# การทดสอบเดินหกนาทีในบุคคลสุขภาพดีที่มีระดับกิจกรรมทางกายที่เพียงพอและไม่เพียงพอ

นาย สิตมนัส สุวรรณฉาย



วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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# SIX MINUTE WALK TEST IN HEALTHY PERSONS WITH SUFFICIENT AND INSUFFICIENT LEVELS OF PHYSICAL ACTIVITY

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A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Sports Medicine

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สิตมนัส สุวรรณฉาย : การทดสอบเดินหกนาทีในบุคคลสุขภาพดีที่มีระดับกิจกรรมทางกายที่เพียงพอและไม่เพียงพอ. (SIX MINUTE WALK TEST IN HEALTHY PERSONS WITH SUFFICIENT AND INSUFFICIENT LEVELS OF PHYSICAL ACTIVIY) อ. ที่ปรึกษา : รศ.ดร.พญ.อรอนงค์ กุละพัฒน์, อ.ที่ปรึกษาร่วม : รศ.พญ.ดุจใจ ชัยวานิชศิริ, 93 หน้า.

การทดสอบเดินหกนาทีเป็นการทดสอบสมรรถภาพที่นิยมใช้ในผู้ป่วยระบบไหลเวียนเลือดและระบบการหายใจ สมการอ้างอิงในปัจจุบันสร้างจากกลุ่มตัวอย่างผู้มีสุขภาพดีที่ส่วนใหญ่เป็นผู้ที่มีกิจกรรมทางกายที่เพียงพอ (86 – 90%) สมการอาจทำนายค่าได้สูงเกินเมื่อใช้กับผู้ป่วยที่มีกิจกรรมทางกายจำกัด **วัตถุประสงค์** : การศึกษาวิจัยในครั้งนี้เพื่อเปรียบเทียบระยะทางที่เดินได้ในการทดสอบเดินหกนาที ในบุคคลสุขภาพดีที่มีระดับกิจกรรมทางกายที่เพียงพอและไม่เพียงพอ **วิธีดำเนินการ** : อาสาสมัครชาวไทยอายุ 45 – 65 ปี ที่อาศัยในเขตกรุงเทพมหานครและปริมณฑล ทั้งหมด 162 คน (ชาย 77 คน, หญิง 85 คน) ทดสอบเดินหกนาทีจำนวนสามรอบโดยวิธีมาตรฐาน ใช้ระยะทางจากรอบที่เดินได้มากที่สุด การแบ่งระดับกิจกรรมทางกายใช้ข้อมูลจากแบบสอบถามเกี่ยวกับกิจกรรมทางกายใน 1 สัปดาห์ที่ผ่านมา วิเคราะห์ผลระยะทางการเดินโดยเปรียบเทียบระหว่างผู้ที่มีกิจกรรมทางกายเพียงพอและไม่เพียงพอ **ผลการทดสอบ** : ระยะทางจากการทดสอบเดินหกนาทีของผู้ที่มีระดับกิจกรรมทางกายที่เพียงพอมากกว่าไม่เพียงพออย่างมีนัยสำคัญทางสถิติทั้งในเพศชาย (701 $\pm$ 89 เมตร และ 652 $\pm$ 55 เมตร; $p = 0.005$) และเพศหญิง (619 $\pm$ 49 เมตร และ 571 $\pm$ 35 เมตร; $p < 0.001$) เมื่อใช้สมการทำนายจาก Hermione และจาก Bernadine จะประเมินระยะทางได้สูงเกินไปในเพศหญิงที่มีกิจกรรมทางกายไม่เพียงพอ สมการจากอาสาสมัครทั้งหมดมีตัวแปรอิสระในการทำนายระยะทางได้แก่ ความสูง พลังงานที่ใช้ต่อสัปดาห์ ร้อยละของอัตราการเต้นหัวใจสูงสุดระหว่างการทดสอบเดินหกนาที เพศ น้ำหนักตัว และ อายุ ($r^2 = 0.58$) สมการจากผู้ที่มีกิจกรรมทางกายที่เพียงพอมีตัวแปรอิสระในการทำนายระยะทางได้แก่ ความยาวก้าวปกติ พลังงานที่ใช้ต่อสัปดาห์ ร้อยละของอัตราการเต้นหัวใจสูงสุดระหว่างการทดสอบเดินหกนาที เพศ น้ำหนักตัว และ อายุ ($r^2 = 0.61$) สมการจากผู้ที่มีกิจกรรมทางกายที่ไม่เพียงพอมีตัวแปรอิสระในการทำนายระยะทางได้แก่ ความสูง ร้อยละของอัตราการเต้นหัวใจสูงสุดระหว่างการทดสอบเดินหกนาที และ เพศ ($r^2 = 0.54$) **สรุปผลการทดลอง** : ระยะทางจากการทดสอบเดินหกนาทีระหว่างผู้ที่มีกิจกรรมทางกายเพียงพอและไม่เพียงพอมีความแตกต่างกัน การประเมินผลในเพศหญิงควรพิจารณาผลที่ได้จากการใช้สมการทำนายต่างๆ ด้วยความระมัดระวัง การแบ่งระดับกิจกรรมทางกายไม่มีผลต่อสมการทำนายในเพศชาย

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SITAMANATS SUWANACHAIY : SIX MINUTE WALK TEST IN HEALTHY PERSONS WITH SUFFICIENT AND INSUFFICIENT LEVELS OF PHYSICAL ACTIVITY. THESIS ADVISOR : ASSOC.PROF.ONANONG KULAPUTANA, M.D., Ph.D., THESIS COADVISOR : ASSOC.PROF.DOOTCHAI CHAIWANICHSIRI, M.D., 93 pp.

Six minute walk test (6MWT) is a common functional exercise capacity test in individuals with cardiopulmonary disease. Recent reference equations were derived from majority healthy subjects with sufficient physical activity (86 – 90%). Predicted walk distance from the equations may overestimate when used in patients with limited physical activity. **Objective**: To compare six minute walk distance (6MWD) between healthy persons with sufficient and insufficient levels of physical activity. **Methods**: Thai volunteers aged 45 – 65 years living in Bangkok and metropolitan area (n = 162; 77 males and 85 females) performed three standard 6MWTs. Best 6MWD of three tests was recorded. Physical activity levels were determined using one week recall physical activity questionnaire. Data analyses were based on 2 groups of sufficient and insufficient levels of physical activity. **Results**: 6MWD in sufficient level of physical activity group was greater than insufficient one in both males (701 $\pm$ 89 m vs. 652 $\pm$ 55 m; $p = 0.005$) and females (619 $\pm$ 49 m vs. 571 $\pm$ 35 m; $p < 0.001$). In women with insufficient physical activity, the predicted 6MWD from the equations of Hermione et al. and Bernadine et al. overestimated real 6MWD. Stepwise multiple regression analysis showed that height, energy expenditure per week, a percentage of the predicted maximal HR (%predHRmax), sex, weight and age were independent contributors of 6MWD in overall ($r^2 = 0.58$). Normal stride length, energy expenditure per week, %predHRmax, sex, weight and age were independent contributors of 6MWD in the group of sufficient physical activity ($r^2 = 0.61$). Height, %predHRmax and sex were independent contributors of 6MWD in the group of insufficient physical activity ($r^2 = 0.54$). **Conclusion**: Subjects with sufficient activity had significantly greater 6MWD than those with insufficiency activity. Using the published equations for females should be cautiously interpreted. Physical activity classification did not affect the prediction equations in males.

Field of study .........Sports Medicine......... Student's signature. Sitamanats Suwanachaiy

Academic year ..............2007..................Advisor's signature. Onanong Kulaputana

Co-advisor's signature. Dootchai Chaiwanichsiri

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# CHAPTER I

# INTRODUCTION

## Background and Rationale

There are several modalities available for the objective evaluation of functional exercise capacity. Some provide a very complete assessment of all systems involved in exercise performance, whereas others provide basic information but are simpler to perform. The modality used should be chosen based on the clinical question to be addressed and on available resources. The most popular clinical exercise tests in order of increasing complexity are stair climbing, six minute walk test, shuttle walk test, detection of exercise induced asthma, cardiac stress test (e.g. Bruce protocol), and cardiopulmonary exercise test.

Assessment of functional capacity has traditionally been done by merely asking patients the following: "how many flights of stairs can you climb or how many blocks can you walk?" However, patients vary in their recollection and may report overestimations or underestimations of their true functional capacity. Objective measurements are usually better than self report. In the early 1960s, Balke developed a simple test to evaluate the functional capacity by measuring the distance walked during a defined period of time (Balke, 1963). A 12 minute field performance test was then developed to evaluate the level of physical fitness of healthy individuals (Cooper et al., 1968). The walking test was also adapted to assess disability in patients with chronic bronchitis (Mcgavin et al., 1976). In an attempt to accommodate patients with respiratory disease for whom walking 12 minutes was too exhausting, a 6 minute walk was found to perform as well as the 12 minute walk (Butland et al.,1982).



Six minute walk test (6MWT) is used as a measure of exercise capacity and predictor of morbidity and mortality. This test is widely used in individual with cardiopulmonary disease (Hermione et al., 2006). Moreover, 6MWT can be used as an indicator of overall physical capacity and mobility in the elderly (Barata et al., 2005). Guyatt et al. described the 6MWT as a simple, inexpensive and safe test (Troosters et al., 1999). It is easier to administer, better tolerated and better reflected activities of daily living than other walk tests (Enright et al., 2003). Interpretation of 6MWT may be done before and after an intervention by reported mean changes in six minute walk distance (6MWD), and interpreting single measurement of functional status (ATS Guidelines, 2002) by calculating the predicted distance using an equations from one of the healthy population base samples using standardized 6MWT methods (Enright et al., 2003; ATS Guidelines, 2002). Some examples of the equations for predicting distance are as follows.

For men, 6MWD = (7.57x$height_{cm}$)-(5.02xage)-(1.76x$weight_{kg}$)-309 m (Enright and Sherrill et al.,1998).

For women, 6MWD = (2.11x$height_{cm}$)-(5.78xage)-(2.29x$weight_{kg}$)-667 m (Enright and Sherrill et al.,1998).

However, recent studies reported differences in predicted 6MWD from various equations (Hermione et al., 2006; Bernadine et al., 2006), despite following ATS guidelines. Previous studies identified sources of variability in 6MWD equations such as race (Hermione et al., 2006) and wide age range of population samples (Barata et al., 2005). Due to such limitations, potential outcomes and considerate rehabilitation may be unrealistic.

Previous studies have found that 6 minute walk performance was significantly associated with the habitual activity levels and self reported physical activity limitations in the elderly persons (Stephen et al.,2002). In the published studies, the reference equations for 6MWD from healthy subjects were not developed specifically for each of the physical activity levels but considered physical activity levels in the samples (Hermione et al.,2006; Troosters et al.,1999; Bernadine et al.,2006). The majority of the subjects (86-90%) (Hermione et al.,2006; Bernadine et al.,2006) had sufficient physical activity for health benefits according to guideline of The University of Western Australia, 1999. A small number of subjects had either insufficiency physical activity or inactive lifestyle (Hermione et al.,2006; Bernadine et al.,2006). Physical activity level was obtained by using a standard questionnaire for physical activity levels of Western Australian adults 1999 (Bull et al.,2000).

Some previous studies, however, indicated that physical activity and 6MWD are not related (Hermione et al.,2006; Bernadine et al.,2006). It is possible that physical activity may not be related to 6MWD only in healthy persons with sufficient physical activity. The reference equations derived from healthy persons with sufficient physical activity may overestimate when used in patients who might have insufficiency of physical activity because of their diseases. The implication of this for the patients could be considerable.

In fact, 6MWD was not related to physical activity in the majority of subjects who had sufficient physical activity, and this finding was consistent with other studies (Hermione et al.,2006; Troosters et al.,1999; Bernadine et al.,2006). It is possible that in individuals with sufficient physical activity, the actual levels of physical activity do not affect 6MWD. However, it is not known whether 6MWD in healthy persons, with insufficient physical activity differs from that of healthy persons with sufficient physical activity.

The main aim of the present study is to evaluate the influence of the level of physical activity as a potential factor of variability in the 6MWD reference equation. If 6MWD is different between healthy persons with sufficiency and insufficiency physical activity, physical activity levels should be included in the reference equation for a better accuracy. Alternatively, prediction equations should be developed specifically according to the levels of physical activity. The outcome of this study is expected to be useful for functional evaluation of the patients with insufficiency physical activity.

**Research questions**

1. Is 6MWD different between healthy persons with sufficiency and insufficiency of physical activity ?

2. Does predicted 6MWD derived from existing reference equations (Hermione et al.,2006; Bernadine et al.,2006) differ from 6MWD determined in healthy Thais with sufficient and insufficient physical activity levels ?

3. What are the factors contributing to variability of 6MWD ?

**Objectives**

1. Compare 6MWD in healthy persons between sufficient and insufficient levels of physical activity

2. Compare predicted 6MWD from previous reference equations (Hermione et al.,2006; Bernadine et al.,2006) and 6MWD from healthy persons with sufficient and insufficient levels of physical activity

3. Identify factors contributing to 6MWD, including age, sex, weight, height, stride length, $FEV_1$, volume of physical activity, and heart rate during 6MWT

**Hypothesis**

1. 6MWD in healthy persons with sufficiency of physical activity differ from healthy persons with insufficiency of physical activity.

2. 6MWD in healthy persons with insufficiency of physical activity differ from the common reference equations derived 6MWD.

**Scope of research**

This study has a cross sectional descriptive design in which healthy persons with sufficient and insufficient physical activity participated as the subjects.

The study approval was obtianed from the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University. Written inform consent was obtained from each subject before the experiment started. On attendance, subjects were given a brief on the experimental procedure and risk involved, and reminded of their right to withdraw at any stage of the study.

**Assumptions**

1. The equipment was calibrated for standard accuracy and reliability.

2. All subjects participated in this study were volunteers.

3. All subjects were asked to refrain from consuming alcohol, caffeine or food for 2 hours and having no vigorous activities for 24 hours before the test sessions (Hermione et al.,2006).

**Limitations**

1. Speed of walking depend on co-operation of participants.

2. Acuracy of information from questionnaire relies on participants.

**Operational definitions**

1.Healthy subjects are persons who had no history of symptomatic cardiovascular disease; family history of arteriosclerosis (before 55 years old in men and before 65 years old in women (Alfredo et al.,2006)); diagnosed hyperlipidaemia; resting blood pressure >150/100 mm Hg (Hermione et al.,2006); resting heart rate (HR) >100 beats per minute (b.p.m.); abnormal lung function (FEV1<80% predicted or FEV1/FVC <70%); blood or metabolic disorders; current illness, including upper respiratory tract infection in the past 4 weeks; use of ambulatory aids; leg length discrepancy >3 cm; severe, disabiling pain of musculoskeletal origin and current pregnancy.

2. Sufficient physical activity (An initiative of the Premier's Physical Activity Taskforce, 2003) is presented in one of the two ways: 1) undertaking 150 minutes of moderate intensity physical activity on five or more sessions or undertaking 60 minutes of vigorous intensity physical activity in the previous week; or 2) undertaking 150 minutes of total physical activity where moderate and vigorous activity (weighted by two) are summated in the previous week.

3. Insufficient physical activity (An initiative of the Premier's Physical Activity Taskforce, 2003) refers to some activity but not enough to reach the levels required for sufficient one.

4. Inactive is used to describe individuals who reported no participation in any walking, moderate, or vigorous physical activity in the past week (An initiative of the Premier's Physical Activity Taskforce, 2003).

**Expected benefits and applications**

1. Data base for making a more optimal reference equation

2. Understand relationship between 6MWT and YMCA cycle test to determine exercise capacity

3. Data base for future research

# CHAPTER II

# REVIEW OF THE LITERATURE

## Six minute walk test (6MWT)

Walking is an activity performed daily even the most severely impaired elderly and patients (ATS Guidelines, 2002). The self paced 6 minute walk test (6MWT) assesses the submaximal level of functional capacity. This test measures the distance that can quickly walk on a flat hard surface in a period of 6 minutes. It evaluates the global and integrated responses of all systems involved during exercise, including the pulmonary and cardiovascular system, systemic circulation, peripheral circulation, blood, neuromuscular units, and muscle metabolism (ATS Guidelines, 2002). It does not provide specific information on the function of each of the different organs and systems involved in exercise or the mechanism of exercise limitations (ATS Guidelines, 2002).

### Sources of variability in six minute walk distance (6MWD)

There are many sources of 6MWD variability. Factors that have been shown to reduce the 6MWD included shorter height, older age, higher body weight, female sex, impaired cognition, a shorter corridor (more turns), pulmonary diseases (COPD, asthma, cystic fibrosis, interstitial lung disease), cardiovascular diseases (angina, myocardial (MI), congestive heart failure (CHF), stroke, transient ischemic attack (TIA), peripheral vascular disease (PVD), aortic arch interruption (AAI)) and musculoskeletal disorders (arthritis, ankle, knee, or hip injuries, muscle wasting, etc.). Factors that have been shown to increase the 6MWD included taller height (longer legs), male sex, high motivation, previously experiencing the test, medication for a disabling disease taken just before the test and oxygen supplementation in patients with exercise induced hypoxemia (ATS Guidelines, 2002).

**The sources of variability caused by the test procedure itself**

**1.Practice tests**

From the guidance to clinicians in the international pulmonary rehabilitation community, a practice test is not needed in most clinical setting but should be considered. If a practice test is done, wait for at least 1 hour before the second test and report the highest 6MWD as the patient's 6MWD baseline. The 6MWD is only slightly higher for a second 6MWT performed a day later. The mean reported increase ranges from 0 to 17% (ATS Guidelines, 2002). A multicenter study of 470 highly motivated patients with severe COPD performed two 6MWTs 1 day apart, and on average, the 6WMD was only 66 feet (5.8%) higher on the second day (Weiss et al.,2000).

Performance (without an intervention) usually reaches a plateau after two tests done within a week (ATS Guidelines, 2002). The training effect may be due to improved coordination. Finding optimal stride length, and overcoming anxiety. The training effect found in patients with severe emphysema is less than previous reports of patients with chronic obstructive pulmonary disease (Frank et al.,2003). There is a possibility that a practice or training effect from tests repeated after a month persists after 2 months (Wu et al.,2003).

There is evidence that learning effect persists after 2 months (Wu et al.,2003). Fifty healthy adults (mean age, 30.6 years) unfamiliar with the 6MWT completed 3 walks at baseline (walks 1–3) and 3 walks at follow up (walks 4–6) after 2 months. The distance walked increased significantly between walks 1 and 3 (2046 $\pm$ 228 ft to 2194 $\pm$ 266 ft). There was no difference in distance walked between walks 3 and 4, which were conducted 2 months apart. The distance walked increased significantly between walks 4 and 6 (2201 $\pm$ 233 ft to 2285 $\pm$ 257 ft). The distance walked was comparable for walks 3 and 4, which were conducted approximately 2 months apart (mean change, 7 ft [0.32%]; P = not significant), suggesting that the initial learning effect was maintained during this period (Wu et al.,2003).

**2.Encouragement**

Encouragement significantly increases the distance walked. Reproducibility for tests with and without encouragement is similar (Guyatt et al., 1984). Some studies have used encouragement every 30 seconds (Troosters et al., 1999; Stephen et al., 2000), every minute (Butland et al.,1982; Enright et al., 2003) or every 2 minutes (Guyatt et al., 1984; Wu et al.,2003).. The standard guideline (ATS Guidelines, 2002) has chosen every minute to standard phrases. Some studies have instructed patients to walk as fast as possible (Troosters et al., 1999). Although larger mean 6MWD may be obtained thereby, it is recommended that such phrases not be used, as they emphasize initial speed at the expense of earlier fatigue and possible excessive cardiac stress in some patients with heart disease (ATS Guidelines, 2002).

**3.Supplemental oxygen**

If oxygen supplementation is needed during the walks and serial tests are planned (after an intervention other than oxygen therapy), then during all walks by that patient oxygen should be delivered in the same way with the same flow (ATS Guidelines, 2002). If the flow must be increased during subsequent visits due to worsening gas exchange, this should be noted on the worksheet and considered during interpretation of the change note in 6MWD. Measurements of pulse and $SpO_2$ should be made after waiting at least 10 minutes after any change in oxygen delivery. For patients with COPD or interstitial lung disease, oxygen supplementation increases the 6MWD (Grove et al.,1996). Carrying a portable gas container (but not using it for supplemental oxygen) reduced the mean 6MWD by 14% in patients with severe respiratory disability, but using the container to deliver supplemental oxygen during the exercise increased the mean 6MWD by 20-35% (Leach et al.,1992).

**4.Medications**

The type of medication, dose and number of hours taken before the test should be noted. Significant improvement in the distance walked, or the dyspnea scale, after administration of bronchodilators has been demonstrated in patients with COPD

(Hay et al., 1992; Grove et al.,1996). Additionally cardiovascular medications has been shown to improve 6MWD in patients with heart failure (DeBock et al.,1994).

**5.Location**

The 6MWT should be performed indoors, along a long, flat, straight, enclosed corridor with a hard surface that is seldom traveled. If the weather is comfortable, the test may be performed outdoors. The walking course must be 30 m in length. A 100 feet hallway is required. The length of the corridor should be marked every 3 m. The turnaround points should be marked with a cone (such as an orange traffic cone). A starting line, which marks the beginning and end of each 60 m lap, should be marked on the floor using brightly colored tape (ATS Guidelines, 2002).

The use of a treadmill to determine the 6MWD might save space and allow constant monitoring during the exercise, but the use of treadmill for 6 minute walk testing is not recommended (Barthelemy et al.,1990). Subjects and patients are unable to pace themselves on a treadmill. In study of Barthelemy et al., patients with severe lung disease, the mean distance walked on the treadmill during 6 minutes (with the speed adjusted by the patients) was shorter by a mean of 14% when compared with the standard 6MWD using a 100 feet hallway. The range of differences was wide, with patients walking between 400-1,300 feet on the treadmill who walked 1,200 feet in the hallway. Treadmill test results, therefore, are not interchangeable with corridor tests.

The course layout had an effect on the distance walked. In a study, participants tested on continuous (circular or oval) courses had a 92.2 foot longer walking distance than walk tested on straight (requiring turns) courses. Course length had no significant effect on walking distance (Frank et al.,2003).

The 6MWT with support (6MWTphy) and without support by a physiotherapist (6MWTw) showed difference in 6MWD. In study of Clenia et al., the 6MWTphy and 6MWTw showed statistically significant difference in the groups with higher average values of the 6MWD, of the heart rate (HR) and respiratory rate (RR) and Borg's rate subjective perceived exertion (RPE) in the 6MWTphy. The 6MWTphy increased average distance covered by 70.33m, approximately 15% for patients with previous MI as compared to 6MWTw. In normal elderly patients, 6MWTphy improved performance of 6MTWphy by increasing average distance covered by 64.84 m approximately 12% (Clenia et al.,2006).

**Interpretation**

**1.Reported mean changes in 6MWD**

Most 6MWTs will be done before and after intervention and the primary question to be answered after both tests have been completed is whether the patient has experienced a clinically significant improvement. With a good quality assurance program, with patients tested by the same technician, and after one or two practice test, short term reproducibility of the 6MWD is excellent. It is not know whether it is best for clinical purposes to express change in 6MWD an absolute value, a percentage change, or a change in the percentage of predicted value (ATS Guidelines, 2002).

A statistically significant mean increase in 6MWD in a group of study participant is often much less than a clinically significant increase in an individual patient. In one study of 112 patients (half of them women) with stable, severe COPD, the smallest difference in 6MWD that was associated with a noticeable clinical difference in the patients' perception of exercise performance was a mean of 54 m. (95% confidence interval, 37-71 m) (Redelmeier et al.,1997). This study suggests that for individual patients with COPD, an improvement of more than 70 m in the 6MWD after an intervention is necessary to be 95% confident that improvement was significant. In an observational study of 45 older patients with heart failure, the smallest difference in 6MWD that was associated with a noticeable difference in their global rating of worsening was a mean of 43 m (O'Keeffe et al.,1998). The 6MWD was more responsive to deterioration than to improvement in heart failure symptoms (O'Keeffe et al.,1998).

**2.Interpreting single measurements of functional status**

Optimal reference equations from health population base samples using standardized 6MWT methods are not yet available. The World Health Organisation defines health as 'a state of complete physical, mental and social well being and not merely the absence of disease (An initiative of the Premier's Physical Activity Taskforce, 2003).' Health refers to metabolic well being as reflected in low risk levels of blood fats, blood pressure and body weight as well as general physical and mental well being (The University of Western Australia, 1999). A low 6MWD is nonspecific and nondiagnostic. When the 6MWD is reduced, a thorough search for the cause of the impairment is warranted (ATS Guidelines, 2002).

In 1998 Enright and Sherrill established reference equations for prediction of the total 6MWD for healthy adults in one single test. The subjects included 117 healthy men and 173 healthy women aged 40 to 80 yr. The mean 6MWD was 576 m (399 – 778 m) for men and 494 m (310 – 664 m) for women. The gender specific models regression equations for predicting 6MWD explained 42% and 38% of the variation for men and women, respectively. The investigators suggested that future population based studies that include additional data, such as knowledge of exercise habits, cardiopulmonary conditioning, and musculoskeletal problems might improve their prediction models and account for the 60% of unexplained variance (Enright and Sherrill et al.,1998).

For men; $6MWD(m) = (7.57 \times height_{cm}) - (1.76 \times weight_{kg}) - (5.02 \times age) - 309$ m.

For women; $6MWD(m) = (2.11 \times height_{cm}) - (2.29 \times weight_{kg}) - (5.78 \times age) + 667$ m

Population studies indicated that more than 75% of the United States population is regularly exposed to environmental tobacco smoke (Pirkle et al., 1996). A smaller but still significant fraction of the population, particularly urban dwellers, are exposed to nontobacco sources of CO. It is thus likely that many subjects of Enright and Sherrill (Enright and Sherrill, 1998) who participated in 6MWT would have an increased blood carboxyhemoglobin concentration (Stephen et al., Correspondence, 2000).

A later study did not find a relationship between 6MWD and smoking habits (Troosters et al., 1999). The investigators evaluated the 6MWD in healthy elderly aged 50 - 85 yrs (Troosters et al., 1999). Tests were performed in a quiet 50 m long hospital corridor. Patients were encouraged every 30 s to continue walking as quickly as possible. A 6MWD test was performed twice with ~2.5 h between the two tests. The mean walking distances of the first and second tests were, respectively, 574.97 and 621.86 m. The first test was the better in eight (15%) patients. The second test was on average 8.5% better than the first test. The mean 6MWD was 673 m for men and 589 m for women. The 6MWD showed significant correlations with age (r = -0.51) and height (r = 0.54). Stepwise multiple regression analysis showed that age, height, sex and weight were independent contributors to the 6MWD in healthy subjects explaining 66% of the variability. The model predicts 6MWD as: 6MWD = 218 + (5.146 x $\text{height}_{cm}$) – (5.326 x $\text{age}_{years}$) - (1.806 $\text{weight}_{kg}$) + (51.316 x sex). The 6MWD was not related to the scores on the daily activities questionnaire nor to the subjects' smoking habits (Troosters et al.,1999).

Although anthropometric parameters of age, weight, and height alone explained some variation in the 6MWD, the large variation remains unexplained (Teramoto et al., 2000). The reference equations of the 6MWD should be simple for clinical usage. Population based studies would obviously be welcome to determine adequate reference equations for the narrow normal range of the 6MWD at a given age (Teramoto et al., 2000).

**Six minute walk distance in healthy subjects aged 55 – 75 years.**

Seventy Caucasian subjects (33 males) aged 55 – 75 years performed three tests using a standardized protocol (ATS Guidelines, 2002). 6MWD was defined as the greatest distance achieved from the three tests. The resting HR prior to commencing successive tests was not different, being 75.3 $\pm$ 10.8 , 76.6 $\pm$ 11.0 and 77.7 $\pm$ 10.8 beats per minute (bpm). 6MWD during tests 1, 2 and 3 was 626 $\pm$ 63, 645 $\pm$ 58 and 655 $\pm$ 61 m. The average 6MWD was 659 $\pm$ 62m (range 484 – 820m). Males walked 59 $\pm$ 13 m further than females being 690 + 53 and 631 + 57 m in males and females, respectively. Height (r = 0.54), weight (r = 0.25) and FEV1 (r = 0.48) were significantly correlated with 6MWD. The forward stepwise multiple regression model explained 33.9% of the variance. Height and FEV1 were identified as significant independent predictors of 6MWD in this group. The regression equation for this relationship is: 6MWD(m) = 216.90 + (4.12 x $height_{cm}$) – (1.75 x $age_{years}$) – (1.15 x $weight_{kg}$) – (34.04 x gender, where males = 0 and females = 1). Sixty three subjects (90%) were classified as undertaking sufficient physical activity for health benefits. The subjects had a high level of education, with 37 subjects (53%) having attended a vocational training college or university (Bernadine et al., 2006).

Of particular interest was the time spent walking for continuous periods of at least 10 minutes either for recreation, exercise or transport. It was found that minutes walked in the previous week was not a predictor of 6MWD (Bernadine et al., 2006). This finding was consistent with other studies that also failed to demonstrate an association between self reported physical activity and 6MWD (Bernadine et al., 2006).

**Six minute walk distance in healthy subjects aged 20 – 50 years**

All subjects performed two 6MWTs according to a standard protocol (Alfredo et al.,2006). The mean 6MWDs were 638 $\pm$ 44 m and 593 $\pm$ 57 m, respectively for men and for women. The equation by stepwise multiple regression analysis included height, age and gender for the 6MWD and accounted for 42% of the total variance. The regression equation for this relationship is: 6MWD (m) = 518.853 + (1.250 x $height_{cm}$) – (2.816 x $age_{years}$) - 39.07 (gender, where males = 0 and females = 1). One potential source of variance may be the different attitudes, beliefs as well as the mood of the participants. Another potential source of variance may be the different peripheral muscle conditioning of the participants, since the investigators included in this study both habitually active and sedentary healthy subjects. The change in heart rate during walking should also be considered (Alfredo et al.,2006).

**Six minute walk distance in healthy subjects aged 7.5 – 9 years.**

Reference values of 6MWT and body mass index (BMI) in children of age 90 – 108 months (38 males; 38 females) have been reported (James et al.,2006). The mean waking distance was 581.7 m (SD = 58.10) for boys and 532.2 m (SD = 52.6) for girls. Mean BMI was 15.5 (SD = 2.00) for boys and 16.3 (SD = 2.9) for girls. There was no relationship between 6MWD and BMI. The baseline values for the 6MWT in healthy, third-grade children, have shown in percentiles for the sample were calculated separately for boys and girls (James et al., 2006).

**Variability in reference equations**

The walk distances predicted by the various equations may not be able to use in some populations of different ethnicity. Comparision 6MWD walked by elderly Brazilian subjects (Barata et al.,2005) with 6MWD predicted by the reference equations of Enright & Sherrill, Troosters et al. and Enright et al. Thirty eight healthy elderly subjects aged 64 - 82 years participated in the trial twice (Barata et al.,2005). The elderly men achieved longer walking distances than did the women (410.5 m vs. 371.0 m). The walking distances predicted by the equations from Enright & Sherrill and Troosters et al. (1999) showed good correlations ($r = 0.7$) with the distances walked by the women, but not with the distances walked by the men. The walking distances predicted by the equation from Enright et al. showed good correlations with the distances walked by men ($r = 0.6$) and by women ($r = 0.7$) (Enright et al., 2003). These results demonstrated the great variation between the distances walked by the elderly Brazilian subjects and the distances predicted by the various equations (Barata et al.,2005).

Measured 6MWD in healthy Singaporeans (Hermione et al.,2006) was compared with predicted 6MWD from two regression equations derived from Caucasian subjects (Hermione et al.,2006). Thirty-five healthy subjects (32 Chinese, 16 men) aged between 45 and 85 years performed three walking tests using a standardized protocol (ATS Guidelines, 2002). Heart rate (HR) was recorded each minute during the 6MWT. 6MWD was $560 \pm 105$ m and was not significantly different between men ($586 \pm 126$ m) and women ($538 \pm 82$m). 6MWD was related to age ($r = -0.36$), height ($r = 0.35$), leg length ($r = 0.38$) and the maximum HR achieved on the 6MWT when expressed as a percentage of the predicted maximum HR (%predHRmax, $r = 0.73$). Stepwise multiple regression analysis showed that age, height, weight and %predHRmax were independent contributors to 6MWD, explaining 78% of the variance. Predicted 6MWD using regression equations derived from Caucasian subjects (Troosters et al., 1999 and Gibbons et al., 2001) exceeded measured 6MWD of Singaporeans by more than 75 m (Hermione et al.,2006). The authors concluded that published equations derived from Caucasian subjects overestimated 6MWD in Singaporean Chinese (Hermione et al.,2006).

Since published equations derived from Caucasian subjects overestimated 6MWD in Singaporean Chinese (Hermione et al.,2006), this will assist in the interpretation of 6MWD in Asian patients with cardiopulmonary disease, as the 6MWD reference values have mostly been published for healthy Caucasian subjects. However, study of Teramoto et al. (Teramoto et al.,2000) determined reference equations for the 6MWD in healthy middle aged and elderly Japanese subjects. One hundred and fifty-eight healthy Japanese subjects were evaluated for 6MWD using three walking tests with a standardized protocol (ATS Guidelines, 2002). Mean values of 6MWD for healthy male and female Japanese adults are 624 m and 541 m, respectively. The authors indicated that the reference value of the 6MWD in healthy elderly Japanese subjects was similar to that in elderly Caucasians (Teramoto et al., 2000). It was suggested that the normal value of the 6MWD at any given age may not be very different between Caucasians and non-Caucasians (Teramoto et al.,2000).

In Caucasians studies, Troosters et al. (1999) reported that the mean values for 6MWD for healthy elderly (50 - 85 years) men and women are 673 m and 589 m, respectively. A study of healthy adults (40 – 80 years) in Enright & Sherrill (1998) determined distances of 576 m and 494 m for men and women, respectively. Benadine et al. (2006) have examined 6MWD in older adults (55 – 75 years) determined distance of 690 m and 631 m for men and women, respectively. For distance difference, the reasons why these reference equations are so different in healthy volunteers in either Caucasian or Asians are not clear (Teramoto et al.,2006). Considered together with the data between test variation and intra-test variation there is no definite reference value of 6MWD in either Caucasian or Asians. Differences in participant recruitment and test instructions may account for the variations among different studies (Teramoto et al.,2006). Thus, The American Thoracic Society has published detailed guidelines for 6MWD procedures in year to standardize the 6MWT (ATS Guidelines, 2002).

The reasons not to believe that such a comparison is valid between study of Enright & Sherrill (1998) and Hermione et al. (2006) include the followings. First, Enright & Sherrill (1998) published regression equation was derived from a single test, which would underestimate the true 6MWD as a consequence of the known effect of familiarization on 6MWD. Second, their regression equation predicted 6MWD substantially lower than 6MWD obtained using other equations developed in similar populations. Third, the magnitude of the heart rate response in their subjects suggested that the subjects' effort level was submaximal. Specifically, Enright & Sherrill (1998) reported a heart rate increase of only 22 b.p.m.3 in contrast to an increase of 37 b.p.m. on the first 6MWD performed by Singaporean subjects. The heart rate increase in both studies was similar to that reported by another authors who measured 6MWD in healthy adults (Sue et al.,2006). The regression equation derived in Caucasian subjects yields 6MWDs that exceed measured 6MWD in the Singaporean cohort by more than 100 m. For these reasons, it may be different when comparing the 6MWDs in the Singaporean cohort with the predicted 6MWDs using Enright & Sherrill's regression equation (Sue et al.,2006).

**Sources of variability in reference equations**

The published reference equations may help in the assessment of functional status in patients with cardiopulmonary diseases, but not necessarily determine the absolute exercise capacity in these patients (Teramoto et al.,2006). The variation in reference equations is affected by external sources and subject related sources. These factors should be taken into consideration when interpreting the results of single measurements made to determine functional status.

**1. External sources of variability**

External sources of variability is related to measurement such as test instructions, type and frequency of encouragement, track (corridor) length, encouragement and repeat the test (Hermione et al.,2006). The publish reference equations for healthy persons should use the previously mentioned standardized procedures (ATS Guidelines, 2002).

Multiple repetition 6MWT performed in healthy adults studied in a wide age range of healthy individuals(older than 20 years). Four 6MWTs were performed on the same day in a 20 m corridor by 41 male and 38 female healthy volunteers ranging in age from 20 to 80 years. The greatest 6MWD by each subject from among four 6MWDs was the primary outcome measure. Eighty six percent had their best 6MWD after the first walk; an average increase of 43 meters was observed from first to best 6MWD. Best 6MWD averaged 698 $\pm$ 96 meters and was inversely related to age, directly to height, and was greater in men than women (Gibbons et al.,2001), this finding consistent with standard guideline (ATS Guidelines, 2002) that performance (without an intervention) usually reaches a plateau after two tests done within a week.

About the relative and intensity of 6MWT in healthy elderly, 12 healthy elderly subjects performed two maximal exercise tests on treadmill and five 6MWT (two in the morning and three in the afternoon) with a portable metabolic measurement system (Cosmed K4, Rome, Italy). The HR was reliable from the first 6MWT and was higher during the tests performed in the afternoon (Kervio et al.,2003).

**2. Subject related sources of variability**

Subject related sources of variability are differences in the population sampled. Factors influencing 6MWD include age, anthropometric and psychological factors.

2.1 Difference of age, sex and anthropometrics data such as weight and height can be adjusted by equations in previous studies (Bernadine et al., 2006). However, each study in healthy subject had different independent predictors of 6MWD and relationship with 6MWD. A stepwise multiple regression of Bernadine et al. (2006) showed height to be independent predictors of 6MWD. Height ($r = 0.54$) and weight ($r = 0.25$) were significantly correlated with 6MWD. Stepwise multiple regression analysis of

Hermione et al. (2006) showed that age, height, weight and were independent contributors. 6MWD was related to age (r = 0.36), height (r = 0.35) and leg length (r = 0.38). Moreover, stepwise multiple regression analysis of Alfredo et al. (2006) showed height, age and gender for the 6MWD. The 6MWD was inversely and directly related, respectively, to age (r = -0.42) and height (r = 0.46).

2.2 Wide age range in healthy volunteers have been used to establish reference equation. Baratar et al. evaluated the applicability of these equations to the elderly Brazilian population aged 64 - 82 years (N = 38) (Barata et al.,2005). Good correlation was found between the distances covered and the distances predicted by the equation put forward by Enright et al. (2003). Using the equation proposed by Enright et al. the women presented a mean performance of 92.5% of the predicted value, and the men 97.8%. The equation proposed by Enright & Sherrill et al. (1998) and Troosters et al. (1999) predicted much higher values than the participants in the present study. Because there were younger participants in the study made by Enright & Sherrill et al. (40 – 80 years) and Troosters et al. (50 - 85 years) vs. older subjects in the Brazilian sample (64-82 years) (Barata et al.,2005).

The 6MWD was inversely related to age. Previous studies provided data for 4 common clinical tests in a sample of community dwelling older adults (Steffen et al., 2002). 6MWT, Berg balance scale (BBS), timed up & go test (TUG) and fast speed walking (CGS and FGS) were collected. 6MWD were analyzed by gender and age (60-69, 70-79, and 80-89 years). Mean test scores showed a trend of age related declines for the 6MWD, BBS, TUG, CGS and FGS for both male and female subjects (Steffen et al.,2002).

2.3 Learning effect following standard guideline in healthy subjects usually reaches a plateau after two tests done within a week (ATS Guidelines, 2002). Additionally, the initial learning effect is maintained during a 2 month period (Wu et al.,2003). Learning effect has been shown to have an effect on 6MWD as reported in previous studies in healthy subjects (Hermione et al.,2006; Barata et al.,2005; Bernadine et al.,2006; Alfredo et al.,2006) when testing was done more than one time.

2.4 Different ethnicity in population sample. The study of Hermione et al. (2006) reported 6MWD for healthy Singaporeans aged 45–85 years lower 6MWD than using regression equations derived from Caucasian subjects (Troosters et al.,1999; Gibbons et al.,2001). This accord to study of Barata et al. (2005) report difference between the distances walked by elderly Brazilian subjects and the distances predicted by the equations (Troosters et al.,1999; Enright and Sherrill et al.,1998; Enright et al.,2003).

In summary, these factors should be taken into consideration when interpreting the results of single measurements made to determine functional status (ATS Guidelines, 2002). There is considerable variation in the normal values of 6MWD even in healthy people. The published reference equations may help in the assessment of functional status in patients with cardiopulmonary diseases, but not necessarily determine the absolute exercise capacity in these patients. The variation in 6MWD is affected by a number of factors that are not solely due to race and ethnicity (Teramoto et al.,2006).

**Relationship between 6MWT and physical activity in healthy individuals**

The 6MWT is a widely used measure of functional exercise capacity in individuals with cardiopulmonary disease. It has advantages over laboratory based tests of exercise tolerance as it more closely resembles the ability to perform activities of daily living (Enright and Sherrill et al.,1998) and does not require sophisticated equipment (Hermione et al.,2006).

More recently, it has been recognized that the 6MWT may be a general indicator of overall physical performance and mobility in populations of older people. Duncan et al. (1993) reported that performance on the 6MWT differed significantly between older men with varying levels of mobility impairment, and Harada et al. (1999) reported moderate correlations between 6MWD and mobility measures, including standing balance, chair stands, and gait speed in people at or over the age of 65 years. Furthermore, performance on the 6MWT has been shown to improve after exercise interventions (Stephen et al.,2002).

Stephen et al.(2002) investigated the relative contributions of a broad range of physiologic, psychologic, and health factors to performance on the 6MWT in older people. The subjects were 515 people whose ages of 62 to 95 years (mean = 79.5 $\pm$ 6.4 years) who resided in retirement villages in Australia. All physiologic, psychologic, and health scores were significantly associated with 6MWD. Thus, 6MWD appears to provide a measure of overall mobility and physical functioning in this population group rather than a specific measure of cardiovascular fitness (Stephen et al.,2002).

6MWD depends on multiple physiologic, psychologic, and health factors. Regarding physical activity, 6MWD performance was also significantly associated with the habitual activity levels and self reported physical activity limitations of the subjects (physical activity/wk (h), $r = 0.44$) (Stephen et al., 2002). Self reported physical activity limitations and habitual activity levels were determined from forced choice items from a structured interview (Stephen et al., 2002).

In some studies, no significant correlations were found between habitual physical activity and 6MWD. A previous study by Troosters et al. established normal values for the 6MWD in healthy elderly subjects (50 - 85 years) (Troosters et al., 1999). The 6MWD was not related to the scores on the daily activities questionnaire nor to the subjects smoking habits. Hermione et al. established regression equations to predict the 6MWD in healthy Singaporean (32 Chinese, 16 men) aged between 45 and 85 years (Hermione et al., 2006). The subjects performed three walking tests using a standardized protocol. The majority of the subjects (86%) reported taking sufficient activity for health benefits and none were inactive (14% insufficient activity) and no significant correlations were found between habitual physical activity and 6MWD (Hermione et al., 2006).

Bernadine et al. determine 6MWD in a population based sample of healthy subjects seventy Caucasian subjects (33 males) aged 55–75 years performed three tests using a standardized protocol (Bernadine et al., 2006). There were also no significant differences between the males and females in minutes walked in the last week, physical activity levels and smoking history. Physical activity levels were sufficient

63 (90.0%), insufficient 6 (8.5%) and inactive 1 (1.5%). The authors hypothesised that 6MWD would be greater in individuals who walked for prolonged periods on a regular basis. Of particular interest was the time spent walking for continuous periods of at least 10 minutes either for recreation, exercise or transport. However, the number of minutes walked in the previous week was not a predictor of 6MWD. It is possible that the speed of habitual walking, which was not assessed in this study, may be a more relevant predictor of 6MWD than time spent walking.

Reference values for the 6MWT were derived in 102 healthy Caucasians, 20–50 years old (Alfredo et al., 2006). The study confirmed that several demographic and anthropometric factors can influence the 6MWT performance in healthy subjects (Alfredo et al., 2006). Regression analysis accounted for 42% of the total variance. Another potential source of variance may be the different peripheral muscle conditioning of the participants, since this study included both habitually active and sedentary healthy subjects. This finding was consistent with other studies that also failed to demonstrate an association between self reported physical activity and 6MWD.

**Physical activity**

Physical activity is any bodily movement produced by skeletal muscles that results in energy expenditure (An initiative of the Premier's Physical Activity Taskforce, 2003). It also refers to any activity that involves significant movement of the body or limbs (The University of Western Australia, 1999). Regular physical activity can also boost the way feel to (U.S. Department of health, 2006) (1) give more energy, (2) help to relax and cope better with stress, (3) build confidence, (4) allow to fall asleep more quickly and sleep more soundly, (5) help to beat the blues and (6) provide an enjoyable way to share time with friends or family. Regular physical activity can help prevent heart disease, stroke and high blood pressure, reduce the risk of developing type II diabetes and some cancers, help build and maintain healthy bones, muscles and joints reducing the risk of injury and promote psychological well being (Department of Health, 2005).

**Types of physical activity**

**Aerobic activity** is any physical activity that uses large muscle groups and causes body to use more oxygen than it would while resting. It is the type of movement that most benefits the heart. Examples of aerobic activity are brisk walking, jogging, and bicycling (U.S. Department of health, 2006).

**Resistance training** also called strength training can firm, strengthen, and tone muscles, as well as improve bone strength, balance, and coordination. Examples of strength moves are pushups, lunges, and bicep curls using dumbbells (U.S. Department of health, 2006).

**Flexibility exercises** stretch and lengthen muscles. These activities help to improve joint flexibility and keep muscles limber, thereby preventing injury. An example of a stretching move is sitting cross legged on the floor and gently pushing down on the tops of legs to stretch the inner thigh muscles (U.S. Department of health, 2006).

**Exercise** is a subset of physical activity and is defined as planned, structured and repetitive bodily movement done to improve or maintain one or more components of fitness (An initiative of the Premier's Physical Activity Taskforce, 2003). It is a type of physical activity defined as a planned, structured and repetitive body movement done to improve or maintain physical fitness (The University of Western Australia, 1999).

**Intensity Levels**

Generally, the more vigorous engage in an activity, and the more time spend doing it, the more health benefits will receive. The vigorous activities are especially helpful for conditioning heart and lungs, and these activities also burn more calories than those that are less vigorous (U.S. Department of health, 2006). Vigorous activity is physical activity requiring 7+ METS (i.e. over 7 times as much energy as at rest). In questionnaires this is often described as activity that causes some huffing and puffing (An initiative of the Premier's Physical Activity Taskforce, 2003), for example, where talking in full sentences between breaths is difficult. Vigorous activity can come from sports such as football, squash, netball and basketball and activities such as aerobics, circuit training, speed walking, jogging, fast cycling or brisk rowing. For best results, this type of activity should be carried out for a minimum of around 30 minutes, three to four days a week (Department of Health, 2005).

Moderate intensity activities can also be excellent fitness choices. Moderate intensity physical activity is physical activity requiring 3-4 METS (i.e. 3-4 times as much energy as at rest). In questionnaires this is often described as activity that causes some increase in breathing and heart rate (An initiative of the Premier's Physical Activity Taskforce, 2003). Moderate intensity activity is not hard. Moderate intensity activity will cause a slight, but noticeable, increase in breathing and heart rate. A good example of moderate intensity activity is brisk walking, that is at a pace where able to comfortably talk but not sing. Other examples include mowing the lawn, digging in the garden, or medium paced swimming or cycling (Department of Health, 2005).

When done briskly for 30 minutes or longer on most days of the week, the moderate intensity activities can help to condition the heart and lungs and reduce risk of heart disease (U.S. Department of health, 2006). In the past, it was thought that for exercise to be beneficial, it had to be carried out vigorously, 3 to 4 days a week for a minimum of 30 minutes. However, a review of exercise research has shown that this only applies to increases in physical fitness. Improvements in indicators of health such as blood pressure, blood cholesterol and body weight can result from putting together shorter amounts of moderate intensity activities totaling a minimum of 30 minutes a day on most days, or doing 30 minutes continuously (The University of Western Australia, 1999).

Moderate intensity activity does not have to be continuous. It can be done by accumulating 30 minutes or more throughout the day by combining a few shorter sessions of activity of around 10 to 15 minutes each or do 30 minutes or more continuously. Moderate intensity activity should be carried out for at least 10 minutes at a time without stopping (Department of Health, 2005).

**Physical activity levels**

Report of physical activity levels of Western Australian adults in 1999 (Bull et al.,2000) and 2002 (An initiative of the Premier's Physical Activity Taskforce, 2003) defined levels of physical activity that sufficient physical activity for health benefits and insufficient activity as some activity but not enough to reach the levels required for sufficient physical activity for health benefits. The level of physical activity was computed using data on number of times and total time (hours and minutes) spent doing vigorous physical activity, moderate physical activity and walking (for at least 10 minutes). Total time represents the sum of time spent in each category of activity (An initiative of the Premier's Physical Activity Taskforce, 2003).

Various measures of recommended level of physical activity have been calculated based on scientific evidence on the health and fitness benefits of exercise and public health recommendations. The American College of Sports Medicine endorsed 20 minutes of vigorous exercise three times a week for the improvement of cardiorespiratory fitness and this has been well accepted for over two decades (American College of Sports Medicine, 1978). More recently, research has shown that health benefits can accrue from regular participation in moderate intensity activity and both America and Australia have adopted this focus for contemporary public health initiatives. The current national recommendation is 30 minutes of moderate activity on most, if not all, days of the week and this is frequently interpreted as 150 minutes of moderate activity over at least five sessions (National Physical Activity Guidelines, 1999 (Bull et al., 2000). Report of physical activity levels of Western Australian adults in 2002 (An initiative of the Premier's Physical Activity Taskforce, 2003) has adopted a definition of sufficient physical activity that combines both the vigorous and moderate intensity recommendations for health and fitness benefits.

**Sufficient physical activity** is a physical activity that can gain health benefits (Hatano, 1993; Yamanouchi et al., 1995; Wilde et al., 2001); (1) 150 minutes of moderate intensity physical activity over five or more sessions or 60 minutes of vigorous intensity activity in the previous week. (2) 150 minutes of total physical activity where moderate and vigorous activity (weighted by two) are summated (An initiative of the Premier's Physical Activity Taskforce, 2003).

**Insufficient activity** is some activity but not enough to improve health benefits and not reach the levels required for sufficient (An initiative of the Premier's Physical Activity Taskforce, 2003).

**Classification of energy cost of human physical activity**

The Compendium of Physical Activities (Ainsworth et al.,1993; Ainsworth et al.,2000) has been developed to facilitate the coding of physical activities and to promote comparability of coding across studies. This Compendium is designed to be useful for investigators who collect data on physical activity by diary, recall or direct observation methods. Energy cost was established by a review of published and unpublished data. Energy expenditure in kilocalories or kilocalories per kilogram body weight can be estimated for all activities, specific activity, or activity type (Ainsworth et al.,1993).

The coding scheme for the Compendium of activities (Ainsworth et al.,1993) employs a five digit code in order to categorize activities by their major heading (first two digit on the left), specific activity (last three digits on the right) and intensity (3 digit column).For example: 01009 08.5 mean 01 = bicycling, 009 = bmx and 8.5 METs (the energy cost of an activity can be measured in units called METs).

All activities are assigned an intensity unit based on their rate of energy expenditure expressed as METs. The intensity of activities in the Compendium are classified as multiples of one MET or the ratio of the associated metabolic rate (RMR). For example, a 2 MET activity requires two times the metabolic energy expenditure of sitting quietly. One MET is also defined as the energy expenditure for sitting quietly, which for the average adult is approximately 3.5 ml of oxygen·kg body weight$^{-1}$·min$^{-1}$ or 1 kcal·kg$^{-1}$ body weight·h$^{-1}$ (Ainsworth et al.,1993).

**Calculation of energy cost**

Energy expenditure values can be expressed in kcal·kg$^{-1}$ body weight·h$^{-1}$, kcal·min$^{-1}$, kcal·h$^{-1}$ or kcal·24·h$^{-1}$. The most accurate way to determine the kilocalorie energy cost of an activity is to measure the kcal expended during rest (i.e., the RMR) and multiply that value by the MET values listed in the Compendium. Because RMR is fairly close to 1 kcal·kg$^{-1}$ body weight·h$^{-1}$(Ainsworth et al.,1993; Zhuo et al.,1984), the energy cost of activities may be expressed as multiples of the RMR. By multiplying the body weight in kg by the MET value and duration of activity, it is possible to estimate a kcal energy expenditure that is specific to a person's body weight. For example, bicycling at a 4 MET value expends 4 kcal·kg$^{-1}$ body weight·h$^{-1}$. A 60 kg individual bicycling for 40 min expends the following: (4 METs x 60 kg body weight) x (40 min/60min) = 160 kcal. Dividing 160 kcal by 40 min equals 4 kcal·min$^{-1}$. Using the same formula for an 80 kg person would yield an energy expenditure of 213 kcal or 5.3 kcal·min$^{-1}$. However, it is important to note that to the extent the RMR is not equal to 1 kcal·kg$^{-1}$ body weight·h$^{-1}$ for individuals, then estimates of energy expenditure that include weight will more closely reflect body weight than the metabolic rate (Ainsworth et al.,1993).

**Physical activity assessment**

In the report of physical activity levels of Western Australian adults in 2002 (An initiative of the Premier's Physical Activity Taskforce, 2003), the sample was generated using a stratified random sample technique involving selection of a random sample of White Pages telephone numbers and interviewing the person in the house who had the most recent birthday and was at least 18 years of age. A maximum of six callbacks were made to obtain a completed interview.

The survey instrument consisted of 38 items. The first eight items collected information on the frequency and duration of participation in various physical activities in the past week and were used with permission of the Australian Institute of Health and Welfare (AIHW). The next set of items collected information on the types of activity and facilities used. A set of questions was directed at providing information about habitual incidental physical activity (i.e. habitual activity undertaken for less than 10 minutes) and habitual incidental activity choices such as stair climbing. Items on perceived workplace activity levels and general practitioner advice on physical activity were also included. Several questions were used to investigate reasons for participating in physical activity and perceived barriers to participation. The level of confidence (self efficacy) in being able to participate in regular, moderate physical activity on five or more days per week was measured. A knowledge question asked the number of minutes of moderate physical activity required for good health (An initiative of the Premier's Physical Activity Taskforce, 2003).

In 1992, Lee et al. provide observations physical activity among college Alumni among 1962-1988. Physical activity was assessed by inquiring about flights of stairs climbed, city blocks walked, and sports or recreation (subsequently referred to as sports) participated. The reliability and validity of this technique for assessing physical activity have been investigated (Lee et al.,1992). With these data, an index of weekly energy expenditure was estimated for 1962/1966, 1977, and 1988. Climbing up and down one flight daily was rated 28 kcal/week and walking one block daily was 56 kcal/week. Each sport was scored according to intensity as a ratio of work metabolic rate to resting metabolic rate (MET score; 1 MET is defined as the energy expended while sitting quietly, which in the average adult is approximately 3.5 ml of oxygen per kilogram of body weight per minute) (Lee et al.,1992).

Self report questionnaires are the most frequently used measure of physical activity. They are convenient to administer, are cost effective, and provide information regarding the types of activity undertaken (Westerterp et al.,1999). The 7-Day physical activity recall (7-DR) questionnaire in individuals with severe mental illness (SMI) over reported moderate physical activity by 16.9 $\pm$ 52.3 min/day, but under reported vigorous physical activity by -10.4 $\pm$ 24.3 min/day (Andy et al.,2007). Test retest intraclass correlation coefficient (ICC) was significant for all outcome measures. Overall, the 7-DR was reliable but exhibited questionable validity in SMI (Andy et al.,2007).

Stanford 7-Day Recall (7-DR), an instrument for surveying work and leisure time physical activity (PA) has been used to assess levels of habitual PA in men and women (Richardson et al.,2001). Comparison of corresponding indices of activity between the 7-DR and the PA record indicated: 1) a closer relationship in men for total than in women and 2) in general, lower and less consistent associations for hard, moderate, and light activity. The ability of the 7-DR to assess habitual PA was greater for more vigorous than for lower intensity PA (Richardson et al.,2001).

# CHAPTER III

# MATERIALS AND METHODS

This cross-sectional analytic research study was designed to compare 6MWD in healthy persons between sufficient and insufficient levels of physical activity in Thais. The study protocol was approved by The Institutional Review Board of the Faculty of Medicine, Chulalongkorn University.

## Population

In this study, the target population was healthy Thai men and women ranging in age from 45 to 65 years old. Thai subjects referred to individuals who had Asian ethnics, were born and lived in Thailand. The study samples were recruited following the inclusion criteria. The volunteers were recruited from individuals who lived in Bangkok and Metropolitan area.

## Screening

Subjects were qualified for the study if they were aged 45 - 65 years and had no documented diseases or conditions listed in the exclusion criteria. All volunteers were initially contacted by telephone to determine their qualification before included in the study.

## Inclusion criteria

1. Thai people aged between 45 - 65 years

2. Consent to participate in the study

## Exclusion criteria

1.A history of symptomatic cardiovascular disease

2.A family history of atherosclerosis (first-degree relative; men before 55 and women before 65) (สถาบันเวชศาสตร์ผู้สูงอายุ, 2548).

3.Diagnosed hyperlipidaemia and medication by doctor

4.Using medications potentially affecting heart rate ( eg. beta blockers)

5.History of diabetes mellitus

6.Out of BMI range of 18.5 – 30 $kg/m^2$

7.Resting blood pressure >150/100 mm Hg

8.Resting heart rate (HR) >100 beats per minute (b.p.m.)

9.Abnormal lung function (FEV1 < 80% predicted or FEV1/FVC < 70%)

10.Blood or metabolic disorders

11. Upper respiratory tract infection in the past 4 weeks

12. Current illness and have other diseases

13.Using of ambulatory aids

14.Leg length discrepancy >3 cm and claudication

15.Severe or disabling pain of musculoskeletal origin

16.Being pregnant

17.Experiencing 6MWT in the past 2 months

Note: Subjects' information for exclusion criteria 1 – 5, 10 – 13, 15 -17 was obtained from questionnaire, while 6 – 9, and 14 from direct measurements.

**Sample**

**Sampling technique**

This study used quota sampling technique and voluntariness for recruiting subjects.

**Sample size determination**

In this study, the sample size determination was obtained from a pilot study.

Three men with sufficiency of physical activity had a mean of 6MWD of 720.33$\pm$71.80 m (770, 753 and 638 m). Another three men with insufficiency of physical activity had a mean of 6MWD of 563$\pm$83.47 m (472, 581 and 636 m).

Pooled variance = 6061.24

Assigned $\alpha$ = 0.05 and $\beta$ = 0.10

n/group = $2(1.96+1.28)^2(6061.24)/(720.33-563)^2 = 5.14$

Three women with insufficiency of physical activity had a mean of 6MWD of 608.67$\pm$22.37 m (604, 589 and 633 m). Another three women with insufficiency of physical activity had a mean of 6MWD of 540.67$\pm$22.30 m (524, 566 and 532 m).

Pooled variance = 498.85

Assigned $\alpha$ = 0.05 and $\beta$ = 0.10

n/group = $2(1.96+1.28)^2(498.85)/(608.67-540.67)^2 = 2.27$

Statistic calculation; least sample study for men is 6 and for women is 3.

In order to determine the 3$^{rd}$ hypothesis to identify factors contributing to 6MWD, including age, sex, weight, height, stride length, $FEV_1$, volume of physical activity, and heart rate during 6MWT, the weight lowest related to 6MWD in previous study (Bernadine et al., 2006) (r = 0.25), the least sample size needed was 164 (power = 0.9).

**Procedure**

**Subject Preparation**

Prior to each test session, subjects were asked to abstain from food, caffeine, all tobacco product, and alcohol for 6 hours. In addition, vigorous physical activity was not allowed 24 hours prior to testing. Comfortable clothing and appropriate shoes (sport shoes) for walking should be worn. Upon arrival to the laboratory, weight, height, leg length, resting heart rate, and resting blood pressure were recorded. The subjects wore a heart rate monitor to determine their heart rate during all exercise tests.

**Standard measurements**

Measurements of height, weight, leg length, resting heart rate, and blood pressure provide a baseline characteristics of the subjects. The following procedures were performed and baseline characteristics of the subjects were recorded.

**Standing height:** The participant was standing barefoot with the heels together, then stretching upward to the fullest extent. Heels, buttocks, and upper back were touching a wall. The chin was not lifted. Measurement was recorded in centimeter.

**Weight:** Weight was recorded with the individual wearing comfortable clothes without shoes. Weight was recorded in kilograms using a weight measuring scale (Yamato, DP-6100GP, Japan).

**Leg length:** Leg length on both right and left sides was measured while the subjects lied on bed and was taken as the distance from anterior superior iliac spine (ASIS) to medial malleolus.

**Stride length:** Stride length was measured while the subject was walking 10 normal and fast steps. The averages of 10 of normal walk and fast walk steps were used for data collection.

**Resting heart rate:** The resting heart rate was counted for 15 seconds and multiplied by 4 for heart rate per minute. The subject was sitting and had an adequate rest period of at least 5 minutes prior to this test. Adequate rest was indicated when the heart rate had stabilized at a low rate and had not changed.

**Resting blood pressure**: The individual was sitting upright in a straightbacked chair. Both feet were flat on the floor, and the left arm was resting on a table with the elbow flexed. The position was relaxed and comfortable, and the individual was allowed to relax for a few minutes in this position. Conversation was discouraged. The blood pressure was measured with a sphygmomanometer and stethoscope. The systolic and diastolic pressures were recorded in millimeters of mercury (mmHg) as indicated on the sphygmomanometer scale.

**Pulmonary function test**

Pulmonary functions that were measured in this study included FEV1 and FVC. They were measured using a handheld spirometer (Spirobank®, MIR, Rome, Italy).

**Preparation for pulmonary function test**

The mouthpiece was inserted into the protruding part of the sensor. The nose clip was fit to the nose in order to ensure that no air can escape from the nostrils. Spirobank was held at either end using two hands, or alternatively it was held in one hand. The free end of the mouthpiece was put well into the mouth, so that at least 2 cm of the mouthpiece were in the mouth so that air cannot escape – the sides of the mouth were closed tightly around the mouthpiece. The subject started to breath into the machine. Testing was made in a standing position.

**Measurement FVC and FEV1**

After breathing at rest for a few moments, when ready to start, the subject inspired slowly as much air as possible and then made a complete expiration as fast as possible. Then with the mouthpiece always held firmly in the mouth, the cycle was completed by inspiring again as quickly as possible. The test was repeated three times by repeating the cycle without taking the mouthpiece out of the mouth. (Spirobank recognizes the best test and will automatically show the results of this best test).

Predicted FEV1 and FVC were calculated from regression equations developed for the local ethnic groups (**สมาคมอุรเวชช์แห่งประเทศไทย**, 2545).

**Physical activity questionnaire**

Subjects completed a modified (in Thai language) subjective physical activity questionnaire (An initiative of the Premier's Physical Activity Taskforce, 2003) by interview to determine the amount of physical activity performed in the previous week. Questionnaire responses were used to classify subjects as undertaking sufficient physical activity, insufficient physical activity for health benefits, or inactive using the definitions from the Survey of Physical Activity Levels of Western Australian Adults 2002 (An initiative of the Premier's Physical Activity Taskforce, 2003).

**Questionnaire instrument**

The survey instrument consisted of 21 items. A copy of the questionnaire is provided at Appendix 1. The first to seventeen items abort demographic and exclusion criteria. Demographic data on age, gender, motivation, education, occupation dependents and medication were collected through six questions.

The next set of items collected information on the types of activity, frequency and duration of participation in various physical activities in the past week. A set of questions to gather information about habitual activity was undertaken for more than 10 minutes. Items on perceived workplace activity levels and general practitioner advice on physical activity were also included. A knowledge question asked the number of minutes of moderate physical activity required for good health.

**Calculation of level of physical activity**

The level of physical activity was computed using data on number of times and total time (minutes) spent doing vigorous physical activity and moderate physical activity (for at least 10 minutes). Total time represents the sum of time spent in each category of activity.

Various measures of recommended level of physical activity have been calculated based on scientific evidence on the health and fitness benefits of exercise and public health recommendations. This study has adopted a definition of sufficient physical activity that combines both the vigorous and moderate intensity recommendations for health and fitness benefits. Thus the following definitions are used:

**Sufficient physical activity**

1) 150 minutes of moderate-intensity physical activity over five or more sessions or 60 minutes of vigorous-intensity activity in the previous week. (An initiative of the Premier's Physical Activity Taskforce, 2003).

2) 150 minutes or more of physical activity (moderate minutes plus vigorous minutes (x2)) in the previous week. (An initiative of the Premier's Physical Activity Taskforce, 2003).

**Insufficient physical activity** is some activity but not enough to reach the levels required for sufficient one (An initiative of the Premier's Physical Activity Taskforce, 2003).

**Vigorous activity** is physical activity requiring >6 METS (Centers for Disease Control, 2006) according to previous studies about cost of energy expenditure (Ainsworth et al.,1993; Centers for Disease Control, 2006).

**Moderate activity** is physical activity requiring 3-6 METS (Centers for Disease Control, 2006) according to previous studies about cost of energy expenditure (Ainsworth et al.,1993; Centers for Disease Control, 2006)

**METs** of each activity calculated from Ainsworth et al. (1993) and Ainsworth et al. (2000).

**Kcal/week** = METs x (kg body weight) x minute/60min/week (1 MET approximate 1 $kcal \cdot kg^{-1}$ body $weight \cdot h^{-1}$) (Zhuo et al.,1984; Paffenbarger et al., 1992; Ainsworth et al., 2000)

**Six minute walk test**

The 6MWT protocol used was based on published guidelines (ATS Guidelines, 2006), using a straight 30 m indoor track (tape stick each 1 m). The length of the corridor was marked every 1 m. The turnaround points marked with a rope at tail end. The same investigator supervised all tests who was assistance investigator not known about levels of physical activity of subjects (single blind). Subjects performed the test three times separated by 20 minutes rest intervals.

**Measurements**

1. The subject sat quietly in a chair, located near the starting position, and pulse rate was measured at 1 min before the start of each test. Before the test started it was ensured that clothing and shoes were appropriate.

2. The subject was instructed as follows: "The object of this test is to walk as far as possible for six minutes. You will walk back and forth along the way by circumambulate robe on floor. Six minutes is a long time to walk, so you will be exerting yourself. You will probably get out of breath or become exhausted. You are permitted to slow down, to stop, and to rest as necessary. You may sit on the chair while resting, but resume walking as soon as you are able. You will be walking back and forth around the rope. You should pivot briskly around the rope and continue back the other way without hesitation. Now I'm going to show you. Please watch the way I turn without hesitation." Demonstrate by walking one lap by the investigator. Walk and pivot around a rope at tail end briskly. "Are you ready to do that? I am going to record of the number of laps you complete. I will record it each time you turn around at this starting line. Remember that the objective is to walk AS FAR AS POSSIBLE for 6 minutes, but don't run or jog. Start now, or whenever you are ready."

3. Baseline rating of perceived exertion (RPE) using the Borg scale was recorded.

4. The subject wore a heart rate monitor (Polar Accurex Plus, Polar electro, Finland) at chest. The timer was set to six minutes. All necessary equipment was

assembled (timer, borg scale, tape measurement and worksheet) and moved to the starting point.

5. The subject was positioned at the starting line. The investigator also stood near the starting line during the test but did not walk with the subjects. As soon as the subject started to walk, the timer was started.

6. The subject was not allowed to talk to anyone during the walk. The investigator used an even tone of voice at the end of each minute for HR measurement and encouragement. While watching the subject, the investigator kept in mind of not get distracted and loses count of the laps. Each time the subject returned to the starting line the lap was marked on the worksheet. The subject was allowed to see investigator doing it. After the first minute, the subject was told the following (in even tones): "You are doing well. You have 5 minutes to go." When the timer showed 4 minutes remaining, the subject was told the following: "Keep up the good work. You have 4 minutes to go." When the timer showed 3 minutes remaining, the subject was told the following: "You are doing well. You are halfway done." When the timer showed 2 minutes remaining, the subject was told the following: "Keep up the good work. You have only 2 minutes left." When the timer showed only 1 minute remaining, the subject was told: "You are doing well. You have only 1 minute to go." Other words of encouragement (or body language to speed up) were not used.

If the subject stopped walking during the test and needed a rest, the investigator said this: "You can sit on the chair if you would like; then continue walking whenever you feel able." The timer still continued. If the subject stopped before the 6 minutes were up and refused to continue (or the investigator decided that the test should not continue), the subject was let to sit on, the walk was discontinued, and the distance was noted on the worksheet, the time stopped, and the reason for stopping prematurely was noted.

When the timer was 15 seconds from completion, the subject was told this: "In a moment I'm going to tell you to stop. When I do, just stop right where you are and I will come to you." When the timer was up, the investigator said this: "Stop!" The investigator walked over to the subjects. The chair was moved to the subjects if they look exhausted. The spot where they stopped was marked by placing a piece of tape on the floor and the distance was noted on the worksheet.

7. Post-test: Pulse rate and blood pressure was measured. The post walk RPE borg scale was recorded. Between test: Pulse rate was measured every minute.

8. The number of laps from tick marks on the worksheet was recorded.

9. The additional distance covered (the number of meters in the final partial lap) using the markers on the rope as distance guide was recorded. The total distance walked, rounding to the nearest meter was calculated and recorded on the worksheet.

10. The subjects were congratulated good effort and offer a drink of water.

**YMCA cycle ergometer test**

The YMCA cycle ergometer test was administered in the same manner for both men and women.

**Equipment**

1. An accurate, easily calibrated, constant torque bicycle ergometer (Monark 818E, Sweden) with a range of 0 to 2, 100 kilogram-meters (kgm) per minute. A kilogram-meter is a unit of work that is equal to the energy required to lift 1 kg vertically a distance of 1 m. Each major gradition should be at 300 kgm, with intermediate marks at 150 kgm. The Monark bicycle ergometer was used for YMCA's in this study.

2. A metronome set at 100 bpm

3. A timer to time riding duration

4. A stopwatch to time heart rate

5. A heart rate monitor (Polar Accurex Plus, Polar electro, Finland)

### Procedure

Prior to testing, the calibration of the bicycle was checked. On the Monark the red line on the pendulum weight had to be sure to read 0 on the workload scale before starting.

The concept of the test was briefly explain to the participant. Later, the participant was asked to sit on the ergometer seat of which height had been adjusted. When the pedal was at its lowest point the knee should be straight, with the ball of the foot on the pedal and the leg stretched. The metronome was set at 100 bpm and the participant was then allowed to pedal freewheel (no load) for a minute to get the pace. At 50 revolutions per minute (rpm) the right foot made 50 complete revolutions in one minute. The metronome set at 100 bpm means that at each "click" a foot should be on the downstroke. This is still 50 rpm.

**YMCA Cycle Ergometry Protocol**

| Stage 1 | 150 kgm/min(0.5 kg) | | | |
|---|---|---|---|---|
| | HR < 80 | HR 80 - 89 | HR 90 - 100 | HR > 100 |
| Stage 2 | 750 kgm/min (2.5 kg) | 600 kgm/min (2.0 kg) | 450 kgm/min (1.5 kg) | 300 kgm/min (1.0 kg) |
| Stage 3 | 900 kgm/min (3.0 kg) | 750 kgm/min (2.5 kg) | 600 kgm/min (2.0 kg) | 450 kgm/min (1.5 kg) |
| Stage 4 | 1050 kgm/min (3.5 kg) | 900 kgm/min (3.0 kg) | 750 kgm/min (2.5 kg) | 600 kgm/min (2.0 kg) |

**Figure 1.** YMCA cycle ergometry protocol (Golding, 1989)

The initial workload was set at 150 kgm/min. On the Monark cycle ergometer, one complete turn of the pedal on the bicycle moves the wheel 6 m. At a pedaling rate of 50 rpm, the total distance covered in 1 minute is 300 m. If the scale is set so that 1 kg of force is acting on the wheel, then 300 m/min* 1 kg = 300 kgm/min.

The participant was allowed to work at the first workload for 3 minutes. The heart rate was counted at the second and third minutes. The difference in heart rates between the second and third minutes should not vary by more than five beats; if it did, the ride for an extra minute was extended or until a stable value was obtained. The workload was subsequently changed. The heart rate was properly recorded after each workload before the next workload was initiated. As each participant's second and third workload differed, those were entered on the score sheet as soon as they were determined to avoid errors later. After the second workload was completed, the heart rate was recorded at the end of the second and third minutes. Again, these should not differ by more than five beats.

Thoughout the test, exertional intolerance or other signs of undue fatigue or unusual response was continuously monitored. The participant was instructed to indicate how he or she felt from time to time. During the testing, the participant was not permitted to engage in conversation.

When the heart rates at the end of the second and third minutes of the third workload were recorded, the test was then complete. The participant was allowed to cool down by riding at no resistance.

**Scoring**

Once the test was complete, the final heart rate in each of the workloads to be used (the two between 110 bpm and 85% of HRmax; approximately 150 bpm) was plotted against the respective workload. The first load was not used in this calculation unless it exceeded to that participant's predicted maximal heart rate.

The point at which the diagonal line intersects the horizontal predicted maximal heart rate line represents the maximal working capacity for that participant. A perpendicular line was dropped from this point to the baseline where the maximal physical workload capacity was read in kgm/min. Maximum oxygen uptake was predicted from this test. VO2max was calculated using formula (Golding, 1989)

$$VO2max = SM2 + b(HRmax - HR2)$$

b = Slope of graph between ploting of heart rate. Slope can be calculated by

$$b = (SM2-SM1)/(HR2-HR1)$$

HR2 = Steady stage heart rate in last stage.

HR1 = Steady stage heart rate in before last stage.

SM2 = Volume of oxygen consumption in last stage.

SM1 = Volume of oxygen consumption in before last stage.

SM1 and SM2 can be calculated to rate of oxygen consumption by the following ACSM formula (ACSM,2000).

$$VO2\ (ml \cdot min^{-1}) = (kgm \cdot min^{-1} \cdot 1.8) \cdot (Body\ Weight\ (kg) \cdot 7)$$

**Data Collection**

1.Characteristics and fundamental data including age (years), height (centimeters), weight (kilograms), leg length (centimetres), normal stride length (metre), fast stride length (metre), resting heart rate (bpm), blood pressure (mmHg), FEV1 (liters), FVC(liters), FEV1/FVC, VO2max ($ml \cdot kg^{-1} \cdot min^{-1}$; YMCA Cycle Test), rating of borg scale before 6MWT, mean HR (bpm; sum of HR every minute during 6MWT) and a percentage of the predicted maximum HR (%predHRmax, %predHR of HRmax (220 - age); during 6MWT).

2.6MWT data including 6MWD (metre, assign 2 decimal; toe to toe) by maximum 6MWD from best of the three tests and HR during 6MWT every 1 minute.

3.Physical activity questionnaire data including type of activity, duration of activity per week (minutes/week), frequency of activity, cost of energy expenditure (calorie; kcal/week; calculated by MET·weight·hour/week) of moderate physical activity least than 10 minutes.

**Statistical Analyses**

Standard statistical methods were used to calculate mean (M) and standard deviation (SD). Repeated ANOVA and pairwise comparisons (Bonferroni) were used to compare distance between three tests both men and women. Unpaired *t*-tests were used to compare 6MWD between subjects with sufficient and insufficient physical activity, and between males and females. The 6MWD measured in this study was compared with predicted 6MWD derived from the studies of Hermione et al and Bernadine et al. using paired t-tests. When comparing data to that of Hermione et al (2006) and Bernadine et al. (2005) the 6MWD were obtained from the best of the three tests. Reproducibility of the 6MWD was examined using intraclass correlation coefficient (ICC) and coefficient of variation (CV).

The relationships between maximum 6MWD (best of the three tests) subject characteristics (age, height, weight, leg length, resting heart rate, blood pressure and FEV1), VO2max, cost of energy expenditure (kcal/week), mean HR (during 6MWT) and %predHRmax (during 6MWT) were examined using Pearson's univariate correlation coefficients (r). Forward stepwise multiple regression analysis was performed on the following variables: age, height, weight, sex, mean HR (during 6MWT) and expressed as a percentage of the predicted maximum HR (%predHRmax, with predHRmax calculated as 220 - age) to determine their contribution to maximum 6MWD. Analyses were performed using the SPSS computer package (Version 14). An alpha value of 0.05 was used to determine significance.

# CHAPTER IV

# RESULTS

**Characteristics of the subjects**

One hundred and eighty three subjects initially volunteered in this study. Table 1 provides baseline characteristics of the subjects (77 men and 85 women) who completed the study. Weight (67.98 $\pm$ 6.94 vs. 55.56 $\pm$ 7.26 kg; $P < 0.001$), height (168.53 $\pm$ 5.44 vs. 155.21 $\pm$ 5.49 cm; $P < 0.001$), leg length (85.01 $\pm$ 3.91 vs. 77.56 $\pm$ 9.28 cm; $P < 0.001$), normal stride length (0.68 $\pm$ 0.08 vs. 0.60 $\pm$ 0.08 m; $P < 0.001$) and fast stride length (0.90 $\pm$ 0.08 vs. 0.76 $\pm$ 0.08 m; $P < 0.001$) were significantly greater in men than women. Height and leg length were strongly correlated in both men ($r = 0.87$; $P < 0.01$) and women ($r = 0.83$; $P < 0.01$). There were no sex differences in age and BMI.

**Table 1.** Characteristics of the subjects (n = 162)

| Characteristics | Males ( n = 77) | Females ( n = 85 ) | Total ( n = 162 ) |
|---|---|---|---|
| Age (year) | 53.61 $\pm$ 5.45 | 54.18 $\pm$ 5.63 | 53.91 $\pm$ 5.54 |
| Weight (kg)* | 67.98 $\pm$ 6.94 | 55.56 $\pm$ 7.26 | 61.47 $\pm$ 9.43 |
| Height (cm)* | 168.53 $\pm$ 5.44 | 155.21 $\pm$ 5.49 | 161.54 $\pm$ 8.61 |
| BMI ($kg/m^2$) | 23.94 $\pm$ 2.28 | 23.04 $\pm$ 2.56 | 23.47 $\pm$ 2.46 |

Values are mean $\pm$ SD

* Significant difference between males and females; $p < 0.001$

**Physical activity levels**

Table 2 presents the proportion of the participants in sufficient physical activity, those doing some activity but not enough to meet the recommendations (insufficient), and those doing no walking (of ten minutes or more that included in insufficiency), vigorous or other moderate physical activities in the past week (sedentary). In this study, individuals with inactive level were included in insufficient level of physical activity groups.

**Table 2.** The proportion of participants in sufficient, insufficient and inactive levels of physical activity.

| Physical activity level | Males ( n = 77 ) | Females ( n = 85 ) | Total ( n = 164 ) |
|---|---|---|---|
| Sufficient | 37 (48.10%) | 45 (52.90%) | 82 (50.60%) |
| Insufficient | 34 (44.20%) | 30 (35.30%) | 64 (39.50%) |
| Inactive | 6 (3.70%) | 10 (11.80%) | 16 (9.90%) |

Values are mean ± SD

Table 3 and table 4 provide physical and physiological characteristics of the subjects classified by levels of physical activity for both males and females. Time spent per week for physical activities was used to define the levels of physical activity. Aerobic performance ($VO_2max$) tended to decrease from males sufficiency activity, males insufficiency activity, females sufficiency activity and females insufficiency activity respectively.

**Table 3**. Physical characteristics at rest of the subjects

| Characteristics | Males with sufficient activity (n=37) | Males with insufficient activity (n=40) | Females with sufficient activity (n=45) | Females with insufficient activity (n=40) |
|---|---|---|---|---|
| Age (year) | 52.7 ± 5.66 | 54.4 ± 5.2 | 53.8 ± 6.0 | 54.6 ± 5.1 |
| Weight (kg) | 67.4 ± 6.7 | 68.4 ± 7.2 | 55.0 ± 7.6 | 56.2 ± 6.8 |
| Height (cm) | 168.6 ± 5.0 | 168.4 ± 5.8 | 154.6 ± 5.9 | 155.8 ± 4.9 |
| BMI (kg/m2) | 23.7 ± 2.2 | 24.1 ± 2.3 | 22.9 ± 2.6 | 23.1 ± 2.4 |
| Leg length (cm) | 85.04 ± 3.66 | 84.97 ± 4.17 | 78.04 ± 3.97 | 78.83 ± 3.52 |
| Stride length (m) | 0.68 ± 0.09 | 0.67 ± 0.06 | 0.61 ± 0.08 | 0.59 ± 0.09 |
| Fast stride length (m) | 0.92 ± 0.09 | 0.89 ± 0.07 | 0.77 ± 0.08 | 0.74 ± 0.07 |

**Table 4**. Physiological characteristics at rest of the subjects

| Characteristics | Males with sufficient activity (n=37) | Males with insufficient activity (n=40) | Females with sufficient activity (n=45) | Females with insufficient activity (n=40) |
|---|---|---|---|---|
| RestingHR(bpm) | 68.4 ± 10.4* | 73.8 ± 11.0 | 72.8 ± 7.4 | 74.7 ± 7.9 |
| SystolicBP(mmHg) | 117.1 ± 14.1 | 118.7 ± 11.5 | 114.4 ± 11.2 | 113.2 ± 11.7 |
| DiastolicBP(mmHg) | 82.2 ± 8.4 | 81.7 ± 8.8 | 76.1 ± 9.9 | 76.5 ± 8.4 |
| FEV1 (L) | 3.23 ± 0.46 | 3.11 ± 0.43 | 2.22 ± 0.39 | 2.18 ± 0.31 |
| FVC (L) | 3.64 ± 0.52 | 3.51 ± 0.51 | 2.48 ± 0.44 | 2.43 ± 0.43 |
| FEV1/FVC (%) | 89.08 ± 7.74 | 89.21 ± 9.18 | 89.99 ± 8.20 | 90.50 ± 7.78 |
| VO2max | 41.94±9.50*** | 33.16 ± 7.67 | 31.70±8.73** | 26.46 ± 5.34 |
| Mean HR (bpm) | 124.0 ± 17.7 | 128.5 ± 19.4 | 127.5 ± 13.2 | 129.1 ± 14.1 |
| %PredictHRmax(%) | 79.1 ± 12.2 | 82.7 ± 13.7 | 82.9 ± 10.7 | 83.0 ± 10.2 |

Significant difference between sufficient activity and insufficient activity;* p = 0.03, ** p = 0.001 and *** p < 0.001

**Six minute walk distance**

Resting HR was recorded before commencing successive tests. It was found that resting HR in test 3 (78.3 $\pm$ 11.0 b.p.m.) was significantly more than that in test 1 (76.3 $\pm$ 10.5 b.p.m.; $p < 0.001$) and test 2 (76.3 $\pm$ 10.0 b.p.m.; $p = 0.008$). No 6MWT was terminated prematurely, and no subject required a rest during any test. The best maximum of 6MWD was 634.83 $\pm$ 75.30 m (range 489.01 – 993.80 m) for the group overall and was 676.50 $\pm$ 77.24 m (range 517.00 – 993.80 m) for men and 597.09 $\pm$ 49.38 m (range 489.01 – 742.96 m) for women. Maximum 6MWD was significantly different between men and women ($P < 0.001$). 6MWD increased significantly between test 1 and test 2 (597.99 $\pm$ 70.25 vs. 614.15 $\pm$ 74.42 m; $P < 0.001$) and between test 2 and test 3 (614.15 $\pm$ 74.42 vs. 628.73 $\pm$ 74.70 m; $P < 0.001$).

**Table 5**. Maximal 6MWD for sufficiency and insufficiency of physical activity groups in both males and females

| 6MWD (m) | Sufficient activity | Insufficient activity | P value |
|---|---|---|---|
| Males | 701.96 $\pm$ 89.12 (n=37) | 652.95 $\pm$ 55.79 (n=40) | p = 0.005 |
| Females | 619.52 $\pm$ 49.24 (n=45) | 571.86 $\pm$ 35.81 (n=40) | P < 0.001 |
| Overall | 656.72 $\pm$ 80.93 (n=82) | 612.41 $\pm$ 61.92 (n=80) | p < 0.001 |

From table 5, subjects with sufficient activity had significantly difference subjects with insufficiency activity ($p < 0.001$). Males with sufficiency activity has significant greater 6MWD than males with insufficient activity ($p = 0.005$). Females with sufficient activity had significantly greater 6MWD than females with insufficient activity ($p < 0.001$).

**Comparison between sufficient and insufficient groups of physical activity.**

The intraclass correlation coefficient (ICC) for the three tests was 0.95 and the coefficient of variation (CV) was 12.07%. Peak HR was 136.05 ± 18.45 b.p.m. (82.03 ± 11.78 %predHRmax) on the best of the three tests. RPE by Borg 10 scale at the end of most 6MWTs was 3.66 ± 2.00 and mode score was 4 (42 %) (n = 162).

**Table 6.** 6MWD from three tests

| | First 6MWD (m) | Second 6MWD (m) | Third 6MWD (m) |
|---|---|---|---|
| All men subjects (n = 77) | $638.10 \pm 69.56^{\#}$ | $653.93 \pm 75.01^{\#\#}$ | $667.48 \pm 80.04^{**}$ |
| All women subjects ( n = 85) | $561.65 \pm 47.65^{**}$ | $578.12 \pm 52.53^{**}$ | $593.62 \pm 47.70^{**}$ |
| Sufficient subjects (n = 82) | $616.36 \pm 72.84^{**}$ | $634.97 \pm 76.37^{**}$ | $651.34 \pm 78.31^{**}$ |
| Insufficient subjects (n = 80) | $579.15 \pm 62.52^{*}$ | $592.81 \pm 66.30^{\#}$ | $605.55 \pm 63.23^{**}$ |
| Overall (n = 162) | $597.99 \pm 70.25^{**}$ | $614.15 \pm 74.42^{**}$ | $628.73 \pm 74.70^{**}$ |

** $p < 0.001$, * $p = 0.001$, # $p = 0.002$ and ## $p = 0.005$

From table 6, mean distance significantly differed between test 1, test 2 and test 3 (repeated ANOVA), for both men ($p < 0.001$) and women ($p < 0.001$). In men, 6MWD during tests 1, 2 and 3 was significantly increased with subjects walking 15.82 ± 39.09 m further on the second test and 13.55 ± 36.60 m further on the third test. Women walked 16.47 ± 31.09 m further on the second test and 15.50 ± 30.08 m further on the third test. 6MWD of the three tests differed significantly in both subjects with sufficient physical activity and insufficient physical activity. The subjects with sufficient physical activity walked 18.61 ± 37.67 m further on the second test and 16.37 ± 34.30 m further on the third test. The subjects with insufficient physical activity walked 13.10 ± 32.25 m further on the second test and 12.74 $\pm$ 32.25 m further on the third test. In overall subjects, walk distance significantly increased 16.16 $\pm$ 35.01 m further on the second test and 14.57 $\pm$ 33.25 m further on the third test.

6MWD increased about 2.07 – 3.01% each additional test. One hundred thirty three (85.1 %) subjects walked their maximum 6MWD after the first walk. Twenty four (14.80 %) subjects walk their maximum for the first test, 31 (19.10 %) for the second test and 107 (66.00 %) for the third test.

**Comparison with published regression equations** (Table 7 - 8)

Published regression equations had been proposed by Hermione et al. and Bernadine et al. for predicting the distance covered in the 6MWT performance as recommended by ATS guidelines. Table 7 and 8 show comparisons between predicted distance and actual distance from this study. Thirty six subjects from sufficient physical activity group had 6MWD that was underestimated from the published Hermione equation, while 32 subjects had 6MWD that was underestimated from the published Bernadine equation. Fifty six subjects from insufficient physical activity group had 6MWD that was underestimated from the published Hermione equation, while 58 subjects had 6MWD that was underestimated from the published Bernadine equation. From table 8, ten men subjects from sufficient physical activity group had 6MWD that was underestimated from the published Hermione equation, while 16 subjects had 6MWD that was underestimated from the published Bernadine equation. Twenty two men subjects from insufficient physical activity group had 6MWD that was underestimated from the published Hermione equation, while 26 subjects had 6MWD that was underestimated from the published Bernadine equation. Twenty six women from sufficient physical activity group had 6MWD that was underestimated from the published Hermione equation, while 16 subjects had 6MWD that was underestimated from the published Bernadine equation. In addition, 34 women from insufficient physical activity group had 6MWD that was underestimated from the published Hermione equation, while 32 subjects had 6MWD that was underestimated from the published Bernadine equation.

**Hermione et al. 2006 :**

$$\text{Predicted distance} = (5.50\text{x}\%\text{predHRmax})+(6.94\text{xheight}_{cm})-(4.49\text{xage})-(3.51\text{xweight}_{kg})-473.27$$

**Bernadine et al. 2006 :**

$$\text{Predicted distance} = (3.12\text{xheight}_{cm}) + (23.29\text{xFEV1}_{liter}) + 64.69$$

**Figure 1.** Proposed reference equations to calculate the distance walked in the 6MWT – Hermione et al. 2006 and Bernadine et al. 2006.

**Table 7.** The actual distance walked and that predicted by the equations of Hermione et al. (2006) and Bernadine et al. (2006) in sufficiency and insufficiency groups of physical activity.

| | **Sufficiency of physical activity** | **Insufficiency of physical activity** |
|---|---|---|
| Actual distance walked (AWD; m) | 656.72 ± 80.93 | 612.41 ± 61.92 |
| **Hermione et al. 2006** | | |
| Predicted distance ($PD_H$; m) | 641.31 ± 69.42 | 646.34 ± 78.60 |
| $PD_H$ – AWD | -15.41 ± 69.31* | 33.93 ± 59.92** |
| %Predicted distance | 91.89 ± 5.44 | 91.75 ± 5.57 |
| **Bernadine et al. 2006** | | |
| Predicted distance ($PD_B$; m) | 629.42 ± 41.40 | 632.20 ± 37.94 |
| $PD_B$ – AWD | -27.2925 ± 71.42** | 19.79 ± 46.32** |
| %Predicted distance | 92.75 ± 6.31 | 93.84 ± 4.46 |

Values are mean ± SD; * $p < 0.05$; ** $p < 0.001$

**Table 8.** The actual distance walked and that predicted by the equations of Hermione et al. (2006) and Bernadine et al. (2006) in males and females.

| | Males with sufficient activity (n=37) | Males with insufficient activity (n=40) | Females with sufficient activity (n=45) | Females with insufficient activity (n=40) |
|---|---|---|---|---|
| Actual distance walked (AWD; m) | 701.96±89.12 | 652.95±55.79 | 619.52±49.24 | 572.81±35.81 |
| **Hermione et al. 2006** | | | | |
| Predicted distance ($PD_H$; m) | 659.74±76.71 | 669.99±86.57 | 626.17±59.48 | 622.69±62.22 |
| $PD_H$ – AWD | 42.21±64.20** | 17.04±66.99 | 6.64±66.10 | 50.83±46.91** |
| %Predicted distance | 92.01±5.48 | 92.18±5.49 | 91.80±5.47 | 91.31±5.68 |
| **Bernadine et al. 2006** | | | | |
| Predicted distance ($PD_B$; m) | 666.17±23.64 | 662.80±25.46 | 599.21±25.09 | 601.59±18.60 |
| $PD_B$ – AWD | -35.78±91.06* | 9.85±55.24 | -20.31±49.94* | 29.73±33.03** |
| %Predicted distance | 91.77±7.77 | 93.83±4.93 | 93.56±4.73 | 93.86±4.00 |

Values are mean ± SD; * $p < 0.05$; ** $p < 0.001$

**Associations between 6MWD and other variables**

Univariate correlation coefficients between 6MWD and other variables are presented in Table 9. There was a direct relationship between 6MWD and height, leg length, normal stride length, fast stride length, weight, FEV1, energy expenditure/week (kcal/wk), meanHR, %predHRmax and VO2max but not with age and BMI.

Significantly high correlations were shown between height and leg length ($r = 0.91$; $p < 0.001$ ), normal stride length and fast stride length ($r = 0.69$; $p < 0.001$), height and normal stride length ($r = 0.48$; $p < 0.001$) and height and fast stride length ($r = 0.66$; $p < 0.001$). Significant correlation was found between meanHR and %predHRmax ($r = 0.94$; $p < 0.001$), and between weight and BMI ($r = 0.72$; $p < 0.001$).

**Table 9.** Univariate correlation coefficients (r) for 6MWD and other variables (n = 162).

| | 6MWD | P value |
|---|---|---|
| Age (years) | -0.07 | 0.337 |
| Height (cm) | 0.51 | < 0.001 |
| Leg length (cm) | 0.46 | < 0.001 |
| Normal stride length (m) | 0.32 | < 0.001 |
| Fast stride length (m) | 0.51 | < 0.001 |
| Weight (kg) | 0.32 | < 0.001 |
| BMI (kg/m2) | -0.04 | 0.586 |
| FEV1 (L) | 0.44 | < 0.001 |
| Energy expenditure/week (kcal/wk) | 0.49 | < 0.001 |
| MeanHR (bpm) | 0.25 | 0.001 |
| %predHRmax (%) | 0.24 | 0.002 |
| VO2max (ml/kg/min) | 0.37 | < 0.001 |

**Predictors of six minute walk distance**

In stepwise multiple regression, fast stride length, energy expenditure/week (kcal/wk), meanHR, sex and BMI were identified as independent contributors to 6MWD ($P < 0.05$) and together explained 58% of the variance in 6MWD. The regression equation for estimating 6MWD (n = 162) is as follows:

**6MWD** (m) = $126.76+(3.07\times\mathbf{height}_{m})+(0.02\times\mathbf{kcal/wk})+(2.42\times\mathbf{\%predHRmax}_{bpm})+(53.12\times\mathbf{sex}$; [male=1, female=0]$)-(2.24\times\mathbf{weight}_{kg})-(1.92\times\mathbf{age})$ ($r^2 = 0.58$).

The following prediction equations are derived from subjects with classified levels of physical activity. The variance in 6MWD can be explained more than fifty percent when the model was derived from subjects with sufficient physical activity (61%) and insufficient physical activity (54%)

Equation derived from sufficient physical activity group (n = 82)

**6MWD** (m) = $521.60+(180.21\times\mathbf{normal\ stride\ length}_{cm})+(0.02\times\mathbf{kcal/wk})+(4.35\times\mathbf{\%predHRmax}_{bpm})+(80.30\times\mathbf{sex}$; [male=1, female=0]$)-(2.30\times\mathbf{weight}_{kg})-(5.19\times\mathbf{age})$ ($r^2 = 0.61$).

Equation derived from insufficient physical activity group (n = 80)

**6MWD** (m) = $32.23+(2.88\times\mathbf{height}_{cm})+(1.09\times\mathbf{\%predHRmax}_{bpm})+(45.02\times\mathbf{sex}$; [male=1, female=0]$)$ ($r^2 = 0.54$).

**Figure 2.** Predicted reference equations for persons with sufficiency and insufficiency physical activity.

# CHAPTER V

# DISCUSSION AND CONCLUSION

This study demonstrated that 6MWD was significantly different between subjects (both men and women aged 45 – 65 years) with sufficiency and insufficiency of physical activity groups. Men with sufficient physical activity had more 6MWD (701.96 $\pm$ 89.12 m) than men with insufficient physical activity (652.95 $\pm$ 55.79 m). Women with sufficient physical activity had more 6MWD (619.52 $\pm$ 49.24 m) than women with insufficient physical activity (571.86 $\pm$ 35.81m). For women with insufficient physical activity, predicted 6MWD from equations by Bernadine et al. 2005 and Hermione et al. 2006 overestimated real 6MWD. Predictors of 6MWD were height, energy expenditure per week, a percentage of the predicted maximal HR (%predHRmax), sex, weight and age.

**Six minute walk distance**

**Comparison of 6MWD between sufficiency and insufficiency of physical activity**

In a study, 6MWD was categorized into a stratified six level classification system according to health status, going from A (completely healthy) to D (signs of active disease at the moment of examination) in community dwelling elderly persons (Ivan et al., 2004). The 6MWD decreased significantly with worsening health status (ANCOVA, corrected for age $p < 0.001$) (Ivan et al., 2004). In the present study, 6MWD can be categorized according to the levels of physical activity, sufficient physical activity and insufficient physical activity in both healthy men and women. Subjects with sufficient activity had 6MWD significantly different from subjects with insufficiency activity ($p < 0.001$). Males with sufficiency of activity had significantly greater 6MWD than males with insufficient activity ($p = 0.005$). Females with sufficient activity had significantly greater 6MWD than females with insufficient activity ($p < 0.001$).

**Comparison of actual 6MWD with published regression equations derived 6MWD**

Although 6MWD significantly differed between persons with sufficient and insufficient physical activity, in men with insufficient physical activity, it was not significantly different from predicted distance derived from reference equations by Bernadine et al 2005 and Hermione et al. 2006. However, in women with insufficient physical activity predicted 6MWD from both equations overestimated real 6MWD. Thus, it appeared that women with insufficient physical activity group can not use previous predicted equations (Hermione et al.,2006; Bernadine et al.,2006). One possible explanation for this may be due to the broad range of the activity levels in women with insufficient physical activity group. In this group, there were 10 (11.80%) subjects who were classified as inactive and had low $VO_2$max. In contrast, both men with sufficient and insufficient physical activity and women with sufficient physical activity can use previous predicted equations (Hermione et al.,2006; Bernadine et al.,2006). It should be noted that all subjects in this study were healthy. Thus, the implication of this overestimation for female patients with disability may be considerable.

**Reference equations derived from Caucasian populations and 6MWD in healthy Thais.**

Published equations derived from Caucasian subjects overestimated 6MWD of Singaporean Chinese men and women (Hermione et al., 2006). In our study, a similar result was found only in women with insufficient physical activity. In our men and women with sufficient physical activity, their 6MWD did not significantly differ from the walk distance predicted from the equation derived from Australian subjects (Bernadine et al., 2006). Therefore, it appears that reference equations derived from Caucasian populations can predict 6MWD in healthy Thais.

It is possible that in this study, men with sufficient physical activity had engaged in activity in the form of exercise. Some types of exercise may create muscle more than general moderate physical activity (not come from exercise). Moreover, men with insufficient physical activity had participated in some forms of exercise too, although the frequencies were not enough to classify as sufficient physical activity as indicated in chapter III (over five or more sessions). It has been discussed that another potential source of variance may be the different peripheral muscle conditioning of the participants (Alfredo et al., 2006). This may explain why our males with either insufficiency or sufficiency levels of physical activity can use prediction equation from Caucasians subjects (Bernadine et al., 2006). Classification by level of exercise may be more appropriate than by levels of physical activity in males.

The present study showed that the published equations (Hermione et al.,2006; Bernadine et al.,2006) derived from majority females with sufficiency of physical activity can not predict 6MWD of Thai females with insufficiency of physical activity. The majority of the subjects (86%) in the study of Hermione et al. (Hermione et al., 2006) reported having sufficient activity for health benefits. However, 19 (56%) females in their study did not identify physical activity levels. Similarly, Bernadine et al. (2006) reported sixty-three subjects (included males and females; 90%) classified as undertaking sufficient physical activity for health benefits, but the investigators did not separate sex and physical activity levels (Bernadine et al., 2005). Both studies (Hermione et al., 2006; Bernadine et al., 2006) did not separately report 6MWD of females with sufficiency and insufficiency of physical activity. The present study was the first to identify a different 6MWD between females with sufficiency and insufficiency of physical activity.

**Learning effect on walk distance**

In this study, we found that most subjects could get the maximum distance from the $3^{rd}$ round test possibly due to learning effect and familiarization. This was similar with the result of the previous study (Bernadine et al., 2005) that 6MWD was significantly increased between consecutive tests at which the subjects walked 18 $\pm$ 30 m further on the second test and 10 $\pm$ 17 m further on the third test. Analysis by gender showed that the increase between the second and third test was only significant for males (Bernadine et al., 2005). The number of subjects achieving their maximum distance on the first, second and third test was 4, 15 and 51, respectively. Another study also showed that 6MWD increased significantly between test 1 and test 2 (524 $\pm$ 95 m vs. 540 $\pm$ 100 m, $P < 0.05$) but not between test 2 and test 3 (540 $\pm$ 100 m vs. 557 $\pm$ 106 m, P-value not shown) (Hermione et al. 2006). Seventy-nine per cent of subjects walked their maximum 6MWD after the first walk (Hermione et al. 2006). These data supported the recommendation on 6MWT of ATS Guidelines 2002. Performance (without an intervention) usually reaches a plateau after two tests done within a week (ATS Guidelines, 2002). The training effect on walk distance may be due to improved coordination, finding optimal stride length, and overcoming anxiety (ATS Guidelines, 2002).

**External sources of variability of 6MWD**

External sources of variability include track length, test instructions and encouragement (Hermione et al., 2006). In this study, 6MWT protocol using a track length of 30 m, standard instructions, and standard encouragement given every minute according to the standard guideline (ATS Guidelines, 2002). Bernadine et al. (2006) and Hermione et al. (2006) also employed similar protocols. The present study found a mean of the maximal distances from the best test to be 634.83 $\pm$ 75.30 m (range 489.01 – 993.80 m) which was more than the maximum of 6MWD in the previous study of Singaporeans 45 – 85 year (560 $\pm$ 105 m; range 405 – 796 m) for the entire group of subjects (Hermione et al., 2006). Because the turn around point in present study was a circumambulate rope placing on the floor, while standard guideline introduced turn around with cone, this may result in a greater distance in the present study. However 6MWD of Caucasian subjects (55-75 year) was greater (659 $\pm$ 62 m; range 484 – 820 m) (Bernadine et al, 2005) than that of our subjects.

**Associations between physical activity and 6MWD**

The present study found that predicted distance from the equations was not affected by the physical activity level in men. This may be similar with some previous studies (Hermione et al.,2006; Troosters et al.,1999; Gibbons et al.,2001) that failed to demonstrate an association between self-reported physical activity and actual 6MWD. 6MWD in the study of Troosters et al. was not related to the scores on the daily activities questionnaire (Troosters et al., 1999). The majority of subjects of the study by Hermione et al. (2006) were physically active and no significant correlations were found between habitual physical activity and 6MWD (Hermione et al., 2006). Bernadine et al. (2006) hypothesised that 6MWD would be greater in individuals who walked for prolonged periods on a regular basis

(Bernadine et al., 2006). Of particular interest was the time spent walking for continuous periods of at least 10 min either for recreation, exercise or transport (Bernadine et al., 2006). However, minutes walked in the previous week was not a predictor of 6MWD (Bernadine et al., 2006). It has been suggested a possibility that the speed of habitual walking, which was not assessed in this study, may be a more relevant predictor of 6MWD than time spent walking (Bernadine et al., 2006).

In this study, there was a correlation between 6MWD and energy expenditure (kcal) per week. Energy expenditure per week of only moderate or vigorous activity $\geq$ 10 minutes was obtained from calculation. Energy expenditure per week was related with 6MWD ($r = 0.49$, $n = 162$) consistent with the findings of Stephen et al. (Stephen et al., 2002). 6MWD was also significantly associated ($r = 0.44$) with self-reported physical activity per week (Stephen et al., 2002). While self-reported physical activity was determined by forced-choice items from a structured interview (Stephen et al., 2002), energy expenditure (kcal) per week in this study was collected by self reported physical activity directly interviewed by the investigator.

Although, the present study did not emphasize the relation of physical activity and 6MWD, physical activity level was used to classify the subjects into groups. So, physical activity quantification may contain some error due to self report. Stephen et al. did not include physical activity level as a possible predictor, even though it was significantly associated with 6MWD (Stephen et al., 2002). They considered that such relationships were correlative rather than explanatory; therefore, inclusion of physical activity could preclude the entry of explanatory variables into the regression model.

The present study did not include all physical activity for analyses, but only physical activities that benefit to health, and were moderate or vigorous ($\geq$ 10 minute for each session) were analysed. Some inactive participants had energy expenditure per week equal 0 kcal/wk due to our classification method. Moreover, physical activity such as running in this present study was calculated as jogging or general running (code: 12020, 7.0 METS; Ainsworth et al.,2000), despite the fact that the running speed of the subjects may have been different in each running session.

**Relationship between 6MWD and $VO_2$max**

In this study, 6MWD was weakly related to $VO_2$ ($r = 0.37$). In contrast with previous studies (Cahalin et al., 1995; Guyatt et al., 1985) good correlations ($r = 0.73$) were found between 6MWD and $VO_2$max for patients with end stage lung diseases. Additionally, Ricardo et al. observed significant positive correlations between mean distance on 6MWT and exercise stress testing $VO_2$max ($r = 0.71$) in patients with severe heart failure (Ricardo et al., 2006). A potential source of variance may be the different measurements in $VO_2$max test. On the contrary, in some study (Michael et al., 2003) 6MWT underestimated the true functional capacity of patients with coronary artery disease eventhough the study compared the cardiovascular responses to the 6MWT with treadmill stress test (Michael et al., 2003).

Good correlation has been shown between 6MWD and $VO_2$max in patients with end stage lung diseases (Cahalin et al., 1995; Guyatt et al., 1985) and those with severe heart failure (NYHA class II (93%) and III (7%)) (Ricardo et al., 2006), but it was not good in patients with coronary artery disease (NYHA class 1) (Michael et al., 2003). There was a possibility that 6MWT did not show actual performance functions in healthy persons as shown in the present study nor in patients with good functional status (class I NYHA) as shown in another study (Michael et al., 2003). Similarly, ATS guideline concluded that the 6MWT is a useful measure of functional capacity targeted at people with at least moderately severe impairment.

If 6MWT can not determine actual functional capacity in healthy persons while correlation between 6MWD and $VO_2$max was low, this may cause some variation in the reference equations for interpreting functional status of the patients. Therefore, it is suggested that 6MWT to be interpreted before and after an intervention or treatment likely to be more optimal than using equations for functional evaluation of some patients.

**Predictors of six minute walk distance**

Significant positive correlations were found between 6MWD and height, leg length, normal stride length, fast stride length, weight, FEV1, energy expenditure/week, meanHR, %predHRmax and VO2max but not with age or BMI. The observed association between height, weight, FEV1, leg length, and %predHRmax with 6MWD is consistent with previous findings (Bernadine et al., 2005; Hermione et al., 2006). This study also found new information that there was a significant correlation between 6MWD and both normal stride length and fast stride length in healthy subjects.

The correlation between height and leg length was as similarly high as between meanHR and %predHRmax. Height was used in preference to leg length as it is more easily measured in the clinical setting (Hermione et al., 2006). While the present study showed a relationship between meanHR and 6MWD, Alfredo et al. did not find such relationship in their healthy subjects (Alfredo et al., 2006). This may be due to age discrepancy among the subjects. In their study, the subjects age range was 20 – 50 years, while it was between 45 – 65 years in the present study.

Height, energy expenditure/week (kcal/wk), %predHRmax, sex, weight and age were significant independent predictors of 6MWD, together explaining 58% of the variance of 6MWD. Predicted equation derived from subjects with sufficiency and with insufficiency of physical activity explaining 61% and 54%, respectively. The equation in the present study explained more 6MWD variability than the studies by Bernadine et al. (33.9%) and Alfredo et al. (42%) (Bernadine et al., 2005; Alfredo et al., 2006). However, 73% of variability of the 6MWD was explained in another study (Hermione et al., 2006). All the studies mentioned have employed the same standard guideline (ATS guideline, 2002).

**Conclusion**

6MWD differed between healthy individuals with sufficiency and insufficiency levels of physical activity. Using the published equation for females should be interpreted cautiously. Physical activity classification did not affect the prediction equations in males. 6MWT may not perfectly determine the actual functional capacity in healthy persons. For future studies finding of reference equations from healthy inactive females and using them for female patients with cardiopulmonary disease or with other limited functional abilities should provide better accuracy when interpreting the results of single measurements made to determine functional status.

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# APPENDICES

# APPENDIX A

## QUESTIONNAIRE

เลขที่................

ส่วนที่ 1 แบบสอบถามข้อมูลเบื้องต้น

1. อายุ..........................ปี
2. เพศ..........................
3. อาชีพ..............................................และภูมิลำเนา................................................
4. ระดับการศึกษาของท่านคือ

   O ต่ำกว่าปริญญาตรี O ปริญญาตรี O สูงกว่าปริญญาตรี

5. ท่านมีแรงจูงใจในการทดสอบมากแค่ไหน (motivation)

   O มากที่สุด O มาก O ปานกลาง O น้อย

6. ท่านเคยทำการทดสอบสมรรถภาพโดยการเดิน 6 นาที หรือไม่ในช่วง 2 เดือนที่ผ่านมา

   O เคย O ไม่เคย

7. อัตราการเต้นหัวใจขณะพักมากกว่า 100 ครั้ง/นาที หรือไม่

   O ใช่ O ไม่

8. ท่านใช้เครื่องช่วยเดิน หรือไม่

   O ใช่ O ไม่

9. ท่านมีอาการเป็นโรคหรือป่วยไข้ เมื่อ 4 สัปดาห์ที่ผ่านมา ใช่หรือไม่

   O ใช่ O ไม่

10. ท่านมีประวัติเป็นโรคหัวใจ หรือไม่ (angina, MI, CHF, stroke, TIA, PVD, AAI)

    O เป็น O ไม่เป็น

11. ผู้ที่อยู่ในครอบครัวของท่านเคยมีประวัติโรคหลอดเลือดหัวใจตีบหรือไม่

    O เป็นเมื่ออายุ..............................(ชาย) O ไม่เป็น

    เมื่ออายุ..............................(หญิง)

12. ท่านมีประวัติเป็นโรคเบาหวานหรือไม่

    O เป็น O ไม่เป็น

13. ท่านมีประวัติเป็นโรคความดันโลหิตสูงหรือไม่

    O เป็น O ไม่เป็น

14. ท่านมีไขมันในเลือดสูงหรือไม่

    O เป็น O ไม่เป็น

15. ท่านมีประวัติเป็นโรคหอบหืด โรคถุงลมโป่งพอง หรือโรคปอดเรื้อรังหรือไม่ (asthma, cystic fibrosis, interstitial lung disease)

O เป็น O ไม่เป็น

16. ท่านมีปัญหาการบาดเจ็บหรือผิดปกติเกี่ยวกับระบบกล้ามเนื้อ กระดูก และข้อต่อหรือไม่ (arthitis, ankle, knee, or hip injury, muscle wasting, etc.)

O มี เจ็บหรือผิดปกติที่.......................... O ไม่มี

17. ปัจจุบันท่านรับประทานยาหรือวิตามินใดเป็นประจำ (โปรดระบุรายละเอียด)

..................................................................................................................

**ส่วนที่ 2 แบบสอบถามการทำกิจกรรมทางกายในหนึ่งสัปดาห์ที่ผ่านมา** (ตั้งแต่วันจันทร์ - วันอาทิตย์ ของอาทิตย์ที่แล้ว)

18. ท่านออกกำลังกายหรือเล่นกีฬาอะไรบ้างในสัปดาห์ที่ผ่านมา

(1).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(2).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(3).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(4).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(5).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(6).........................................................นาน........................กี่ครั้ง/สัปดาห์........

19. ท่านมีกิจกรรมที่ปฏิบัติต่อเนื่องติดต่อกันเกิน 10 นาที ที่หนักจนทำให้รู้สึกเหนื่อยมาก หรือไม่ เช่น งานที่ทำแล้วเหนื่อยหอบมากๆ ไม่สามารถพูดหรือคุยได้ขณะทำกิจกรรมนั้น

(1).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(2).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(3).........................................................นาน........................กี่ครั้ง/สัปดาห์........

20. ท่านมีกิจกรรมที่ปฏิบัติต่อเนื่องติดต่อกันเกิน 10 นาที ที่หนักปานกลางหรือเหนื่อยปานกลาง หรือไม่ เช่น กิจกรรมที่ขณะทำหายใจแรง หรือร้องเพลงไม่สะดวก แต่ยังพอพูดได้

(1).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(2).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(3).........................................................นาน........................กี่ครั้ง/สัปดาห์........

21. ท่านมีการเข้าร่วมกิจกรรมอื่นๆ เพื่อสุขภาพ หรือคอร์ดสอนต่างๆ หรือไม่ เช่น ชี่กง โยคะ

(1).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(2).........................................................นาน........................กี่ครั้ง/สัปดาห์........

(3).........................................................นาน........................กี่ครั้ง/สัปดาห์........

**รวมมีกิจกรรมทางกายระดับปานกลางทั้งหมด..............................นาที............... ครั้ง/สัปดาห์**

**รวมมีกิจกรรมทางกายระดับหนักทั้งหมด....................................นาที ............... ครั้ง/สัปดาห์**

**รวมมีกิจกรรมทางกายระดับปานกลาง + 2(กิจกรรมทางกายระดับหนัก)............................นาที**

**รวมมีการใช้พลังงานทั้งหมด....................................................กิโลแคลอรี่/สัปดาห์**

**การคำนวณระดับของกิจกรรมทางกาย**

**Sufficient physical activity** 1.มีกิจกรรมทางกายระดับปานกลาง 150 นาที ภายในเวลา $\geq$5 ครั้ง/สัปดาห์ หรือ กิจกรรมทางกายระดับหนัก $\geq$60 นาทีในอาทิตย์ที่ผ่านมา (An initiative of the Premier's Physical Activity Taskforce, 2003)

2.มีกิจกรรมทางกายระดับปานกลางรวมกับกิจกรรมทางกายระดับหนักคูณสอง $\geq$150 นาทีในอาทิตย์ที่ผ่านมา

**Insufficient physical activity** กิจกรรมบางอย่างที่ไม่เพียงพอต่อการมีระดับกิจกรรมทางกายที่เพียงพอ

**Vigorous activity** คือกิจกรรมทางกายที่ต้องใช้พลังงานตั้งแต่ 6 METS ขึ้นไป (Centers for Disease Control and Prevention, 2006)

**Moderate-intensity** คือกิจกรรมทางกายที่ต้องใช้พลังงาน 3 - 6 METS (Centers for Disease Control and Prevention, 2006)

**METs** ของแต่ละกิจกรรมคำนวณจาก Ainsworth et al. (Ainsworth et al., 1993; Ainsworth et al., 2000)

**Kcal/Weeks** คำนวณจาก METs x น้ำหนักตัว (kg.) x ชั่วโมงต่อสัปดาห์
โดย 1 METs มีค่าประมาณเท่ากับ 4.2 Kcal/kg/hr (Zhuo et al., 1984; Paffenbarger et al., 1992; Ainsworth et al., 2000)

# APPENDIX B

## CASE RECORD FORM

## แบบบันทึกผลการทดสอบ

1. น้ำหนัก........................กิโลกรัม **เลขที่**....................

2. ส่วนสูง.........................เซนติเมตร

3. ดัชนีมวลกาย......................................กก./ม$^2$

4. ความยาวขาข้างขวา..................เซนติเมตร, ความยาวขาข้างซ้าย...................เซนติเมตร

   ความยาวขาทั้งสองข้างต่างกันเท่ากับ..............................เซนติเมตร

5. ระยะทางที่เดินได้ทั้งหมด 10 ก้าว ...................................เมตร

   ความยาวก้าวปกติ 1 ก้าว เท่ากับ.....................................เซนติเมตร

6. อัตราการเต้นของหัวใจขณะพัก..................................................................ครั้ง/นาที

7. ระดับความดันโลหิตขณะพัก......................................................................มม.ปรอท

8. FEV1.........................(มล.)FEV1 predicted.....................(มล.).%FEV1.....................

9. FVC............................(มล.).FVC predicted....................(มล.)%FVC........................

10. FEV1/FVC...................(มล.) FEV1/FVC predicted..........(มล.).%FEV1/FVC..............

11. ระดับของความเหนื่อยก่อนการทดสอบ (Borg scale)....................................................

12. อัตราการเต้นหัวใจขณะทำการทดสอบ 6 MWT

| | ก่อนการทดสอบ 1 นาที | ครบ นาทีที่ 1 | ครบ นาทีที่ 2 | ครบ นาทีที่ 3 | ครบ นาทีที่ 4 | ครบ นาทีที่ 5 | ครบ นาทีที่ 6 | Borg scale (score) |
|---|---|---|---|---|---|---|---|---|
| $1^{st}$ | | | | | | | | |
| $2^{nd}$ | | | | | | | | |
| $3^{th}$ | | | | | | | | |

13. peakHR ของการทดสอบที่เดินได้มากที่สุด........................................................ครั้ง/นาที

14. HRmax(220- อายุ).........................................................................................ครั้ง/นาที

15. %predictHRmax = ........................................................... (%peakHR ของ HRmax)

16. อัตราการเต้นหัวใจเฉลี่ยในการทดสอบที่เดินได้ระยะทางมากที่สุด....................ครั้ง/นาที

ระยะทางที่เดินได้ครั้งที่1.....................................เมตร(.........................................รอบ)

ระยะทางที่เดินได้ครั้งที่2.....................................เมตร(.........................................รอบ)

ระยะทางที่เดินได้ครั้งที่3.....................................เมตร(.........................................รอบ)

ระยะทางที่เดินได้มากที่สุด..................................เมตร(.........................................รอบ)



**วันที่**...................**เดือน**.....................**พ.ศ**.............

**แบบบันทึกผลการทดสอบ YMCA Cycle test**

1. ประมาณอัตราการใช้ออกซิเจนสูงสุด โดยจักรยานวัดงาน (YMCA Cycle Test)

Predicted $HR_{max}$ 85%..........................................................................ครั้ง/นาที

อัตราการเต้นของหัวใจก่อนการทดสอบ..........................................................ครั้ง/นาที

ระดับความดันโลหิตก่อนการทดสอบ............................................................มม.ปรอท

| | Workload | BP | HR | RPE |
|---|---|---|---|---|
| Warm Up | ............. | ............. | ............. | ............. |
| Stage 1 | ............. | ............. | ............. | ............. |
| Stage 2 | ............. | ............. | ............. | ............. |
| Stage 3 | ............. | ............. | ............. | ............. |
| Stage 4 | ............. | ............. | ............. | ............. |

| | Stage A | Stage B |
|---|---|---|
| Work Load | | |
| Heart Rate | | |

$VO_2max$ = ...........................................................................ml/kg/min

**วันที่**...................**เดือน**.....................**พ.ศ**.............

# APPENDIX C

## INFORMATION SHEET AND INSTRUCTION
## เอกสารชี้แจงข้อมูล/คำแนะนำแก่ผู้เข้าร่วมโครงการ

**ชื่อโครงการ** การทดสอบเดินหกนาทีในบุคคลสุขภาพดีที่มีระดับกิจกรรมทางกายที่เพียงพอและไม่เพียงพอ (Six minute walk test in healthy persons with sufficient and insufficient levels of physical activity.)

**ผู้ทำการวิจัย** นายสิตมนัส สุวรรณฉาย
นิสิตหลักสูตรวิทยาศาสตร์มหาบัณฑิต สาขาเวชศาสตร์การกีฬา

**อาจารย์ที่ปรึกษาโครงการ** ผู้ช่วยศาสตราจารย์ ดร. แพทย์หญิง อรอนงค์ กุละพัฒน์
**อาจารย์ที่ปรึกษาร่วม** รองศาสตราจารย์ แพทย์หญิง ดุจใจ ชัยวานิชศิริ

**ผู้ดูแลที่ติดต่อได้**

1. ผศ.ดร.พญ. อรอนงค์ กุละพัฒน์ ภาควิชาสรีรวิทยา คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัยโทรศัพท์ 02-252 7854 ต่อ 114 (ที่ทำงาน)
2. รองศาสตราจารย์ แพทย์หญิง ดุจใจ ชัยวานิชศิริ ภาควิชาเวชศาสตร์ฟื้นฟู คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย โทรศัพท์ 02-256 4433 (ที่ทำงาน)
3. นายสิตมนัส สุวรรณฉาย ภาควิชาสรีรวิทยา คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย โทรศัพท์ 02-256 4267 , มือถือ 086-627 8207

**สถานที่วิจัย**

1. ภาควิชาสรีรวิทยา คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
2. ชั้น 6 ตึก อปร. โรงพยาบาลจุฬาลงกรณ์

**ความเป็นมาของโครงการ**

Six minute walk test (6MWT) เป็นการทดสอบสมรรถภาพร่างกายที่นิยมใช้กับผู้ป่วยทางด้านระบบไหลเวียนและปอด เช่น ผู้ป่วยที่เป็นโรคหัวใจ โรคปอดเรื้อรังต่างๆ เป็นต้น โดยการประเมินนั้นนอกจากจะทำการวัดผลในการรักษาเพื่อดูสมรรถภาพร่างกายก่อนและหลังทำการรักษาแล้ว ยังสามารถประเมินได้จากการเทียบค่าอ้างอิงโดยใช้สมการและค่าระยะทางที่เดินได้ของผู้ที่มีสุขภาพปกติเพื่อใช้เป็นเกณฑ์หรือเป้าหมายสำหรับผู้ป่วยเหล่านี้ โดยค่าที่อ้างอิงถึงนี้ส่วนใหญ่นำมาจากผู้ที่มีสุขภาพดีที่มีระดับกิจกรรมทางกายที่เพียงพอที่จะทำให้เกิดประโยชน์แก่ร่างกาย ซึ่งอาจจะทำให้ได้ค่าอ้างอิงที่สูงเกินไปเมื่อผู้ป่วยกลับสู่การมีระดับสุขภาพที่ปกติแต่ยังไม่มีระดับของกิจกรรมทางกายที่มากเพียงพอ

ดังนั้นการศึกษานี้จึงทำการเปรียบเทียบระยะทางที่เดินได้จากการทดสอบ 6MWT ของคนสุขภาพดีระหว่างผู้ที่มีระดับกิจกรรมทางกายที่เพียงพอ กับผู้ที่มีระดับกิจกรรมทางกายที่ไม่เพียงพอที่จะทำให้เกิดประโยชน์ต่อร่างกายได้ เพื่อแสดงให้เห็นว่าการนำค่าอ้างอิงที่สร้างจากผู้ที่มีสุขภาพดีที่มีระดับกิจกรรมทางกายที่ไม่เพียงพอนั้นอาจจะมีความเหมาะสมกว่า

**วัตถุประสงค์ของการวิจัย** (Objectives)

1.เพื่อเปรียบเทียบค่า 6MWD ของผู้มีสุขภาพดีไม่เป็นโรคที่มีกิจกรรมทางกายที่เพียงพอและไม่เพียงพอต่อการเกิดประโยชน์แก่สุขภาพ

2.เพื่อเปรียบเทียบค่า 6 MWD ของการศึกษาที่ผ่านมากับค่า 6MWD ของผู้มีสุขภาพดีไม่เป็นโรคที่มีกิจกรรมทางกายเพียงพอและไม่เพียงพอต่อการเกิดประโยชน์แก่สุขภาพ

3.เพื่อศึกษาความสัมพันธ์ระหว่างระดับของกิจกรรมทางกาย กับสมรรถภาพของร่างกาย (aerobic fitness)

4.เพื่อหาปัจจัยที่ส่งผลต่อ 6MWD

**รายละเอียดที่จะปฏิบัติต่อผู้เข้าร่วมวิจัย**

1.ผู้เข้าร่วมวิจัยจะได้รับการชี้แจงรายละเอียดเกี่ยวกับงานวิจัยโดยย่อและได้รับการแจ้งให้ทราบว่าการเข้าร่วมโครงการศึกษาวิจัยในครั้งนี้ผู้เข้าร่วมวิจัยไม่ต้องเสียค่าใช้จ่ายใดๆทั้งสิ้น ได้รับการสัมภาษณ์และคัดกรองความเสี่ยงเบื้องต้นโดยผู้วิจัยตามเกณฑ์คัดเลือกเข้ามาศึกษา เมื่อผู้เข้าร่วมวิจัยตัดสินใจเข้าร่วมงานวิจัย ผู้เข้าร่วมวิจัยจะต้องลงนามยินยอมเข้าร่วมในการวิจัย ทำการตอบแบบสอบถามเบื้องต้นและแบบสอบถามเกี่ยวกับกิจกรรมทางกายภายใน 1 อาทิตย์ที่ผ่านมาของผู้เข้าร่วมวิจัย

2. ขั้นตอนการวิจัย ผู้เข้าร่วมวิจัยจะถูกขอร้องให้งดการดื่มสุรา เครื่องดื่มที่มีส่วนผสมของคาเฟอีน หลีกเลี่ยงการมีกิจกรรมที่มีความหนักมาก เช่น การออกกำลังกายอย่างหนัก อย่างน้อย 24 ชั่วโมง และงดรับประทานอาหารก่อนมาเข้าร่วมงานวิจัย อย่างน้อย 2 ชั่วโมง เพื่อรักษาระดับ

การไหลเวียนของโลหิตและอัตราการเต้นของหัวใจให้คงที่ เมื่อผู้เข้าร่วมวิจัยมาถึงห้องปฏิบัติการ ให้ผู้เข้าร่วมวิจัยนั่งพัก 10 นาที ทำการวัดอัตราการเต้นของหัวใจขณะพัก (Resting Heart Rate), ความดันเลือด (Blood Pressure), ชั่งน้ำหนัก, วัดส่วนสูง, วัดความยาวขาทั้งสองข้างในท่านอนหงาย (ที่ตำแหน่ง anterior superior iliac spine (ASIS) จนถึง medial malleolus), วัดความสามารถของปอด (FEV1 และ FVC) วัดระดับของความเหนื่อยโดยใช้ Borg scale และ ติด Heart Rate Monitor บริเวณใต้ราวนมของผู้เข้าร่วมงานวิจัย

3.การวัดความสามารถของปอด โดย sprirometry นั่งตัวตรงและหน้าตรง เท้าทั้งสองข้างแตะกับพื้น หนีบจมูกด้วย nose clip หายใจเข้าช้าๆจนเต็มที่ อม mouthpiece และปิดปากให้แน่นรอบ mouthpiece หายใจออกให้เร็วและแรงเต็มที่จนหมด สูดหายใจเข้าและเร็วเต็มที่ ทำซ้ำประมาณสามครั้ง

4.วิธีการทดสอบเดิน 6 นาที โดยให้เดินให้ได้ระยะทางที่มากที่สุดภายในเวลาหกนาทีเป็นเส้นตรงไปกลับ โดยพักและเดินช้าลงได้ถ้าผู้เข้าร่วมงานวิจัยต้องการ ระหว่างทางเดินจะมีเก้าอี้ซึ่งสามารถนั่งได้ระหว่างการทดสอบการเดิน ในทุกๆ 1 นาที ผู้วิจัยจะทำบันทึกอัตราการเต้นของหัวใจ ไม่ควรพูดคุยระหว่างทำการทดสอบ ผู้วิจัยจะแจ้งเวลาเมื่อเวลาเหลืออีก 1 นาที การทำการทดสอบเดินจะทำทั้งหมด 3 ครั้ง เพื่อหาครั้งที่สามารถเดินได้มากที่สุด โดยนั่งพักระหว่างการทดสอบแต่ละครั้ง 20 นาที หรือ อัตราการเต้นของหัวใจเท่ากับอัตราการเต้นของหัวใจขณะพัก ควรสวมเสื้อผ้าและรองเท้าที่สะดวกต่อการเดินทดสอบ เช่น รองเท้าผ้าใบและชุดกีฬา

5.การทดสอบโดยการปั่นจักรยาน ทำการทดสอบโดยให้ผู้เข้าร่วมวิจัยปั่นจักรยานที่ความเร็ว 50 รอบ/นาที โดยเริ่มที่ความหนักน้อย แล้วค่อยๆเพิ่มความหนักขึ้นทุกๆ 3 นาที จนกระทั่งอัตราการเต้นของหัวใจอยู่ที่ประมาณ 85% ของอัตราการเต้นหัวใจสูงสุด จะใช้เวลาในการทดสอบประมาณ 10 – 15 นาที ควรสวมเสื้อผ้าและรองเท้าที่สะดวกต่อการทดสอบ เช่น รองเท้าผ้าใบและชุดกีฬา

**ผลหรือประโยชน์ที่ท่านจะได้รับจากการร่วมงานวิจัย**

1. ท่านจะได้ทราบถึงผลการทดสอบในการเดิน 6 นาที ว่าจะได้ระยะทางเท่าที่ควรจะเป็นหรือไม่ ทราบระยะทางที่เดินได้ (หน่วยเป็นเมตร) ทราบระยะทางที่ควรเดิน เมื่อเทียบกับอายุ น้ำหนักและสวนสูงของท่านแล้ว

2. ท่านจะได้ทราบสมรรถภาพการทำงานของร่างกาย และปริมาณการใช้ออกซิเจนสูงสุดของท่าน

3. ท่านจะได้รับคำแนะนำเกี่ยวกับการทำกิจกรรมทางกายที่เพียงพอและการออกกำลังกาย

**ค่าตอบแทนอาสาสมัครผู้เข้าร่วมโครงการวิจัย**

ท่านจะได้รับค่าชดเชยการเดินทางสำหรับการเข้าร่วมโครงการวิจัยท่านละ 200 บาท/วัน

**ผลหรือประโยชน์ที่คาดว่าจะได้รับจากงานวิจัย**

1.เป็นข้อมูลในการสร้างสมการทำนาย 6MWD และนำสมการไปใช้ทำนาย 6MWD ได้อย่างเหมาะสมมากขึ้น

2. ข้อมูลที่ได้จากการทดสอบของท่านจะเป็นข้อมูลในการพัฒนางานวิจัยในอนาคตต่อไป

**ผลข้างเคียงที่อาจเกิดขึ้นแก่ผู้เข้าร่วมโครงการ**

ขณะทำการทดสอบการออกกำลังกาย ท่านอาจจะมีโอกาสเกิดอาการต่อไปนี้ รู้สึกเจ็บแน่นหน้าอก หายใจลำบาก ชีพจรเต้นเร็วมาก เหนื่อยหอบมาก หรือมีอาการปวดล้าบริเวณขามากจนทนไม่ได้ หากมีอาการดังกล่าวสามารถแจ้งผู้วิจัยได้ทันที หรือผู้วิจัยเห็นว่าท่านมีอาการดังที่กล่าวมาผู้วิจัยจะหยุดการทดสอบ

หลังจากทำการทดสอบกาเดินอาจมีผลข้างเคียง คือ อาการเมื่อยล้าของกล้ามเนื้อขาเนื่องจากการเดินเร็ว สามารถแก้ไขโดยหลังทำการทดสอบเสร็จ ให้ท่านทำการผ่อนคลายกล้ามเนื้อ (Cool Down) ทันที หรือการประคบเย็นให้เพื่อลดอาการเมื่อยล้า และ และหลังจากทำการทดสอบเสร็จขอให้ท่านพักผ่อนให้เพียงพอ อาการเมื่อยล้าก็จะหายไป

การเก็บข้อมูลเป็นความลับ

ผู้ทำวิจัยขอยืนยันว่า ข้อมูลเกี่ยวกับตัวผู้เข้าร่วมงานวิจัยจะถูกเก็บไว้เป็นความลับ และจะใช้สำหรับงานวิจัยนี้เท่านั้นและชื่อของผู้เข้าร่วมงานวิจัยจะไม่ปรากฎในแบบฟอร์มการเก็บข้อมูลและในฐานข้อมูลทั่วไป โดยมีผู้ทำวิจัยเพียงคนเดียวเท่านั้นที่ทราบรายละเอียดของข้อมูลนี้ ผู้ทำวิจัยขอขอบพระคุณผู้เข้าร่วมงานวิจัยที่ให้ความร่วมมือในการทำวิจัยครั้งนี้ และท่านสามารถขอถอนตัวออกจากโครงการวิจัยได้ทุกเวลาผู้วิจัยขอขอบพระคุณท่านที่ให้ความร่วมมือมาเข้าโครงการวิจัย

ทั้งนี้ หากท่านมีปัญหาทางด้านจริยธรรมการวิจัย ท่านสามารถร้องเรียนได้ต่อคณะกรรมการจริยธรรมการวิจัยที่เบอร์ (02) 256 4455 ต่อ 14, 15

# APPENDIX D

## Consent form

## ใบยินยอมเข้าร่วมการวิจัย

**การวิจัยเรื่อง** การทดสอบเดินหกนาทีในบุคคลสุขภาพดีที่มีระดับกิจกรรมทางกายที่เพียงพอและไม่เพียงพอ

วันให้คำยินยอม วันที่ .................. เดือน...................... พ.ศ. ..............................

ก่อนที่จะลงนามในใบยินยอมให้ทำการวิจัยนี้ ข้าพเจ้าได้รับการอธิบายจากผู้วิจัยถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตราย หรืออาการที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่เกิดขึ้นจากการวิจัยอย่างละเอียด และมีความเข้าใจดีแล้ว

ผู้วิจัยรับรองว่าจะตอบคำถามต่างๆ ที่ข้าพเจ้าสงสัยด้วยความเต็มใจไม่ปิดบังซ่อนเร้นจนข้าพเจ้าพอใจ

ข้าพเจ้าเข้าร่วมโครงการวิจัยนี้โดยสมัครใจ และสามารถบอกเลิกการเข้าร่วมการวิจัยได้ตลอดเวลา

ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะเกี่ยวกับตัวข้าพเจ้าเป็นความลับ โดยเปิดเผยได้เฉพาะในรูปที่เป็นสรุปผลการวิจัย การเปิดเผยข้อมูลเกี่ยวกับตัวข้าพเจ้าต่อหน่วยงานต่างๆ ที่เกี่ยวข้องกระทำได้เฉพาะกรณีจำเป็นด้วยเหตุผลทางวิชาการเท่านั้น

ผู้วิจัยรับรองว่าหากเกิดอันตรายใดๆจากการวิจัยดังกล่าวจะได้รับการรักษาพยาบาลในโรงพยาบาลจุฬาลงกรณ์โดยไม่คิดค่าใช้จ่ายใดๆ

ข้าพเจ้าได้อ่านข้อความข้างต้นแล้ว และมีความเข้าใจดีทุกประการ และได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ

ลงนาม......................................................................................ผู้ยินยอม

(.............................................................................................)

ลงนาม..........................................................................................พยาน

(.............................................................................................)

ลงนาม......................................................................................ผู้ทำวิจัย

(.............................................................................................)

## APPENDIX E

### Borg scale

| | |
|---|---|
| 0 | ไม่รู้สึกอะไรเลย (nothing at all) |
| 0.5 | เบามากมาก (just noticeable) |
| 1 | เบามาก (very weak) |
| 2 | เบา (weak, light) |
| 3 | ปานกลาง (moderate) |
| 4 | เหนื่อยบ้าง (somewhat strong) |
| 5 | เหนื่อย (heavy) |
| 6 | |
| 7 | เหนื่อยมาก (very strong) |
| 8 | |
| 9 | เกือบเหนื่อยมากที่สุด(extremely strong, almost maximal) |
| 10 | เหนื่อยมากที่สุด (maximal) |

# APPENDIX F

## Compendium of Physical activity

| CODE | METS | SPECFIC ACTIVITY | EXAMPLES |
|---|---|---|---|
| 01010 | 4.0 | Bicycling | Bicycling, <10 mph, leisure, to work or for pleasure |
| 01020 | 6.0 | Bicycling | Bicycling, 10-11.9 mph, leisure, slow, light effort |
| 01030 | 8.0 | Bicycling | Bicycling, 12-13.9 mph, leisure, moderate effort |
| 01040 | 10.0 | Bicycling | Bicycling, 14-15.9 mph, racing or leisure, fast, vigorous effort |
| 02030 | 3.5 | Conditioning exercise | Calisthenics, home exercise, light or moderate effort, general (example: back exercises), going up & down from floor |
| 02070 | 7.0 | Conditioning exercise | Rowing, stationary ergometer, general |
| 02100 | 2.5 | Conditioning exercise | Stretching, hatha yoga |
| 02130 | 3.0 | Conditioning exercise | Weight lifting (free, nautilus or universal-type), light or moderate effort, light workout, general |
| 03020 | 5.0 | Dancing | Aerobic, low impact |
| 03031 | 4.5 | Dancing | Ballroom, fast (disco, folk, square), line dancing, Irish step dancing, polka, contra, country |

| | | | |
|---|---|---|---|
| 03040 | 3.0 | Dancing | Ballroom, slow (e.g. waltz, foxtrot, slow dancing), samba, tango, $19^{th}$ C, mambo, chacha |
| 05020 | 3.0 | Home activity | Cleaning, heavy or major (e.g. wash car, wash windows, clean garage), vigorous effort |
| 05025 | 2.5 | Home activity | Multiple household tasks all at once, light effort |
| 05030 | 3.0 | Home activity | Cleaning, house or cabin, general |
| 08050 | 5.0 | Lawn and garden | Digging, spading, filling garden, composting |
| 08095 | 5.5 | Lawn and garden | Mowing lawn, general |
| 08150 | 4.5 | Lawn and garden | Planting trees |
| 08230 | 1.5 | Lawn and garden | Watering lawn or garden, standing or walking |
| 08246 | 3.0 | Lawn and garden | Picking fruit off trees, picking fruits/vegetables, moderate effort |
| 12010 | 6.0 | Running | Jog/walk combination (jogging component of less than 10 minute) |
| 12020 | 7.0 | Running | Jogging, general |
| 12180 | 10.0 | Running | Running, on a track, team practice |
| 15030 | 4.5 | Sports | Badminton, social singles and doubles, general |

| | | | |
|---|---|---|---|
| **15100** | 12.0 | Sports | Boxing, in ring, general |
| **15255** | 4.5 | Sports | Golf, general |
| **15660** | 4.0 | Sports | Table tennis, ping pong |
| **15670** | 4.0 | Sports | Tai chi |
| **15675** | 7.0 | Sports | Tennis, general |
| **17152** | 2.5 | Walking | Walking, 2.0 mph, level, slow pace, firm surface |
| **17190** | 3.3 | Walking | Walking, 3.0 mph, Level, moderate pace, Firm surface |
| **17200** | 3.8 | Walking | Walking, 3.5 mph, Level, brisk, Firm surface, walking for exercise |
| **18240** | 7.0 | Water activities | Swimming laps, freestyle, slow, moderate or light effort |
| **21025** | 3.5 | Volunteer activities | Standing – moderate (lifting 50 lbs., assembling at fast rate) |

**Source:** Ainsworth B. E., Haskell W. L., Whitt M. C., Irwin M. L., Swartz A. M., Strath S. J., O'Brien W. L., Bassett D. R., Schmitz K. H., Emplaincourt P.O., Jacobs D. R. and Leon A. S. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 2000: s498 - s516.

# APPENDIX G

## Demographic profile

| Characteristics | (n = 162) | % |
|---|---|---|
| **Birthplace** | | |
| Bangkok | 119 | 73.50 |
| Up-country | 43 | 26.50 |
| **Education** | | |
| Higher than bachelor's degree | 18 | 11.10 |
| Bachelor's degree | 62 | 38.30 |
| Under bachelor's degree | 82 | 50.60 |
| **Employment Categories** | | |
| Merchant | 47 | 29.00 |
| Employee | 34 | 21.00 |
| Work for hire | 19 | 11.70 |
| Retirement | 15 | 9.30 |
| Teacher | 6 | 3.70 |
| Housewife | 41 | 25.30 |
| **Motivation** | | |
| Very high | 23 | 14.20 |
| High | 102 | 63.00 |
| Medium | 37 | 22.80 |
| Low | 0 | 0.00 |
| **Supplement and vitamins** | | |
| None | 87 | 53.70 |
| Take | 75 | 46.30 |

# APPENDIX H

Types of activity

| Type of activity | Male sufficiency activity | Male insufficiency activity | Female sufficiency activity | Female insufficiency activity | All subjects activity |
|---|---|---|---|---|---|
| Walking, 2.0 mph, level, slow pace, firm surface | 6(7.4%) | 10(14.1%) | 8(5.7%) | 14(16.1%) | 38(10%) |
| Walking, 3.0 mph, Level, moderate pace, Firm surface | 5(6.2%) | 2(2.8%) | 13(9.3%) | 8(9.2%) | 28(7.4%) |
| Walking, 3.5 mph, Level, brisk, Firm surface, walking for exercise | 3(3.7%) | 13(18.3%) | 23(16.4%) | 14(16.1%) | 53(14%) |
| Jog/walk combination (jogging component of less than 10 minute) | 0(0%) | 0(0%) | 1(0.7%) | 1(1.1%) | 2(0.5%) |
| Jogging, general | 30(37%) | 20(28.2%) | 12(8.6%) | 2(2.3%) | 64(16.9%) |
| Running, on a track, team | 2(2.5) | 2(2.8%) | 1(0.7%) | 0(0%) | 5(1.3%) |

| | | | | | |
|---|---|---|---|---|---|
| practice | | | | | |
| Bicycling, <10 mph, leisure, to work or for pleasure | 3(3.7) | 0(0%) | 1(0.7%) | 0(0%) | 4(1.1%) |
| Bicycling, 10-11.9 mph, leisure, slow, light effort | 1(1.2%) | 4(5.6%) | 3(2.1%) | 4(4.6%) | 12(3.2%) |
| Bicycling, 12-13.9 mph, leisure, moderate effort | 4(4.9%) | 2(2.8%) | 1(0.7%) | 0(0%) | 7(1.8%) |
| Bicycling, 14-15.9 mph, racing or leisure, fast, vigorous effort | 0(0%) | 0(0%) | 0(0%) | 0(0%) | 4(1.1%) |
| Rowing, stationary ergometer, general | 3(3.7%) | 0(0%) | 0(0%) | 1(1.1%) | 16(4.2%) |
| Swimming laps, freestyle, slow, moderate or light effort | 4(4.9) | 1(1.4%) | 9(6.4%) | 2(2.3%) | 16(4.2%) |
| Weight lifting (free, nautilus or | 8(9.9%) | 6(8.5%) | 4(2.9%) | 5(5.7%) | 23(6.1%) |

| | | | | | |
|---|---|---|---|---|---|
| universal-type), light or moderate effort, light workout, general | | | | | |
| Aerobic, low impact | 3(3.7%) | 1(1.4%) | 18(12.9) | 4(4.76%) | 26(6.9%) |
| Ballroom, fast (disco, folk, square), line dancing, Irish step dancing, polka, contra, country | 0(0%) | 0(0%) | 4(2.9%) | 0(0%) | 4(1.1%) |
| Ballroom, slow (e.g. waltz, foxtrot, slow dancing), samba, tango, 19$^{th}$ C, mambo, chacha | 0(0%) | 0(0%) | 2(1.4%) | 0(0%) | 2(0.5%) |
| General, Greek, Middle Eastern, hula, flamenco, belly, swing | 0(0%) | 0(0%) | 0(0%) | 0(0%) | 0(0%) |
| Tai chi | 0(0%) | 1(1.4%) | 18(12.9%) | 13(14.9%) | 32(8.4%) |
| Stretching, hatha yoga | 0(0%) | 1(1.4%) | 13(9.3%) | 12(13.8%) | 26(6.9%) |

| | | | | | |
|---|---|---|---|---|---|
| Golf, general | 1(1.2%) | 2(2.8%) | 0(0%) | 1(1.1%) | 4(1.1%) |
| Tennis, general | 2(2.5%) | 0(0%) | 1(0.7%) | 0(0%) | 3(0.8%) |
| Boxing, in ring, general | 1(1.2%) | 0(0%) | 0(0%) | 0(0%) | 1(0.3%) |
| Table tennis, ping pong | 0(0%) | 1(1.4%) | 0(0%) | 0(0%) | 1(0.3%) |
| Badminton, social singles and doubles, general | 2(2.5%) | 0(0%) | 1(0.7%) | 0(0%) | 3(0.8%) |
| Multiple household tasks all at once, light effort | 1(1.2%) | 2(2.8%) | 1(0.7%) | 1(1.1%) | 5(1.3%) |
| Cleaning, heavy or major (e.g. wash car, wash windows, clean garage), vigorous effort | 1(1.2%) | 0(0%) | 0(0%) | 0(0%) | 1(0.3%) |
| Cleaning, house or cabin, general | 0(0%) | 0(0%) | 0(0%) | 1(1.1%) | 1(0.3%) |
| Mowing lawn, general | 0(0%) | 0(0%) | 0(0%) | 1(1.1%) | 1(0.3%) |
| Digging, | 0(0%) | 1(1.4%) | 0(0%) | 0(0%) | 1(0.3%) |

| | | | | | |
|---|---|---|---|---|---|
| spading, filling garden, composting | | | | | |
| Picking fruit off trees, picking fruits/vegetables, moderate effort | 0(0%) | 1(1.4%) | 0(0%) | 0(0%) | 1(0.3%) |
| Watering lawn or garden, standing or walking | 0(0%) | 0(0%) | 1(0.7%) | 1(1.1%) | 2(0.5%) |
| Planting trees | 0(0%) | 0(0%) | 1(0.7%) | 0(0%) | 1(0.3%) |
| Calisthenics, home exercise, light or moderate effort, general (example: back exercises), going up & down from floor | 0(0%) | 0(0%) | 3(2.1%) | 2(2.3%) | 5(1.3%) |
| Standing – moderate (lifting 50 lbs., assembling at fast rate) | 1(1.2%) | 1(1.4%) | 1(0.7%) | 0(0%) | 3(0.8%) |

# APPENDIX I

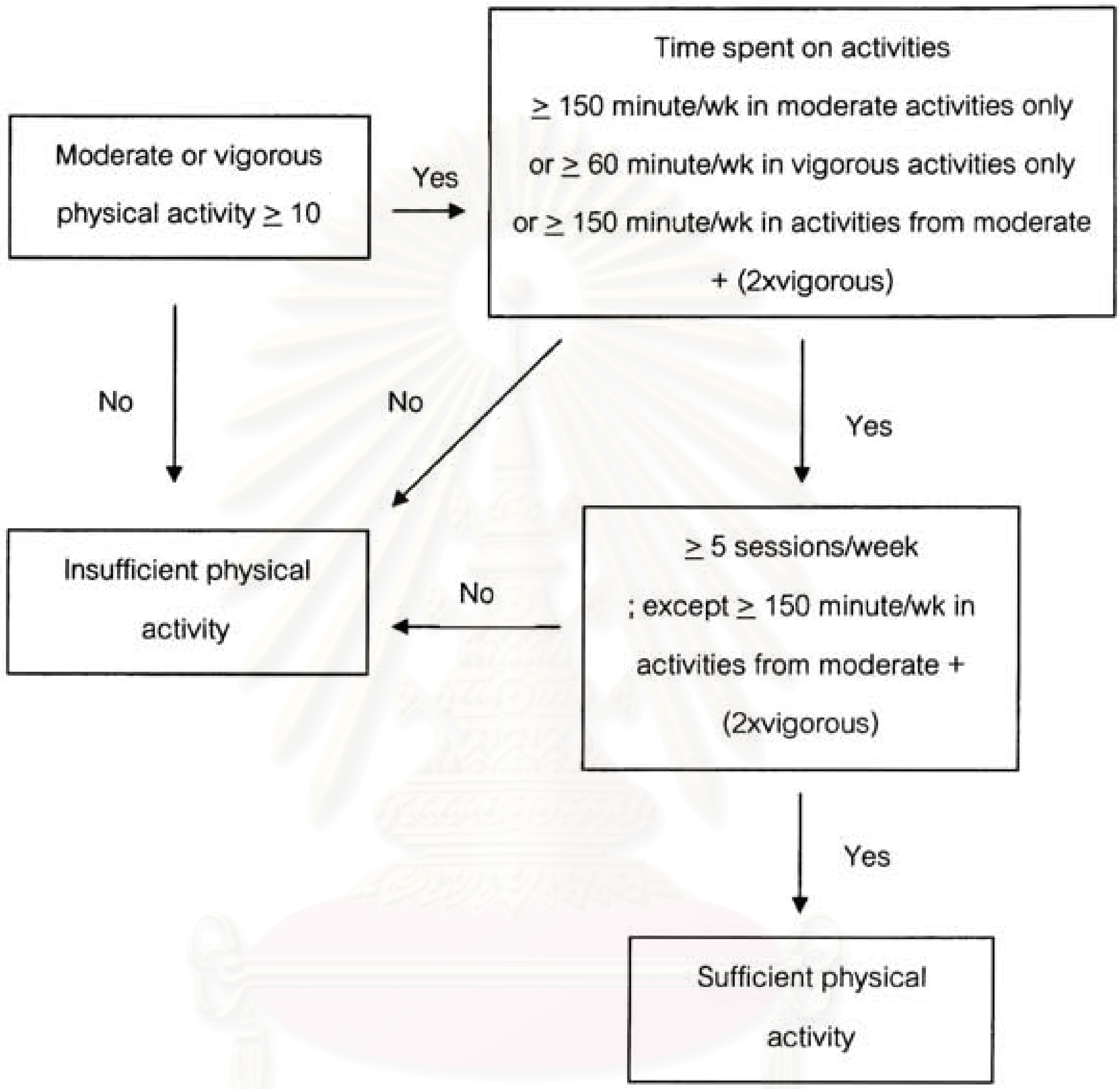
**Energy expenditure from physical activity (kcal/wk)**

| | Energy expenditure per week (kcal/wk) | Note |
|---|---|---|
| Male with sufficiency physical activity | 2612.25±1785.15 | - |
| Male with insufficiency physical activity | 660.98±502.46 | 6 subjects* |
| Female with sufficiency physical activity | 1411.19±620.74 | - |
| Female with insufficiency physical activity | 321.81±313.55 | 10 subjects* |
| All subjects | 1231.29±1279.24 | 16 subjects* |

* : Energy expenditure from physical activity = 0 kcal/wk

# APPENDIX J

**Definition of sufficient physical activity**



## APPENDIX K

### Reference equations for the 6MWT in healthy age 45 – 65 years

Equation derived from healthy age 45 – 65 years (n = 162)

6MWD (m) = 126.76+(3.07x$\textbf{height}_{m}$)+(0.02x**kcal/wk**)+(2.42x%$\textbf{predHRmax}_{bpm}$)
+(53.12x**sex**; [male=1, female=0])-(2.24x$\textbf{weight}_{kg}$)-(1.92x**age**) ($r^2$ = 0.58).

*Suggestion equation for persons age 45 – 65 years*

6MWD (m) = 234.29+(2.33x$\textbf{height}_{cm}$)+(48.28x**sex**; [male=1, female=0]) ($r^2$ = 0.30).

Equation derived from sufficient physical activity group (n = 82)

6MWD (m) = 521.60+(180.21x**normal stride**
$\textbf{length}_{cm}$)+(0.02x**kcal/wk**)+(4.35x%$\textbf{predHRmax}_{bpm}$) +(80.30x**sex**; [male=1, female=0])-
(2.30x$\textbf{weight}_{kg}$)-(5.19x**age**) ($r^2$ = 0.61).

*Suggestion equation for persons with sufficient physical activity*

**6MWD** (m) = 488.10+(3.92x%$\textbf{predHRmax}_{bpm}$)+(93.34x**sex**; [male=1, female=0])-
(3.60x**age**) ($r^2$ = 0.48).

Equation derived from insufficient physical activity group (n = 80)

**6MWD** (m) = 32.23+(2.88x$\textbf{height}_{cm}$)+(1.09x%$\textbf{predHRmax}_{bpm}$)+(45.02x**sex**; [male=1,
female=0]) ($r^2$ = 0.54).

*Suggestion equation for persons with insufficient physical activity*

**6MWD** (m) = 111.12+(2.95x$\textbf{height}_{cm}$)+(43.73x**sex**; [male=1, female=0]) ($r^2$ = 0.50).

## APPENDIX L

**RPE from borg 10 scale between 6MWT and YMCA cycle test**

| | 6MWT | YMCA cycle test | Note |
|---|---|---|---|
| Subjects with sufficient activity (n = 79) | 3.29 $\pm$ 2.02 | 5.03 $\pm$ 2.40 | Missing 3 subjects |
| Subjects with insufficient activity (n = 80) | 4.11 $\pm$ 1.88 | 5.23 $\pm$ 2.40 | |
| All (n = 159) | 3.70 $\pm$ 1.99 | 5.13 $\pm$ 2.47 | Missing 3 subjects |

Values are mean $\pm$ SD

## BIOGRAPHY

| | |
|---|---|
| Name | Mr Sitamanats Suwanachaiy |
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