ORIGINAL ARTICLE

Effects Of 10,000 Steps Walking Program In Cardiorespiratory Endurance Of Obese Adolescent

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ABSTRACT

Background: Sedentary life style lead to obesity which related into deterioration of cardiac function, and deconditioning on musculoskeletal system, particularly on walking function. Walking is an important activity in human life, that automatically repeated in daily activity. Doing exercise by walking activity is a simple and safe exercise. However, in walking exercise prescription, we need to establish what is the objective to achieve. The ten thousand steps of Walking Program (10,000 SWP) is pedometer-based walking program begin in Japan for adult and elderly, thus the effects in obesity adolescent remains unclear. The aimed of this study was to find the effect of 10,000 SWP in Cardiorespiratory Endurance (CE) on obese adolescent.

Methods: This study was pre and post randomly experimental design with control, in 24 high school obese adolescent. Subjects divided into two groups, the intervention group that received 10,000 steps walking program 5 days in a week for 6 weeks, and the control group that number of step walking recorded by a pedometer without daily target. The cardiorespiratory endurance (VO2 max) was evaluated by the six minute walking test (6MWT), that measured before and after intervention.

Results: The Intervention and control groups each contain 12 obese high school students, that equal in age, body mass index, and the mean number of walking steps per day. There was no differences between VO2max 1 (12.45 ml/Kg) and VO2max 2 (12.38 ml/Kg) (p=0.852) in control group, while there was the differences between VO2max 1 (12.44 ml/kg) and VO2max 2 (17.06 ml/kg) (p=0.002) in treatment group.

Conclusion: The 10,000 SWP has proven increasing the Cardiorespiratory Endurance of Obese Adolescent.

Keywords: *10,000 Steps Walking Program, 6 Minute Walking Test, Cardiorespiratory Endurance, Obese Adolescent*

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INTRODUCTION

In 1998, the *World Health Organization* (WHO) stated that obesity is a medical condition in which there is excess body fat to interfere with one's health status. According to the 2007 WHO anthropometric standard for children aged 5-18 years, obesity nutritional status is determined based on the *Z score of* Body Mass Index per Age (IMT / U), children categorized as obese if *Z score* > + 2SD. According to Basic Health Research by Indonesian Health Ministry (Riskesdas) on 2013, the prevalence of obese nutritional status in adolescents aged 16-18 years rose from 1.4 percent (2007) to 7.3 percent (2013).[1,2]

Obesity caused by an energy imbalance between incoming calories and calories out. Two factors related to obesity are genetic and environmental factors. Environmental factors include eating habits with excessive caloric intake, sedentary / less active behavior, hormonal, and socioeconomic. Increased incidence of excess body weight in adolescents in the United States is associated with low physical activity of high school adolescents. Previous research has shown that the strongest factor correlated with higher BMI in adolescents is a decrease in physical activity, that might cause in increasing the risk of chronic diseases, such as diabetes, hypertension, and coronary heart disease. Physically inactive on obese students have proven by a study in New Zealand that found the average number of walking steps per day in a week was 6789 steps.[3-5]

The obesity subjects may have different walking parameters that decreased mechanical effectiveness and increased metabolic requirements compared with normal weight subjects. Several recent studies have shown that overall individuals with obesity experience a decreased on functional capacity and cardiorespiratory endurance in daily activity. Data from *Centers for Disease Control and Prevention* showed that 32.1% of obese adolescents (12-19 years of age) had a decreased cardiorespiratory endurance associated with metabolic abnormalities. Regular physical activity may decrease the risk of chronic diseases and increasing the tendency to be a healthy adult. It is important to encourage the obese adolescents to do measurable variety of physical activity that has correlation with their age, functional capacity, and fun.[1,6,7]

The recommendation from WHO was a moderate intensity exercise of at least 150 minutes per week for obese people. The common kind of exercise is walking or other physical activity with moderate intensity for at least 30 minutes per day for 5 days a week. Walking activity measured by pedometer based on number steps of walking is become popular. In 1960s at Japan has begun suggesting the people to walk 10.000 steps per day in. Nowadays, the pedometer becomes easier to get, cheap and

user friendly. A pedometer is a tool that can help motivate a person to achieve the goal of walking exercise. Studies have shown that walking 10,000 steps per day has beneficial in weight loss, increasing the glucose tolerance, reduce the blood pressure, increasing the physical activity and functional ability. The Guide to Community Preventive Services has recommended to do walking activity as much 10,000 steps per day, counted by a pedometer, as a health promotion program. The 10.000 steps walk exercise is a flexible program can customized individually and has several advantages i.e., cost-efficiency and can be applied by any age/gender/specific population, and has been supported by many studies that have beneficial on health outcomes.[3,8,9,10]

Cardiorespiratory endurance is the ability of the heart to supply blood and oxygen during dynamic physical activity in mild to severe intensity, and as an indicator of the status of individual physiological. One of the simple methods to measure the cardiorespiratory endurance is by 6 Minute Walking Test (6 MWT). The test is reliable and valid for assessing exercise tolerance and cardiac fitness in healthy individuals, and individual who has health problem i.e., heart failure, overweight, and other medical conditions. In addition, the 6 MWT is more secure, and more reflected the activity of daily life than other methods.[11,12,13]

Several previous studies have examined the effects of a 10,000 steps walking program (10.000 SWP) on physical activity, BMI, balance, and cardiac fitness, however the study of Cardiorespiratory endurance in the obesity's adolescent still has limited number of studies, and never been studied in Indonesia.

METHODS

The design was randomized controlled pre and post experimental group. The study has done at two private senior high school in Semarang. Subjects were 24 high school students, divided into two groups. The inclusion criteria were: age 15-17 years, high school students who able to follow the instructions, have maximal (five) lower limb muscle strength by manual muscle testing, lave a sedentary physical activity (> 3999 - <7000 steps per day), and able to walk more than 15 minutes. While the exclusion criteria were subjects have the 6 MWT was less than 3 METs, have history of heart related diseases, have one or more "yes" answer on the PAR-Q questionnaire, have a history of pulmonary diseases such as pneumonia, tuberculosis, or asthma; low peak Flow Meter, hypertension (≥140 / 100 mmHg), smoking, history of lower extremities joint disease, and history of surgery, fracture, and dislocation in lower limbs in less than 6 months.

Subjects have to excluded (dropout) whenever did not do the exercise program for 3 consecutive times (attendance rate was less than 75%), and not completed the examination.

All of the subjects have done the *6* MWT a day before and after the intervention. Both groups performed the *6* MWT by the operational examination.

The Cardiorespiratory endurance reflected in the maximum of oxygen uptake ($V0_2max$) in ml / kg / min unit. The maximum of oxygen uptake obtained from the conversion of 6 MWT by the Nury formula:$V0_2max$ = 0.053 x distance (cm)

+ 0.022 x age (years) + 0.032 x height (cm) - 0.164 x body weight (kg) -2.22 x sex*(male=0, female=1) - 2,287.

The intervention procedure on intervention group was put the digital pedometer in the left hand, that used during daily activities, and released during bathing and sleeping. The pedometer should not be used by other individual. In addition, the participants also received a weekly lifestyle modification by education to be more active in to achieve the target, as well as additional supervised walking exercises on 3000 - 4000 steps to achieve 10,000 steps per day. The intensity of walking was moderate (100 steps/ min), and not running.

The program has done for 5 days, excepted Saturday and Sunday that participants do usual daily normal routine activity. The subjects who were not reached the 10,000 steps required to keep walking to achieved the target. The duration of intervention was 6 weeks (30 days) with the sequence of progression as followed by i.e., target of first was 8000 steps, second week was 9000 step target, then 10.000 steps on third week. Subjects instructed to write down the step number in the *log book* every day. The log book was signed by the subject's parent.

Target of Steps frequency was ≥9,500 steps, and not exceeding 10,500 steps per day, to prevent excessive exercise. Subjects who was not reach the target of 10,000 steps need to write down the reasons in the log book.

The control group received a digital pedometer was using in the left hand, during activity and also removed while bathing and sleeping. Subjects in control group was instructed to write down the number of daily steps in the *log book* and reported it to researchers at night. Subjects in the control group instructed to remained in usual sedentary live.

Statistical Analysis

Data is collected in the data collector sheet and coded, tabulated and entered into the computer. Data analysis includes descriptive analysis and hypothesis test. Differences before and after treatment using paired t-test or Wilcoxon test. The p value is considered significant by less than 0.05 with 95% confidence interval.

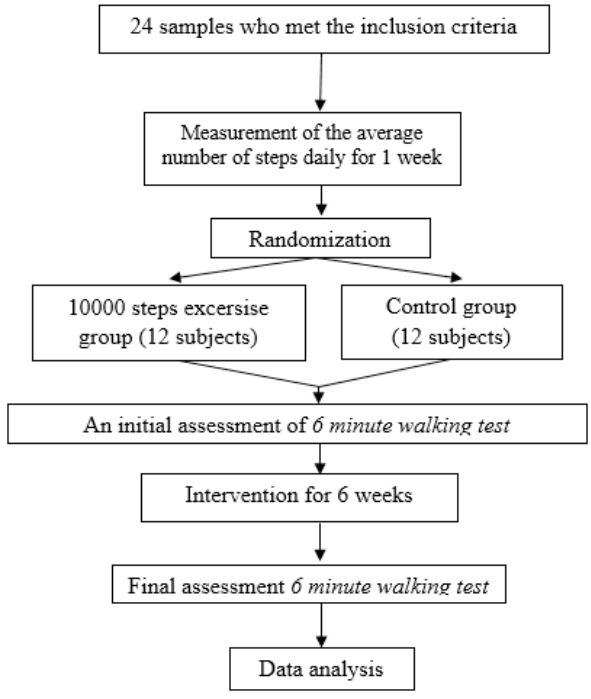

Figure 1. Flow diagram of this study

RESULTS

Each group consisted 12 subjects, and the proportion of sex on both groups were equal. The characteristics of the subjects were similar

between the treatment group and the control group in terms of mean age (p = 0.830), sex (p = 0.276), body weight (p = 0.248), body height (p = 0.726), body mass index (p = 0.073) and the number of steps per day (p = 0.078).

The cardiorespiratory endurance score (VO_2 max) measured by the 6 MWT in both groups. There was no significant difference in mean VO_2 max between control group; 12,45 (11,71-16,92) ml/Kg and treatment group; 12,44 (11,18-17,03) ml/Kg (p = 0.954) on initial study. There was no significant difference between the initial VO_{22} max;12.45 (11.71-16.92) ml/Kg and the final VO_2 max; 12.38 (11.31-17.18) ml/Kg (p = 0.582) in the control group, while there was a significant difference between the initial VO_2 max; 12,44 (11,18-17,03) and the final VO_2 max;17,06 (14, 89-19,78) ml/Kg (p = 0,002). The increasing of final VO_2 max from the initial VO_2 was obtained by calculated the difference value between the initial and final VO_2max.

There was no differences between the initial and final VO_2max on control group (p=0.954), while there was differences between the initial and final VO_2max on treatment group (p<0.001) as seen in Table 1.

Table 1. Comparison of VO_2 Max Mean and Score Change in Treatment and Control Group

VO_2 max	Group		*P*
	Control	Treatment	
	N=12	N=12	
VO_2max 1	12.45 (11.71-16.92)*	12.44 (11.18-17.03)*	0.954[y]
VO_2max 2	12.38 (11.31-17.18)*	17.06 (14.89-19.78)*	0.000[y]
P	0.852[€]	0.002[Δ]	
Δ VO_2 max	(-0,71 - 0,26)*	3,79 (2,54-5,74)*	0,000[y]

* Median (minimum-maximum); [Δ]Paired sample T Test; [€] Wilcoxon Test; [y] Mann-Whitney

DISCUSSION

Characteristics of Research Subjects

The age range of participants in both study groups was between 15-17 years, there was no significant difference between the two study groups (p = 0.830). Data from *Centers for Disease Control and Information* shows that adolescents have a moderate average of moderate physical activity and the lowest daily weight compared to other productive ages. Guo has proven that BMI on the age of 18 years is a very good predictor of BMI in adulthood.[14]

The value of VO_2 max men was higher than women. In adolescents the difference was about

22-24%. In the elderly there was an average difference of 23% and 35% in the sedentary activity group.[1,15] The difference in values in both sexes was due to the difference in stroke volume and maximum cardiac output. This difference was also caused by hormonal differences that cause women to have lower hemoglobin concentrations and greater body fat. In addition women also had less muscle mass than men. However, in this study there was no statistically significant difference between the groups, so the sex did not affect the results of the study.

Changes in Cardiorespiratory Fitness Score (VO_2 max)

Significant differences in VO_2 max occurred because the treatment group received a of 10,000 steps walk program while the control group was not given treatment, where the subject of research still undergo sedentary or less active activity. This suggests that a 10,000 steps walk program per day for 6 weeks can improve cardiorespiratory fitness of obese adolescents.

In the treatment group there was a change of physical activity from less active to moderate. Participants in the treatment group had an average failure to achieve the target of 3.4 times but none met the criteria for drop out research. The main reason for not reaching the target is the weather and there are other activities or interests in the afternoon. The average change in the number of daily steps in accordance with the VO_2 max score change before and after the treatment, this indicates that an increase in the number of daily steps correlates with an increase in cardiorespiratory fitness of obese adolescents.

The study of Zoltan Pataky et al showed that individuals with obesity had worse performance than individuals who had normal weight during a 6-minute walk. It is explained that the decrease is due to increased energy requirements, changes in walking parameters (slower walking speed, shorter steps, and increased step width) and reduced mechanical efficiency. Such mechanical efficiency interruptions include *swings* heavier and reduced stability control so that the current metabolic requirements are higher in obese individuals compared to individuals with normal weight.[1,6]

The 10,000-steps program according to Tudor-Locke et al can increase the physical capacity assessed by the amount of distance traveled during a 6-minute walking test this corresponds to changes in walking parameters where the cadence increases, as well as improved stability control during walking.[16] The results of this study are also in accordance with previous studies conducted by Iwane et al, which gave the 10,000 step walk program in mild hypertensive patients and assessed cardiorespiratory fitness score (VO2 max) where there was a significant increase. Also in accordance with the study by Morgan et al., where the study provided a 10,000 step walk program to individuals aged 59.8 ± 5.78 years and found an increase in distance on a significant 6-minute walking test.[17,18]

The 10,000 steps walk program using a pedometer as a daily achievement guide, where the pedometer according to Sebely Pal et al, will provide a direct visual feedback mechanism through the number of steps indicated by the pedometer. The recommended program for individuals with obesity so far is moderate intensity physical activity for at least 30 minutes per day for 5 days per week, the program provides a less objective target in its implementation. Pedometers provide

more objective targets for the achievement of daily physical activity.[19,20]

The intervention provided for the 10,000-step program is minimal, requires no large and specialized tools, it can be done anywhere and is flexible in accordance with the creativity of the participants of the 10,000 step program, and is relatively safe for all age groups and medical conditions. This is in accordance with the research where all research subjects who follow the program 10,000 steps walk in this study can complete the study in accordance with the procedures and targets provided by the researchers and without found any meaningful side effects of the 10,000 steps walking program.

Catrine Tudor-Locke et al also supports this study result, which states that obese teens need to walk 10,000-11700 steps per day to improve anthropometric values and functional abilities.[21] Moderate activity programs for 30 minutes per day only resulted in the addition of about 3,000 steps per day, when compared to the 10,000 step program, the increased activity was not enough for adolescents with obesity. The 10,000 step program also changes the "weekend effect" that sports are usually performed only at the end of the week. A daily 10,000-step program can affect the adaptation of mechanisms lactic acid buffering that may affect exercise tolerance when compared to exercises not performed sustainable.[21,22]

A slightly different result was show in a study by Iwane et al. In the study, mild hypertensive patients were given a 10,000-steps program for 12 weeks and assessed their cardiorespiratory fitness score (VO_2 max), suggesting a significant increase in cardiorespiratory fitness score increase (VO_2 max). The increase was 26.1 ± 2.4 to 29.5 ± 2.5 ml / kg / min.[23] While in this study obtained an increase from 12.44 (11.18-17.03) to 17.06 (14.89-19.78) ml / kg / min. The increase in this study was found to be greater than that of Iwane et al., Probably due to lower initial cardiorespiratory fitness scores. This is in line with statements by Manson et al., Where in the effect of aerobic exercise on cardiorespiratory fitness will be felt greater especially in individuals who have lower cardiorespiratory fitness scores than individuals with higher cardiorespiratory fitness scores.[24]

The mechanism of significant improvement in cardiorespiratory fitness score at the end of the study by Iwane that explained through various mechanisms. Walking is an aerobic exercise that also trains muscles especially the lower limb muscles in a comprehensive way (flexibility, endurance, motion coordination, and balance). Increased endurance of lower limb muscles which is a muscle with a large volume can improve the function of the striated muscle returning pump, thereby increasing *cardiac output* which will increase aerobic metabolism and exercise capacity.[17,25]

The results of this study indicate that a 10,000 step walk program can be an alternative exercise that is safe and can be given to improve cardiorespiratory fitness of obese teenagers. Further research needed to assess the long-term effects of 10,000 SWP on BMI and health status, and the changing lifestyle, that can prevent the progression of cardiovascular disease in adulthood.

CONCLUSION

The cardiorespiratory endurance was increasing after 6 weeks of a 10,000-SWP. To prevent the

incidence of cardiovascular disease need to consider about intervention of 10.000 SWP.

REFERENCES

1. Pataky Z, Armand S, Muller-Pinget S, Golay A and Allet L. Effects of Obesity on Functional Capacity. Obesity Journal 22, 56–62. DOI:10.1002 /oby.20514. 2014. Available at: www.obesityjournal.org.
2. Depkes RI. Hasil Riset Kesehatan Dasar (Riskesdas). Jakarta: Depkes RI. 2013.
3. American Academy of Pediatrics. Active Healthy Living: Prevention of Childhood Obesity Through Increased Physical Activity. Pediatrics. 2006:117; p. 1834-42.
4. Alton I. Chapter 7: The Overweight Adolescent. In: Stang J, Story M (eds) *Guidelines for Adolescent Nutrition Services. New York:* American Obesity Association. 2005; p. 77-91.
5. Anderson et al. Physical activity is low in obese New Zealand children and adolescents. Scientific Reports 7:41822. DOI: 10.1038/ srep41822. 2017. Available at: www.nature.com/scientificreports/.
6. Rowland TW. Effect of Obesity on Cardiac Function in Children and Adolescents: A review. Journal of Sports Science and Medicine. 2007; p. 319-326. Available at: http://www.jssm.org.
7. U.S. Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. ODPHP Publication. 2008. Available at: www.health.gov/paguidelines.
8. Pillay et al. The Association between Daily Steps and Health, and the Mediating Role of Body Composition: A Pedometer-Based, Cross-Sectional Study in an Employed South African Population. BMC Public Health: 2015; p. 15:174.
9. Rosenkranz RR. Validity of the Stages of Change in Steps instrument (SoC-Step) for achieving the physical activity goal of 10,000 steps per day. BMC Public Health. 2015; p. 15:1197.
10. Richardson CR, Newton TL, Abraham JJ, Sen A, Jimbo M, Swartz AM. A Meta-Analysis of Pedometer-Based Walking Interventions and Weight Loss. Annals of Family Medicine. 2008; p. 6:69-77.
11. Piniero JC, Ortega F, Keating X, Montesinos JG, Sjontorm M, Ruiz J. Precentile Values for Aerobic Performance Running / Walking Field Test in Children Aged 6 to 17 years; influenced of Weight Status. Nutr Hosp. 2011;26(3):572-8.
12. Thompson WR, Gordon NF, Pescatello. ACSM's Guidelines for Exercise Testing and Prescription. 8th ed. Philladelphia: Lippincot Williams & Wilkins; 2009. P. 1-11, 73,88,153-5, 188,253-8.
13. Li AM, Yin J, Au J, So H, Tsang T, Wong E. Standard Reference for the Six Minute Walking Test in Healthy Children Aged 7 to 16 Years. Am J Respir Crit Care Med. 2007; 176;174-80.
14. Mathew B et al. Clinical Review: Obesity: Effects on Cardiovascular Disease and its Diagnosis. J Am Board Fam Med. 2008;21:562– 8. Available at: http://www.jabfm.org.
15. Velde SJ et al. Paterns in Sedentary and Exercise Behaviours and Associations with Overweight in 9-14 Year Old Boys and Girls – a Cross-sectional Study. BMC Public Health Vol: 7. 2007.
16. Guo SS, Wu W, and Chumlea WC. Predicting

overweight and obesity in adulthood from body mass index values in childhood and adolescence. *American Journal of Clinical Nutrition* 288. 2002; p. 1728-1732.

17. Bridgey T, Childhood Obesity and Cardiovascular Disease. Paediatr Child Health;14(3). 2009; p. 177-182.
18. American College of Sports Medicine. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in overweight and obesity individuals: guidance for prescribing exercise. *Med Sci Sports Exerc*. 2011 Jul; 43(7): 1334-59.
19. Manson JE, Greenland P, LaCroix AZ, et al. Walking compared with vigorous exercise for the prevention of cardiovascular events in women. N Engl J Med. 2002;347:716–25.
20. Golbidi S, Laher I. *Review Article:* Exercise and the Cardiovascular System. Cardiology Research and Practice Article ID 210852 doi:10.1155/2012/210852. 2012
21. Morgan AL, Tobar DA, Snyder L. The Impact of Prescribed Walking 10,000 Steps/Day on Physical and Psychological Well-Being. Journal of Physical Activity and Health. 2010: 7, 299-307.
22. Bravata DM et al. A Systematic Review: Using Pedometers to Increase Physical Activity and Improve Health. JAMA, Vol 298, No. 19. 2007.
23. Iwane M et al. Walking 10,000 Steps/ Day or More Reduces Blood Pressures and Sympathetic Nerve Activity in Mild Essential Hypertension. Hypertens Res Vol. 23, No. 6. 2000; p. 573-580.
24. Shultz SP, Browning RC, Schutz Y, Maffeis C, Hills AP. Childhood Obesity and Walking: Guidelines and Challenges. International Journal of Pediatric Obesity. 2011; p. 332-341.
25. Tudor-Locke et al. WalkMore: a Randomized Controlled Trial of Pedometer-Based Interventions Differing on Intensity Messages. BMC Public Health 14:168. 2014. Available at http://www.biomedcentral.com/1471-2458/14/168.