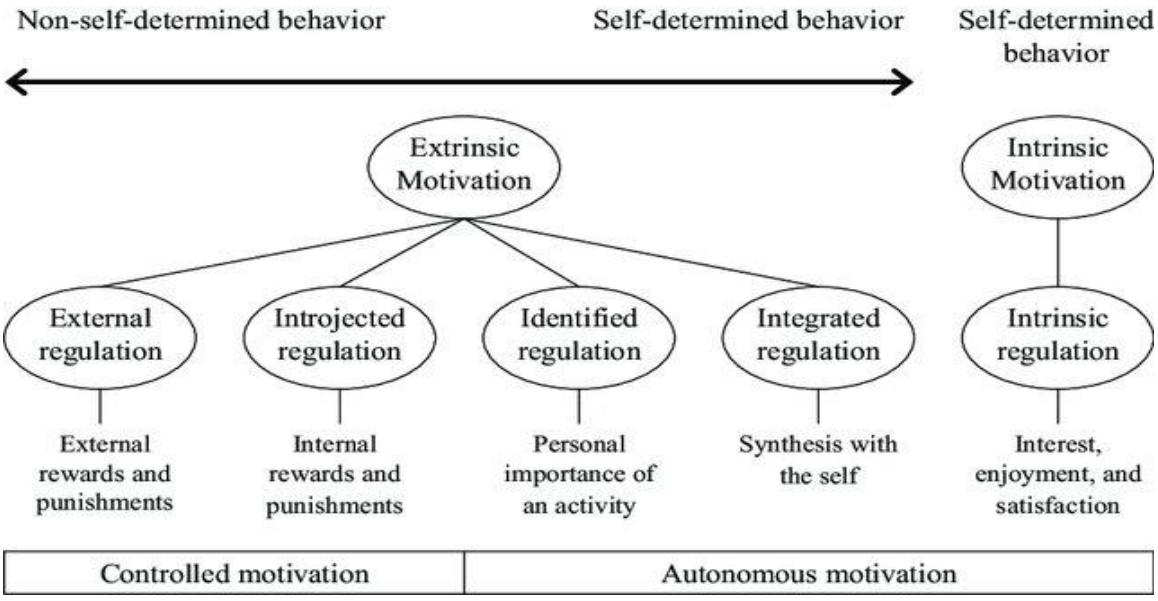

Figure 9 Self-determination theory and the promotion and maintenance of sport, exercise, and health (Buning, 2016)

2.3.3 Section summary

This section overviewed a range of theoretical basis in nurturing physical activity behavior correlated predictors. To explore the mediators behind increases the potential of

physical intervention effect. Invisible hinder may exist in the mediated predictors of physical activity adoption and maintenance. Psychological predictors and behavior processes have been emphasized; nevertheless, the knowledge about the long-term effect of such intervention constructs are necessarily recommended by incorporating demographic characteristics.

The literature interpreted in this section provided micro and macro evidence to extend the possibility of physical exercise to be fully and effectively implemented. Findings in demographic correlations displayed basic knowledge about the factors that may confound the effect of physical intervention. In addition, it highlighted that the scope of physical intervention should stand on a global level not only at national or regional levels. Due to the social factors that impact significantly on physical exercise habits, it is of good reason to identify the similarities and differences in social characters between countries. Recent research has successfully stood with the benefits of physical activity, more effort should be made to achieve the benefits at a large scale with respect to demographic predictors.

Literature also revealed a number of psychological theory-based physical activity behavior and health outcome rationales. These theories facilitate the physical intervention from the theoretical point of view, and more investigations are needed to examine the theories in practice. On the contrary, physical practice could facilitate the theoretical construct in physical activity issues. At present, the sport psychological theories are relatively adequately constructed. Creating effective and functional intervention policies and interventions are necessarily needed to promote the and implement the theories. Given the causal relationship between psychological capacity and DPA via physical and health functional capacity is consistent, it is insightful to combine the health capacity and intervention strategies, which may produce the most physical intervention efficiency.

To develop long-term effective interventions that increase physical activity and decrease time spent in sedentary behaviors in young people, more efforts are requested in both internal and external considerations. Taking comprehensive consideration of all advantages and limitations of physical intervention, it is essential to prepare cost-effective regular physical activity habits in the population. The next section will provide a review of the literature about the exploration of walking as a physical exercise intervention together with the main study variables in this current dissertation (i.e., sleep quality, stress and life satisfaction). Gaps and limitations are identified.

2.4 OVERVIEW OF WALKING ACTIVITY AND WALKING RESEARCH

Walking activity as putting one foot in front of the other in a rhythmic manner is as much human nature as breathing (Stamatakis, Hamer, & Murphy, 2018). Given the concrete belief that walking activity is beneficial for health, the exploration of walking activity and health outcomes becomes popular. The research in walking activity has lasted for decades in multidisciplinary researchers and scientists, practitioners and policy-makers in walking intervention and physical activity have engaged in this seemingly mundane activity-walking (Ogilvie et al., 2007). The growth of this area of research and global advocacy for physical activity complied with the goal of the WHO global physical activity action plan to promote physical activity: more active people for a healthier world (WHO, 2019). The purpose of this section is to provide an overview of the walking activity-based researches and explorations.

This section, at the beginning, illustrates the developmental history of walking research by providing a retrospective understanding of this field (Section 2.4.1). Then, the following section interprets the mechanisms between walking activity and health outcomes (Section 2.4.2). A literature review of walking interventions is documented and the associated determinants of walking activity intervention are discussed by answering "where" and "how" to walk will be the best way of health promotion (Section 2.4.3). In the end, a section summary is made by restating the literature on walking activity and walking research (Section 2.4.4).

2.4.1 The development of walking research

The recent investigations of walking activity were mainly focused on identifying general principles of change in motor skills during life span from infant to elder age (Zelazo, 1983). In recent years, in compliance with the need for increasing physical activity levels and reducing health risks, scientists started to take walking as an activity in health science. As known, increasing the population level of physical activity, particularly among the most sedentary, has therefore become a leading aim of contemporary public health policy (Conn, Hafdahl, & Mehr, 2011). A guidebook forecasted that walking activity or pedestrian activity as a useful tool for broad sociodemographic characters (Kuzmyak, Walters, Bradley, & Kockelman, 2014). Apart from the updated knowledge and explorations in walking, this section reviews walking research from historical consciousness.

The scientific analysis of walking began a little more than 100 years ago, of which the walking research aimed to clarify the walking movements of all kinds of animals in unprecedented detail (Pearson, 1976). A notable discovery, which was not quite generally recognized until quite recently, was Graham Brown's demonstration in 1911. He proposed that the mechanisms located entirely within the spinal cord are responsible for generating the basic rhythm for stepping in each leg because he found that rhythmic contractions of leg muscles were similar to those that occur during walking (Stuart & Hultborn, 2008). In addition, Sherrington stressed the importance of sensory input generated during any part of the step circle in initiating and coordinating walking movements (Pearson, 1976). The two concepts (from Graham Brown and Sherrington) of a spinal rhythm generator for each leg and triggering of leg movements by sensory signals are not incompatible. Indeed, a number of supportive evidence had yielded the results about the nature of walking in human beings at that time (Kremer, 1958).

For almost 40 years later till the middle of the 20th century, there were no significant advances in the understanding of the mechanism between the nervous system and walking activity (Pearson, 1976). Starting from the middle of the 20th century, the emphasis of the following research was to investigate walking activity in a limited scope for rehabilitation in organic cardiovascular disease (Detected, 1944) and gangrene (Foley, 1957). Researchers started to observe blood vessels and exercise, further, to involve walking in disease prevention (Kremer, 1958). Dozens of years later, growing evidence gained in hypertension treatment (Degano et al., 2010), intermittent claudication (Janzon, Bergentz, Ericsson, & Lindell, 1981), musculoskeletal disorders (Wells, Zipp, Schuette, & McEleney, 1983) and chronic respiratory disease (Chetta et al., 2007). Nevertheless, the exploration of walking trails applied to clinical patients with symptoms, such as patients with Alzheimer's disease (Friedman & Tappen, 1991). The possibilities of walking activity have been expanded, early research indicated that mall walking might be an effective mental health intervention for elder adults (Travis, Duncan, & McAuley, 1996). Researchers in early time contributed insightful and directive findings in walking related activities and exercises.

Walking as a healthful form of physical activity began to receive attention in the 1990s (Lee & Buchner, 2008). Morris, in the later 20th century, highlighted walking research on public health implications (Morris & Hardman, 1997). He documented that walking develops and sustains physical fitness such as cardiovascular capacity and endurance (stamina) for bodily work. At that time, the amount of walking that produces physical benefits had not been explicitly examined. It was hypothesized that any amount of walking, and at any pace had potential in long term effect for weight control and enhanced a multitude of bodily processes

that were inherent in skeletal muscle activity (Bassey, Bendall, & Pearson, 1988). The pleasurable and therapeutic, psychological and social dimensions of walking, whilst evident, had not been specifically studied. Not even an economic assessment of the benefits and costs of walking has been attempted (Morris & Hardman, 1997). Overall, walking, by quantity and pace, is under-researched around 30 years ago attributing the published literature from public health perspectives. In other words, the investigation of walking research had seldom been comprehensively tested on the public health dimensions.

In the recent decade, there was an explosion in walking research. Curing diseases is not the only goal of health, it is also an important issue to promote health for general status with the concern of economic and medical expenses (Rush, Shiell, & Hawe, 2004; Serxner, Gold, Grossmeier, & Anderson, 2003). Considering the physical activity recommendations, it has indicated that walking at a moderate pace of 5 km/hour (3 miles/hour) expends sufficient energy to meet the definition of moderate intensity physical activity (Ainsworth et al., 2000). Compared with many sports and other recreational pursuits, walking is a popular, familiar, convenient, and free form of exercise that can be incorporated into everyday life and sustained into old age (Mutrie & Hannah, 2004). There are compelling reasons to encourage people to walk more (e.g., obesity (Skinner, Ravanbakht, Skelton, Perrin, & Armstrong, 2018), sedentary health risks (Lavie, Ozemek, Carbone, Katzmarzyk, & Blair, 2019), etc.), not only to improve their own health but also to address the importance of lifestyle change and healthy behavior (Millward, Spinney, & Scott, 2013).

2.4.2 Walking activity and health mechanism

Walking is a rhythmic, dynamic, aerobic activity with the cooperation of skeletal muscles that confers the multifarious benefits of this with minimal adverse effects. There is clear evidence that physical activity, including walking, has substantial benefits for health. Nevertheless, previous studies have linked regular physical activity such as walking with a reduced likelihood of developing important health benefits (Rippe, Ward, Porcari, & Freedson, 1988). Does walking have the potential to have a large public health impact? The answer is yes. Indeed, because most people do not attain recommended levels of physical activity, walking could have an even greater public health impact given that sedentary lifestyle prevalence is increasing among adults (Bauman, Petersen, Blond, Rangul, & Hardy, 2018). Even though the health benefits of walking are relatively clear based on the present findings, it is still of great

importance to understand how those benefits come out, which will enable researchers and policy makers to better facilitate the intervention process at a populational level.

In this section, the mechanism between walking activity and health indicators will be discussed including several biomechanical mechanisms and physiobiological considerations from experimental studies investigating the association of walking and health, which supports the large public health importance of walking.

Walking kinematics

There are concurrent transitions in phase and frequency between arm and leg movements. It was predicted that the occurrence of the concurrent transitions was a function of (1) changes in the magnitude ratio of shoulder accelerations at step and stride frequencies that accompany changes in walking speed and (2) proximity of these frequencies to the natural resonance frequencies of the arms modeled as a pair of passive pendulums (Kubo, Wagenaar, Saltzman, & Holt, 2004). The acceleration waveforms at the shoulder are composed primarily of stride and step frequency components. Maintaining and increasing walking speed and walking length is important to make a change in health status (Beijersbergen, Granacher, Vandervoort, DeVita, & Hortobágyi, 2013). In addition, gait speed in young adults signified multi-systemic wellbeing and slowed gait suggests clinical or sub-clinical impairments (van Kan, Houles, & Vellas, 2012). Consequently, self-selected habitual gait speed is a marker and predictor of daily functions, life mobility, health, etc. (IJmker & Lamoth, 2012; Van Kan et al., 2009).

Walking speed is a marker of daily life mobility, but biomechanical mechanisms that underlie the metabolic cost of walking were not fully understood. Even though the current dissertation did not emphasize on measuring the metabolic, kinetic and kinematic effects of walking, it is still good to have a brief knowledge about the biomechanics. Evidence on the biomechanical mechanisms yielded how strength and power training increase gait speed. More precisely, step length, step rate and their product, walking velocity, are fundamental sagittal plane biomechanical descriptors of walking. Self-selected walking velocity in young adults is about 1.32 m/s and changes in gait kinematics are identified as greater than approximately 5° (Wilken, Rodriguez, Brawner, & Darter, 2012). Additionally, the walk ratio (WR) represents the relationship between the amplitude and frequency of rhythmic leg movement during walking and it was identified as a reliable measure for evaluating pathological walking patterns (Sekiya & Nagasaki, 1998). In healthy adults, the step length/cadence ratio [walk ratio (WR) in

mm/(steps/min) and normalized for height] is known to be constant around 6.5 mm/(step/min) (Rota, Perucca, Simone, & Tesio, 2011). The decline in walking velocity is associated with reduced step length and increased step rate or cadence (Latt, Menz, Fung, & Lord, 2008). However, self-selected walking velocities are important in identifying different aspects of locomotion biomechanics, which is behaviorally meaningful in public health scope.

There was scant evidence for biomechanical mediators of increased walking velocity associated with exercise interventions that influence gait speed (Beijersbergen et al., 2013). The nature of interventions varied widely and included strength, power, balance, flexibility, aerobic, and mobility exercise protocols or combinations thereof (Dedeyne, Deschodt, Verschueren, Tournoy, & Gielen, 2017). Hence, most intervention studies used self-selected gait velocity as a primary outcome to quantify the effects of an intervention along with performance-oriented tests. It is easy to understand that differences in vertical displacement profiles would be a direct outcome of differences in muscle work and would be associated with different metabolic and mechanical costs of walking. Therefore, to increase the efficacy of intervention studies designed to improve gait speed and other critical mobility functions, there is a need for a walking paradigm from more sophisticated biomechanical analyses that examine joint kinematics, kinetics, energetics, muscle-tendon function, and musculoskeletal modeling before and after interventions.

Energy expenditure

The walking variables (e.g., step rate, step length) reflects energy expenditure, it is good to acknowledge the relationship between walking and energy expenditure. Walking can be robustly separated as horizontal walking and vertical walking. The energy expenditure of walking at natural step frequency on the horizontal treadmill is linearly related to the vertical lift work, which is the product of lift per step, stop frequency and body weight (Cotes & Meade, 1960). Prediction of walking energy expenditure (E_{O2}) has been attempted using both the lift work and velocity squared (u^2) relationships. Calculation of walking energy expenditure requires knowledge both of leg and foot lengths and of the pace which the subject will adopt at a given velocity. Physiological Cost Index (PCI) is a tool for walking energy expenditure by measuring breath-by-breath oxygen uptake, heart rate (HR), and walking speed at a self-selected comfortable speed. However, when comparing oxygen cost (EO_2) and the PCI, EO_2 is to be recommended instead of the PCI with regard to the statistical power of outcome measure (IJzerman & Nene, 2002).

The investigation on energy expenditure (rate of oxygen uptake, energy cost per meter, and heart rate) and the gait characteristics (speed, cadence, stride length) in slow, normal, and fast walking speeds developed energy–speed relationship (Waters, Lunsford, Perry, & Byrd, 1988). There were no significant differences due to sex in the velocity for children and teens, and in young adult subjects at their customary normal speeds. Whereas, there were significant differences between males and females in young adults at their customary slow and fast speeds (47.65 vs. 37.01 m/min and 110.44 vs. 99.36 m/min), not even the energy cost. Waters' study also showed that an individual who requires more oxygen to walk a unit distance is less efficient than one who consumes more oxygen. Young adults are the most efficient ambulators (Table 3) (Waters et al., 1988).

Table 3 Energy expenditure of customary normal, slow and fast walking[a]

	Heart rate (beats/min)			Rate O_2 consumption (ml/kg-min)			O_2 cost (ml/kg-m)		
Group	Normal	Slow	Fast	Normal	Slow	Fast	Normal	Slow	Fast
Children (6-12yr)									
F	118.33[b]	110.77	132.15[b]	14.70	12.28[b]	19.31	0.217	0.223	0.218
	12.11	12.53	14.54	2.90	3.06	3.71	0.040	0.058	0.035
M	111.32[b]	105.11	122.94[b]	15.82	13.64[b]	19.88	0.224	0.237	0.229
	11.12	12.62	12.07	2.06	1.88	3.32	0.030	0.035	0.039
T	114.43	107.16	126.93	15.32	12.73	19.63	0.221	0.231	0.224
Teens (13-19yr)									
F	102.75[b]	99.63[b]	124.11[b]	12.62	10.60	18.52	0.172	0.188	0.190
	11.65	11.74	19.25	1.66	1.28	3.33	0.015	0.037	0.026
M	90.12[b]	87.79[b]	107.84[b]	13.16	11.23	19.95	0.181	0.207	0.201
	10.13	9.04	13.59	1.89	1.48	4.68	0.025	0.049	0.028
T	96.79[c]	94.06[c]	116.93[c]	12.88[c]	10.89[c]	19.19	0.176[c]	0.197[c]	0.195[c]
Adults (20-59yr)									

F	103.21[b]	88.83	127.34	12.05	7.54	17.43	0.155	0.218	0.175
	12.09	11.80	19.66	2.43	2.18	3.67	0.024	0.066	0.025
M	96.10[b]	85.33	122.08	12.04	8.43	19.23	0.148	0.186	0.174
	13.28	13.65	18.76	2.04	1.87	5.00	0.021	0.038	0.030
T	99.41	86.97[c]	124.39[c]	12.05[c]	8.02[c]	18.44	0.151[c]	0.201	0.174
Seniors (60-80yr)									
F	105.85[b]	95.09[b]	120.40	11.88	8.95	14.36[b]	0.166	0.184	0.169
	11.25	10.84	16.03	1.69	1.52	2.55	0.018	0.043	0.020
M	97.15[b]	86.83[b]	116.04	12.21	9.16	17.09[b]	0.160	0.188	0.176
	12.70	13.27	16.61	2.25	1.45	3.34	0.019	0.029	0.024
T	102.75	92.22[c]	118.80[c]	12.00	9.02[c]	15.36[c]	0.164[c]	0.185[c]	0.171
	12.43	12.30	16.26	1.89	1.48	3.14	0.018	0.039	0.021

Note F: female; M: male; T: total

[a] Mean and SD

[b] Significant ($p < 0.05$) difference between male and female subjects

[c] Significant ($p < 0.05$) difference between preceding value in younger age group

Real-world environments with a variety of surface irregularities and inconsistencies that humans often traverse may interrupt steady gait and require additional effort (Looney et al., 2019). Such effects have, however, scarcely been demonstrated quantitatively, since few laboratory biomechanical measures apply outdoors (Ludlow & Weyand, 2016). The most recent study that quantified the effect of five different outdoor terrains on foot motion (from foot-mounted inertial measurement) and net metabolic rate (from oxygen consumption) in healthy adults found a significant increase in energy expenditure (Kowalsky, Rebula, Ojeda, Adamczyk, & Kuo, 2019). In combination, such measures can also roughly predict the metabolic cost. Accelerometry-based method (e.g., physical activity monitors) for assessing energy expenditure is popular nowadays. However, these devices showed acceptable accuracy under laboratory control; they were not yet equivalent to the research outcomes, which may due to the interference from real-world environments (Chowdhury, Western, Nightingale, Peacock, & Thompson, 2017).

Evidence for health benefits of walking

The evidence for the health benefits of walking is growing. Existing integrative syntheses of the physical and mental health outcomes associated with walking need to be clarified. Furthermore, it is required to understand the specific health outcomes associated with walking since it will help researchers/individuals on how to promote walking behavior. Considering the global health perspective, four main public health risks (i.e., cardiovascular diseases, metabolic disease, overweight and obesity, blood pressure and hypotension) are discussed below.

Cardiovascular disease

Large observational studies consistently show associations between walking and cardiovascular disease (CVD) endpoints over long periods of follow-up (Grazzi et al., 2014). Intervention studies further support the health benefits of walking, showing improvements in clinical biomarkers and measures after shorter periods of follow-up (Murtagh et al., 2015). Walking appears to have CVD-related health benefits in younger, middle, and older men and women, in both healthy and patient populations (Boone-Heinonen, Evenson, Taber, & Gordon-Larsen, 2009; Lovasi, Grady, & Rundle, 2011). The following paragraph explains the health mechanism of walking on CVD.

The principle of cardiovascular benefit from walking can be explained by leg blood flow during walking. Low-intensity exercise such as walking can provide significant muscle strength and hypertrophy. The leg blood flow restriction during walking requires greater cardiac work and decreases endothelial function, which complies with heart rate increase and blood pressure increase (Renzi, Tanaka, & Sugawara, 2010). Markers of inflammation are emerging as novel indices of cardiovascular risk. The inflammatory response to walking is worthy of examination to assess cardiovascular function. Once, there was a study that evaluated the effects of a 45-min walk on C-reactive protein (CRP) and interleukin 6 (IL-6), in sedentary men. The results suggested that 45 min walking causes a decrease in IL-6, but does not evoke a significant response in CRP levels, which indicates that moderate intensity exercise such as walking in healthy individuals lack enough laboratory evidence in supporting cardiovascular function, thereby prevent cardiovascular diseases (Murtagh et al., 2015). Whereas, the efficacy of walking in reducing the risk of and preventing coronary heart disease (CHD) has not been completely understood (Zheng, Orsini, Amin, Wolk, & Ehrlich, 2009). Additionally, biological

level non-significance cannot predict and is not equivalent to populational significance among healthy adults. Self-rated walking of 50 225 walkers from 11 population British cohorts revealed that walking at an average or brisk/fast pace was associated with a reduced risk of CVD mortality (Stamatakis, Kelly, et al., 2018). Therefore, from the perspective of health promotion, it is of great importance to corporate both laboratory and populational studies together to consolidate the existing evidence of the impact of walking on cardiovascular function.

Metabolic disease

Sedentary time is independently associated with an increased risk of metabolic disease (Junghoon Kim, Tanabe, Yokoyama, Zempo, & Kuno, 2013). The data describing the impact that walking has on metabolic syndromes (MetS) is little. The existing data showed that low levels of walking increase the likelihood of having MetS (Strath, Swartz, Parker, Miller, & Cieslik, 2007). The menopause transition is associated with an increased prevalence of metabolic syndrome (Roussel et al., 2009), thus, to examine the impact of walking programs on the metabolic risk of menopause women could bring a particular message in understanding the walking impact on metabolic function. Convinced data supported that walking is sufficient to reduce metabolic risk (Roussel et al., 2009). Moreover, arm swing reduces the metabolic cost of walking in young adults by contributing to stability (Ortega, Fehlman, & Farley, 2008). Therefore, it is clear that walking postures, walking speed and health status may violate the results of the metabolic function and metabolic syndrome according to the existing findings (Donelan, Kram, & Kuo, 2002).

Overweight and obesity

Overweight and obesity is an increasing concern in modern society (Hales, Carroll, Fryar, & Ogden, 2017). Consequently, health concerns (e.g., vascular risks) are along with overweight and obesity (Kivimäki et al., 2017). Hungarians are the fourth most obese nation in the world (OECD, 2017.). There is an urgent need for actions to decrease the obesity rate and promote active lifestyles nationwide. Walking can be taken as one possible method to achieve the goal of weight control. It is demonstrated that gender and ethnic subgroups display substantially different weight outcomes across different levels of walkability (Frank, Kerr, Sallis, Miles, & Chapman, 2008). To explore the relationship between walking and obesity, the

demographic factors need to be taken into account. Despite the interaction of those influential factors, walking intervention among the overweight or obese subgroups was conducted, which showed various health outcomes among overweight or obese population (see below).

Overweight or obese people have an increased risk of lower extremity musculoskeletal injuries and dysfunction (McMillan, Auman, Collier, & Williams, 2009). Therefore, moderate exercise such as walking is an optimal option for physical training. In overweight women, increasing daily walking improves glucose tolerance but there is no weight loss effect (Swartz et al., 2003). Nevertheless, moderate exercise training (e.g., walking) alone may not be a sufficient stimulus to affect body composition and serum lipid profiles favorably (Hinkleman & Nieman, 1993). It was suggested that walking at a moderate speed (5.0-5.5 km·h-1) may be used as a convenient way to exercise at an intensity eliciting peak fat oxidation in overweight individuals (Bogdanis, Vangelakoudi, & Maridaki, 2008). In addition, exercise walking was found to reduce pain and improve physical functioning (Martin et al., 2001), reduce arterial stiffness (Kearney, Murphy, Davison, O'Kane, & Gallagher, 2014), overall improved quality of life among overweight adults (Fritz & Lusardi, 2009).

Blood pressure and hypotension

Evidence showed a close relationship between walking and blood pressure, indicating that walking program is effective in lowering systolic blood pressure in postmenopausal women with borderline to stage 1 hypertension (Moreau et al., 2001). Furthermore, walking exercise programs reduce resting blood pressure in adults stated in a meta-analysis (Kelley, Kelley, & Tran, 2001). There were also studies that quantified the number of steps that may be beneficial for hypertensive patients. For example, existed evidence indicated that walking 10, 000 steps/days or more, irrespective of exercise intensity or duration, is effective in lowering blood pressure, and reducing sympathetic nerve activity in hypertensive patients (Iwane et al., 2000; Lee, Watson, Mulvaney, Tsai, & Lo, 2010). Habitual walking may lower blood pressure by reducing sympathetic nerve activity and have beneficial effects on blood adiponectin and DHEA-S levels, and habitual walking exercise may have beneficial effects on blood NT-proBNP levels (Li et al., 2011). It has been examined that 10-min treadmill walks at 50% of peak oxygen uptake (VO2peak) showed a significant effect on systolic blood pressure, whereas none was found in diastolic blood pressure (Park, Rink, & Wallace, 2008). Taken together, the use of walking exercise for elevated blood pressure requires dose-effect relationships to optimize regimens (Kingwell & Jennings, 1993).

Walking interventions to reduce sedentary level

Walking interventions have been implemented with a variety of social communities and specific populations under particular circumstances. With the consideration that walking, as an easily implemented exercise, may be conducted in different settings including medical setting, nursery setting, home setting, etc. this review only focuses on the settings where healthy adults stay. Walking interventions have been established with different groups of the adult population including at workplaces and off-work places. Therefore, the subsections below briefly describe the walking interventions inside and outside workplaces.

Work-based walking intervention

Working adults may accrue health benefits by accumulating at least 30 min of moderate intensity physical activity at least five days a week (Stanner, 2004). This need may not occur through sports or gym-based exercise for people during work time. Walking behavior generally remains sporadic and infrequent for those employed within sedentary occupations. Office-based employees typically accumulate only 4000–6000 steps/day, and a high potential for work-based walking to positively influence employee health (Bassett & Tudor-Locke, 2004; Marshall, 2004). Even though challenges exist in offices where time pressures to complete daily tasks which curtail walking opportunities, there is still a demand for health enhancement strategies. Sitting occupies a majority of total daily sedentary behavior among desk-based employees. It is quite well known that prolonged sedentary behavior has been associated with various detrimental health risks especially in workplace settings (Chu et al., 2016).

Based on the notion that walking activity contributes to improved health, a preliminary study examined how to promote physical activity through walking at work-base. The results indicated that both prescribed walking (walking at least 15 min continuous, brisk walking every workday) and walking with a task (accumulated step counts) through the working day were effective alternatives in encouraging employees to walk more during their working day (Gilson, McKenna, Cooke, & Brown, 2007). It is highly recommended to establish prescribed routes and to promote an ‘active tasks’ attitude through daily working life. Workplace walking interventions using pedometers can increase daily step counts, for example, stair walking at workplace as a way of behavior interaction reveales health signs (e.g., better cardiovascular function) (Andersen et al., 2013). Rare evidence examined the long-term effectiveness of

working setting intervention programs. The was one study examined lunchtime walking (a 16-week long) in workplace across different seasonal periods demonstrated that long-term involvement in walking at the workplace could be acceptable.

The use of physical devices or exercise machines was adopted in workplaces to reduce sedentary time. An office stepping device was tested in a workstation and suggested the device is portable, cost feasible, nearly silent, but the feasibility of the device in a real-life setting requests for more examinations (McAlpine, Manohar, McCrady, Hensrud, & Levine, 2007). Lucas tested a portable pedal exercise machine (3D Innovations) through a PC connection in a work setting feasible tool for reducing time spent sedentary while at work. Such equipment may be good strategies in promoting physical energy expenditure (Carr, Walaska, & Marcus, 2012). Also, the linkages between the workplace and external settings should be emphasized, and encourage management support for behavioral adjustments to the organization.

Leisure walking intervention

Off the workplace, people spend their time on a leisure basis. Walking interventions outside of workplace are always community based and voluntary based. Among healthy adults, physical activity programs, incorporating walking exercise, is effective in promoting physical level, but it may lack of significant changes in health outcomes (Baker et al., 2008). Conducting physical activity trials face difficulties in recruiting participants and the drop off rate is relatively high (Foster et al., 2011). Despite these constraints, trials conducted among off-work settings added adequate evidence in walking interventions. Interventions to promote walking include individual (brief advice, supported use of pedometers, telecommunications) or household (individualized marketing) or through groups, which can encourage people to walk more (Ogilvie et al., 2007). From a perspective of improving population health, walking efficacy is more frequently concerned than walking effectiveness. To improve the walking efficacy, the National Walking Strategy in Scotland launched a “Scotland Walking” program (“Let’s Get Scotland Walking - The national walking strategy,” 2014). Scotland has outstanding opportunities for walking both in urban and rural areas. But, infrastructure alone will not be enough to transform people's habits and change their behavior. Practical intervention strategies together with policy, social culture, knowledge, etc. should also be addressed in leisure walking interventions.

The majority of walking interventions collected accumulated walk steps to measure walking capacity. Given the health benefits, walking interventions conducted among patients

with clinical symptoms are adequate rather than healthy populations (Chang et al., 2008; Collins et al., 2011). To facilitate the intervention process, pedometers or mobility sensors are the most frequently used devices for either group walking or individual walking for tracking activities (Spence, Burgess, Rodgers, & Murray, 2009). In addition, pedometers are supposed to motivate walking intention (Richardson et al., 2008). Given the potential uncertainty of the daily life schedule and workload, public health efforts to promote walking should focus on making time for regular walking and the affective advantages that walking can provide. There is a call for self-regularity of walking exercise based on self-efficacy; little evidence interpreted walking as a type of behavior. Fostering walking behavior publicly is essential for health promotion.

2.4.3 Where and how to walk

A clear understanding of walking benefits and health mechanisms has been reviewed above. There comes another crucial issue, that is, to clarify what influences walking behavior, which offers to develop effective strategies to promote walking activity. Walking can be regarded as the primary focus of population-based physical activity initiatives but a theoretical understanding of this behavior is still elusive. Previous research indicated that walking behavior is theoretically complex, which may integrate intention, personality and social cognition to predict leisure-time walking (Rhodes, Courneya, Blanchard, & Plotnikoff, 2007). The literature review in the above section has discussed "why" to walk, the review in this section provides literature that explored "where" and "how" to walk for the general population.

Types of walking

To discuss the type of walking that produces large public health importance of walking is evitable for implementing health promotion successfully. It has been a challenge to communicate the information about walking types to the public. For example, walking can be performed at light intensity (e.g., strolling while window shopping), moderate intensity, or (less commonly) at vigorous intensity (e.g., fast walking on an incline). It is not always distinguishable for adults which walking is recommended. Messages about how to walk usually refer to the step count measured by pedometers, but pedometers cannot assess the intensity of walking. In order to be pertinent in walking research, the subsection reviews only the existing explorations about any types of walking, which have provided scientific merits.

For young adults, walking activities that are designed to be social, game-like, and/or competitive would be beneficial (Prusak & Darst, 2002). Young people may be particularly receptive to messages emphasizing the benefits of walking and the opportunities offered for social contact with friends and family (Lorenc, Brunton, Oliver, Oliver, & Oakley, 2008). Thus, it is understandable that walking types for young adults can be influenced by social environments. Additionally, the gesture of walking (e.g., pronated and supinated feet) exerts more noticeable changes in muscular activity compared with normal foot type (Khodaveisi, Sadeghi, Memar, & Anbarian, 2016). Dual-task paradigms can be used to examine the interactions between cognition and the control of posture and gait. Dual-task walking, a combination of cognitive tasks and walking, supported the idea that the ability to shift attention allocation flexibly and task performance in response to instructions depends on the difficulty of the postural control task (Kelly, Janke, & Shumway-Cook, 2010). Overall, walking prioritization is dynamic and flexible among young adults (Kelly et al., 2010).

For general adults, recreational walking and walking for transport are two main types of walking (Spinney, Millward, & Scott, 2012). Reported data indicated that more than two-thirds of recreational walks are home-based, compared with less than one-fifth of transport walks (Spinney et al., 2012). Gym exercise (e.g., walking on a treadmill) can be a good choice for walking. The degree of difference between treadmill and floor walking in kinematic, electromyographic (EMG), and heart rate measurements were compared. During treadmill walking, subjects tended to use a faster cadence and shorter stride length than during floor walking. Accordingly, average EMG activity and heart rate were usually greater on the treadmill than on the floor; however, in general, treadmill walking was not found to differ markedly from floor walking in kinematic measurements or EMG patterns (Murray, Spurr, Sepic, Gardner, & Mollinger, 1985). Walking happens not only on flat but also on uneven surfaces, evidence showed that the EMG activities of peroneal muscles increase when walking on the medial incline ramp, which could be an effective exercise to improve the neuro-muscular function of the peroneal muscles (Zdolšek, Strojnik, & Dolenec, 2018). In addition, Nordic walking, performed with specially designed walking poles, is a total body version of walking that can be enjoyed by non-athletes, as a sport. A comparison between Nordic walking and regular walking revealed that Nordic Walking results in a significant increase in oxygen use and caloric expenditure compared to regular walking (Church, Earnest, & Morss, 2002).

For elderly adults, the ability to safely conduct different types of walking concurrently with a cognitive task (i.e., dual-task) is crucial for daily life. The effect of walking in three different directions (forward, backward, and sideways) was examined to explore the strategies

of older adults to allocate their attention in response to different motor task demands, of which the results showed that walking forward was the least demanding cognitive task (Agmon, Kodesh, & Kizony, 2014). It also should be mentioned about the physiological energy cost produced during gait with a walker. The use of a fixed walker leads to a major increase in gait, probably due to the required repeated efforts for lifting the walker (Cetin, Muzembo, Pardessus, Puisieux, & Thevenon, 2010). In addition, walking patterns should be taken into account among the elderly. Walking upstairs and walking downstairs could be distinguished by locomotion and total power in the anteroposterior direction (Sekine, Tamura, Fujimoto, & Fukui, 2000). It needs to be concerned that walking at a faster pace with changes in the lower-limb walking kinematics in older adults may indicate an augmented risk of falling (Oliveira, Vieira, Machado Sousa, & Vilas-Boas, 2017).

Walking environments

A body of literature has highlighted the influence of environmental factors that may interact with walking activity (Owen, Humpel, Leslie, Bauman, & Sallis, 2004). Very few studies have examined specific environment–walking relationships. Existing evidence showed that walking for commuting purposes was associated more strongly with neighborhood location than with the neighborhood-built environment, whereas walking for shopping-eating purposes had a stronger association with the neighborhood-built environment (Cho & Rodríguez, 2015). Hence, walkable neighborhood development is essential for encouraging walking for commuting.

Identifying environmental factors that can influence physical activity is a public health priority. Males are more positive in the aesthetical neighborhoods and females perceived accessibility in the neighborhood (Humpel, Owen, Iverson, Leslie, & Bauman, 2004). Different environmental attributes were associated with different walking preferences. For instance, environmental facilitators in the neighborhood for outdoor walking are highly recommended to promote the mobility of older adults (Eronen, von Bonsdorff, Rantakokko, & Rantanen, 2014). The characteristics that could promote walking activity including proximity of destinations, good weather condition, safety and well-designed pedestrian facilities can significantly contribute to better perceptions of the walking environment (Ariffin & Zahari, 2013). Pedestrian behaviors may respond to characteristics of the environment. As a consequence, a substantial body of descriptive and typological studies examined pedestrian environments. The need to understand the mechanism of choice has prompted microscale and laboratory-based

research on exploratory spatial behavior within walking districts (Zacharias, 2001). Walking behavior in relation to comfort, dynamic experience of neighborhoods that affect individual itineraries has developed as specialized walking research characteristics.

Walking speed (WS)

Walking speed is reported as a reliable indicator for walking activity and it reflects both functional and physiological changes (Robinett & Vondran, 1988). Walking speed, theoretically, can be separated into two components (e.g., step length and cadence) (Schwameder, Lindenhofer, & Müller, 2005). At any given walking speed, it is possible to select different combinations of stride frequency and stride length. Self-selected walking speed, also termed as gait velocity, correlates with functional ability, and balance confidence. Walking speed can be used as a functional predictor to help determine outcomes such as functional status, discharge location and the need for rehabilitation (Fritz & Lusardi, 2009). Walking speed may be influenced by many variables such as health status (Bautmans, Lambert, & Mets, 2004), muscle performance and musculoskeletal condition (Dodd et al., 2011), perception (Li et al., 2019), activity habits (Pettigrew et al., 2016), cognitive status (Callisaya et al., 2017), motivation (Niven & Markland, 2016) etc. In addition, a real-life model that describes factors influencing walking pace, highlighted factors that involved on a real-life basis (Figure 10) (Taylor, Fitzsimons, & Mutrie, 2010). In general, walking speed can be influenced by nine themes (i.e., arera where walking takes place, dog, mood, walking with others, weather, ground surface, individual influences, footwear, time restraints) and specific influences on walking pace (see Figure 11) (Taylor et al., 2010).

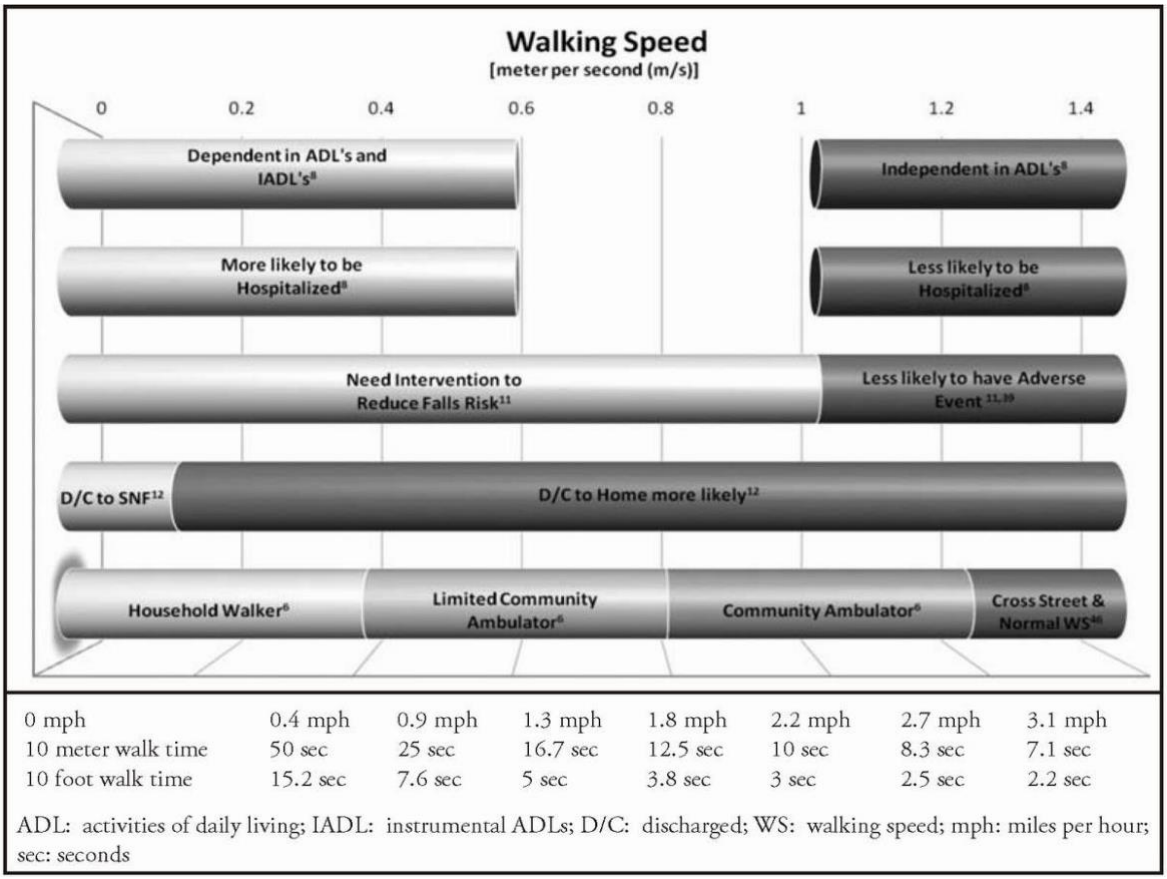

Figure 10 A collection of walking speed times that are linked to dependence, hospitalization, rehabilitation needs, discharge locations, and ambulation category (Taylor, Fitzsimons, & Mutrie, 2010)

Walking speed can be expected to be reduced in individuals of greater age and lesser height and lower extremity muscle strength (Bohannon, 1997). The comfortable and walking speed for individuals varies with age (Mohler, Thompson, Creem-Regehr, Pick, & Warren, 2007). Gait speed was homogeneous within strata and ranged from a mean of 143.4 cm/second for men aged 40 to 49 years to a mean of 94.3 cm/second for women aged 80 to 99 years, and the grand mean gait speed was relatively consistent for the decades 20 to 29 years to 60 to 69 years for men (133.9 to 143.3 cm/second) and women (124.1 to 139.0 cm/second) (Bohannon & Andrews, 2011). There is a hysteresis effect associated with human gait transitions, with the Run–Walk transition occurring at a slightly slower speed than the Walk–Run transition (Thorstensson & Roberthson, 1987). To be specified, walking near self-selected speeds (1.2 m/s) improves the utilization of elastic energy storage and recovery in the uni-articular ankle plantar flexors and reduces negative fiber work, when compared to faster or slower speeds (Neptune, Sasaki, & Kautz, 2008).

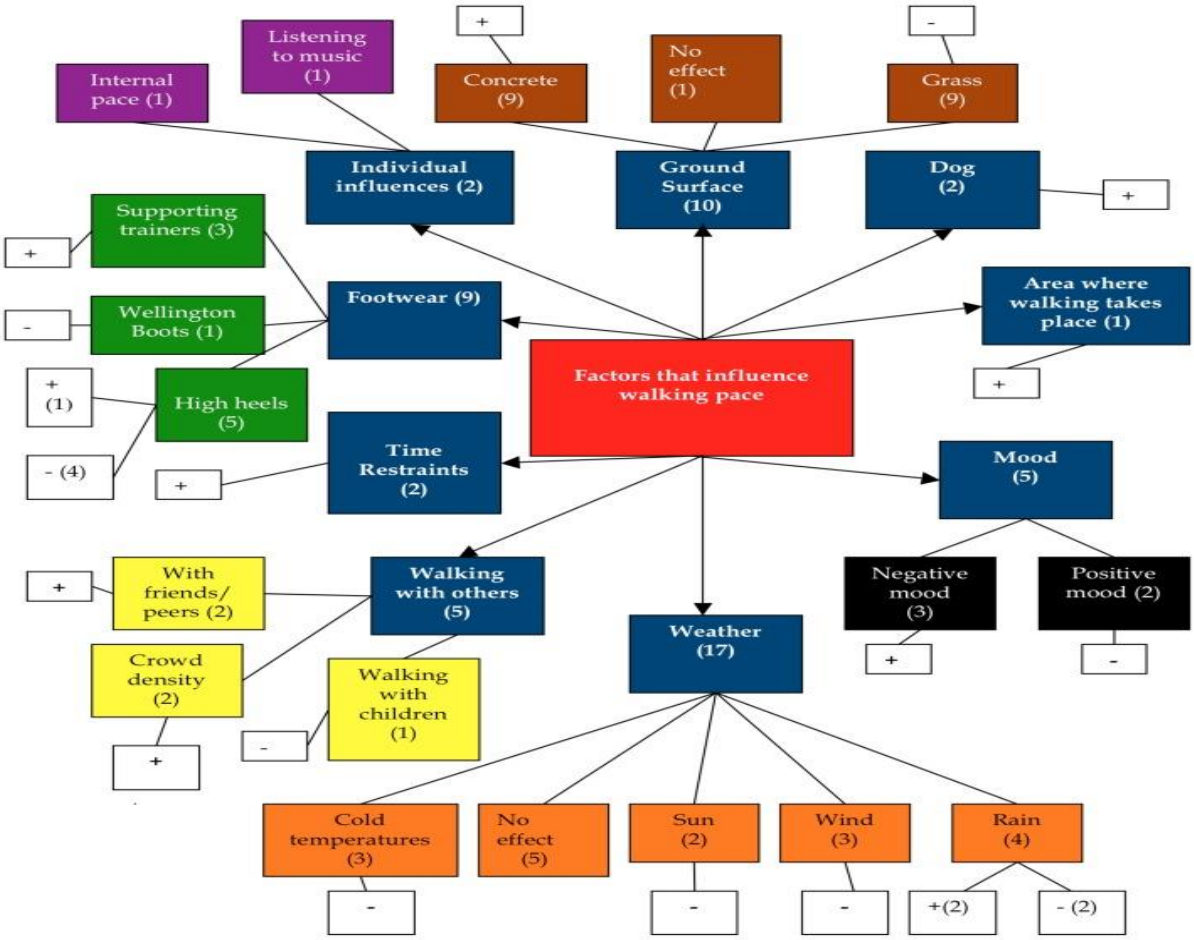

Figure 11 Spider diagram displaying the nine themes and specific influences on the participants' walking pace (Taylor et al., 2010)

Note: The number inside the smaller boxes displays the number of participants' views on a specific influence within a theme. The symbols (−) and (+) indicate whether the influence decreases (−) or increases (+) walking pace.

Measurements of walking

Walking efficiency and walking ability are not precisely measurable due to the flexibility of walking choices, particularly for the ambulatory population (Vale, Saraiva, & Pereira, 2016). Experimental measures of walking activity are usually limited to a timed short-distance walk and the distance walked in a fixed time. Epidemiological studies usually refer to steps trackers to collect walking data. Given the laboratorial and non-laboratorial equipment used for walking testing and investigation, the current review will mainly focus on

measurements that have the potential for large scope data collection. This subsection will discuss the subjective and objective measurements that are frequently used in walking research.

Subjective measurements: self-reports

Self-report measures of walking capacity are largely used in walking research. The validity and reproducibility of self-report instruments are supported by some evidence in the evaluation of walking capacity (Tomkins-Lane & Battié, 2010). These measures focus on outcome measures of walking according to their psychometric properties and international classification of functioning, disability and health domains. The most commonly used outcome measures were: Functional Ambulation Category (FAC), 10-Meter Walking Test, Motricity Index, 6-Minute Walking Test, Rivermead Mobility Index and Berg Balance Scale (Geroin et al., 2013). Even though these measures are tested with patients with stroke, the use of these measures is not limited to patients with stroke. For example, the FAC is proved to be a functional walking test that evaluates ambulation ability. This 6-point scale assesses ambulation status by determining how much human support is required when walking, regardless of whether or not they use a personal assistive device, and it has good predictive validity, and good responsiveness (Mehrholz, Wagner, Rutte, Meiβner, & Pohl, 2007).

Individual's perceptions of factors that influence walking pace should be concerned when evaluating the walking ability. Over the last ten years, an increasingly popular method of assessing walking in free-living conditions, the conflicting factors including ground surface and footwear were reported to be influential (Taylor et al., 2010). Therefore, despite the criticism of the accuracy of these measurements, the measurements of walking in real life are confounded by a combination of influences (Scott, Eves, French, & Hoppé, 2007).

Objective measurements: wearable devices

Objective measurement provides a potential advantage and offers more accurate assessments for investigating outdoor walking compared with subjective measurements. The popularity of activity trackers has grown in recent years, and health-conscious consumers are interested in using them for personal motivation and goal setting (Toth et al., 2018). The Global Positioning System (GPS) device showed enormous potential as a human locomotion measurement tool, enabling participants to walk unobstructed and unobserved in an outdoor setting, making the results relevant to real-life situations (Taylor et al., 2010). Accelerometer-

based commercial activity trackers are a low-cost and convenient method for monitoring and assessing health measures such as gait (Wong, Mentis, & Kuber, 2018). The most feasible objective measurements that exaggerate the function of GPS are wearable devices, such as pedometers, actigraphy and smartphone APPs etc. (Korinek et al., 2018).

Findings suggested that electronic pedometers are useful for examining questions about walking distance, steps count, energy expenditure (Bassett, Cureton, & Ainsworth, 2000). There was a new integrated system of 5 accelerometers that have been tested to determine if the accelerometers offered a practical option for the acquisition of spatiotemporal gait parameters. The system provided reliable and valid spatiotemporal measures of gait for the upper range of speeds likely to be targeted for rehabilitation interventions (Saremi et al., 2006). The validity of electronic devices for tracking walking activities is fundamental in scientific research. Once there was a study examined the effects of walking speed on the accuracy and reliability of 10 pedometers: Yamasa Skeletone, Sportline 330 and 345, Omron, Yamax Digiwalker SW-701, Kenz Lifecorder, New Lifestyles 2000, Oregon Scientific, Freestyle PacerPro, and Walk4Life LS 2525, and comparisons were made based on three categories: steps, distance, and energy cost. The results suggested that pedometers are most accurate for assessing steps, less accurate for assessing distance, and even less accurate for assessing kilocalories (Crouter, 2004). The accuracy of smartphone applications that are used for tracking walking activities may vary due to walking speed, walking distance and the mode of the device, but it turns out to be a user-friendly tool for the assessment of gait (Ho, Truong, & Jeong, 2016).

Steps we need

With the assumption that walking volume can be translated by steps count, how many steps individuals need every day to meet the physical activity guidelines? In February 2010, the Public Health Agency of Canada (PHAC) commissioned a literature review designed to identify how many steps are approximately equivalent to public health guidelines in children/adolescents, adults, and older adults/special populations. Normative data indicate that healthy adults typically take between 4,000 and 18,000 steps/day, and that 10,000 steps/day is reasonable for this population (Morgan, Tobar, & Snyder, 2010). The “10,000 steps/day” message attracted a great deal of interest in multi-strategy community-based approaches to changing physical activity or health behaviors. In addition, gender, weight need to be taken into account when evaluating the health effects of walking. For example, in persons of low body weight, the necessary steps per day to maintain bone mineral density can be substantially greater

than 10,000 steps (Boyer, Kiratli, Andriacchi, & Beaupre, 2011). Further, given that there is a strong relationship between cadence and intensity, despite some inter-individual variation, 100 steps/minute represents a reasonable floor value indicative of moderate intensity walking. A direct estimate of minimal amounts of moderate physical activity accumulated in the course of objectively monitored free-living behavior is 7,000-8,000 steps/day among young adults (approximately 20-50 years of age) (Tudor-Locke & Myers, 2001).

It is notable to mention that the recommended number of steps is on a daily basis, which could not reflect the intensity and speed of walking activity. In fact, studies started to highlight the disparity between the number of steps believed to be needed per day and the recommended time-intensity guidelines to achieve positive health benefits (White et al., 2013). There is a goal-setting principle (e.g., 10,000steps/day goal) that motivates people to be active with the strategy of achieving a certain amount of step goals (Kang, Marshall, Barreira, & Lee, 2009). Currently, it is still under debate about the threshold of suitable step count per day. From the perspective of health benefits, cardiometabolic marker differences and BMI were compared between step categories (low active: 5000 to 7499, somewhat active: 7500 to 9999, and active: ≥ 10,000 steps/day vs. inactive: < 5000 steps/day) in approximately 6000 Canadian adults (41.5 years, SD 14.9), of which the results indicated that 7500 step/day produced more benefits compared with 10,000 steps/day (Hajna, Ross, & Dasgupta, 2018). The findings from Hajna suggested that 7500steps per day is more recommended. Moreover, the recommended 10,000 steps/day seems insufficient for postmenopausal women and based on the obtained results, this age group should walk at least 12,500 steps per day to improve their health (Kroemeke et al., 2014). By reviewing the existing evidence on walking steps, the evidence did not specify the walking steps, which was only a total step count for one day. It is still unknown what are the outputs when walking is treated as a specific type of exercise within certain requirements (e.g., duration, intensity etc.). In other words, a certain number of steps is done at one block rather than calculating accumulated steps for the whole day, which enables to make the walking intensity much more accurate.

2.4.4 Section summary

This section reviewed the literature on walking research from multiple aspects. By standing on the primary consciousness that tailors to health promotion on a populational level among young adults. The literature review focused on the investigations which may correlate

with public health promotion potentials. A range of literature from theoretical to practical investigation on walking capacity, efficiency, and ability that supports the aim of the Ph.D. research were comprehensively discussed across the questions on “why”, “where” and “how” to walk for adults. It has been emphasized, moderate physical activity such as walking has the possibility to be widely implemented at international and national levels. Therefore, to review the knowledge about the characteristics and outcomes of walking implementation under specific features is necessary for planning further exploration in walking research.

The literature review in this section starts with the interpretation of the development history of walking activity-based researches, which addressed the historical perspectives in investigations of walking and offered an epidemiological understanding of walking studies. Then, this section also reviewed the mechanism between walking activity and health benefits in terms of the major health problems (e.g., cardiovascular disease, hypotension and sedentary control etc.) in the general population. Evidence from micro to macro level was provided to analyze the health mechanisms and relationships with walking intervention. It is important to emphasize that biological researches and public intervention researches are addressing issues of walking from different angles, positive biological interactions may not ensure a positive intervention at a populational level. Several categories (e.g., types of walking, walking environments, walking speed, measurements of walking etc.) were made to better discuss the optimal walking intervention for general adults. Supportive theories and practices were reviewed, alongside, existing vacancy in walking research were also pointed out.

The overview offered in this section is relevant to the present study since the findings of this dissertation on walking intervention can be examined based on the theoretical guidance and research evidence summarized here. Through the literature review in this section, a better understanding of what has been known and what has not been known in walking research allows the priority of the current Ph.D. study.

The next section will provide a literature review related to walking research and the main research variables (i.e., sleep quality, stress and life satisfaction), which will synthesize relevant theories and researches on each variable. Meanwhile, the review tries to sort the existing knowledge in the field as well as to identify gaps and limitations the current study aims to address.

2.5 WALKING AND THE MAIN RESEARCH VARIABLES: SLEEP, STRESS AND LIFE SATISFACTION

Moderate exercise is associated with greater longevity. It is recommended that regular participation in moderate intensity activities such as walking should be encouraged among the general communities. The benefits of physical activity have been thoroughly elaborated above. Given the benefits of moderate exercise are adequate, it makes sense to connect the specific activity (i.e., walking) and health indicators (i.e., sleep, stress and life satisfaction) to understand the mechanisms in-between.

Why did the current dissertation choose walking as the type of physical activity intervention? After reviewing the existing evidence about physical activity and health efficacy, there is a need to develop easy-following physical activity instructions, which can enlarge the possibility of regularity and consistency. Research indicated that young adults could adapt appropriately to repeated trip perturbations and to reduce trip-induced excessive instability in both proactive and reactive manners (Wang, Bhatt, Yang, & Pai, 2012). Evidence also indicated that both low and high spatiotemporal might reflect gait stability in healthy adults (Beauchet et al., 2009). Brisk walking accumulated throughout the day has higher potential in improving aspects of mood in previously sedentary individuals (Murphy, Nevill, Neville, Biddle, & Hardman, 2002). In current society, an important health issue is to decrease sedentary rate and increase physical activity level nationwide in order to prevent health risks (Dutta, Koepp, Stovitz, Levine, & Pereira, 2014; Hankonen et al., 2017).

Why did the current dissertation choose sleep, stress and life quality as the main variables to investigate? On one hand, poor sleep quality is an increasing health risk. On the other hand, the prevalence of sleep disorders is increasing and there is a need for intervention (Alhejaili, Altayyari, & Wali, 2019). Sleep and stress may have bidirectional associations, that is, poor sleep quality may lead to stress and stress may also contribute to poor sleep. The interaction between sleep quality and stress revealed by the previous study explicated the metabolism from basic physiology to pathological conditions (Hirotsu, Tufik, & Andersen, 2015). The overlap between sleep and stress can explain, at least in part, the outcomes observed in modern society, where sleep is deprived. Physical activity is a common strategy for coping with stress (Nguyen-Michel, Unger, Hamilton, & Spruijt-Metz, 2006). Sleep quality and stress status are two main indicators for life quality. The association between sleep, stress and life satisfaction is meaningful to be explored with physical intervention. In addition, scientific

reports emphasized the need for larger studies to evaluate the long-term benefits of walking programs on sleep patterns, psychological function and life (Gary & Lee, 2007).

This section will discuss the literature on walking exercise and sleep quality, stress and life satisfaction. The review will interpret the theories and findings between walking exercise and the three variables separately. The studies conducted with walking exercises and experimental evidence are discussed in separated sections. Briefly, walking exercise and sleep are discussed in Section 2.4.1 followed by stress (Section 2.4.2). The review of walking exercise and life satisfaction is not limited to satisfaction with life, and also the general concepts about life quality (Section 2.4.3). Last but not least, the section concludes with a reflection on the literature and its implications for the present dissertation (Section 2.4.4).

2.5.1 Walking exercise and sleep

Walking has been used as an alternative therapy in clinical patients who are frequently suffering from disturbed sleep (Chiu, Huang, Chen, Hou, & Tsai, 2015). The effects of physical activities on sleep in older adults are rich and experimental studies have elicited the effectiveness of walking intervention. For example, sound data suggested that walking exercise intervention improves sleep in older women who were suffering from pathological-related diseases (Joanne Held & Shaw, 2008). Walking exercise may also have a preventive effect on lifestyle-related diseases (Sugaya et al., 2007). Outside of clinical settings, the results may be violated. One trial that examined the effectiveness of exercise in a population within an elderly population showed that total sleep duration, sleep onset latency and global sleep quality significantly improved but sleep efficiency was not significant (Montgomery & Dennis, 2002). There was an opposite finding conducted in real-world showing that walking intervention might reduce sleep latency but increase total sleep duration (Hori, Ikenouchi-Sugita, Yoshimura, & Nakamura, 2016). The reason to explain the difference is that the subgroup of subjects differs, one study worked with people with insomnia, and one study worked with working people who are undergoing a sedentary lifestyle. It is reasonable to believe the effect of walking intervention varies along with different subgroups of the population. It was proposed that the way of walking may influence sleep efficacy, too. Nordic walking showed a positive effect on depression and sleeping disorders (Park & Yu, 2015). A walking program has been suggested as an effective intervention for improving subjective and objective sleep quality (Chen, Tsai, Wu, Lin, & Lin, 2016).

Walking has the possibility of leading to healthy brain function (Hatta, Nishihira, & Higashiura, 2011). Epidemiologic studies have consistently reported significant positive associations between self-reported exercise habits and better self-reported sleep, which vary across a wide range of demographics (Youngstedt & Kline, 2006). In midlife women, frequent adherence to walking is a significant predictor of change in sleep symptoms, even though walking does not improve most symptoms (Wilbur, Miller, McDevitt, Wang, & Miller, 2005). Adults maintaining low-active, high-walking habits exhibited a significantly lower rate of sleep disturbance than those who walked less (Cheng et al., 2019). Home-based outdoor walking for community-based healthy people may be helpful in improving the rehabilitation process (Morita, Imai, Okawa, Miyaura, & Miyazaki, 2011). There has been growing interest in understanding how neighborhoods may be related to sleep enhancement. Living in neighborhoods with a low walking environment score is associated with greater severity of sleep apnea (Billings et al., 2016).

Evidence showed that more intense daily walking activity appeared to translate to greater improvements in walking speed (Mansfield et al., 2015). Hence, walking intensity, or walking speed, can be another important issue to be considered in physical intervention. Decreased gait speed and increased gait variability are associated with lower sleep efficiency (Agmon, Shochat, & Kizony, 2016). There is a biological reaction: walking speed is possibly related to cortisol awakening response (Pulopulos, Puig-Perez, Hidalgo, Villada, & Salvador, 2016). The cortisol awakening response of reduced magnitude would contribute to less diurnal cortisol variability and affects walking speed through a possible negative effect on executive function (Pulopulos et al., 2016). It is important to mention that walking speed has a significant association with physical functioning such as bodily pain (Sampaio et al., 2015). A slower walking speed was associated with a greater prevalence of sleep-disordered breathing, independently from other common screening factors (Suri, Batterham, Ells, Danjoux, & Atkinson, 2015). It is recommended to justify the balance of walking speed (Sampaio et al., 2015).

2.5.2 Walking exercise and stress

Walking intensity is closely associated with biological response. It has been found that brachial artery shear stress is greatest following high-intensity walking and that the rate of decline in shear stress is similar across all walking intensities (Padilla, Harris, Rink, & Wallace, 2008). In general, the stress-reduction effect of walking is characterized as moderate physical

exercise. A single bout of aerobic walking exercise can improve fibrinolysis profiles, and the implications are that walking may modify clot lysing potential, thereby affecting biochemical mechanisms (Ivey et al., 2003). Effects of walking include reduced stress hormones such as adrenaline and noradrenaline and relaxing effect which due to walking exercise reduced the levels of serum N-terminal pro-B-type natriuretic peptide (NT-proBNP) and urinary dopamine (Li et al., 2011). The physiological responses to low-intensity walking are influenced by cold weather, and less marked influence on the thermoregulatory responses was found compared with high-intensity walking (Weller, Millard, Stroud, Greenhaff, & Macdonald, 1997).

Factors in combination with life stage should be taken into account, for instance, pram-walking is recommended for mothers to reduce depressive symptomatology for postnatal women (Armstrong & Edwards, 2004). Also, significantly lower levels of stress, lower symptoms of depression were found in prenatal women (Urizar Jr et al., 2004). Walking exercises have a positive effect on the improvement of self-esteem, stress, or depression for housewives (Kim, 2015). The comparison made between older and younger adults indicates that walking may be particularly beneficial for older individuals who are previously sedentary (Navalta, Sedlock, & Park, 2004). On the contrary, oxidative stress is an independent predictor of a decrease in walking speed and progression to severe walking disability (Semba et al., 2007). Regardless of the controversial relationship between walking ability and stress among older adults, the positive effect of walking on stress among young adults should be addressed. Recent evidence argues that walking is quite effective in reducing stress in young adults (Chaudhuri, Goswami, Ray, Hazra, & Bera, 2016). The questions remaining are when and how to walk.

Environmental factors show a mediating effect when considering stress reduction. Outdoor exercise may account for some of the psychological benefits (Plante et al., 2007). It was revealed that outdoor activities were better for restoring attention compared to indoor activities (Weng & Chiang, 2014). Decades ago, exercise was suggested as an important strategy for promoting health status and outdoor walking exercise is good for not only physical function but also the emotional state of older adults (Shin, 1999). The psychological effects of forest environments on healthy adults were found and forest environments are advantageous with respect to acute emotions (Morita et al., 2007). Results suggested that forest walking may have the possibility to reduce mental stress and stress markers in both young and aged people (Horiuchi et al., 2013). A bunch of additional evidence was found in young adults and suggested that brisk walking may buffer improved mood state and mindful awareness (de Bruin, van der Zwan, & Bögels, 2016; Edwards & Loprinzi, 2018).

Physiological and psychological measurements strengthened the relaxing effects of walking in a bamboo forest on adults (Hassan et al., 2018). Walking outside improves mood for healthy individuals (Teas, Hurley, Msph, & Mph, 2007). The most convincing evidence demonstrated that spending time in outdoor environments, particularly those with green space, may reduce the experience of stress, and ultimately improve health (Kondo, Jacoby, & South, 2018).

2.5.3 Walking exercise and life satisfaction

Walking is important for maintaining autonomy and life quality from the aspect of health output. Previous findings concluded that physical activities have a significant part to play in life (Crone, 2007). Overall life satisfaction, even though it is individualistic, has been defined as the global judgment of a person's life quality (Rodríguez, Látková, & Sun, 2008). The current dissertation focuses on improving life satisfaction, which can be approached by physical exercise intervention. Our understanding of life satisfaction and physical needs is grounded in a more theoretical framework. Life satisfaction is associated with efforts focused on the different components of subjective wellbeing. A need theory framework (i.e., activity theory and need theory) is available, which provided support from theoretical perspectives (Table 4) (Rodríguez et al., 2008). Six groups of needs (i.e., social need, autonomy need, family togetherness need, physical fitness need, jogging/walking for exercise and computer games) are summarized to predict life satisfaction.

Table 4 Hierarchical multiple regression analysis summary predicting life satisfaction

Predictors	B	SEB	β (Beta)	Adjusted R^2	ΔR^2
Step 1: Social need	1.88	.19	.44	.19	.19**
Step 2: Autonomy need	1.01	.23	.23	.22	.04**
Step 3: Family togetherness need	.64	.20	.17	.24	.02**
Step 4: Physical fitness need	.60	.16	.19	.27	.03**
Step 5: Jogging/walking for exercise	.06	.03	.10	.27	.01*
Step 6: Computer games	-.11	.03	-.17	.30	.03**

* $p < .05$

** $p < .01$

The links between health-related behaviors and life satisfaction showed that regular physical activity and leisure-time activities are significantly related to life satisfaction (Inal, Subasi, Ay, & Hayran, 2007). Life satisfaction is suggested as a component of comprehensive assessments of adolescent physical activity behaviors (Valois, Zullig, Huebner, & Drane, 2004). How may walking interact with life satisfaction? Updated evidence indicated that walking could promote life satisfaction by providing the enjoyment of walking as physically active leisure (Sato, Yoshida, Wakayoshi, & Shonk, 2017). Insights into the perceived benefits acquired by participating in walking intervention to promote well-being (Hitzig et al., 2013). In addition, walking interferes in a positive way at autonomy, aerobic resistance and life quality (Fraga, Cader, Ferreira, Giani, & Dantas, 2011).

Life satisfaction is associated with a number of variables including gender, age, marital status, years of education, chronic illness, functional impairment, self-rated health, financial strain etc. (Chou & Chi, 1999). Even though accumulating evidence claims that daily fluctuations in physical activity have important implications for well-being regardless of age, and clarifies developmental differences in life satisfaction dynamics (Maher, Pincus, Ram, & Conroy, 2015). In order to best enhance life satisfaction, researchers still need to seek solutions for daily physical activity with regard to the above variables. To be more precisely, it has been known that younger elderly persons with less financial strain, better social support, fewer somatic complaints and more education reported a higher level of life satisfaction (Chou & Chi, 1999). Considering social circumstance including socioeconomic status, education background, social relations, family/relatives, work/study etc. and other stereotypes of sub-groups of populations, the theories and approaches investigating walking activity and life satisfaction is not as solid as it seems to be, though, positive feedbacks have been found. The existing evidence of walking exercise and life satisfaction is reported by underlining the health promotion effect of physical exercise (Son & Lee, 2006). More evidence is need when discussing specific groups of population with regards to life stage and social characters.

2.5.4 Section summary

This section addressed the relevant literature on walking activity exploration and walking interventions associated with sleep quality, stress and life satisfaction by exploring the effectiveness and potential confounding factors.

The literature in this section reviewed the existing explorations of walking exercise as an intervention strategy in health promotion trials. The literature on walking exercise and sleep

quality and stress management has been examined from different angles with particular participants. The literature on walking and life satisfaction is waiting for more evidence, especially among young adults. The importance of walking activity among healthy adults has not been fully addressed. Scientific research examining physical activity and health should be acknowledged by a pre-understanding that the benefits of promoting physical activity level is not limited to disease rehabilitation, but more to prevent diseases and improve life quality.

Overall, the section provided detailed knowledge about walking and its exploration with sleep quality, stress and life satisfaction. Prior researches established an experimental foundation in health promotion strategy exploration and provided basement evidence in physical activity-based interventions. More practical studies are needed to consolidate the current understanding of physical interventions and expand the implications of walking exercise as a physical activity habit.

2.6 JUSTIFICATION AND IMPLICATIONS

Chapter 2 presented the literature about physical activity and health promotion concerning the physiological and psychological impacts. The literature review offered in this chapter (1) deliberated the correlative concepts of physical activity, (2) highlighted the importance of physical activity and health promotion as well as explaining (3) the determinants of physical activity-based health promotion. Particularly, the literature focused on the existing evidence on walking and main research variables by reviewing (4) previously published walking intervention studies associated with sleep quality, stress and life satisfaction.

Walking is an affordable physical activity. After reviewing the important definitions, theories, approaches of physical activity and explorations of physical exercise interventions, the conception of promoting physical intervention at an international level appeals to high feasibility and possibility as a functional intervention for public health. The gaps in walking intervention and health outcomes among young adults needs further exploration. By the evidence offered in this literature review, actions are needed not only in scientific research but also in daily life actualization. Very little is known about what types of walking improve sleep the most, and how much walking is needed to improve sleep and what time of day is best for walking to improve sleep in people (Chalise & Lamsal, 2017).

With the preliminary overview above, it has been concluded that (1) there is a need to synthesize recent findings on physical activity intervention and its relation to public health

promotion with a special focus on the role of walking intervention, and (2) to explore in-depth about walking excise and its maintenance with consideration of psychological effects.

Physical activity can always be a fun part of your day. Regular activity can play as a part of a lifelong health promotion plan.

CHAPTER 3: RESEARCH METHODOLOGY AND DESIGN

This chapter will discuss the research methodology and research design adopted by this dissertation to explore the introduction chapter's research questions. The research methodology and research design of the Ph.D. project are dedicated to achieve the research aims. The research methodology will be discussed in Section 3.1, which interprets the overarching strategy and rationale of the current research project. The research design presented in this chapter describes the initiation and creation of the study regarding the research questions (Section 3.2). Individual study designs are discussed unitarily in Chapter 4 (study 1), Chapter 5 (study 2), Chapter 6 (study 3) subsequently.

3.1 INTERPRETATION OF RESEARCH METHODOLOGY

The concept of research paradigm is elusive to articulate for many young researchers and Ph.D. students. A preliminary understanding of the research paradigm is a requisite in understanding research methodology. Therefore, it is important to explain the meaning of the research paradigm before explaining research methodology. This section starts with concise understandings of the research paradigm (Section 3.1.1), followed by an exclusive identification of the pragmatic paradigm adopted in the dissertation and research methodology (Section 3.1.2).

3.1.1 Understanding of research paradigms

Research paradigms comprises four major elements, namely, epistemology, ontology, methodology and axiology (Lincoln & Guba, 1985). Epistemology is used to describe how we come to know something; how we know the truth or reality (Kivunja & Kuyini, 2017); Ontology is a branch of philosophy concerned with the assumptions we make in order to believe that something makes sense or is real, or the very nature or essence of the social phenomenon we are investigating (Scotland, 2012). The methodology is the broad term used to refer to the research design, methods, approaches and procedures used in an investigation that is well planned to find out something (Keeves, 1990). Axiology considers the philosophical approach

to making decisions of value or the right decisions (Finnis, 2011). Understanding these paradigms has significant implications for every decision made in the research process, including choice of methodology and methods.

The word paradigm means a philosophical way of thinking, which is used to describe the researcher's perspective or beliefs that informs the meaning or interpretation of research data (Kivunja & Kuyini, 2017). It constitutes the abstract beliefs and principles that shape how a researcher sees the world, and how s/he interprets and acts within that world. Table 4 shows the common languages that reflect the nature of research paradigms (Mackenzie & Knipe, 2006). Hence, research paradigms are not limited to the four concepts below. The emerging paradigms replenished the theoretical constructs of research. For instance, many new research paradigms were created to solve distinct research questions (Kellett, 2005; Robinson & Sirard, 2005).

Table 5 Commonly used languages associated with major research paradigms

Positivist/ Postpositivist	Interpretivist/ Constructivist	Transformative	Pragmatic
Experimental	Naturalistic	Critical theory	Consequences of actions
Quasi- experimental Correlational	Phenomenological	Neo-Marxist	Problem-centered
Reductionism	Hermeneutic	Feminist	Pluralistic
Theory verification	Interpretivist	Critical Race Theory	Real-world practice oriented
Causal comparative	Ethnographic	Freirean	Mixed models
Determination	Multiple participant meanings	Participatory	
Normative	Social and historical construction	Emancipatory	
	Theory generation	Advocacy	
	Symbolic interaction	Grand Narrative	
		Empowerment issue-oriented Change-oriented	

	Interventionist Queer theory Race specific Political

Even though there are different paradigms for qualitative research and quantitative research, it is also possible to follow the same research paradigm for qualitative research and quantitative research (Ochieng, 2009). Reliability and validity of a study are the issues that have been discussed by quantitative and qualitative researchers. It is suggested that the validity and the norms of rigor that are applied to quantitative research are not entirely applicable to qualitative research. Validity in qualitative research means the extent to which the data is plausible, credible and trustworthy; and thus, can be defended when challenged (Bashir, Afzal, & Azeem, 2008). Therefore, it is important to adopt a compatible research paradigm when proposing research.

3.1.2 Pragmatic paradigm and research methodology

The current dissertation refers to a pragmatic paradigm to guide the research methodology and research design. Pragmatism as a research paradigm supports the use of a mix of different research methods as well as modes of analysis and a continuous cycle of abductive reasoning while being guided primarily by the researcher's desire to produce socially useful knowledge (Yvonne Feilzer, 2010). The evolution and development of pragmatism as a philosophy is a long process, and it is marked by transformations. The present dissertation does not intend to review the history of pragmatism but to highlight the practical relevance of philosophical pragmatism to research methodology. Pragmatists question the dichotomy of positivism and constructivism and call for a convergence of quantitative and qualitative methods, reiterating that they are not different at an epistemological or ontological level and share many commonalities (Hanson, 2008; Johnson & Onwuegbuzie, 2004). Furthermore, it has been identified that pragmatic approach to problem-solving in the social world offers an alternative, flexible, and more reflexive guide to research design and grounded research (Larsen, Madsen, Thomsen, & Larsen, 2008; Serfaty, Shafran, Vickerstaff, & Aspden, 2020). Pragmatism is seen as the paradigm that provides the underlying philosophical framework for mixed-methods research (Somekh & Lewin, 2005; Teddlie & Tashakkori, 2003).

From pragmatists' perspective, knowledge is viewed both based on the reality of the world we experience and live in as well as constructed by the human mind. Rather than

positioning themselves as distant observers, relational researchers, or socially and historically contextualized inquirers, pragmatists are free to study what interests them and is of value to them, in the different ways they deem appropriate, and use the results in ways that can bring about positive consequences within their value system (Stubbs et al., 2016). I appreciate the pragmatists' efforts to provide the best answers that currently can be mustered. I also welcome the pragmatic approach to gain knowledge in the pursuit of desired ends. The values rooted in the present study included human being, health promotion, habit change, physical exercise implementation and health promotion. These values have been shaped by my personal experience both as a nurse working in the clinical units and as a health education researcher investigating exercise, health and life quality. The present study presents my own expectations in health education and health promotion practices. I realized that the physical exercise level of general human beings is decreasing even though physical exercise guidelines are prepared by governments to help people be physically healthy and active. I also noticed that physical exercise is mostly encouraged in elderly adult population rather than the young adult population. Therefore, in my research, I am interested to investigate possible health promotion strategies.

3.2 RESEARCH DESIGN: MIXED-METHOD

Mixed-method research is becoming increasingly articulated, attached to research practice. This dissertation adopted a mixed-method research design. Mixed methods research strives for integration of quantitative and qualitative research strategies. The definition of mixed-methods is taken as one of the three major "research paradigms" (quantitative research, qualitative research, and mixed methods research) (Sogunro, 2002). Figure 12 indicates the graphic of the three major research paradigms (Johnson, Onwuegbuzie, & Turner, 2007). Quantitative research is defined as "an inquiry into a social or human problem, based on testing a theory composed of variables, measured with numbers, and analyzed with statistical procedures" and qualitative research is defined as "an inquiry process of understanding a social or human problem based on building a complex, holistic picture, formed with words, reporting detailed views of informants and conducted in a natural setting" (Cresswell, 1994). Both quantitative and qualitative research are important and useful. The following subsections (Section 3.2.1 and Section 3.2.2) will interpret the quantitative and qualitative research design tailoring to the research questions in the current dissertation.

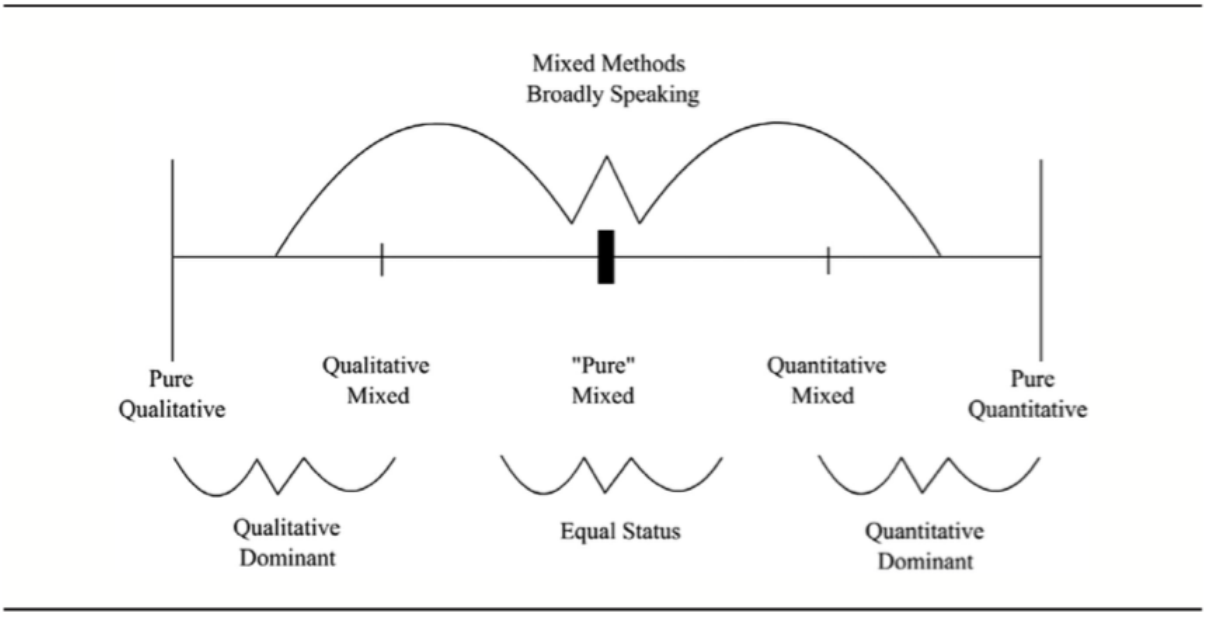

Figure 12 Graphic of the three major research paradigms, including subtypes of mixed methods research (Johnson, Onwuegbuzie, & Turner, 2007)

3.2.1 Quantitative research design

Quantitative methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. Given the principle of conducting quantitative research study is to determine the relationship between one thing (an independent variable) and another (a dependent or outcome variable) within a population, it is coincident with the research aims to explore the relationships between sleep quality, stress and life satisfaction. Also, quantitative research designs are either descriptive (subjects usually measured once) or experimental (subjects measured before and after treatment). An experimental study establishes the changes in sleep quality, stress and life satisfaction before and after walking intervention would be essential to investigate the effectiveness of a certain type of walking intervention. As known, quantitative research focuses on convergent reasoning rather than divergent reasoning (Labaree, 2009). Therefore, it would be reasonable to combine experimental and descriptive quantitative research in the present study.

Given the characteristics of quantitative research, the present dissertation followed a quantitative-driven mix-method research approach. The overall aim of the research was to

explore the interaction between physical exercise and stress, sleep quality and life satisfaction. In the "QUAN" studies, a cross-sectional study and an intervention study were conducted to seek answers for overarching research questions about the relationship between physical exercise and sleep quality, stress and life satisfaction and the interaction between physical exercise and sleep quality, stress reduction and life satisfaction in adults. Detailed research processes, findings, discussions, and conclusions of these studies will be presented separately in the following chapters (Chapter 4 & 5).

Given its complex nature, physical exercise intervention allowed a more thorough and comprehensive investigation of the research topic. Since the purpose of the dissertation was to explore the association between physical activity and stress, sleep quality and life satisfaction, and then to examine a suitable type of physical exercise, a quantitative research paradigm was seen as appropriate. Finally, the design for the quantitative research was sequential: first, a cross-sectional survey study was conducted to assess the correlational relations between physical exercise and stress, sleep quality and life satisfaction, meantime, to explore their potential associations with demographic and life-style based factors (Study 1), followed by a 12-week crossover intervention study of which the data was quantitative-based (Study 2) to resolve the issues uncovered by the survey study and to provide an empirical extension to it. Thus, the importance of Study 2 was emphasized considering the ultimate goal of the dissertation.

3.2.2 Qualitative research design

Qualitative research is often defined as being subjective. The design of qualitative research presents a conceptual framework which provides evidence to understand "whys" and "hows" of the phenomenon (Astalin, 2013). In qualitative research, researcher examines why events occur, what happens, and what those events mean to the participants studied (Teherani, Martimianakis, Stenfors-Hayes, Wadhwa, & Varpio, 2015). Further, qualitative research focuses on outcomes the events transpire from the perspectives of research participants/individuals involved. Therefore, a further step is needed to enhance the understanding of how daily walking exercise impacts on mental and cognitive construction regarding sleep quality, stress and life satisfaction. Consequently, a post-intervention "QUAL" study (interview study) was conducted. The interviews were semi-structured, and research participants were invited for an individual interview. The qualitative study aimed to investigate the effect of regular aerobic walking exercise on mental & cognitive construction. The detailed

research instruments, outcomes, and discussions are explicitly presented in Chapter 6. The implementation of the qualitative study is to fulfill and expand the research findings by selecting feedback from the participants involved in the experimental study.

3.3 OVERVIEW OF THE RESEARCH FRAMEWORK

The topic of the dissertation is identical and applicable. The Ph.D. research is in a sequential research framework, which allows discovering this issue comprehensively. Figure 13 describes the research framework of the dissertation. Given the substantial literature reviews that support further discovery of physical interventions in health promotion, it is theoretical based research to examine the hypotheses by using quantitative and qualitative research methods. Firstly, a cross-sectional study was conducted to examine the relationship between the three main variables in this dissertation (sleep quality, stress and life satisfaction). This study provided a pre-understanding about interaction and correlation in sleep quality, stress and life satisfaction. Secondly, a pedometer-based physical exercise (aerobic walking) intervention was conducted to investigate the effect of a daily walking exercise on sleep quality, stress and life satisfaction. The findings gained in this study enriched and supplemented the knowledge in physical education and health regarding sleep quality, stress and life satisfaction. Last but not least, an interview study was conducted to explore the cognitive outcomes and feedback from the research participants. This study expanded our understanding of physical exercise intervention. Figure 13 provides a graphic overview of the mixed-method research design applied in the present dissertation, including research questions tailored to each study. The major goal of the research topic was to examine the possible implementable physical exercise intervention strategies for health promotion with the aim of generalization.

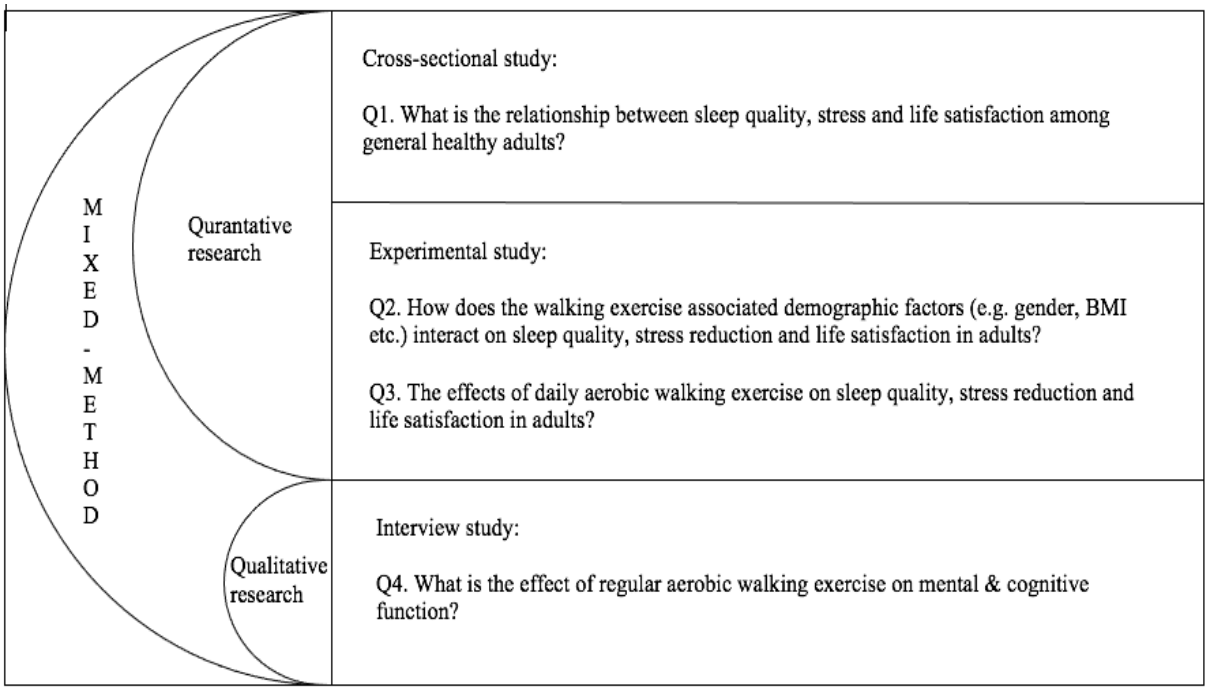

Figure 13 Overview of the mixed-method research design used in the dissertation

As Figure 13 shows, to implement the selected research design, three independent studies were conducted. Each study was responsible for answering specific research questions. The methods and materials, participants, instruments/measures, research design, the procedure of data collection, findings, discussions and conclusions of these studies will be presented separately in Chapter 4, Chapter 5 and Chapter 6. The overall discussion and conclusions of the mixed-method investigation in this dissertation will be presented in Chapter 7.

CHAPTER 4 THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY, STRESS AND LIFE SATISFACTION (Study 1)

Note: This article has been accepted for publication and the final published version is presented in this dissertation. The final published version can be found and downloaded online from the publisher's website: http://efsupit.ro/images/stories/ianuarie2019/Art%2034.pdf

Wang, F., & Boros, S. (2019). The relationship between physical activity, stress, life satisfaction and sleep quality. Journal of Physical Education and Sport, 19, 227-234. DOI:10.7752/jpes.2019.s1034

4.1 ABSTRACT

Problem statement: The factors that are related to sleep quality are diverse. A body of studies examined physical activity and stress, life satisfaction and sleep quality, but to date no studies investigated the association amongst them regarding the age. Little is known about the difference of stress, life satisfaction and sleep quality between physically active and non-active people. Approach: A cross-sectional study was launched with 292 participants, who answered a battery of questionnaires formulated by Qualtrics online research platform. Purpose: The aim of this study was to present the relationship between demographic factors (e.g. gender, age) with physical activity, life satisfaction, stress and sleep quality. Results: The prevalence of moderate (69.9%) stress was the highest compared with those reporting low (24.7%) and high (5.5%) stress. Stress and life satisfaction were significantly correlated with sleep quality ($p < .05$), but only stress associated significantly with sleep quality ($p<.00$, SE=.03, B=.43). In addition, there was no significant relationship between sleep quality and physical activity. Sedentary lifestyle is not beneficial for life satisfaction, and people who carry on a sedentary lifestyle are more easily stressed. Conclusion: It is suggested to take into consideration age when discussing the mechanism between physical activity and sleep quality. The effect of physical activity on sleep quality among healthy populations needs more evidence. Future studies are suggested to classify the substantial benefits of specific physical activity types on stress and sleep quality.

Key words: physical activity, stress, life satisfaction, sleep quality, PSQI

4.2 INTRODUCTION

The spectrum of physical activity on health issues is wide according to epidemiological evidence (LAPORTE et al., 1984). To our best acknowledgement, physical inactivity has a major effect on non-communicable diseases worldwide (Lee et al., 2012). In addition, participating in physical activity affects psychological well-being (Norris, Carroll, & Cochrane, 1992). Moreover, physical activity is often recommended as a strategy for managing mental pressure, and health promotion programs are frequently used as solutions (Nguyen-Michel et al., 2006). World Health Organization (WHO) (2010) recommended physical activity in primary prevention of noncommunicable diseases (NCDs) at population level. The prevalence of regular physical activity, stress, life satisfaction varies in different regions. Even though the benefits of physical activity were highly announced, its effect on sleep lacks of quantitative investigation in general population.

Physical activity, stress, life satisfaction and sleep quality have demonstrated increasing attention in academic research in recent years. Early studies have reported positive effectivity of physical activity on public health (Pate et al., 1995). According to WHO, in the document of global recommendations on physical activity for health, which emphasized that adults aged 18–64 should do at least 150 minutes of moderate- intensity aerobic physical activity throughout the week.

Academic stress for college students has drawn considerable attention, but job-related stress has been a neglected area of research (Beehr & Newman, 1978). The life satisfaction was declined (Proctor, Linley, & Maltby, 2009) and sleep quality showed decreasing tendency (Pilcher, Ginter, & Sadowsky, 1997). Stress and poor sleep quality were potential risks for health, specifically, stress was associated with increased sleep complaints and low level of perceived health (Gerber, Hartmann, Brand, Holsboer-Trachsler, & Pühse, 2010). Sleep quality has been identified as key issue for health, however, the awareness of sleep hygiene was low (Voinescu & Szentagotai-Tatar, 2015).

Different levels of physical activity imply a differential effect on stress-related neurophysiological systems in response to psychosocial stress (Rimmele et al., 2009). In addition, vigorous exercisers who exercise frequently were found cognitively younger than those inactive people (Clark, Long, & Schiffman, 1999). Furthermore, individuals with high levels of physical activity are less likely to develop depressive illness than those people who carry out lower levels of physical activity (Kesaniemi et al., 2001). As indicated, physical activity level was consistently positive associated with health-related quality of life (Bize,

Johnson, & Plotnikoff, 2007). It is well known that age is a key factor to physical activity, physical exercise works well among elder population (Reid et al., 2010). Whereas, how age increase associated with physical activity has barely been mentioned in previous research.

Insufficient physical activity and sedentary behaviors are common in the society (Van Der Horst, Paw, Twisk, & Van Mechelen, 2007). The proportion of 13–15-year-olds doing fewer than 60 minutes of physical activity of moderate to vigorous intensity per day is 80.3% (80.1–80.5); boys are more active than are girls (Hallal et al., 2012). Additionally, most college students did not meet the requested physical exercise volume which was assessed by physical activity guidelines (Huang et al., 2003). Nevertheless, insufficient sleep and irregular sleep–wake patterns have been extensively documented in younger adolescents and college students (Lund, Reider, Whiting, & Prichard, 2010). College students did not meet the sleep duration guidelines, 7 to 9 hours per day, for health issues (Hirshkowitz et al., 2015). An estimated 26% of adults reported frequent (≥14 days in the past 30 days) sleep insufficiency (Strine & Chapman, 2005). An American study illustrated that work overload was positively associated with the frequency of poor sleep quality (Knudsen, Ducharme, & Roman, 2007).

Increasing number of studies have provided supporting evidence on the associations between physical activity, stress, life satisfaction and sleep quality in the past decade. Psychological stress and physical activity are believed to be reciprocally related, and they result in physically inactive (Stults-Kolehmainen & Sinha, 2014). As revealed in the Scottish Health Survey, any kind of daily physical activities were associated with a lower risk of psychological distress (Hamer, Stamatakis, & Steptoe, 2009). Stress is also a predictive factor for life satisfaction, moreover, the interaction between perceived stress and life satisfaction was associated with physical exercise (Fang, Huang, & Hsu, 2019). But more evidence is needed to figure out how much exercise is necessary to trigger stress-buffer effects.

To date, several studies have worked out the benefits of physical exercise as mentioned above. However, one meta-analysis showed that in older adults, aerobic exercise (e.g. Tai chi) showed weak benefits for sleep quality (Du et al., 2015). How physical activity benefits sleep quality? Up to now, the association between different exercise intensity and sleep quality has not, though, hitherto been subject to explicit investigation. Furthermore, sedentary behavior, inactive lifestyle and active lifestyle may undergo different life satisfaction, stress, sleep quality. The association between physical activity, stress, life satisfaction and sleep quality were not elaborately stated. We hypothesize that 1) there is gender difference between physical activity, perceived stress, life satisfaction and sleep quality; 2) there is difference in perceived stress, life satisfaction and sleep quality between sedentary and non-sedentary life status; 3) physical

activity, perceived stress, life satisfaction are associated with sleep quality, and the relationship between physical activity and sleep quality becomes closer with the increase of age. The purpose of this study was, firstly, to assess the level of physical activity, perceived stress, satisfaction with life, and sleep quality. Secondly, to investigate the interaction between physical activity, perceived stress, satisfaction with life and sleep quality and explore the predictive power of these factors on sleep quality.

4.3 MATERIALS AND METHODS

4.3.1 Participants

The online questionnaire was sent to adults above 18 years old. Participants included 106 males (36.3%) and 186 females (63.7%). Responses were collected from both studying (49.7%) and working (46.2%) voluntary samples from 18 years old adults. One response was excluded due to missing data. Approximately twice more participants were single (62.7%) than those who married or living in a cohabiting relationship (37.3%).

4.3.2 Instruments

The questionnaire was composed by self-administrated demographic questions followed by a series of questionnaires on physical activity (PA), perceived stress (PS), life satisfaction (LS) and sleep quality (SQ). We collected biophysical data (e.g. age, gender, height, weight), and social characteristic data (e.g. marital status, identity, region). We calculated exercise volume by asking two questions: 1. How many times do you exercise (minimum 10 minutes each time) each week? 2. On the average, how many minutes do you exercise each time? Physical activity, perceived stress, life satisfaction and sleep quality were assessed by International Physical Activity questionnaire short form (IPAQ-SF) (Cora L Craig et al., 2003), Perceived Stress Scale (PSS) (S. Cohen, Kamarck, & Mermelstein, 1983), Satisfaction With Life Scale (SWLS) (Diener, Emmons, Larsen, & Griffin, 1985), Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), respectively.

International Physical Activity questionnaire (IPAQ) comprises four elements: vigorous exercise, moderate exercise, waking and sitting. By asking the exercise frequencies and exercise duration per week, vigorous physical activity, moderate physical activity and walking were

calculated, the sitting time was evaluated directly by the question: During the last 7 days, how much time did you spend sitting on a weekday? The physical activities were recorded in minutes last week. High reliability (α >.80) indicated good stability and reliability of the questionnaire, and criterion validity had a median p value of about 0.30, which was comparable to most other self-report validation studies (Cora L Craig et al., 2003).

Perceived Stress Scale (PSS-10) is a classic stress assessment instrument with 10 questions. Each item in this scale asks about feelings and thoughts during the last month and is rated on a 5-point scale (0=Never, 1= Almost never, 2=Sometimes, 3=Fairly often, 4=Very often). Individual scores on the PSS can range from 0 to 40 with higher scores indicating higher perceived stress. Scores ranging from 0-13 would be considered low stress; scores ranging from 14-26 would be considered moderate stress and scores ranging from 27-40 would be considered high perceived stress. The PSS-10 showed marginal satisfactory Cronbach's alpha values (α=0.69) (Andreou et al., 2011), and Cronbach's alpha above 0.7 was considered as satisfied.

Satisfaction With Life Scale (SWLS) is a 5-item scale designed to measure global cognitive judgments of one's life satisfaction. Participants indicate how much they agree or disagree with each of the 5 items (In most ways my life is close to my ideal; The conditions of my life are excellent; I am satisfied with my life; So far I have gotten the important things I want in life; If I could live my life over, I would change almost nothing.) items by using a 7-point scale that ranges from 7 strongly agree to 1 strongly disagree. Higher score indicates better life satisfaction. The SWLS has satisfactory inter-item correlations (r > .60), and reliability (α= .84) (Galanakis, Lakioti, Pezirkianidis, Karakasidou, & Stalikas, 2017). Pittsburgh Sleep Quality Index (PSQI) is an effective instrument used to measure the quality and patterns of sleep in adults. It differentiates "poor" from "good" sleep quality by measuring seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month. The global PSQI score > 5 yielded a diagnostic sensitivity of 89.6% and specificity of 86.5% (kappa = 0.75, $p \leqslant 0.001$) in distinguishing good and poor sleepers (Buysse et al., 1989).

Data collection and analysis

A set of online questionnaires were distributed via smartphone applications (e.g. Facebook, Wechat etc.) and several online communities specially tailored to sports and physical activities (e.g. fitness and lifestyle.co.uk, freeads.co.uk, quertime.com etc.). All the participants were provided a written consent at the first page of the questionnaire before taking part in the

study, and only by accepting the consent, the participants were allowed to complete the questionnaire. The consent letter appears at the first page of the questionnaire to inform the participants the terms and conditions to answer the questionnaire as well as the ethical permission. By clicking ”YES”, the participants were able to continue with the questionnaires. Data were collected in April and May 2018. Responses were excluded or partially excluded for the following reasons: 1) repeated responses; 2) abnormal responses(outliers).

4.3.3 Statistical analysis

We used SPSS 24 software (Chicago, IBM) to do the statistical analysis. In the present study, descriptive analysis was used to show the prevalence of physical activity volume, stress, life satisfaction and sleep quality. Independent t-test and one-way ANOVA was used to examine the gender difference of physical activity, stress, life satisfaction and sleep quality. Independent t-test was also used to examine stress, life satisfaction and sleep quality in sedentary (exercise more than 150 minutes per week) and non-sedentary groups (exercise less than 150 minutes per week). In order to test the correlations between physical activity, stress, life satisfaction and sleep quality, bivariate correlation was performed followed by linear regression analysis. At last, the relationship between physical activity and sleep quality in different age groups was tested by scatter analysis.

4.4 RESULTS

The participants’ mean age were at the end of their twenties at males (M=29.12, SD=7.72) and females (M=28.73, SD=7.47). In addition, the number of married or living cohabiting relationship is slightly less than the number of single participants for men 35/106(33%) and women 74/186(40%). The number of people who work and study were approximately the equal in the current study (men: 50/106(49%), women: 85/186(46%)). Approximately seven out of ten participants had physical activity less than 150 minutes per week with physical exercise volume M=112.02 (SD=129.66) minutes per week. It is statistically significant that males (M=146.37, SD=155.52) do more exercise than females (M=93.85, SD=109.84) per week ($p<.001$). In addition, a majority of people (69.9%) suffering moderate stress, small amount of people (5.5%) were in high perceived stress, and low percentage (24.7%) of people reported low stress. Females (M=17.71, SD=6.06) present much severer perceived stress than males (M=16.42, SD=5.70). The results showed that, males

(M=4.62, SD=1.48) were more satisfying with life than females (M=4.53, SD=1.69). The mean score of PSQI for male is 5.70 (SD=3.21) and female is 5.13(SD=3.08) with more good sleepers (60.3%) than bad sleepers (30.7%) in the sample. Table 6 shows the demographic characters of the participants.

Table 6 Demographic characters of the participants

Measures	Men	Women
Number of participants (n)	106	186
Age (M±SD)	29.12±7.72	28.73±7.47
Married or living in cohabiting relationship (n)	35/106(33%)	74/186(40%)
Workers (n)	50/106(49%)	85/186(46%)
Physical activity (minutes, M±SD)*	146.37±155.52	93.85±109.84
Perceived stress (M±SD)	16.42±5.70	17.71±6.06
Life satisfaction (M±SD)	4.62±1.48	4.53±1.69
Sleep quality (PSQI score, M±SD)	5.70±3.21	5.13±3.08

*Note: Men and women differed statistically significantly in physical activity volume($p<.001$), men do more physical activity than women.

To test the associations of physical activity, stress, life satisfaction and sleep quality, bivariate correlation analyses were conducted followed by linear regression, the results were presented in Table 7 and Table 8. Stress and life satisfaction are correlated with each other with statistical significance ($p<.001$), and both stress($p<.001$) and life satisfaction ($p<.05$) are significantly correlated with sleep quality. According to the results of linear regression, only stress was statistically negatively associated with sleep quality with a relatively high predictive power ($p<.001$, SE=.03, B=.43), life satisfaction did not show predictive power (Beta=.009) with sleep quality. Physical activity did not show any significance with sleep quality ($p>.05$) in statistical analysis.

Table 7 The correlations between physical activity volume, stress, life satisfaction and sleep quality by bivariate correlation analysis

	Physical activity	Stress	Life satisfaction	Sleep quality

Physical activity	Pearson Correlation	1			
	Sig. (2-tailed)				
Stress	Pearson Correlation	-.07	1		
	Sig. (2-tailed)	.27			
Life satisfaction	Pearson Correlation	.10	-.34**	1	
	Sig. (2-tailed)	.09	.00		
Sleep quality	Pearson Correlation	-.01	.26**	-.14*	1
	Sig. (2-tailed)	.9	.00	.01	

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Table 8 The associations between physical activity volume, stress, life satisfaction and sleep quality by linear regression.

Model	Unstandardized coefficients		Standardized coefficients			95% Confidence interval for β	
	B	Std. Error	Beta	t	Sig.	Lower bound	Upper bound
Physical volume	.000	.001	.009	.165	.869	-.002	.003
Stress	.228	.033	.436	6.944	.000	.164	.293
Life satisfaction	-.026	.031	-.052	-.827	.409	-.087	.035

Table 9 illustrated whether there is difference in life satisfaction/perceived stress/sleep quality between people who do exercise and who do not by using independent t-test analysis. We define people who do not do physical activity as sedentary group, people who do physical activity as non-sedentary group (exercise volume more than 150 minutes per week). Life satisfaction (p= .02, Cohen's d=.48) and perceived stress (p= .04, Cohen's d= -.27) are significantly different between people who do physical activity and who do not. No significant association was found in sleep quality between sedentary lifestyle and non-sedentary lifestyle(p>0.05, Cohen's d= -.12).

Table 9 The difference of life satisfaction/perceived stress/sleep quality between people who live in sedentary and non-sedentary life status by independent t-test.

	Non-sedentary group (n=76)		Sedentary group (n=186)		Sig.	95%CI		Effect size (Cohen's d)
Variables	M	SD	M	SD		Lower	Upper	
Life satisfaction	4.77	1.57	4.22	1.65	.02	-.98	-.11	.48
Perceived stress	1.74	.52	1.88	.51	.04	.01	.28	-.27
Sleep quality	1.37	.48	1.43	.50	.41	-.08	.19	-.12

No association was found between general physical activity and sleep quality as mentioned above, thus, the association between physical activity and sleep quality in different age groups (young: 18-28 years old, middle: 29-39 years old, old: above 40 years old.) was investigated by scatter analysis as an additional analysis. Figure 14 showed that with the increase of physical activity volume, there is almost no change in sleep quality in young age populations (Linear=.001). Nevertheless, middle aged population (Linear=.016) and old population (Linear=.034) showed stronger effect between physical activity and sleep quality.

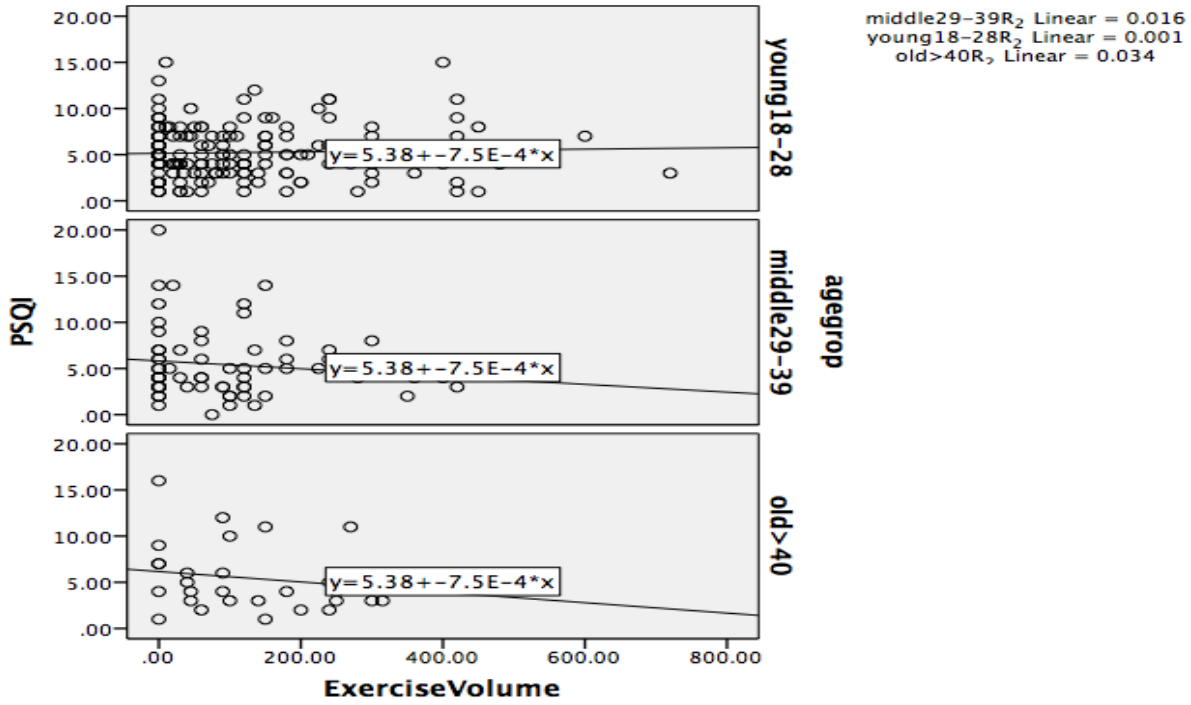

Figure 14 Correlation between physical activity and sleep quality in different age groups

4.5 DISCUSSION

This cross-sectional study unfolded the relationship between physical activity, stress, life satisfaction and sleep quality with considering the demographic characters. Gender difference in physical exercise is significant, males do more exercise than women. However, there is a study demonstrated that the magnitudes of gender difference in physical activity is moderate (Trost et al., 2002). The reason of the gender difference may due to the different physical activity motivations (Kilpatrick, Hebert, & Bartholomew, 2005). Even though there is no statistically significant gender difference in stress and life satisfaction between men and women, women live in more stressful life status than male, moreover, women showed less satisfaction with life compared with men. Our result supported the previous study that life satisfaction is gender independent with marginal exceptions and having no partner implies for relatively low level of satisfaction (Fugl-Meyer, Melin, & Fugl-Meyer, 2002).

Previous study elaborated the effect of stress in predicting life satisfaction showed that high perceived stress predicts low satisfaction (Extremera, Durán, & Rey, 2009). In addition, perceived stress was found to be a good predictor of life satisfaction for young adults (Hamarat Karen M. Zabrucky, Don Steele, Kenneth B. Matheny, Ferda Aysan, Errol, 2001). In the present study, we found that stress and life satisfaction are closely correlated, and the predictive effect to sleep quality is different. Bivariate correlation showed that stress predicted stronger predictive power on sleep quality than life satisfaction. The evidence from linear regression showed that only stress is significantly associated with sleep quality. However, in PSQI scale, there are seven components of sleep quality, stress influences different aspects of sleep quality (Fortunato & Harsh, 2006).

The stress status and life satisfaction are different between people who do physical exercise and who do not do physical exercise, but there is no difference in sleep quality, no positive result was found in the association between physical activity and sleep quality in our study. We did not take into the people who do physical exercise less than 150 minutes per week when categorizing the sedentary group in statistical analysis, which strengthened the statistical accuracy in data analysis. Our resulted supported the previous study which revealed that there is no correlation between sleep and daily activities in normal sleepers (Sexton-Radek & Pichler-Mowry, 2011; Youngstedt et al., 2003).

Nevertheless, even though the correlation was not significant between physical activity and sleep quality, we found that age played an important role as a mediator of the relationship between sleep quality and physical activity. With the increasing of age, the relationship between

physical activity and sleep quality becomes stronger and correlation between them becomes tighter. Prior research on older adults has mainly focused on investigating whether increasing levels of physical activity leads to improvements in sleep quality. Current researches only proved that physical exercise interventions launched among older adults showed more positive effects on improving sleep quality than young adults (Benloucif et al., 2004; Holfeld & Ruthig, 2014). While, no study has examined the correlation between physical activity and sleep quality by the increase of age. Social rhythms (e.g. getting into or out of bed, eating, and adhering to a work schedule) have important implications for sleep among young adults rather than physical activity (Carney, Edinger, Meyer, Lindman, & Istre, 2006).

4.6 CONCLUSIONS

The associations between physical activity, stress, life satisfaction and sleep quality have been discussed in different communities, the outcomes varied due to age, gender etc.. The investigation on daily physical activity rather than organized exercise is lack of effort. This paper addressed the associations between physical activity, stress, life satisfaction and sleep quality as well as putting demographic factors (e.g. gender, age etc.) into consideration. In the general population, no association was found between daily physical activity and sleep quality, whereas, we found that the association between physical activity and sleep quality becomes intense with age increasing. Despite new efforts to explore the health effectiveness of physical activity, more research is needed to develop new exercise methods which will benefit in improving sleep quality and decrease the number of poor sleepers.

4.6.1 Limitations

Although this study was fully prepared, there were unavoidable limitations. Firstly, the number of voluntary samples is small, which may be the obstacle in finding a meaningful relationship between physical activity and sleep quality. Secondly, the actual amount of physical activity was not clearly controlled in the questionnaire. Self-reported data in physical exercise can contain several potential sources of bias, which rarely be independently verified.

4.7 IMPLICATIONS FOR STUDY 2

The goal of the current dissertation was to explore the interaction between physical activity and sleep quality, stress and life satisfaction with the aim of exploring the implementable health promotion strategies. The dissertation adopted a mixed-research methodology by including both cross-sectional and experimental studies. The survey study (Study 1) was conducted to determine the association between physical activity and sleep quality, stress and life satisfaction, then the empirical research (Study 2) was carried out to examine the effectiveness of a designated goal-setting walking exercise to answer the issues that were not covered by the cross-sectional survey study. The main implications of the survey study (Study 1) for the empirical research (Study 2) were the following:

- Study 1 showed the context of physical activity and stress, life satisfaction and sleep quality and the association between indicated that attention should be paid to age and gender. Demographic indicators and lifestyle habits are important in physical exercise research. Therefore, Study 2 was conducted by selecting participants with similar demographic features and lifestyle habits.
- Study 1 showed that moderate stress is prevalent among general adults and was significantly correlated with sleep quality. Even though the results in Study 1 did not show correlation between sleep quality and physical activity, it was suggested to take into consideration about age when discussing the mechanism between physical activity and sleep quality. Therefore, Study 2 conducted an in-depth exploration of stress, sleep and physical exercise.
- Study 1 showed that a sedentary lifestyle is not beneficial for life satisfaction, and people who carry on a sedentary lifestyle are more easily stressed. Study 1 suggested to explore specific physical activity types that can be beneficial for stress, sleep and life satisfaction. Therefore, Study 2 designed a goal-setting walking program to prevent sedentary lifestyle and seeking for its benefits on stress, sleep and life satisfaction.
- Finally, Study 1 highlighted the necessity of promoting physical exercise levels among adults and unfolded several research issues in health promotion interventions. Therefore, Study 2 was designed to explore further the physical exercise intervention process and its benefits to provide more explicit evidence in physical exercise intervention.

The next Chapter 5 will present the invention study (Study 2) which was conducted with young adults to explore the interaction between walking physical exercise and stress, sleep and

life satisfaction. Thus, to extend the research findings and adopt the suggestions on physical exercise based health promotion.

CHAPTER 5 WALKING INTERVENTION ON SLEEP QUALITY, STRESS AND LIFE SATISFACTION (Study 2)

Note: The manuscript is accepted by American Journal of Health Education, which is awaiting the production list when submitting this dissertation. For this reason, the accepted version of the article is presented in this dissertation.

Wang, F., & Boros, S. (2021). Aerobic Walking Exercise and Lifestyle Habits interact with Sleep Quality, Stress and Life Satisfaction: Results from a Randomized Crossover study. American Journal of Health Education. The article can be found via the permanent link: https://doi.org/10.1080/19325037.2021.1877219

5.1 ABSTRACT

Background: Physical exercise is supposed to interact with sleep quality, stress and life satisfaction. Purpose: The current study aimed to examine the effectiveness of regular aerobic walking on sleep quality, stress and life satisfaction and to explore the associations between lifestyle habits and sleep quality, stress and life satisfaction. Methods: A 12-week randomized crossover study with 54 participants was conducted. Results: Sleep quality (p=.002, r=-.46), stress (p=.007, r =-.38) and life satisfaction (p=.003, r=-.42) showed favorable changes in the intervention group and only life satisfaction increased in the control group (p=.003, r=-.43). Alcohol consumption showed positive correlation with sleep quality ($p < 0.05$). Males and females did not differ regarding sleep quality, stress and life satisfaction (p> .05). Discussion: The improvement of sleep quality, stress and life satisfaction was significant in the intervention group, although changes in control group did not indicate big differences. Translation to Health Education Practice: The observation of this study may be an appeal that when physical exercise is expected to improve life functions and daily activity, regularity and continuity of exercise should be emphasized.

Keywords: walking; physical exercise; sleep; life satisfaction; crossover intervention

5.2 INTRODUCTION

Epidemiological studies showed that exercise is perceived to be helpful in promoting sleep (O'Connor & Youngstedt, 1995). With the increase in sleep disorders, several research paradigms have been used to examine the effect of exercise on sleep (Santos, Tufik, & De Mello, 2007). Exercise is widely believed to have large effects on sleep due to the traditional hypotheses that sleep serves energy conservation, thermoregulatory functions, or body restoration (Driver & Taylor, 2000). Sleep physiology underlined the mechanism(s) between sleep and exercise (Dolezal, Neufeld, Boland, Martin, & Cooper, 2017). Exercise intensity may also play a role in the efficacy of exercise-associated sleep promotion, further, regular physical activity (PA) is supposed to be more useful in improving sleep quality than acute exercise from the standpoint of public health promotion (Faulkner & Taylor, 2005).

Physical exercise is predicted to generate intermediate effects between well-being and stress (Wunsch, Kasten, & Fuchs, 2017). Exercise can be beneficial to general well-being, but it is necessary to choose proper volume and intensity (Santos et al., 2007). Empirical evidence demonstrated that regular exercise is purported to relieve stress because exercise protects against the negative emotional consequences of stress (Childs & de Wit, 2014). Furthermore, specific types and dosages of exercise are reported to be associated with mood benefits, self-esteem, and stress activity (Berger, 1994). Given the present evidence, there are conceptual issues related to using exercise as a stress-management tool.

Life satisfaction can be influenced by health, physical activity, socioeconomic variables and the amount of PA are important variables related to life satisfaction (Palmore & Luikart, 1972). In addition, life satisfaction is considered as one indicator of well-being, and PA is considered as a valuable tool to produce important consequences for daily well-being (Maher et al., 2013). Physical exercise should be implemented in national policies to enhance life satisfaction; however, the association between physical activity and life satisfaction appears to involve age and exercise level in enhancing life satisfaction dynamics when trying to bring physical exercise intervention strategies into effect (Maher et al., 2015).

The impact of aerobic exercise and sleep quality on chronic disease has been documented, including osteoarthritis (Kujala, 2009), pain symptoms (Johansen, 2005; Kurella, Luan, Lash, & Chertow, 2005), chronic kidney disease etc. and stress is assigned a causal role in disease pathogenesis (Moylan & Reid, 2007). Other conditions such as obesity, arthritis, diabetes, lung diseases, stroke and osteoporosis are associated with other sleep-related problems such as breathing pauses, snoring, daytime sleepiness, restless legs or insufficient sleep (<6 h

nightly) (Foley et al., 2004). Evidence on the effects of exercise supports that aerobic/functional capacity and muscle strength can be improved by exercise training among patients with chronic diseases. Furthermore, psychological health and health behaviors are valuable elements of comprehensive chronic disease management strategies (Brady et al., 2013).

Sleep, stress and life satisfaction are associated with the interaction with physical exercise; thus, it is feasible and practical to examine physical interventions for health promotion. Despite the influence of age on physical exercise intervention to promote health physically and mentally, potential factors such as sex and lifestyle habits (e.g., alcohol and caffeine consumption, smoking, etc.) may also influence the efficacy of exercise (Feige et al., 2006). Therefore, health-promoting exercises for adults need to be established empirically by considering influential factors to provide supplemental physiological evidence. With the existing evidence discoursed, this study aimed to 1) examine the effectiveness of an aerobic daily walking exercise on sleep quality, stress and life satisfaction; 2) explore the potential social factors that may be associated with sleep quality, stress and life satisfaction. Based on previous reports, we hypothesize that regular exercise exhibits beneficial outcomes regarding to sleep quality, stress and life satisfaction.

5.3 METHODS

5.3.1 Study design

This crossover study was conducted between March and May 2019 to investigate regular aerobic walking exercise. A crossover study design is generally restricted to the study of short-term outcomes in clinical diseases or pharmacological processes. In theory, intervention effects can be estimated with greater precision given the same number of participants (Sibbald & Roberts, 1998). This study was approved by the university ethics committee (registration code: 2018/421). This study was registered at ClinicalTrails.gov (Identifier: NCT04427696).

5.3.2 Participants

Research volunteers were recruited in Budapest, Hungary. Online and offline advertisements were used to recruit volunteers. The selection criteria included age between 18

and 60 years old. The volunteers were interviewed with questions (e.g., 1. Do you participate in any kind of regular exercise programs (e.g., weight-lifting, walking, running, swimming etc.)? 2. Are you involved in any physical or sport teams?) through textual (e.g., messenger communications) or verbal (e.g. WhatsApp interviews) conversations. Of 60 volunteers contacted, a total of 54 volunteers were eligible to participate in this study. Participants were aged 19 to 36 years old (24.28±4.55) and were not involved in any regular physical activity programs. Participants were randomly assigned to intervention and control group (intervention, n=27; control, n=27).

Participants received incentives for participation. Participants who were students at Eötvös Loránd University could obtain 2 elective credits by completing the study. Participants who were not students at Eötvös Loránd University were provided voucher for a free Yoga course. All participants who completed the intervention were eligible to win a mountain bike; the winner was chosen by drawing names from a bowl.

5.3.3 Measurements

Daily walking activity was tracked by an Omron HJ-112 pedometer, which provides valid step counts (Hasson, Haller, Pober, Staudenmayer, & Freedson, 2009). The pedometer can record aerobic steps, total steps, calorie expenses, miles and time (Omron Instruction Manual). The aerobic steps were counted when walking more than 60 steps per minute and more than 10 minutes continuously. A break of less than 1 minute during a continuous walk of more than 10 minutes was regarded as part of the continuous walk. Our study required one-hour of continuous aerobic walking as a PA intervention.

Sleep quality, stress status and life satisfaction were assessed pre- and post-intervention (i.e., first and third session). Sleep quality was measured by Pittsburgh Sleep Quality Index (PSQI), which includes 7 sleep components (i.e., sleep duration, sleep disturbance, sleep latency, daytime dysfunction due to sleepiness, sleep efficiency, overall sleep quality, and sleep medication use) for the past month (Buysse et al., 1989). The PSQI shows good convergent and divergent validity and moderate reliability among young people (Cronbach's alpha = .72) (de la Vega et al., 2015).

Perceived stress was assessed by four questions from the Perceived Stress Scale (PSS-4): 1. In the last month, how often have you felt that you were unable to control the important things in your life? 2. In the last month, how often have you felt confident about your ability to handle your personal problems? 3. In the last month, how often have you felt that things were

going your way? 4. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?) responded with Likert score from 0 to 4, where 0 indicates never and 4 indicates often (Cohen et al., 1983). The PSS-4 was found to have acceptable psychometric properties in an English sample (n = 1568) and the PSS-4 has been confirmed to provide a reliable measure of global perceptions of stress (Warttig, Forshaw, South, & White, 2013).

The Satisfaction With Life Scale (SWLS) is a 5-item scale designed to measure one's cognitive judgments about life satisfaction (Diener et al., 1985). The responses range from 1 to 7, and a summary score of the 5 items indicates how satisfied the respondent is with his or her life, where a higher score indicates better life satisfaction. The SWLS is recommended as a complement scale with a focus on psychopathology or emotional well-being. In addition, it has also shown good convergent validity and discriminant validity in relation to emotional well-being (Pavot & Diener, 2009).

Data on alcohol consumption, smoking habits, sex, bodyweight, and height were collected at the baseline of the intervention. Self-administrated questions were used to assess related variables.

5.3.4 Procedure

The intervention lasted for 12 weeks and was split into 3 sessions (4 weeks for each session): 4 weeks of the intervention followed by a 4-week wash period and a 4-week control period. Participants in the control group maintained their lifestyle without any change in the first and second session, and the third session included 4 weeks of intervention. Figure 15 shows the allocation process; the figures does not show the final enrolled number of participants enrolled but shows the procedures of the intervention process. The reporting model of the intervention process was based on the Consolidated Standards of Reporting Trials (CONSORT) statement (Dwan, Li, Altman, & Elbourne, 2019) and partially adapted from Marchetti's paradigm for reporting crossover interventions (Marchetti et al., 2011).

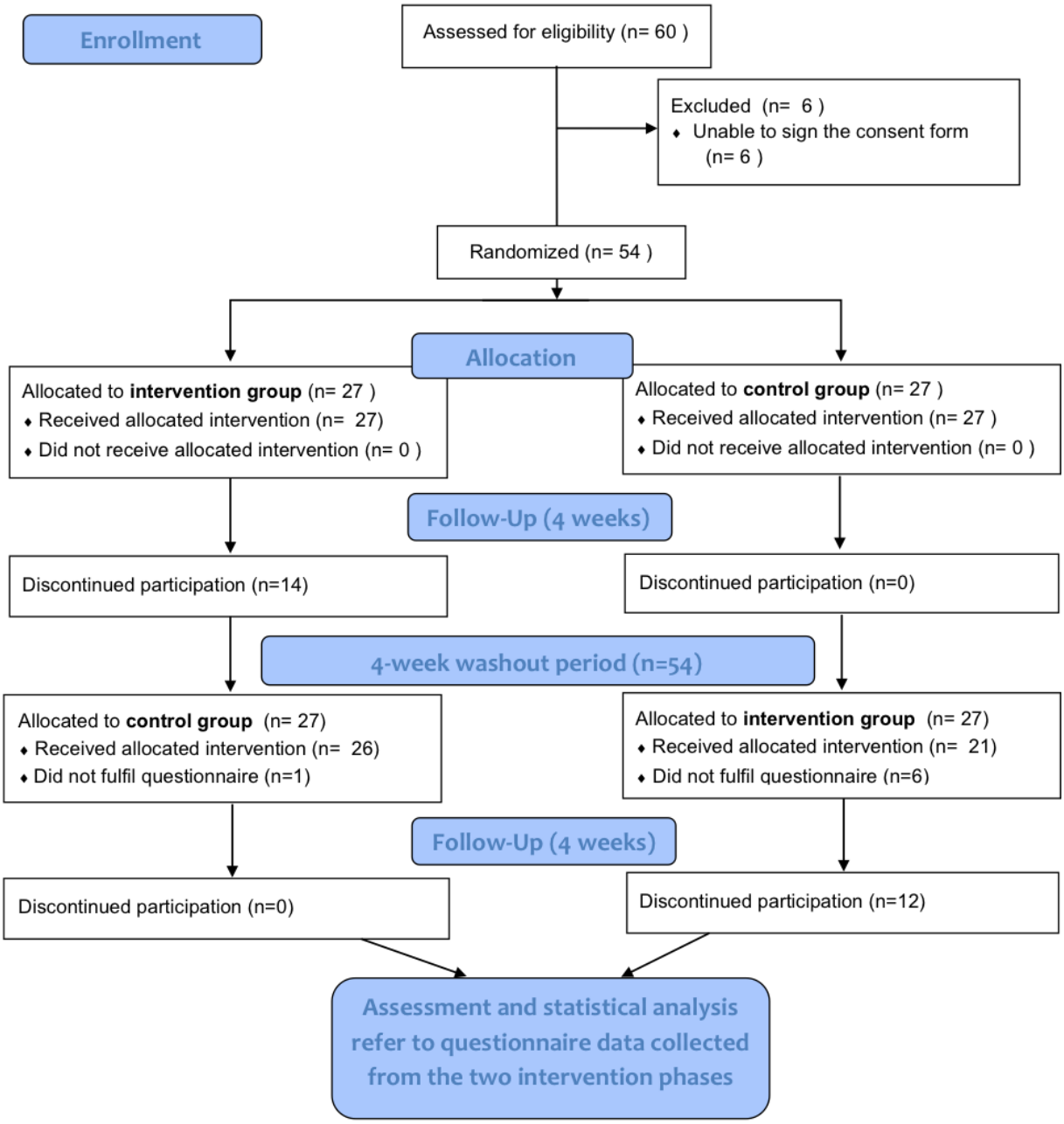

Figure 15 The intervention process of the randomized cross-over trial

One researcher was responsible for collecting the everyday walking data from the participants in the active aerobic walking exercise. All the participants were asked to keep a dairy to record the parameters of their walking activity from the pedometer. Participants could perform the walking activity indoors or outdoors.

5.3.5 Data and statistical analysis

We used Wilcoxon Signe-Rank Tests to compare the intervention and control groups in terms of sleep quality, stress status, and life satisfaction to examine whether the aerobic walking intervention had an effect on these variables. In addition, after calculating the differences in sleep quality, stress and life satisfaction between pre- and post-intervention, the Mann-Whitney U test was used to compare the magnitude of changes (delta scores) between the intervention and control groups. We examined the correlations of age, BMI, coffee consumption, alcohol consumption, and smoking with changes in sleep quality, stress status and life satisfaction as well as changes in the main variables by sex. Statistical analyses were performed using SPSS version 24 (IBM). In all analysis, the level of significance was set at $p<0.05$.

5.4 RESULTS

Results were analyzed using nonparametric tests for two reasons: (a) the assumption of normality was violated in the data and (b) the sample size was relatively low as based on the design sample size calculation with G* Power software (Faul, Erdfelder, Lang, & Buchner, 2007). To test the hypothesis that the walking intervention had an effect on the dependent measures, Wilcoxon Signed-Rank tests were used separately for the control- and intervention group. The results are summarized in Table 10. As seen in Table 10, all measures changes were statistically significantly positive in the intervention group, but only life satisfaction increased in the control group.

Table 10 Results of the Wilcoxon Signed Rank Tests testing the changes over one month in the Intervention- (walking) and Control group (no walking).

Group	Measure	Time	N	M (SD)	*Z*	*p*	*r*
Intervention	PSQI	Pre-	22	5.27 (3.01)	-3.08	.002	-.46
		Post-	22	3.59 (2.30)			
	LS	Pre-	22	25.4 (5.6)	-2.93	.003	-.42
		Post-	27	28.3 (5.76)			
	PSS	Pre-	22	6.77 (2.78)	-2.68	.007	-.38
		Post-	27	5.52 (2.42)			
Control	PSQI	Pre-	24	5.12 (2.98)	-1.47		-0.21

		Post-	25	4.56 (2.38)		.141 (NS)	
	LS	Pre-	22	23.9 (6.36)	-2.94	.003	-.43
		Post-	24	27.0 (5.35)			
	PSS	Pre-	24	6.0 (2.70)	-.652	.051	-0.94
		Post-	24	6.17 (2.35)		(NS)	

Note: Dependent measures are: PSQI = Pittsburgh Sleep Quality Index; LS = Life Satisfaction; PSS = Perceived Stress. The effect size (r) is indicated in the last (far right) column. NS = Not Significant.

Subsequently, we calculated the change (delta) scores by subtracting the second measurement (after one month / after intervention) from the baseline, or the initial measures obtained at the start of the study. These changes, or delta scores reflect the magnitude of changes that were reported in the three dependent measures. These were compared between the intervention and the control group. There were no statistically significant differences in any of the three measures between the two groups. The results are summarized in Table 11.

Table 11 Mann and Whitney U test comparing the magnitude of changes (delta scores) in three dependent measures between the intervention and control group.

	Group	N	Mean Rank	*Z*	p	η^2
Delta PSQI	Control	22	25.32	-1.47	.141 (NS)	0.005
	Intervention	22	19.68			
Delta Life Satisfaction	Control	21	22.98	-.500	.617 (NS)	0.006
	Intervention	22	21.07			
Delta Perceived Stress	Control	21	25.74	-1.931	.054	0.08
	Intervention	22	18.43			

Note: η^2= effect size

We also examined the correlations between the change scores. We found a statistically significant ($p < 0.05$) correlation between delta SPQI and change in perceived stress. Alcohol consumption showed a positive correlation ($p < 0.05$) with the PSQI (see Table 12).

Table 12 Means, Standard deviations and Spearman correlation matrix of measured variables (N = 54)

Variables		Mean	SD	2	3	4	5	6	7	8
1	Age	24.28	4.55	-.142	.107	-.053	-.176	-.153	-.003	-.172
2	BMI	22.39	3.06	1.00	-.103	.190	.281*	.021	-.180	-.055
3	Coffee	1.53	0.87		1.00	.303*	.150	-.063	-.102	-.039
4	Alcohol	2.03	0.99			1.00	.062	.319*	-.257	.158
5	Smoking	1.57	1.16				1.00	.007	-.059	.092
6	Delta PSQI	-1.31	2.49					1.00	.021	.330*
7	Delta LS	3.30	4.37						1.00	.145
8	Delta PS	-1.00	2.34							1.00

Note: *Correlation is significant at the 0.05 level (2-tailed). PSQI = Pittsburgh Sleep Quality Index; LS = Life Satisfaction; PS = Perceived Stress

Finally, to assess whether the observed statistically significant differences could be due to sex effect, we performed Mann-Whitney U tests to compare the magnitude of changes during the one-month interval between men and women. These results revealed that there were statistically no significant differences between sexes in term of sleep quality, stress and life satisfaction (Table 13).

Table 13 Comparison of sleep quality, life satisfaction and perceived stress between males and females

	gender	N	Mean Rank	*Z*	p	η^2
Delta PSQI	male	7	15.43	-1.956	.051	0.182
	female	15	9.67			
Delta Life	male	7	12.07	-.562	.57	0.016
Satisfaction	female	14	10.46			
Delta	male	7	10.79	-.114	.909	0.001
Perceived	female	14	11.11			
Stress						

Note: Grouping Variable: gender; η^2= effect size

5.5 DISCUSSION

This crossover intervention study investigated the effects of aerobic walking in young adults who were not engaged in regular physical exercise habits. Three key variables (i.e. sleep quality, stress and life satisfaction) were tested before and after the aerobic walking intervention. The improvements of sleep quality, stress and life satisfaction were significant in the intervention group, whereas, there were no significant changes in the control group. In addition, correlated life habits (e.g., BMI, coffee intake and alcohol consumption) showed a significant influence on the behavioral intervention. At present, regular aerobic walking is supposed to contribute to health promotion and improve quality of life. The observations in this study suggest that regularity and continuity of exercise should be emphasized in PA interventions.

The pre-post comparison indicated that regular aerobic walking exercise showed beneficial outcomes in improving sleep quality, stress and life satisfaction. However, no difference was found when establishing between-group comparison of the intervention and control groups. There are several possible reasons: On one hand, one-hour aerobic walking might be helpful in improving sleep, stress and life satisfaction among healthy adults. However, sleep quality was not an inclusion criterion in this study. Therefore, participants could experience minor sleep complaints due to alcohol consumption (Kenney, LaBrie, Hummer, & Pham, 2012). Daily alcoholic beverage consumption may be a moderator between anxiety and sleep quality, and people who sleep poorly should avoid misusing alcohol (Chueh, Guilleminault, & Chia-Mo, 2019). Nevertheless, the selection of volunteers was not geared toward those who suffer from sleep disorders but was focused on the general population. On the other hand, influential factors (e.g., lifestyle, behaviors) cannot be neglected when evaluating people's perspectives on health and life. Lifestyle behavior interventions may interact daily life with short-term effects.

Walking is broadly believed to have positive effects on public health (Cook et al., 2019; Nordh, Vistad, Skår, Wold, & Bærum, 2017). Moderate physical exercise, compared to vigorous physical exercise, is a priority for the general population (Lee & Paffenbarger Jr, 2000). However, the intensity of walking as well as moderate or vigorous intensity physical interventions should be feasible and manageable. For example, there was a study supported 30 minutes as the target duration of activity (Lee & Buchner, 2008). Another study suggested that a target of 10,000 steps per day is important for good health (Wilde, Sidman, & Corbin, 2001). It is hard to estimate the intensity of walking from duration and step counts. Thus, there is a need to define walking requirements to facilitate public health education and communication,

and quantifications of the exercise volume should be clarified when conducting public health intervention studies.

Walking at a standardized pace appears to be suitable for estimating physical function and deterioration due to chronic disease. There is no consensus regarding optimal walking requirements such as walking distance, instructed pace and stride (Kim, Park, joo Lee, & Lee, 2016). A previous study reported that clinical assessments of walking velocity have not been conducted uniformly and common methodologic factors might influence the clinical interpretation of walking performances (Graham, Ostir, Kuo, Fisher, & Ottenbacher, 2008). Though walking interventions have been examined against physical function, measures of general health, body composition and chronic diseases, the results of current study provide a valid walking strategy including walking distance and walking pace for adults to promote health.

Limitations of this study include the use of pedometers to track daily participation data, and there was not potential pedometer effect in which pedometers could act as an external motivation to exercise (Tully, Cupples, Chan, McGlade, & Young, 2005). The study had a relatively high drop off rate, not uncommon in physical intervention studies, which may impact the efficacy of the intervention. Reasons for dropout include: 1) Maintaining regular physical exercise as a daily habit is not easy, 2) Weather conditions need to be considered when conducting long-term outdoor interventions, and 3) Physical exercise motivations and the consistency of participation should be addressed during intervention period.

5.6 TRANSLATION TO HEALTH EDUCATION PRACTICE

Physical interventions to promote health have been widely examined. Quantified aerobic walking might be an important and easy way to maintain good health due to its feasibility and effectiveness. Pedometers are recommended for tracking walking activities from this perspective. The findings in this study highlighted a standardized recommendation of walking that has implications for the public. Wearable devices are recommended but may not provide a positive motivation for young adults (Kerner & Goodyear, 2017). Health educators and policymakers should emphasize the importance of maintaining regular physical exercise to prevent chronic diseases.

The findings of the present study apply to several areas of responsibility and competencies for health education specialist practices (HESPA II 2020) (National Commission for Health Education Credentialing. Areas of Responsibility, 2020), including the following

1.3.1 Determine the health status of the priority population(s).

1.3.2 Determine the knowledge, attitudes, beliefs, skills, and behaviors that impact the health and health literacy of the priority population(s).

1.4.2 Prioritize health education and promotion needs.

3.2.4 Deliver health education and promotion interventions.

3.3.1 Monitor progress in accordance with the timeline.

3.3.2 Assess progress in achieving objectives.

4.4.5 Identify implications for practice.

4.5.4 Translate findings into practice and interventions.

7.4.4 Justify value of health education and promotion using economics (e.g., cost-benefit, return-on-investment, and value-on-investment) and/or other analyses.

To facilitate sleep health and mental health in young adults, practical healthy lifestyle guidance should be provided. Health educators and policymakers should work together to prevent diseases and promote health by formulating healthy life habits at a young age. Evidence supports that a healthy lifestyle reduces rates of cardiovascular disease and mortality (King, Mainous III, & Geesey, 2007). Health educators should promote healthy life habits, including less smoking, less drinking, more exercise etc., among the general population.

Though physical exercise is recognized as a feasible treatment for chronic diseases and clinical symptoms, the motivation to exercise varies between individuals (Stubbs et al., 2016). Physical interventions should work on the motivational strategies aimed to increase compliance before implementing any types of physical exercise. Qualified professionals (e.g., physical therapists/exercise physiologists) should prescribe supervised physical activity especially for those who needs specific training (e.g., patients with chronic diseases) to obtain sound intervention outcomes. Future studies are suggested to examine the psycho-physiological mechanisms between walking exercise and health indicators.

Acknowledgments: Thanks to all of the research volunteers who devoted their time to support the study. Thanks to my colleague Darma Juwono, who helped with daily data recording in the first phase of the intervention.

Disclosure statement: No potential conflict of interest was reported by the authors.

5.7 IMPLICATIONS FOR STUDY 3

Study 2 examined the effectiveness of goal-setting-based aerobic walking exercise on sleep quality, stress and life satisfaction and explored the associations between lifestyle habits and sleep quality, stress and life satisfaction. The empirical research (Study 2) comprehensively responded to the research questions from Study 1. However, there was a lack of qualitative evidence on the effectiveness of aerobic walking exercise on stress, sleep quality and life satisfaction. An interview study (Study 3) was conducted to provide additional evidence on participants' feedbacks on walking intervention. Detailed implications of the walking exercise intervention study (Study 2) for the subsequent interview study (Study 3) were the following:

- Study 2 showed an expected trend of walking exercise intervention in stress, sleep quality and life satisfaction, which indicated that walking exercise was an effective strategy among young adults. However, there were a number of participants dropped out from the intervention study, therefore, Study 3 conducted an interview study to provide better understanding of the walking intervention with the research participants.
- Study 2 compared the changes between the intervention group and the control group. Although favourable changes in the intervention group were found, the life satisfaction in the control group was also improved. Therefore, one purpose of Study 3 was to understand how life satisfaction was perceived during the intervention period of the participants.
- Study 2 appealed that when physical exercise is expected to improve life functions and daily activity, regularity and continuity of exercise should be emphasized. A follow-up of the participants would provide better evidence in understanding the regularity and continuity of the walking exercise. Therefore, Study 3 was conducted to get further feedback from the participants on whether they continued the walking exercise.
- Study 2 implemented the aerobic walking exercise intervention by organizing a walking research program, which was orientated, regulated, structured and supervised. Further understanding of habit formulation in physical exercise should be explained. Therefore, Study 3 was conducted to seek for reasons and hinderers of fostering physical exercise habits.
- Finally, Study 2 collected data by self-reported measures, further investigation on participants' cognitive feedback were needed. Besides, physical exercise interventions are human-being based research, therefore, it is necessary to know about findings from the standpoint of the participants.

The next Chapter 6 will present an interview study (Study 3) conducted with the research participants in Study 2 to look for cognitive feedback and analyze the potential possibilities in physical exercise intervention. The long-term effectiveness of walking exercise was not discussed in Study 2; Study 3 provides supplementary data on this issue. Nevertheless, Study 3 interviewed participants who completed intervention requirements and explored the cognitive feedback from the participants.

CHAPTER 6 QUALITATIVE ANALYSIS OF THE OUTCOMES OF WALKING INTERVENTION (Study 3)

Note: This article has been accepted for publication by Hungarian Review of Sport Science and the final published version is presented in this dissertation.

Wang, F., & Boros, S. (2021). Walking: a moving meditation for sleep, stress and life satisfaction - a qualitative study. Hungarian Review of Sport Science, 22(89), 57-64. The doi number is not yet availble when submitting the dissertation.

6.1 ABSTRACT

Recent researches have investigated walking exercise adequately, but most of the interventions were in self-selected walking mode and lack of post-intervention follow-up. The aim of the study is to explore the cognitive feedbacks from volunteers who participated in a structured 4-week aerobic walking intervention with regards to sleep quality, stress and life satisfaction. Ten participants responded to take part in the individual semi-structured interview. Each interview lasted for 1-1.5 hours long and audio recorded. Content analysis was conducted with the transcribed audio records. Poor sleepers experienced much more significant improvement than good sleepers. The walking exercise under specified requirements revealed "sleep deeper and wake up fresher" phenomenon. Furthermore, aerobic exercise exerted positive emotions which supported stress liberation and life satisfaction. Many participants realized that aerobic walking contributed to meditation effect that benefited concentration and calmness. Further studies are suggested to explore the long term mental, emotional and physical effects of walking,

Keywords: walking intervention; cognitive benefit; health promotion, sleep

6.2 INTRODUCTION

Existing evidence has investigated the mechanism between physical exercise and health including biological, psychological and social factors (Warburton, Nicol, & Bredin, 2006). Even though the role of physical exercise on health improvements from the physiological aspect has been examined by a number of studies (Francescomarino, Sciartilli, Valerio, Baldassarre, & Gallina, 2009; Fairey, Courneya, Field, & Mackey, 2002; Molsted, Eidemak, Sorensen, & Kristensen, 2004). There was a novel research showed that a decrease of physical activity is assumed to be associated with increase of pain and fatigue (Glass et al., 2004). Nevertheless, both laboratorial and sociological studies addressed the impact of moderate physical activity on health promotion (Dawes et al., 2016; van Waart et al., 2015). Knowing the state-of-art research findings, it is important to evaluate experimental physical exercise trials and examine health outputs. Therefore, physical exercise and health outcomes still need deeper and further discussion.

As known, reducing sitting time is essential to reduce cardiological risk factors and walking exercise appears to be effective in interacting with cardiometabolic risk factors, mood, and cognition (Duvivier et al., 2017). Scientific exploration in walking behavior is increasing in recent years and the evidence for walking benefits is growing (Kassavou, Turner, & French, 2013; Lee & Buchner, 2008). To our best knowledge, the examination of health effects of walking focuses mainly on decreasing disease risks (e.g. cardiovascular disease, osteoporosis problems etc.) (Kelly, Murphy, & Mutrie, 2017). However, for healthy adults, increasing physical exercise level and reduce sedentary time is of great importance for public health promotion (Salmon, Tremblay, Marshall, & Hume, 2011). Thus, cognitive benefits of walking seem to be valuable in healthy population. Outdoor walking evokes higher level of meditative effect and cognitive gains compared with indoor walking (Bailey, Allen, Herndon, & Demastus, 2018). Most of the walking interventions were conducted at self-selected pace in a relaxed speed, which are hardly to be standardized. Quantified and structured walking guidance would be helpful in filling the gap (Tudor-Locke, Sisson, Collova, Lee, & Swan, 2005).

Sleep quality, stress and life satisfaction, which are regarded as key health indicators, are closely associated (Wang & Boros, 2019). It was well documented that poor sleep quality is related to higher levels of mental stress due to higher activation of sympathetic nervous system (Huang et al., 2011). Life satisfaction reveals a complicated influence exerted by various factors, such as sociodemographic characteristics, health related characteristics and job-related characteristics as well as quality of sleep (Lee, Lee, Kwon, & Cho, 2011). Current studies found

clear links between physical exercise and sleep together with stress management mentioned above (Park, 2014; Vollert et al., 2011). The evidence of physical exercise on life satisfaction is still unexplained (Cruz-Ferreira et al., 2011). Given the close connections between sleep, stress and life satisfaction, it is of great value to examine a particular physical exercise, e.g. walking, on the interventions in between.

With the emergence of portable exercise, walking was regarded as the most cost-effective one (Gusi, Reyes, Gonzalez-Guerrero, Herrera, & Garcia, 2008). Aerobic walking is a feasible and easy implementable exercise at population level. Aerobic walking can be expressed in walking distance and walking speed. So far, intervention studies have demonstrated walking capacity is positively associated with motor and cognitive functions (Chen, Leys, & Esquenazi, 2013). With regards to the close associations between sleep, stress and life satisfaction, the interacted benefits of walking can be expected in sleep improvement, coping with stress as well as life satisfaction. Therefore, an integrated explanation of physical exercise and health implications is under discovery. Additionally, walking appears to be an accessible exercise among people with a low prevalence of leisure-time physical activity, and the implications and effectiveness of aerobic walking among healthy sedentary young adults needs further exploration (Barkley & Lepp, 2016; Kurti & Dallery, 2013).

Walking interventions have been performed with different groups of participants (Meurisse, Bastien, & Schepens, 2019; Peterson & Martin, 2010), whereas, it is rarely seen follow-up and post-intervention feedbacks (Harris et al., 2019). Considering the sedentary rate is still increasing and the health concern is emphasized even after a body of exercise interventions in public health, the aim of the interview study was to evaluate how volunteers who took part in the aerobic walking intervention, perceived about the aerobic walking exercise and the effects on sleep quality, stress and life satisfaction, and furthermore, to explore the cognitive feedbacks of daily aerobic walking exercise.

6.3 METHODS

6.3.1 Participants and design

The interviewees (n=10) come from volunteers who took part in an aerobic walking intervention research. There were 54 participants involved in the walking intervention. The intervention study was a cross-over experimental study design (including three sessions) and

was conducted to examine the effect of aerobic walking activity (8000-10.000 steps/day) on sleep quality, stress and life satisfaction between March and May 2019. Two intervention sessions (first month and third month) were separated by one-month wash period (second month). Participants were randomized into intervention group and control group at the beginning of the intervention and they exchanged their roles in the third session (the intervention group became controls). During the intervention period, volunteers were instructed to follow several requirements of walking exercise: a. continually walking for at least 10 minutes; b. walk at least 60 steps per minute. Omron HJ-112 (Omron Corporation, Kyoto, Japan) pedometer was used to track the daily walking activity.

Participants who completed the whole intervention were contacted (n=28, all with written consent). Finally, ten research volunteers accepted to take part in the current interview study (male n=4; female n=6), four months after the walking intervention. One out of ten interview was conducted online via Skype, and the rest of the interviews were face-to-face interview. All of the interviewed participants walked in outdoor environment.

6.3.2 Interview process

The interviews were semi-structured, facilitated by a self-designed interview protocol and interviews were conducted in December 2019 and January 2020. The invited interviewees were instructed to speak in their own words in terms of physical exercise, sleep quality, stress and life satisfaction. The interviewer introduced the aim of the interview and asked for the signature on the consent form before starting each interview. The interview focused on perceived feedbacks from the interviewees. Both interviewer and interviewee were free to share spontaneous opinions or comments that came up during the interview process.

At the beginning of the interview, interviewer asked about the basic background of the participant and general impression of the intervention process with two questions: *"Could you briefly introduce yourself? "*and*" Could you share with me your general impression of imbedding walking exercise in your daily life?"* Further questions asked about the physical exercise habits of the participant by using four questions: *"What have been the motivations for you to take part in the walking intervention?" "Could you briefly describe how is your physical activity habits before taking part in the walking intervention?" "When you were walking, is the walking activity enough to raise your breathing rate? Please give me details about how do you feel the intensity of walking." "What time(s) did you usually go with the walking exercise?"* Another four questions, *"How difficult and helpful do you think the aerobic walking was?",*

"To what extent has aerobic walking exercise interacted your sleep?", "To what extent has aerobic walking exercise impacted on your stress management?", " To what extent has aerobic walking exercise changed your life satisfaction?", were asked to explore the interaction between aerobic walking and sleep, stress and life. At the end of each interview, the participant rated the difficultness and helpfulness of the aerobic walking intervention, and also the effectiveness of the aerobic walking intervention on sleep quality, stress management and life satisfaction on a 0-10 scale.

All interviews took place in quiet locations and the conversations were audio-recorded and transcribed into textual record. Each interview lasted for 1-1.5 hours. The interview study was approved by university ethical committee (registration code: 2019/415).

6.3.3 Data analysis

The transcribed audio recordings were categorized for data analysis. The categorizations were based on the interview guideline and the results were attributed into several themes by the assistance of content analysis. Content analysis was performed according to the guidelines by Steve Stemler with the notion that content analysis means doing a word-frequency count (Stemler, 2000). After systematical analysis of the content, simplified but explicit categories were created by attributing similar discourses into the same theme. Thematic analysis helped to sort out the themes for each term (i.e. sleep quality, stress and life satisfaction). Additionally, in order to better present the verbal results, sample illustrations were chosen to represent each theme.

6.4 RESULTS

There were various reasons for them to join the aerobic walking study, but in general, the participants thought there had been a need for exercise in their daily life. Additionally, an obligatory exercise task such as joining a research study could be a strong motivation for them to keep consistency (e.g. *I'm very lazy when it comes to exercises but I like walking very much. So this is when I saw the advertisement on the first floor of room in a studio then idea is that walking research that sounds interesting and I like trying new things when it is not moving very much out of my comfort zone. So I did it. I decided I volunteer*.).

6.4.1 Summarized themes and concepts

The interview data summarized in this study redefined the terminology of aerobic walking. The walking exercise was categorized into four perspectives considering intervention itself, process control, motivations of the participants and the achievements. Table14 summarizes the concepts of aerobic walking regarding the answers of the participants.

Table 14 Categories and key issues of the aerobic walking intervention

Category	Key issues	Example statements
Intervention	Easy walking; with friends; without thinking; explore neighborhood	*"It's efficient in the way that you keep away your mind from the classes, from the daily routine. You just enjoy your walking and just looking for the people or just looking around."* *"It is like you're walking and trying to empty your mind and try to focus. So, it's like a meditative experience. Like I let out my emotions"*
Process control	Time management; pedometer effect, weather condition	*"The walking itself is not difficult, to find the time every day is difficult".* *"I was very surprised when I use this pedometer, because I could follow my daily walking steps. I thought that I was collecting my exercise and I walked a lot."*
Self-motivation	Interest; credits; need for exercise; get back to sleep, competition	*"It is not a burden, but a time for entertainment. A time for myself."* *"It was energetic. It was kind of competition affected."*
Achievements	Feeling of achievement; Ability to manage time;	*"I think it was good because I felt that I could really manage my life."* *"It's the feeling of success that gives you more motivation to do all your to do list in the day."*

	"When I go for a walk, it makes me feel much better. I come back with a clear mind that makes me feel good."

Several reports tailored to the effect of aerobic walking on sleep quality, stress management and life satisfaction from the analysis were listed below. Table 15 shows the concepts of sleep quality, stress and life satisfaction before and after intervention period by thematic terms.

Table 15 Concepts of sleep quality, stress and life satisfaction before and after intervention period

	Sleep quality	Stress	Life satisfaction
Before intervention	Unable to sleep; irregular sleep;	Miserable feeling; bear with the stress	Life is stressful; want to change life;
After intervention	Wake up fresher; sleep quickly and deeply, relaxed; longer duration	Relaxed; helpful; Good for mood; meditate problems, peaceful, rethink things, alleviate distress; released	Proud of my life; Feeling of success; Able to manage daily routine; motivated

The statements presented in Table 15 are a summary of the key concepts from the interviewees. The table should be understood as an outlook of sleep, stress and life satisfaction before and after the walking program. There are both common reports and single reports. For example, "mediate effect", "relaxed" were reported more than once, "unable to sleep" "miserable feeling" was reported only once. The table did not highlight the frequency because it included almost all thematic reports, which aimed to show the diversity of various feedbacks.

The analysis explicitly followed the themes developed from each interview and identified the most important issue in all interviews. There were both positive and neutral answers from the participants. The interview reflected that the aerobic walking activity makes participants emotionally agile, which was like doing a meditation and intimate imitation. Participants were able to integrate and try to be concentrated, which helped to increase stamina.

6.4.2 Aerobic walking exercise and sleep

According to the interview, participants were categorized into “good sleeper” (n=3) , “normal sleeper” (n=3) and “bad sleeper” (n=4). For instance, there were participants who always sleep well, and have no trouble with sleeping, there was participants who lost her Mum when she participated in the study; and participants who was in tensive life status during the intervention period. They experienced an ambivalence of feelings coupled with life status, personality and perceived achievement etc. They considered aerobic walking as a promising strategy to moderate life specially for those who were undergoing unpleasant life status. Here are sample reports:

P.2.

“I think I felt an effect on it. Usually I have bad sleeping habits, like, I'm sleeping very late at two or three o'clock, but during the exercise, I felt that if I wanted to sleep, I could sleep, If I wanted to wake up, I can also wake up.”

P.3.

“I'm a really good sleeper and it doesn't matter if I'm physically active or not.”

P.7.

“I think when I do more activity, I sleep longer, but I wake up fresher. Better to say it affected my mood to my sleeping.”

P.8.

“At the beginning, I didn't feel any special feeling. I really couldn't sleep at all because I lost my Mum. But at the end, I felt that I can sleep a little bit more, not so much, but a little bit more.”

P.1.

“I think it was really helpful for me because during of walking, I could walk with my feelings.”

6.4.3 Aerobic walking exercise and stress

The walking exercise exerted an influence on mental development. The participants experienced positive feeling during the specified aerobic walking intervention. The positive feeling includes happiness, calmness and satisfaction. Apart from cognitive effectiveness, the participants also encountered psychological connection between physical exercise and self-

disciplinary. The participants usually felt better after walking, since they thought that the stressful feeling can be evacuated through body movement. Below are sample reports:

P.4.

"During of walking, it was easier for me to think because it was time for thinking. And it's good to connect some easy sport with thinking, because we can manage them together."

P.2.

"I would say that after the exercise, I felt that I have done something positive because of that. It would motivate you to do other things as well. So, it would motivate you to make a timetable for your studies as well."

P.3.

"I used walk to sort up my feeling and my stress. yeah, sometimes it helps me."

P.1.

"The exercise itself makes me feel like I can release. Yeah, like I can relax for a bit. It's a moment of freedom in your day to just go and work on do nothing else."

P.5.

"It feels like you are letting out your emotion during the activity. And then you are calmer. It makes me feel calmer and better and managing my stress."

6.4.4 Aerobic walking exercise and life satisfaction

The effect of aerobic walking on life satisfaction can be violated because there was a large spectrum of risk factors for life satisfaction. Even though the stress source which interrupted life satisfaction may not be removed by walking, but there was a mediate effect of walking exercise. Moreover, aerobic walking exercise helped to cope with stressors in life, which may affect life satisfaction. Participants also mentioned that walking exercise can only work at the moment of walking period, it did not show helpfulness when the aerobic walking terminated.

P.3.

"I would like to say that I was proud of myself. I was proud of myself that I'm taking part in the experiment because as a PhD student and there's a psychology, it was interesting at the same time to take part."

P.4.

"I must say that at that time I was very stressed and this exercise help me to cope daily in that moment. But I still feel helpless, I still feel not sure about what I'm going to do. It helps

to alleviate daily symptoms, but the problems were still there. It's like giving you like a buffering protective factors on a daily basis."

P.6.

"I would say there is a little bit impact on my life satisfaction. I can say, I felt that I could manage my emotions and they were in my control."

P.10.

"It makes you feel relaxed, which is a positive effect in my daily life."

The participants reported that the aerobic walking exercise was not difficult except scheduling it every day (M=3.89, SD=2.21). Aerobic walking activity improved sleep quality (M=4.60, SD=2.72), stress (M=5.30, SD=1.77) and life satisfaction (M=4.70, SD=2.06) in different levels. Overall, the participants thought that aerobic walking was helpful (M=5.56, SD=1.59).

6.5 DISCUSSION

Walking is the most common physical exercise on daily basis. Brisk walking is of a sufficient intensity to improve aerobic fitness and will achieve cardiorespiratory and health benefits (Quell et al., 2002). Ottawa Panel Evidence-Based Clinical Practice Guidelines (EBCPG) for aerobic walking programs found great improvement in pain, quality of life and functional status (Loew et al., 2012). Walking speed and intensity can be varying according to age groups. As reported, lower efficiency was associated with lower walking speed within a group of older participants with a wide range of function (Coen et al., 2013). The present study examined an aerobic walking with specific requirements can function well among young adults. In addition, this study elicits that psychological effects exist behind the walking activity (Priest, 2007). Daily aerobic walking activity is associated with emotional fulfilments such as successfulness, satisfaction, happiness, and dedication etc. It is important to state that to fulfil the aerobic walking requirements is not difficult, the difficulty is to maintain it as a daily habit. The findings in this study supports aerobic walking as a psychology instrument which can bring mental achievements.

6.5.1 Aerobic walking: effectiveness, significance and correlates

This interview study tried to explore how aerobic walking would be beneficial for sleep quality, stress management and life satisfaction. It has been revealed that moderate-intensity aerobic exercise session improved sleep quality in older women (Wang & Youngstedt, 2014). However, little effect was found among young adults who were good sleepers (Youngstedt et al., 2003). Aerobic walking helps to facilitate sleep process in term of sleep depth, sleep latency between bad sleepers. Stress can be risk factor for poor sleep quality and life satisfaction. Integrated effects were found during walking onset. For instance, the meditative effect behind brisk walking could release the stress level and maintain a peaceful moment. The walking exercise cannot solve the problem that caused stress, but it helps to rethink and calm down. Life satisfaction can be violated by many factors happens in life, with the same rational, walking exercise can play a role in ameliorating rather than cure dilemmas.

Given that regular physical exercise habit has numerous benefits, aerobic walking is a good example of exercise, which is easy to perform and does not require any training or equipment and less chance of injury. WHO recommended adults aged 18–64 should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week (WHO, 2010). However, irregularity of daily exercise limited the implementation on public manipulation. It is of great importance to figure out the recommended length of regular walking. Thirty minutes per day of moderate or brisk walking, or 60 minutes per day of slow walking, could increase physical activity at the population level (Morabia & Costanza, 2004), but it is not clear whether there is a meditative effect of walking activity. Thus, walking with specific requirements can be a good strategy to quantify physical exercise volume.

Participants reported that the pedometer and the outdoor sights could influence the mood and efficacy of walking experience. On one hand, previous findings demonstrated that the utility of pedometer is associated with significant increases in physical activity (Bravata et al., 2007). Pedometers irritated the motivation of doing regular exercise. On the other hand, evidence showed that walking in nature has restorative effects on cognitive functioning (Berman, Jonides, & Kaplan, 2008). Therefore, the mechanism between visual effects and cognitive functions in body movement is suggested for exploration.

6.5.2 Limitations

The interviews were conducted half year later than the intervention, this can be a reason that the response rate is relatively low due to student transfer and unavailability. The lower number of participants could cause distortion in statistical analysis. The interview was

conducted in between the exam period, which may also be a reason for the low response rate. For those un-participated volunteers, they may concern that fragment memory may not able to provide enough information because they are not able to recall every detail of the intervention moments. The good thing is that all of the participated volunteers showed enough willingness and kindness to participate the interview, which enlarged the possibility of gathering useful information and maximized the content. There were some questions in the interview that might suggested how to answer regarding expectations.

6.6 CONCLUSIONS

Regular aerobic walking might be helpful in relieving distress and might bring a sense of good mood and improve life satisfaction. Since the global trend is labor saving and leading to epidemic for long term, all efforts should be made to create public awareness in promoting physical activity. Physical exercise behavior change has high implications for global health promotion. In addition, the mechanism between regular moderate physical exercise and psychology is worthy of more efforts.

Strengthens of this study include the cooperative participation of the volunteers who provided useful and valuable feedbacks and pertinent attitudes. It is essential to notify that volunteers did not continue with the aerobic walking exercise after intervention. The dis-continuity of physical exercise should be concerned in health promotion interventions. Future study should pay attention to motivating individual's persistency in doing physical exercise. In summary, results from the interview study emphasized the cognitive benefits of regular walking exercise among young adults, and it also suggests further studies to concern about physical exercise motivation for young adults.

Declarations of interest: none.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CHAPTER 7 DISCUSSION AND CONCLUSIONS

The goal of the current dissertation is to interpret the relationship between physical exercise and sleep quality, stress and life satisfaction and explore the effectiveness of a specific type of walking exercise on these three variables with the aim to promote physical interventions on public health as well as to increase the overall physical activity level among adults. This study adopted a mix-method research approach in the investigation process of the above-mentioned aims. Both quantitative and qualitative research methods were utilized in answering consequential research questions. Quantitative researches were conducted in a cross-sectional study (Study 1) and an experimental study of walking intervention (Study 2) to investigate the relationships between physical exercise and sleep quality, stress and life satisfaction and examine the effectiveness of the designated walking exercise. Qualitative research (Study 3) was carried out with research participants in study 2. The qualitative research focused on exploring the psychological impacts of the walking exercise and aimed to find out the potential strengthens and weaknesses of walking exercise intervention.

Chapter 7 will make a general discussion about the findings and conclude the investigation presented in the dissertation. The overall contributions, limitations as well as suggestions for future directions will be addressed in this chapter. To be specified, this chapter starts with a summary of the findings (Section 7.1), followed by interpreting the scientific contributions of the present dissertation from both individual health and public health level (Section 7.2). And then, a description of the limitations of this dissertation and directions for future studies will be presented (Section 7.3). In the end, an overall conclusion is made to provide an overarching interpretation of the present dissertation (Section 7.4).

7.1 SUMMARY OF THE FINDINGS

The increasing number of walking investigation as a strategy for improving health status became popular in recent decades. In response to the recommendation of the physical activity guidelines from WHO, scientific interest and research in walking intervention grew greatly with the invention of the digital devices that could be used for tracking body movements. The findings of the dissertation have several insightful results that can help to emphasize the inputs

and outputs of implementing walking exercise in daily life as well as to better understand the importance of moderate exercise for public health. This section summarizes the findings with a wide scope of strongly related topics epitomized from Study 1, Study 2 and Study 3. The discussion is categorized into three subsections. The relationships between physical exercise and sleep quality, stress and life satisfaction are clarified (Section 7.1.1). Furthermore, the role of walking exercise is addressed on sleep quality, stress and life satisfaction on a daily basis (Section 7.1.2). The cognitive effects of walking together with internal and external mediators are discussed (Section 7.1.3). In the end, a brief presentation about the practical implications of implementing walking exercise among general adults is made (Section 7.1.4).

7.1.1 Physical exercise and sleep quality, stress and life satisfaction

Demographic factors such as gender and age should be taken into consideration when discussing the effect of physical exercise on sleep quality, stress and life satisfaction. Our results showed that there was a gender difference in doing physical exercise. Males did more exercise than females in the general population. There was no significant gender-specific difference in stress and life satisfaction. Exploratory analyses revealed significant relationships between dose responses to exercise with gender. The dose-response relations between exercise and in women help to refine our understanding of the physical activity effect (MORSS et al., 2004). Acute exercise resulted in significant and equal tissue oxidative stress in both genders as indicated by tissue glutathione status. With some exceptions, tissue vitamin C and vitamin E concentrations were generally unaffected by acute exercise in either gender (Tiidus, Bombardier, Hidiroglou, & MADERE, 1999). Hence, initiation and maintenance of health-promoting practices need to follow the rationale that gender difference exists in physical activity level and stress response ability. In addition, age is an important parameter when assessing the relationship between physical activity and sleep quality. With the increasing of age, the effect of physical activity on sleep quality becomes more sensible. Although, age-related decline in physical activity level functional fitness was due to the aging process (Milanović et al., 2013).

The cross-interaction between stress and life satisfaction is best captured by considering their joint effects. Our results found that stress and life satisfaction were closely correlated. Both stress and life satisfaction showed a predictive effect on sleep quality. Whereas, stress presented a stronger predictive effect on sleep quality than life satisfaction. Furthermore, stress during the day predicts subsequent sleep quality on a day-to-day basis; particularly, bedtime

stress and worries were the main predictors of sleep quality (Åkerstedt et al., 2012). Physical activity may play an indirect role in mediating the relationship between sleep quality and stress. For instance, evidence indicated that movement-based courses could account for changes in perceived stress, which explain, in part, improved sleep quality (Caldwell, Harrison, Adams, Quin, & Greeson, 2010). Even though the reversed relations between stress and sleep quality have been widely documented, the bidirectional relations of the mechanism in the association between stress and sleep quality were also demonstrated in previous findings (Van Laethem et al., 2015). Life satisfaction can be both a reason and a result of sleep quality. There are a number of predictors of life satisfaction including health status, depression and sleep quality (Jin-Hee Park, Yoo, & Bae, 2013).

Physical exercise and sleep quality are analyzed by comparison between physical activity and physical inactive groups, the result of which did not show statistical significance. The reason can be explained that sleep quality is predicted by integrated influential factors including stress and life satisfaction as mentioned. As revealed in a meta-analytic review, the effects of physical exercise on sleep were moderated by sex, age, baseline physical activity level of participants, as well as exercise type, time of day, duration, and adherence (Kredlow, Capozzoli, Hearon, Calkins, & Otto, 2015). For elderly adults, aerobic exercise is an effective treatment approach to improve sleep quality (Reid et al., 2010). There was a conclusion that activity was associated with sleep only in older adults (Christie, Seery, & Kent, 2016). The evidence for young adults needs more investigation by taking the moderators into consideration.

7.1.2 The role of the walking exercise in daily life

The aerobic walking exercise showed beneficial outcomes in improving sleep quality, stress and life satisfaction. Studies that integrating walking exercise with sleep quality, stress and life satisfaction are scant in healthy adult population. The walking exercise was applied in clinical settings with patients under treatment, for instance, moderate-intensity walking exercise is effective in improving sleep in individuals with cancer (Chiu et al., 2015). The backward rationale of the functions of walking on sleep enhancement was discovered by laboratory examination, which showed that walking exercise might enhance EEG sleep spindle activities including alteration in temporal architecture of sleep and selective prolongation of sleep Stage 2 (Meier-Koll, Bussmann, Schmidt, & Neuschwander, 1999). However, the exploration of walking at a populational level by integrating lifestyle habits (e.g., coffee intake and alcohol consumption) has rarely been discussed; this study highlighted the significance of the

influential effect on behavior intention. With this prior knowledge, it is essential to connect life behavior factors to stress and life satisfaction when evaluated on a daily-life basis. Walking activity is an easy activity to perform, but the basement requirements for walking with beneficial impacts on sleep quality, stress and life satisfaction need further investigation.

The role of walking exercise in daily life is not limited to benefiting physical health but also contributes to physical exercise behavior. Numerous findings have addressed the high-leverage opportunities for linking research and implementation. A prediction that integrated personality, the perceived environment, and the theory of planned behavior framework to leisure-time walking indicated that walking behavior is theoretically complex but maybe best implemented by facilitating strong intentions and adjusting individual differences (Rhodes et al., 2007). It has been revealed that when engaged in cognitively distracting tasks, such as listening to headphones, or mentally going over a to-do list during walking, the ability to detect objects and recognizing details in a real-world environment can be affected (Kuzel, Heller, Gray, Di Jorio, & Straughn, 2008). A recent study provided generalizable results of the consciousness of walking behavior on the way of thinking (Oppezzo & Schwartz, 2014).

Even though the technological devices in the present era support a lot in measuring physical activities, the assessment of the intensity of walking exercise is not enough to be estimated by walking duration or step counts. Therefore, the importance of walking regularity and consistency should be addressed. In compliance with the behavioral models, exercise habits are supposed to exert psychological benefits. High-active and low-active subjects reported their psychological effect in the last 30 s of and 5 min after exercising at 60 and 90% VO_2max workloads (Parfitt, Markland, & Holmes, 1994). Many walking intervention studies chose a self-selected walking speed to assess the walking activity rather than assessing gait and stride in real life intervention. It is understandable that leisure time walking faces with the obstacle of measurable gaits or stride in real life. Nevertheless, the requirement of a certain number of steps could help, which is more flexible and convenient. For instance, in the present aerobic walking exercise, participants are free to choose where they would like to walk but with a goal-intended walking (steps are validly counted when walking more than 60 steps per minute and more than 10 minutes continuously), which allows the possibility of speed control. It is a good strategy in standardizing the walkability at a populational level. This finding supports the previous comparison between walking on a treadmill and walking at self-selected paces from the perspective of energy cost (Pearce et al., 1983).

7.1.3 Internal and external mediators of walking

Aerobic walking contributes to not only physical but also mental health. Psychological effects occurred during the walking process. The meditative effect may appear when walking at a brisk speed as mentioned above. Existing evidence showed that meditative walking had greater effect on the psychological aspects than athletic walking (Shin et al., 2013). The walking environment can be an important factor influencing psychological effects during the walking process. Walking in the forest increased happiness to a greater degree than walking in the gymnasium at the same pace. Therefore, it is indispensable to acknowledge city construction in facilitating the walking activity (Shin et al., 2013). There was one study in which walking was used as a spiritual practice demonstrated that walking is a social practice operating at the nexus between body and self (Slavin, 2003). In our research, a number of participants reported bettering feeling and a better mood after walking session but they do not understand why it happened. A qualitative study that combined methods from grounded theory and ethnography with regards psychological benefits of the physical activity categorized the possible reasons: *Closer to What is More Natural; Feeling Safe; Being Part; Striving; Getting Away; Being Me; Finding Meaning* (Priest, 2007). Hence, it is highly encouraged to walking outdoors.

Due to the fact that leisure time walking activity is a robustly measurable activity, the motivations of walking activity have been documented. Generally, participants were diverse in orientations and motivations, and positive about their participation. Research and conceptual models of sport orientation must extend beyond achievement motives to capture the diversity of adult participants (Gill, Williams, Dowd, Beaudoin, & Martin, 1996). At present, motivational processes underpinning walking behavior are not well understood. Nevertheless, walking-specific motivation measures were developed from self-determination theory (SDT). This preliminary evidence highlighted the advantages of behavioral regulations in walking and psychological needs (Niven & Markland, 2016). Even though not all aspects of motivation were autonomous and self-determined, the participants felt motivated for walking when “walking is a task”.

The effect of the use of a pedometer could not be neglected. Participants’ motivation for walking was evident due to pedometer use. Self-Selected walking speed increases when individuals are aware of being recorded (Hutchinson, Brown, Deluzio, & De Asha, 2019). It has been suggested that the effectiveness of health promotion to increase walking may be enhanced by combining motivational health-related messages with the dissemination and adoption of an easy-to-use tool for self-monitoring purposes (Craig, Tudor-Locke, & Bauman,

2007). In this case, the accuracy and validity of walking exercise tracking tools should be emphasized. The validity of the instrument (Omron HJ-112 pedometer) used in the study was acceptable by assessing steps in different BMI groups during constant- and variable-speed walking (Hasson et al., 2009). The smartphone pedometer applications were not accurate in counting steps and showed low validity, which could not be used is not be used as a valid instrument for monitoring walking activity in scientific research (Bergman, Spellman, Hall, & Bergman, 2012).

Implications for planning, health policy, and public education of walking exercise shall be highlighted in light of these findings. Summarized suggestions synthesized from the findings of the dissertation in successfully implementing efficient walking activity in public society includes walking motivation, walking environment, walking supervision (e.g., walking speed) and self-regulation (e.g., time management). In other words, both internal and external factors should be taken into consideration when implementing walking exercise with regards to the physical and mental health benefits. Last but not least, the magnitude of walking habits should be emphasized in the public health promotion sector.

7.1.4 Practical implications

The findings of the present dissertation that to discover the effectiveness of a particular type of daily aerobic walking activity on sleep quality, stress and life satisfaction provided specific suggestions for health intervention and health promotion strategies. Our long-term goal of the dissertation is to foster a walking culture and habit in the public domain focusing on the general adult population. As mentioned, a walking-friendly environment is essential for facilitating the walking activity. The use of determined walking has great psychological implications including nurturing cognition and meditative effect. Study 1 highlighted the interacted relationship between sleep quality, stress and life satisfaction. Study 2 deliberated the effectiveness of walking on sleep quality, stress and life satisfaction individually. Study 3 made a further investigation on the psychological reactions of goal-setting walking activity. These evidence enhanced the positive effects of walking exercise and supplemented the research in walking activity among the healthy adult population. In addition, the findings in the dissertation play a key role in calling attention from policy makers, researchers and health educators to develop easily accessible/implementable health recommendations.

7.2 CONTRIBUTIONS OF THE PRESENT STUDY

This dissertation provided valuable contributions in physical activity research to the existing literature in the following sections. For completeness, this section focuses on the contributions of the dissertation as a whole rather than restating the contributions of the individual studies that were conducted within its framework.

The dissertation established a new walking framework in better understanding the physical exercise volume for health promotion purposes. This dissertation provided a better and deeper knowledge about aerobic walking tailored to healthy adults. Though the health guidelines and recommendations for physical activity from WHO have been explicitly announced, there is still a lack of practical instructions to fulfill the recommendations. Therefore, detailed physical exercise type including volume, intensity, duration, etc. is highly needed for public health education. This dissertation provided an applicable type of walking exercise, which is not the same as self-selected speed walking but walking with required speed requirements and duration. Given that walking speed could be measured by step frequency rather than step counts (Jonghoon Park, Ishikawa-Takata, Tanaka, Mekata, & Tabata, 2011), the present dissertation acknowledged the step frequency by using a pedometer with such function. Thus, the walking volume and walking intensity were clearly defined under certain perspectives.

The dissertation accomplished the goal of implementing walking exercises to facilitate sleep quality, stress and life satisfaction for adults. As known, sleep quality, stress status and life satisfaction are important indicators for life quality. Walking exercise dominantly contributed to sleep quality improvement and stress releasement. Even though the evidence of walking exercise is not that much clear for life satisfaction, a better mood is reported by individual participants during the walking process. The study provides insights into physical activity implementation on health indicators by informing researches and practices about possible effective physical activities. Furthermore, it also supported the finding that indicated the determinants of life satisfaction are adequate including gender, income, and political orientation etc. (Bjørnskov, Dreher, & Fischer, 2008).

The dissertation piloted the meditative effect of goal-setting walking. One of the most significant contributions of the present dissertation is the meditation effect of walking was found. Previous researches demonstrated the mood mediation and cognitive benefits of walking (Bailey et al., 2018; Streeter et al., 2010), but it has been rarely acknowledged about the

meditative effect of walking. To our best knowledge, there was a term named "meditative walking" published in previous literature (Shin et al., 2013). However, the walking meditation mentioned in this dissertation is a phenomenon that occurs during the walking onset, which differs from the term "meditative walking". The meditative effect of walking may elicit the possible healing effects of psychological disorders such as stress.

The dissertation provided informative suggestions in facilitating and promoting healthy walking habits among public population. To implement physical exercise programs at public level is never a facile task. The experimental process of walking intervention in the dissertation summarized practical suggestions and recommendations when implementing walking-related intervention. The dissertation highlighted the importance of walking habits and habit formulation theory for healthy adults. Walking habits seem to have a partial role in life quality with the existing finding revealed that attaining recommended levels of walking is positively associated with several aspects of health-related quality of life (Hörder, Skoog, & Frändin, 2013). The formulation of walking exercise habits with respect to the recommendations stated in individual studies in the dissertation addressed the potential mediators. Meanwhile, during normal activities of daily life, influential factors for walking have been comprehensively discussed in the present dissertation.

7.3 LIMITATIONS AND FUTURE DIRECTIONS

Despite the contributions of the dissertation stated above, there are limitations that should be addressed. There are restrictions for conducting the intervention process and there are also practical concerns detected after the studies.

First of all, the measurements used in the studies to assess sleep quality, stress and life satisfaction are questionnaire-based. The day to day variation of the sleep, perceived stress and life satisfaction could not be measured by self-reported scales, which could lead to potential biases (e.g., social desirability bias or recall bias). Even though pedometers were used during the intervention process, it was used for tracking daily walking activities rather than measuring health predictors (e.g., sleep, stress). For this reason, future studies should include more objective indicators for sleep and stress measurement (if possible). Given the cross-over RCT design (12 weeks in total), it is also important to mention the drop off rate of the participants. To address this issue, further studies are recommended to adopt motivational intervention

strategies. Another future direction would be to conduct intervention trials based on a large scale of the participants.

Secondly, most, but not all, of the participants selected in the present dissertation are living in the urban area of the city (Budapest). The availability and accessibility of walking environments may differ from those who live in the rural area of the city. As discussed, the walking environment may affect walking efficiency. Therefore, in order to reduce the potential bias caused by the environment, future walking intervention studies are suggested to choose similar locations for walking activities.

Thirdly, participants reported discontinuity of the daily walking exercise after the intervention period, which reminds researchers to promote the possibility of fostering walking habits in the long run. In addition, the long-term effects of daily aerobic walking activity has not been discussed in the present dissertation. Future studies are suggested to discover the long-term effectiveness of walking exercise, meanwhile, to find a solution for developing habits for walking. Based on the reports in the qualitative study, time management is a challenge for the participants. Hence, it is recommended to consider time factor when conducting intervention studies of walking. Leisure time walking can be a good choice, but the walking intensity and frequency cannot be standardized; therefore, researchers need to consider the integrated effect of these confounding factors.

Finally, the studies have identified several barriers in walking intensity and walking duration (e.g., distance, time etc.), and emphasized the importance of the clarification for public health promotion. Future studies could investigate further to determine how appropriate walking instructions could apply to general adults and to refine the physical activity guidelines.

7.4 CONCLUSIONS

In conclusion, the present dissertation provided three empirical studies for a more detailed understanding of the ongoing research of walking exercise and sleep quality, stress and life satisfaction. One important contribution of the dissertation is that it established a new instruction for walking, which also can be understood as goal-setting walking. The feasibility and accessibility of the walking activity showed promising health implications in the public domain. In addition, this dissertation also documented the need for the assistance of policy makers and health educators to facilitate the successful implementation of health promotion at public level. Finally, the dissertation might be used as a foundation in future studies

implementing physical interventions to foster physical and mental health, which in turn, result in better life satisfaction not only at an individual level, but also at a populational level.

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APPENDICES

Appendix 1

Appendix 1. Global Recommendations on Physical Activity for Health

Global Recommendations on Physical Activity for Health

18–64 years old

These guidelines are relevant to all healthy adults aged 18–64 years, unless specific medical conditions indicate to the contrary, irrespective of gender, race, ethnicity or income level. They also apply to individuals in this age range with chronic noncommunicable conditions not related to mobility such as hypertension or diabetes. These recommendations can be applied to adults with disabilities. However they may need to be adjusted for each individual based on their exercise capacity and specific health needs. Pregnant, postpartum women and persons with cardiac events may need to take extra precautions and seek medical advice before striving to achieve the recommended levels of physical activity for this age group.

Strong evidence demonstrates that compared to less active adult men and women, individuals who are more active:

- have lower rates of all-cause mortality, coronary heart disease, high blood pressure, stroke, type 2 diabetes, metabolic syndrome, colon and breast cancer, and depression;
- are likely to have less risk of a hip or vertebral fracture;
- exhibit a higher level of cardiorespiratory and muscular fitness; and
- are more likely to achieve weight maintenance, have a healthier body mass and composition.

Recommendations:
In adults aged 18-64, physical activity includes leisure time physical activity, transportation (e.g. walking or cycling), occupational (i.e. work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities.
The recommendations in order to improve cardiorespiratory and muscular fitness, bone health, reduce the risk of NCDs and depression are:

1. Adults aged 18–64 should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate - and vigorous-intensity activity.

2. Aerobic activity should be performed in bouts of at least 10 minutes duration.

3. For additional health benefits, adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate - and vigorous-intensity activity.

4. Muscle-strengthening activities should be done involving major muscle groups on 2 or more days a week.

Inactive people should start with small amounts of physical activity and gradually increase duration, frequency and intensity over time. Inactive adults and those with disease limitations will have added health benefits when they become more active.

For further information see: http://www.who.int/dietphysicalactivity/pa/en/index.html
or contact WHO on dietandhealth@who.int

World Health Organization

Appendix 2

Appendix 2. Pittsburgh Sleep Quality Index (PSQI)

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. **Please answer all questions.**

1. During the past month, what time have you usually gone to bed at night? _____
2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night? _____
3. During the past month, what time have you usually gotten up in the morning? _____
4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.) _____

5. During the past month, how often have you had trouble sleeping because you...	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reason(s), please describe:				

6. During the past month, how often have you taken medicine to help you sleep (prescribed or “over the counter”)?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
	No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?				
	Very good	Fairly good	Fairly bad	Very bad
9. During the past month, how would you rate your sleep quality overall?				

Appendix 3

Appendix 3. Scoring method of the Pittsburgh Sleep Quality Index

PSQIDURAT DURATION OF SLEEP

IF Q4 $\geq$ 7, THEN set value to 0

IF Q4 < 7 and $\geq$ 6, THEN set value to 1

IF Q4 < 6 and $\geq$ 5, THEN set value to 2

IF Q4 < 5, THEN set value to 3

Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQIDISTB SLEEP DISTURBANCE

IF Q5b + Q5c + Q5d + Q5e + Q5f + Q5g + Q5h + Q5i + Q5j (IF Q5JCOM is null or Q5j is null, set the value of Q5j to 0) = 0, THEN set value to 0

IF Q5b + Q5c + Q5d + Q5e + Q5f + Q5g + Q5h + Q5i + Q5j (IF Q5JCOM is null or Q5j is null, set the value of Q5j to 0) $\geq$ 1 and $\leq$ 9, THEN set value to 1

IF Q5b + Q5c + Q5d + Q5e + Q5f + Q5g + Q5h + Q5i + Q5j (IF Q5JCOM is null or Q5j is null, set the value of Q5j to 0) > 9 and $\leq$ 18, THEN set value to 2

IF Q5b + Q5c + Q5d + Q5e + Q5f + Q5g + Q5h + Q5i + Q5j (IF Q5JCOM is null or Q5j is null, set the value of Q5j to 0) > 18, THEN set value to 3

Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQILATEN SLEEP LATENCY

First, recode Q2 into Q2new thusly:

IF Q2 $\geq$ 0 and $\leq$ 15, THEN set value of Q2new to 0

IF Q2 > 15 and $\leq$ 30, THEN set value of Q2new to 1

IF Q2 > 30 and $\leq$ 60, THEN set value of Q2new to 2

IF Q2 > 60, THEN set value of Q2new to 3

Next

IF Q5a + Q2new = 0, THEN set value to 0

IF Q5a + Q2new ≥ 1 and ≤ 2, THEN set value to 1

IF Q5a + Q2new ≥ 3 and ≤ 4, THEN set value to 2

IF Q5a + Q2new ≥ 5 and ≤ 6, THEN set value to 3

Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQIDAYDYS DAY DYSFUNCTION DUE TO SLEEPINESS

IF Q8 + Q9 = 0, THEN set value to 0

IF Q8 + Q9 ≥ 1 and ≤ 2, THEN set value to 1

IF Q8 + Q9 ≥ 3 and ≤ 4, THEN set value to 2

IF Q8 + Q9 ≥ 5 and ≤ 6, THEN set value to 3

Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQIHSE SLEEP EFFICIENCY

Diffsec = Difference in seconds between day and time of day Q1 and day Q3

Diffhour = Absolute value of diffsec / 3600

newtib =IF diffhour > 24, then newtib = diffhour – 24

IF diffhour ≤ 24, THEN newtib = diffhour

(NOTE, THE ABOVE JUST CALCULATES THE HOURS BETWEEN GNT (Q1) AND GMT (Q3))

tmphse = (Q4 / newtib) * 100

IF tmphse ≥ 85, THEN set value to 0

IF tmphse < 85 and ≥ 75, THEN set value to 1

IF tmphse < 75 and ≥ 65, THEN set value to 2

IF tmphse < 65, THEN set value to 3

Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQISLPQUAL OVERALL SLEEP QUALITY

Q6

	Minimum Score = 0 (better); Maximum Score = 3 (worse)
PSQIMEDS	NEED MEDS TO SLEEP
	Q7
	Minimum Score = 0 (better); Maximum Score = 3 (worse)
PSQI	TOTAL
	DURAT + DISTB + LATEN + DAYDYS + HSE + SLPQUAL +
MEDS	
	Minimum Score = 0 (better); Maximum Score = 21 (worse)
	Interpretation: TOTAL $\leq$ 5 associated with good sleep quality
	TOTAL > 5 associated with poor sleep quality

Appendix 4

Appendix 4. Perceived Stress Scale

The Perceived Stress Scale (PSS) is a classic stress assessment instrument. The tool, while originally developed in 1983, remains a popular choice for helping us understand how different situations affect our feelings and our perceived stress. The questions in this scale ask about your feelings and thoughts during the last month. In each case, you will be asked to indicate how often you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer fairly quickly. That is, don't try to count up the number of times you felt a particular way; rather indicate the alternative that seems like a reasonable estimate.
For each question choose from the following alternatives:
0 - never 1 - almost never 2 - sometimes 3 - fairly often 4 - very often

l. In the last month, how often have you been upset because of something that happened unexpectedly?

2. In the last month, how often have you felt that you were unable to control the important things in your life?

3. In the last month, how often have you felt nervous and stressed?

4. In the last month, how often have you felt confident about your ability to handle your personal problems?

5. In the last month, how often have you felt that things were going your way?

6. In the last month, how often have you found that you could not cope with all the things that you had to do?

7. In the last month, how often have you been able to control irritations in your life?

8. In the last month, how often have you felt that you were on top of things?

9. In the last month, how often have you been angered because of things that happened that were outside of your control?

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

Appendix 5

Appendix 5. Scoring of Perceived Stress Scale

- First, reverse your scores for questions 4, 5, 7, and 8. On these 4 questions, change the scores like this:

  0 = 4, 1 = 3, 2 = 2, 3 = 1, 4 = 0.

- Now add up your scores for each item to get a total. **My total score is _____.**
- Individual scores on the PSS can range from 0 to 40 with higher scores indicating higher perceived stress.
  - ► Scores ranging from 0-13 would be considered low stress.
  - ► Scores ranging from 14-26 would be considered moderate stress.
  - ► Scores ranging from 27-40 would be considered high perceived stress.

Appendix 6

Appendix 6. Satisfaction With Life Scale and Scoring

Instructions: Below are five statements that you may agree or disagree with. Using the 1 - 7 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item. Please be open and honest in your responding.

- 7 - Strongly agree
- 6 - Agree
- 5 - Slightly agree
- 4 - Neither agree nor disagree
- 3 - Slightly disagree
- 2 - Disagree
- 1 - Strongly disagree

- ____ In most ways my life is close to my ideal.
- ____ The conditions of my life are excellent.
- ____ I am satisfied with my life.
- ____ So far I have gotten the important things I want in life.
- ____ If I could live my life over, I would change almost nothing.

Scoring: Though scoring should be kept continuous (sum up scores on each item), here are some cut- offs to be used as benchmarks.

▪ 31 - 35 Extremely satisfied

▪ 26 - 30 Satisfied

▪ 21 - 25 Slightly satisfied

▪ 20 Neutral

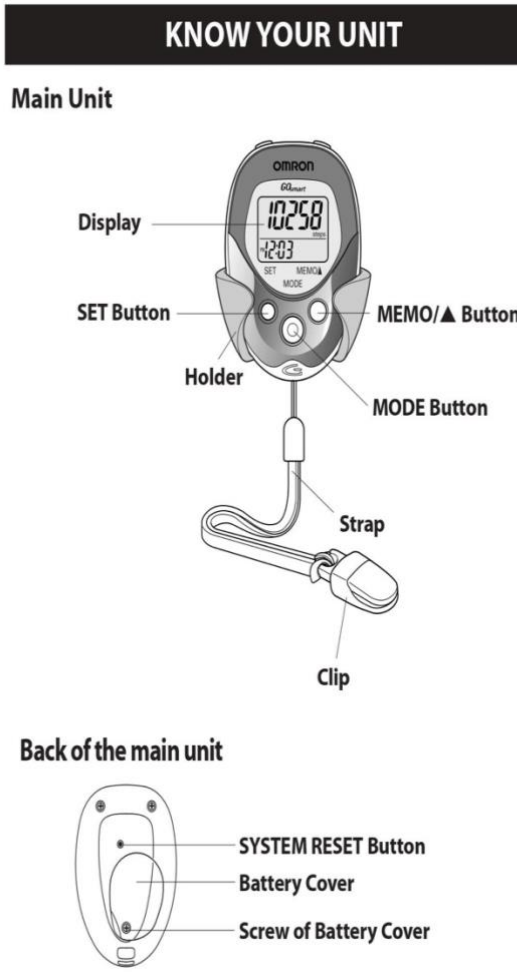
▪ 15 - 19 Slightly dissatisfied

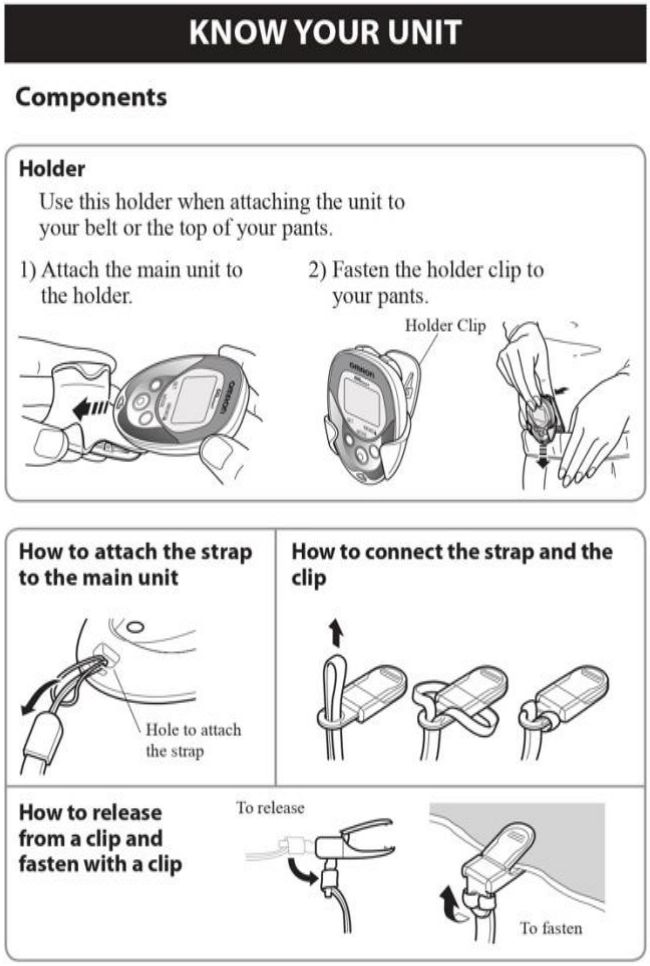
▪ 10 - 14 Dissatisfied

▪ 5 - 9 Extremely dissatisfied

Appendix 7

Appendix 7. Structure of the HJ-112 pedometer





Appendix 8

Appendix 8. Post-observation interview protocol

Script prior to interview:

I'd like to thank you once again for being willing to participate in the interview of my study. As I have mentioned before, my study seeks to understand how young adults, who took part in the aerobic walking exercise intervention, feel about the effect of the intervention on sleep quality, stress and life satisfaction. The aim of this interview is to explore the subjective feedbacks of daily walking exercise. Our interview today will last approximately one hour and a half during which I will be asking you about your ***physical activity habits, decision to attend the intervention, your emotional and spiritual experiences*** *during the aerobic walking, and ideas that you may have about yourself and your life in terms of SQ, PA, stress management and life satisfaction.*

We are interested in your opinions and your reactions. In no way is this interview designed to individually evaluate a person's opinions. The task is not diagnostic, nor can it provide a measure of the "effect" of aerobic walking. Your only requirement was to do the best job that you could.

[review aspects of consent form]
I prepared another consent form for you, please indicate that I have your permission (or not) to audio record our conversation. Are you still ok with me recording (or not) our conversation today? ___Yes ___No

If yes: Thank you! Please let me know if at any point you want me to turn off the recorder or keep something you said off the record.
If no: Thank you for letting me know. I will only take notes of our conversation.

Before we begin the interview, do you have any questions? [I yes, discuss questions]
If any questions (or other questions) arise at any point in this study, you can feel free to ask them at any time. I would be more than happy to answer your questions.

As you know, in the online questionnaire, you've answered the questions on sleep quality, stress and life satisfaction, now I would like to ask you in greater details about some of those variables [and also about a few others that have come up in our research.]

PART 1: Background of the Respondent

Q 1: Could you briefly introduce yourself?

Q 2: Could you share with me your general impression of imbedding walking exercise in your daily life?

You've mentioned your general feedback about the daily walking experience, now I would like to ask you in greater detail about participating this activity [and also about a few others that have come up in our research.]

PART 2: Physical Activity

Q 1: What have been the motivations for you to take part in the walking intervention?

Q 2: Could you briefly describe how is your physical activity habits before taking part in the walking intervention?

Q 3: When you were walking, is the walking activity enough to raise your breathing rate? Please give me details about how do you feel the intensity of walking.

Q 4: What time(s) did you usually go with the walking exercise?

PART 3: SQ, Stress and Life Satisfaction

Q 1: Could you briefly describe your emotional experience when walking?

Q 2: To what extent has aerobic walking exercise interacted your sleep?

Q 3: To what extent has aerobic walking exercise impacted on your stress management?

Q 4: To what extent has aerobic walking exercise changed your life satisfaction?

PART 4: Summary

Q 1: On a scale from 0 – 10, (where 0 = not difficult at all and 10 = extremely difficult), how difficult is the walking activity?

Describe the experiences that led you to rate yourself in this way.

Q 2: On a scale from 0 – 10, (where 0 = not related at all and 10 = extremely related), how is do you think about the relationship between walking activity and your SQ, stress management and life satisfaction?

Describe the experiences that led you to rate yourself in this way.

Q 3: On a scale from 0 – 10, (where 0 = not helpful at all and 10 = extremely helpful), how helpful is the walking activity in your daily life?

Describe the experiences that led you to rate yourself in this way.

Is there any other information regarding your experience that you think would be useful for me to know?

Yes/No

Again, thank you for participating. (TURN TAPE-RECORDER OFF.)

Appendix 9

Appendix 9. Call for research volunteer

Title of the Study: "The effects of walking exercise on sleep quality in sedentary healthy adults"

Research Team:

We are from ELTE (a PhD student and two supervisors), and we are conducting a study to improve the sleep quality by a feasible and cost-effective way among people in all age groups in adults.

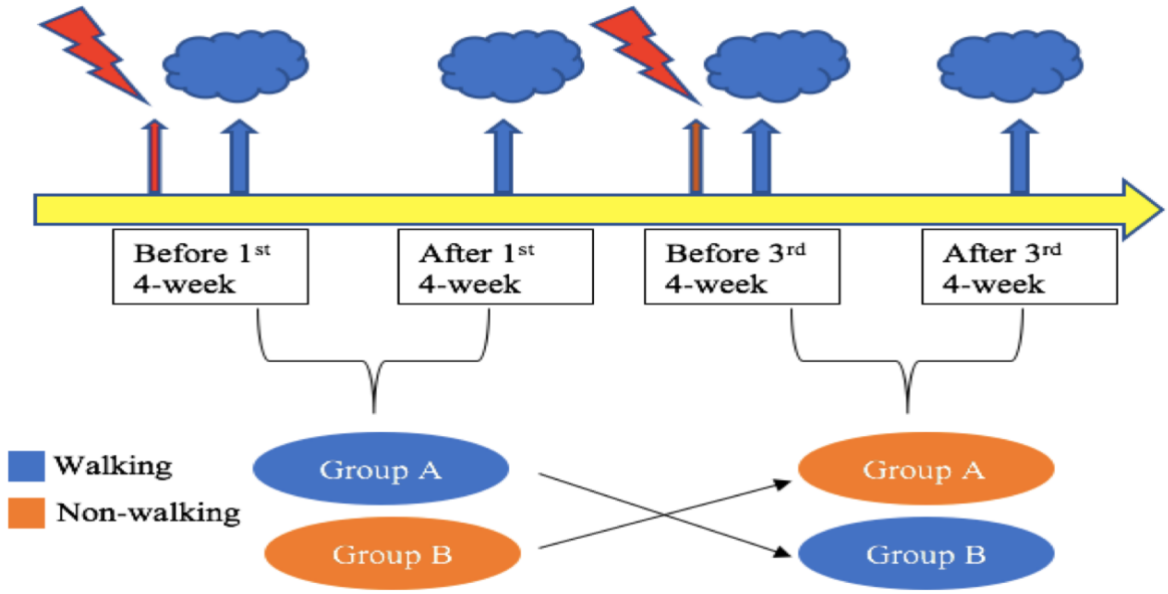
Why you?

We need you! We feel strongly that it would be very helpful to us if you would help us with our research. Your participation will help identify how daily walking influence sleep quality as well as provide us with a better understanding of how the sleep quality among people who lives in sedentary lifestyle.

What will I need to do?

We are looking for volunteers to participate in four-week walking exercise (10,000 steps) every day. You will be asked to record the details of your walking everyday (e.g. starting and ending time of your walking, steps, heart rate and calories etc.). During the intervention period, you are not allowed to join any kind of organized or non-organized physical activities.

The whole study will last for 3 months, participants will be randomly assigned to two groups. Below is the structure of the and activity of this study.



Who can volunteer?

To be eligible, you must meet all of the following criteria:

1. An adult over the age of 18 living in a sedentary life style. (you will be test by sedentary behavior questionnaire to see whether you meet the criteria of having a sedentary life style)

2. Have no organized or non-organized physical exercise.

3. Basic English-speaking skills (participants with English as a second language are encouraged to participate)

4. Able to read and understand basic instructions

5. Living in Budapest, Hungary.

Our thank you:

In appreciation for your participation in this study you will have a chance to won a bicycle at the end of intervention. We will also provide you with free course of Yoga.

If you have questions about the study or think you want to volunteer please contact Feifei Wang – either by telephone +36702833412 WhatsApp: +36702833412 or email at feifei.wang@ppk.elte.hu

Thank you for your interest and we hope to hear from you soon!

Feifei WANG Institute of Health Promotion and Sport Sciences, Doctoral School of Education, ELTE Eötvös Loránd University, HUNGARY

Dr. Silvia BOROS Institute of Health Promotion and Sport Sciences, ELTE Eötvös Loránd University, HUNGARY

Appendix 10

Appendix 10. Consent form and description of research

You are about to participate in a research coordinated by Dr. Boros Szilvia. The research is carried out by highly qualified professionals and their assistants. The aim of this study is to investigate the effect of daily walking exercise on sleep quality and stress.

Participation is voluntary. Performing the various tasks and filling out the questionnaires is harmless and it is without any foreseen risks. It is possible to suspend participation so that it should not be tiresome. It is also possible to withdraw consent and terminate participation at any time without any reason and without any consequences. Monetary compensation is due for participation.

During the study recording of the daily walking exercise will also be performed by pedometer attached to the volunteer's body. The recording has no health hazards, causes no pain. This investigation lasts for about one month for each group.

The results of this study later may be used in publications and will also be presented at scientific conferences. If requested, written or verbal information will be provided on these events.

All information collected during this research will be handled with strict confidentially. Data obtained during the research is stored as coded information on a secure computer and paper-based material (e.g. questionnaires) is kept in a safe or a locked office also in a coded format. The individual codes are provided by the assistant in charge, and these are accessible and known only to her/him. Data of the research are analyzed statistically during which no personal identification is possible. The document with the rules regulating personal data processing (General Data Protection Regulation, GDPR) is attached with its enclosures.

No medical or laboratory report will be prepared about the results of the study. Verbal account can be provided about the findings upon request.

Please sign the agreement below if you agree with the conditions outlined above and endorse participation in the study. We thank you for your collaboration.

I……(undersigned) declare that I was given thorough information regarding the circumstances of my participation in the present research. I agree with the conditions and to participate in the study. I also give my consent to use the anonymous data collected during this process so that these may be accessible to other researchers. I reserve the right to terminate my participation at any time in which case the data belonging to my person should be erased.

I am not (and have not been) treated for any kind of neurological or mental disease.

ELTE FPP as data processor handles my above personal data confidentially and does not allow access to these for other data processing or data analyzing organizations of any kind. Details of this statement are found in the "Information of Processing of Data (GDPR)" which I agree with as proven by my signature.

Budapest,…….

date signature

Appendix 11

Appendix 11. Daily diary report forms for group A and group B

Daily Diary Report Form (Group A) **Name:**

	Date	Start time	End time	Aerobic steps	Calories	Miles	Total steps
First week	4th March (Monday)						
	5th March (Tuesday)						
	6th March (Wednesday)						
	7th March (Thursday)						
	8th March (Friday)						
	9th March (Saturday)						
	10th March (Sunday)						
Second week	11th March (Monday)						
	12th March (Tuesday)						
	13th March (Wednesday)						
	14th March (Thursday)						
	15th March (Friday)						
	16th March (Saturday)						
	17th March (Sunday)						
Third week	18th March (Monday)						
	19th March (Tuesday)						
	20th March (Wednesday)						
	21st March (Thursday)						
	22nd March (Friday)						
	23rd March (Saturday)						

	24th March (Sunday)						
Fourth week	25th March (Monday)						
	26th March (Tuesday)						
	27th March (Wednesday)						
	28th March (Thursday)						
	29th March (Friday)						
	30th March (Saturday)						
	31st March (Sunday)						
	Date				Calories	miles	Total steps
First week	29th April (Monday)						
	30th April (Tuesday)						
	1st May (Wednesday)						
	2nd May (Thursday)						
	3rd May (Friday)						
	4th May (Saturday)						
	5th May (Sunday)						
Second week	6th May (Monday)						
	7th May (Tuesday)						
	8th May (Wednesday)						
	9th May (Thursday)						
	10th May (Friday)						
	11th May (Saturday)						
	12th May (Sunday)						
Third week	13th May (Monday)						
	14th May						

	(Tuesday)						
	15th May (Wednesday)						
	16th May (Thursday)						
	17th May (Friday)						
	18th May (Saturday)						
	19th May (Sunday)						
Fourth week	20th May (Monday)						
	21st May (Tuesday)						
	22nd May (Wednesday)						
	23rd May (Thursday)						
	24th May (Friday)						
	25th May (Saturday)						
	26th May (Sunday)						

Daily Diary Report Form (Group B) **Name:**

	Date				Calories	Miles	Total steps
First week	4th March (Monday)						
	5th March (Tuesday)						
	6th March (Wednesday)						
	7th March (Thursday)						
	8th March (Friday)						
	9th March (Saturday)						
	10th March (Sunday)						
Second week	11th March (Monday)						
	12th March						

	(Tuesday)						
	13th March (Wednesday)						
	14th March (Thursday)						
	15th March (Friday)						
	16th March (Saturday)						
	17th March (Sunday)						
Third week	18th March (Monday)						
	19th March (Tuesday)						
	20th March (Wednesday)						
	21st March (Thursday)						
	22nd March (Friday)						
	23rd March (Saturday)						
	24th March (Sunday)						
Fourth week	25th March (Monday)						
	26th March (Tuesday)						
	27th March (Wednesday)						
	28th March (Thursday)						
	29th March (Friday)						
	30th March (Saturday)						
	31st March (Sunday)						
	Date	Start time	End time	Aerobic steps	Calories	miles	Total steps
First week	29th April (Monday)						
	30th April (Tuesday)						
	1st May (Wednesday)						
	2nd May (Thursday)						

	3rd May (Friday)						
	4th May (Saturday)						
	5th May (Sunday)						
Second week	6th May (Monday)						
	7th May (Tuesday)						
	8th May (Wednesday)						
	9th May (Thursday)						
	10th May (Friday)						
	11th May (Saturday)						
	12th May (Sunday)						
Third week	13th May (Monday)						
	14th May (Tuesday)						
	15th May (Wednesday)						
	16th May (Thursday)						
	17th May (Friday)						
	18th May (Saturday)						
	19th May (Sunday)						
Fourth week	20th May (Monday)						
	21st May (Tuesday)						
	22nd May (Wednesday)						
	23rd May (Thursday)						
	24th May (Friday)						
	25th May (Saturday)						
	26th May (Sunday)						