ISSN: 2586-7342 © 2020 KODISA & KJFHC
KJFHC website: http://www.kjfhc.or.kr
doi: http://dx.doi.org/10.13106/kjfhc.2021.vol7.no6.17.

Energy Consumption and Exercise Effect of University Students During Automatic Stepper Exercise*

Hwang-woon MOON[1], Youn-Jin CHOI[2]

[1.First Author] Professor, Department of Sports & Outdoor, Eulji University, Seong Nam, Korea, E-mail: mhwgo21@eulji.ac.kr
[2.Corresponding Author] Professor, College of Art & Physical Education, Sangji University, Won Ju, Korea, E-mail: highjin99@naver.com

Received: Decmber 10, 2021. Revised: Decmber 10, 2021. Accepted: Decmber 31, 2021.

Abstract

This study investigates the exercise-physiological changes in stages through the movement of the automatic stepper and to analyze the usefulness of the automatic stepper. For 18 male university students, out of 10 levels, 5 level and 10 level of automatic stepper exercise were performed. At each 10, 20, 30 minutes during exercise, 5 and 10 minutes after exercise stop the subjects were examined to analyze the changes in energy consumption after minutes, respiratory exchange rate, heart rate, oxygen consumption per body weight, METs, cumulative energy consumption, and lactic acid to verify the usefulness of the automatic stepper. The mean and standard deviation were calculated using the SPSS, and one-way ANOVA with repeated measure was performed to verify the difference in the mean between time periods. The LSD method was used for the post-hoc test, and the significance level was set to $\alpha = .05$. There were no significant changes in both 5 and 10 level, but the cumulative energy consumption over time increased significantly. In addition, as a low-intensity exercise intensity is shown, a low increase in lactic acid indicated a safe exercise level. In future studies, in-depth studies of various variables through regular exercise programs are needed for those who need safe exercise.

Keywords: Automatic stepper, Energy Expenditure Metabolic, Volume of oxygen consumption, lactic

Major classifications: Exercise Physiology

1. Introduction

Currently, the number of confirmed cases of COVID-19 in Korea is 348,969, and 2,725 of them are dying (Korea Centers for Disease Control and Prevention, 2021). In the future, it will gradually decrease due to vaccination and the supply of

* This study was supported by the MEDINESS Corp. in 2021(2021-027).

therapeutic agents, but serious problems continue to arise. People's sports activities were stopped due to the suspension of the National Fitness 100 project (Kim, 2021). Physical activity in leisure time has a positive effect on individuals' subjective health status and healthy quality of life, rather than physical activity performed during working time and traveling time and serious mental health problems. Reduced outdoor physical activity, increased sedentary lifestyle, and social distancing cause chronic disease and regression of physical function, requiring physical activity.

Various methods have been recently proposed to relieve the decreased physical activity or amount of exercise, and exercise programs such as home training, mountain climbing, and walking are increasing. Walking is known to be a safe and highly efficient exercise for both men and women of all ages (Jang. et al., 2013), and has effects such as increase in energy consumption and fat oxidation rate, alleviation of stress, enhancement of immune function, promotion of blood circulation and prevention of cardiovascular disease (Qiu et al., 2014). In addition to these walking activities, stair walking requires external force of vertical movement of body weight, and there is a difference in body control to prevent falls when going down appears (Roy, 2001). Stair walking moves the body up and down through significant muscle activity. At this time, although there may be differences depending on the walking speed, it requires 10 to 15 times more energy consumption than for flat walking (Paffenbarger. et al., 1993). When climbing stairs, muscle activity of the tibialis anterior and medial gastrocnemius increases, requiring more force than walking on flat ground (Han, Park & Lee, 2009). knee joint, and ankle joint extension raises the body and raises the posterior lower extremity forward for the next step, resulting in the highest muscle activity of the tibialis anterior (Kim, Kim & Kwon, 2007).

The stepper, an exercise device that can achieve the stair climbing effect, can achieve the same effect as the treadmill exercise (Zeni et al., 1996), and the stair climbing ability is also improved (Teixeira-Salmela et al., 1999). In addition, aerobic exercise can lead to improvements in body composition, physical strength, and cardiovascular response (Kang, 2018). It increases the flexibility of the ankle, knee, and femoral joints along with the elasticity of the muscles, and has the advantage of maximizing the effect of training as it can adjust the amount and intensity of exercise according to the individual's physical condition (Chae, 2005).

However, if a patient with abnormalities in the knee joint or for the purpose of therapeutic rehabilitation after surgery performs high-intensity exercise within the normal joint range of motion, an unbearable excessive load is generated on the joint, which may aggravate the injury. Therefore, it should be done with caution (Chae, 2005). In the case of the elderly, musculoskeletal disorders, and the disabled, it is necessary to pay attention to stair movement or steppers. In the case of the elderly, tripping or slipping falls easily occur due to a decrease in balance due to the aging process, deterioration of the nervous system function, a decrease in walking ability, and muscle weakness, etc. In the case of stairs or steppers, as the compressive force generated in the joint increases, the compressive force changes according to the flexion and extension of the knee joint. As the contact area of the body decreases, the compressive force is distributed over the narrowed area, increasing the risk of injury (Chae, 2005). As a result, the stairs themselves appear as an obstacle due to increased instability of the knee joint and decreased muscle strength in the stair descending motion, leading to avoidance of descending activities (Moon, & Choi, 2014).

Therefore, safe and effective exercise programs such as stair exercise or stepper exercise will be required for the elderly, musculoskeletal disorders that require rehabilitation, and the disabled. For these subjects, the automatic stepper has the advantage of being able to easily perform stepper exercise for the elderly or people with musculoskeletal disorders who cannot keep pace with themselves or have difficulty rotating through repeated rotation and various loads and direction changes. However, studies on specific energy consumption and exercise physiological changes according to the exercise time of these automatic steppers are very insufficient. Therefore, in this study, for the purpose of reviewing the kinematics of the newly developed automatic stepper exercise device, the exercise load test was first conducted on college students through the exercise load test, and then, a portable wireless respiratory gas analyzer (COSMED K5b2, Rome, Italy) was used to conduct the exercise load test step by step. The purpose of this study is to measure exercise physiological changes over time during automatic stepper exercise, and to compare and analyze the intensity.

2. Method

2.1. Subjects

In this study, a total of 18 university students located in S-city, Gyeonggi-do, who had no musculoskeletal disorders in the past 6 months, gave a sufficient explanation of the experimental process and obtained informed consent to express their intention to participate voluntarily before the experiment. All subjects were instructed to refrain from alcohol intake, excessive exercise, and physical activity 24 hours before the start of the experiment, and to get a good night's sleep. The physical characteristics of the study subjects are shown in <Table 1>.

Table 1: physical characteristics of subjects

Variable	5 stage (n=9)	10 stage (n=9)
Age(yrs)	19.67±4.18	20.78±1.20
Height(cm)	174.56±5.94	175.89±5.0
Weight(kg)	74.01±11.07	73.98±9.67
% body fat(%)	19.52±7.07	19.08±4.82
Fat Free Mass(kg)	33.50±3.42	33.82±3.51
Vo2max(㎖/kg/min)	52.93±3.97	52.40±4.85

Values are expressed as Mean±SD.

2.2. Research procedures

In this study, in order to investigate the physiological changes that occur during automatic stepper exercise, first, the maximum exercise load test of the study subjects was conducted. Then, 9 subjects were divided into two groups of steps 5 and 10 among steps 1 to 10 of the automatic stepper and measured. At this time, exercise physiological variables were measured 6 times at rest, 10 minutes after exercise, 20 minutes after exercise, 30 minutes after exercise, 5 minutes after exercise cessation, and 10 minutes after exercise cessation.

2.3. Metrics and Methods

2.3.1. Body Composition Variable

While participating in the study, the subjects were asked to wear comfortable clothes and to limit their intake of caffeinated beverages and to refrain from heavy exercise 4 hours before the start of the measurement for accurate body measurements. In order to reduce errors in body measurements, the same researcher continuously measured the measurements in the same way. The height was measured using an automatic height meter (BSM 330, Biospace, Korea) in light clothing and in an upright position. Bioelectrical impedance analysis).

2.3.2. Energy Consumption

(1) Exercise load test

The submaximal exercise load test was performed by applying the Modified Astrand protocol (Benjaminse, A et al., 2008). The warm-up exercise was conducted for 5 minutes, and the starting exercise load was started at a speed of 6-8 mph for 3 minutes and the slope was 0%, and the speed was constant every 2 minutes, and the exercise load was increased by 2 ½% of the slope to the maximum until the subject reached exhaustion. of the aerobic exercise capacity was evaluated. At this time, an expert with a lot of experience in treadmill operation asked the subjects to take stability in advance, and only those who were prepared could climb on the treadmill and Borg (1982)'s method of judging the rating of perceived exertion [RPE], instructions to stop in case of exhaustion, etc. were explained.

Using a portable wireless breathing gas analyzer (Cosmed K5b2, COSMEDs.rl, Rome, Italy), the amount of oxygen intake (VO2) and carbon dioxide emission (VCO2) measured in seconds for every breath is monitored in real time to obtain energy expenditure (Energy Expenditure) and METs were calculated, and the measurement variables were analyzed by the breath-by-breath method. At this time, the maximum heart rate (HRpeak), oxygen intake per body weight (O2 peak ml/kg/min), and respiratory exchange rate (RQ) were measured for all subjects.

(2) Measurement of energy consumption during automatic stepper movement

Maximum heart rate (HRpeak), oxygen intake per body weight (O2 peakml/kg/min), oxygen intake 6 times before exercise, after 10 minutes, after 20 minutes, after 30 minutes, after 5 minutes and 10 minutes after stopping exercise (VO2) and carbon dioxide emissions (VCO2) were monitored in real time to measure Energy Expenditure and METs calculated values.

In the case of an automatic stepper (MD-998, Mediness, Korea), the number of steps and distance are shown in steps 5 and 10 as shown in <Table 2> and <Figure 1>.

Table 2: Automatic Stepper Specification

	Stage	Exercise 10min	Exercise 20min	Exercise 30min
RPM(rep/min)	5	739	1474	2215
	10	1100	2212	3312
Distance(m)	5	665	1326	1993
	10	990	1990	2980

Figure 1: Automatic stepper

2.3.3. Lactic Analysis

Lactate was measured to examine changes in energy metabolism activity and fatigue state during exercise. For lactic acid, 20 μl capillary blood was collected by the finger-tip method, and the collected whole blood was put in a hemolyzing solution solution and mixed 5 to 10 times, and then the blood was analyzed using a lactate meter (BIOSEN C-Line).

2.3.4. Data analysis method

For all data, the mean and standard deviation were calculated using the SPSS 24.0 statistical program. One-way ANOVA with repeated measure was performed to verify the difference in the mean between periods for measurement variables, and the LSD method was performed for the post hoc test if there was significance between periods. At this time, the statistical significance level was set as α = .05.

3. Results

3.1. Changes of body composition during 5 level exercise

In order to investigate the change in energy consumption during the 5th stage of automatic step exercise from 1 to 10, the physiological changes using respiratory exchange rate, heart rate, oxygen consumption per body weight, METs, and accumulated energy consumption over time were analyzed.

As a result, the accumulated energy consumption showed statistically significant changes after 10 minutes of exercise, 20 minutes after exercise, 30 minutes after exercise, 5 minutes after exercise cessation, and 10 minutes after exercise cessation in <Table 3> (p<.001).

Table 3: Level 5 of response of RQ, HR, VO2, METs

Variable	BE	E10	E20	E30	R5	R10	F	P
RQ	.74±.10	.83±.06	.80±.06	.80±.08	.82±.07	.81±.09	2.412	.053
HR	73.33±2.40	72.22±9.21	70.44±7.93	70.44±11.41	72.89±8.38	73.11±8.63	.489	.782
O_2 (㎖/㎏/min)	4.45±1.97	5.28±2.57	4.91±2.22	4.19±1.70	4.18±2.44	4.82±2.54	.650	.663
METs	1.40±.52	1.52±.74	1.4±.62	1.38±.49	1.26±.61	1.34±.68	.367	.868
AEE (kacl/min)	0	19.05±7.53a	36.93±14.17b	53.73±21.37c	61.36±24.45d	69.60±27.16e	55.186	.000***

M±SD, *** : p<.001
RQ : Respiratory Quotient, HR: Heart Rate, O2 : Volume of oxygen consumption, METs : Metabolic equivalents
AEE : Accumulated Energy Expenditure Metabolic
BD : Before Exercise. E10 : After 10 minutes of exercise.
E20 : After 20 minutes of exercise. E30 : After 30 minutes of exercise.
R5 : After 5 minutes of Recovery
R10 : After 10 minutes of Recovery
a, b, c, d, e : significant difference among the measuring times within time

Table 4: Level 10 of response of RQ, HR, VO2, METs

Variable	BE	E10	E20	E30	R5	R10	F	P
RQ	.76±.05	.79±.09	.80±.07	.81±.08	.78±.06	.80±.05	1.525	.203
HR	69.33±10.32	70.78±6.70	71.89±6.71	72.78±8.88	67.44±7.93	72.67±9.61	1.269	.296
O_2 (㎖/㎏/min)	4.47±1.86	4.91±2.37	5.42±2.24	5.68±2.81	4.61±1.24	4.95±1.84	.742	.597
METs	1.28±.52	1.41±.66	1.55±.63	1.62±.79	1.55±.62	1.42±.52	.528	.754
AEE (kacl/min)	0	21.07±7.21a	41.19±16.14b	62.10±26.52c	70.74±27.41d	79.86±26.49e	63.349	.000***

M±SD, *** : p<.001
RQ : Respiratory Quotient, HR: Heart Rate, O2 : Volume of oxygen consumption, METs : Metabolic equivalents
AEE : Accumulated Energy Expenditure Metabolic
BD : Before Exercise. E10 : After 10 minutes of exercise.
E20 : After 20 minutes of exercise. E30 : After 30 minutes of exercise.
R5 : After 5 minutes of Recovery
R10 : After 10 minutes of Recovery
a, b, c, d, e : significant difference among the measuring times within time

3.2. Changes of body composition during 10 level exercise

To investigate the change in energy consumption during 10 steps of automatic step exercise from 1 to 10, physiological changes using respiratory exchange rate, heart rate, oxygen consumption per body weight, METs, and cumulative energy consumption over time were analyzed.

As a result, the accumulated energy consumption showed statistically significant changes after 10 minutes of exercise, 20 minutes after exercise, 30 minutes after exercise, 5 minutes after stopping exercise, and 10 minutes after stopping exercise in <Table 4> ($p<.001$).

3.3. Changes of lactic acid during each level exercise

In order to examine the change in lactic acid according to time during the 5th and 10th steps of the automatic step exercise, 10 minutes after exercise, 20 minutes after exercise, 30 minutes after exercise, 5 minutes after stopping exercise, and 10 minutes after stopping exercise analyzed.

As a result, there was no statistically significant change during the 5th step exercise, and a statistically significant difference was found between 20 minutes after exercise and 5 minutes after stopping the exercise among 10 steps in <Table 5>($p<.05$).

Table 5: Responses of lactic

Variable	Stage	BE	E10	E20	E30	R5	R10	F	P
Lactic (mmol/L)	5	1.99±.68	2.29±1.29	1.61±.89	2.20±1.40	2.15±.96	1.41±.67	1.487	.216
	10	1.60±.51	1.93±.56	1.78±1.06a	1.88±.855	1.32±.93b*	1.41±.52	1.239	.309

4. Discussion

For this study, 18 male college students performed steps 5 and 10 of the automatic stepper exercise from step 1 to 10, 9 each. At this time, in order to find out the change in energy consumption for 10, 20, and 30 minutes after exercise, the results of analysis of respiratory exchange rate, heart rate, oxygen consumption per body weight, METs, accumulated energy consumption, and lactic acid should be considered. The main reason that stair walking is differentiated from general horizontal walking is that the body is lifted along with horizontal movement as the gait progresses. At this time, joint flexion and extension occur, and energy consumption occurs significantly (Paffenbarger-Jr et al., 1993). In this study, in step 5 of automatic stepper exercise, METs were 1.52±.74 and heart rate per minute corresponded to about 73 beats/minute 10 minutes after the start of the exercise, which was similar to the exercise effect of walking at a speed of about 1 km/h. This could suggest the usefulness of physical activity as the accumulated energy consumption after 10 minutes, 20 minutes, 30 minutes, and after exercise stop was statistically significantly increased after automatic stepper exercise. In the study of Lee (2008), various walking activities were performed on a treadmill for 7 male college students. In 15-minute slow walking, normal walking was 70.4 kcal/h, and power walking was 68 kcal/h. In this study, energy consumption was found to be 36.93±14.17kcal/min in 5th step and 41.19±16.14kcal/min in 10th step during 20-minute automatic stepper exercise. In addition, in the study of Kim, Wang and Kim (2016) for measuring energy consumption through treadmill walking exercise in college students, when walking at a low intensity of 2.4 speed, it was 2.88 METs and 3.65±0.84 kcal/min. Step exercise appeared as a form of low-intensity exercise (Ainsworth et al., 2000).

In the study of Ainsworth et al. (2000), the criteria for METs according to the intensity of physical activity in adults were 3 METs or less for low intensity, 3 to 6 METs for medium intensity, and 6 METs or more for high intensity. In this study, both levels 5 and 10 showed low-intensity physical activity. The reason for the low energy consumption in this study is that stationary bicycle exercise lasts for a long time in a sitting position, reducing the need for postural control, and limiting it to local exercise, resulting in less energy consumption during exercise (Zeni et al., 1996). In this study, it is thought that energy consumption was reduced by maintaining the same posture without showing movement of the upper extremities during exercise with the sitting automatic stepper. The exercise of the treadmill can be performed at the same speed so that oxygen intake and energy consumption can be compared at a standardized rate, but it requires a well-equipped laboratory environment and is difficult to implement in a large group. In addition, one's own stride length and frequency must be adjusted at a constant speed, so oxygen intake can be intentionally increased or decreased (Kim, Wang, & Kim, 2016).

On the other hand, the stepper can be used easily and conveniently at home, can be loaded in all directions, and can affect the development of basic functional movements, making it easy for patients (Cho et al., 2010). However, in this study, male college students with VO2peak of 50ml/kg/min or higher and excellent cardiorespiratory endurance were considered to have low relative exercise intensity.

In the case of the original stepper, the level of exercise is relatively lower than that of the original exercise, but it can be said that it is an effective exercise that can be obtained without much effort. It consumes twice as many calories (Chae, 2005). However, in a study by Kim et al. (2014), stair walking and stepper training were conducted on 23 college students in their 20s. As a result, stair walking showed higher muscle activity than stepper exercise for the rectus femoris, fascia latissimus, and trapezius muscles. appeared high. In addition, in the study of Kang (2018), as a result of performing stepper exercise on 19 middle-aged women, Vo2max showed a significant increase with time from 27.15±3.25ml/kg/min before exercise to 30.68±5.42ml/kg/min before exercise. As such, during stepper exercise, blood lactate is a representative physiological indicator that can be evaluated as a fatigue aid that buffers hydrogen ions in the exercise cells (Sung, Heo, & Lee, 2020). When performing low-intensity exercise, lactic acid accumulation does not occur much. During high-intensity exercise, a large amount of lactic acid is accumulated in the muscles and has been suggested as an indicator of anaerobic capacity (Song, et al., 2017). In this study, the level of lactate increased from 1.99±.68 mmol/L at rest in stage 5 to 2.29± 1.29 mmol/L after 10 minutes of exercise, and in stage 10, exercise stopped at 1.93±.56 mmol/L after 20 minutes of exercise After minutes, it decreased significantly to 1.32±.93 mmol/L. However, all lactic acid levels were not high, indicating that the fatigue caused by exercise was low. In particular, it appears to be more sensitive to the metabolic rate of the muscle per unit area than to the overall body metabolism and reflects muscle fatigue and exercise intensity (Cairns, 2006). Low intensity of exercise does not affect lactic acid production, which is an intensity that can be exercised safely in the vulnerable group.

5. Conclusion

For this study, 18 male college students performed steps 5 and 10 of the automatic stepper exercise from steps 1 to 10, 9 each. At this time, the usefulness of the automatic stepper was evaluated by analyzing respiratory exchange rate, heart rate, oxygen consumption per body weight, METs, accumulated energy consumption, and lactic acid to determine the change in energy consumption for 10, 20, and 30 minutes after exercise. wanted to verify. The cumulative energy consumption over time increased statistically significantly. In future research, an in-depth study of various variables through a regular exercise program for the elderly, disabled, and patients who need to exercise safely will be required.

References

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Srath, S. J. (2000). Compendium of physical activities: au update of activity codes and MET intensities. *Med Sci Sport Exerc*, *32(9),* 498-504.

Benjaminse, A., Habu, A., Sell, T. C., Abt, J. P., Fu, F. H., Myers, J. B., & Lephart, S. M. (2008). Fatigue alters lower extremity kinematics during a single-leg stop-jump task. *Knee Surgery, Sports Traumatology, Arthroscopy, 16(4)*, 400-407.

Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise, 14(5)*, 377-381.

Cairns, S. P. (2006). Lactic acid and exercise performance: culprit or friend? *Sports Medicine*. *36(4),* 279-291.

Chae, W. S. (2005). Electromyographic Analyses of the effects of different foot positions during exercise on a stair-climbing machine. *Korean Society of Sport Biomechanics*, *15(1)*, 2007-219.

Cho, N. J., Kim, K. H., Choi, M. S., Choi, D. Y., Kwon, J. B., Hyun, J. H., & Son, K. H. (2010). The effects of the stepper exercise using lower extremity patterns of pnf on ankle muscle strength and balance ability of females in their twenties. *PNF and Movement*, *8(3)*, 27-37.

Han, J. T., Kong, W. T., & Lee, Y. S. (2009). Comparison of Muscle Activity with Lower Extremity during Stairs and Ramp Climbing of Old Adults by EMG. *The Journal of Korean Physical Therapy, 21(1)*, 35-40.

Jang, Y. H., Kim, S. H., Kim, Y. S., Jung, S. H., & Park, J. (2013). The relationship between walking exercise and quality of life for Korean adults. *J Digit Policy Manag*, *11(5)*, 325-334.

Jeffriess M. D, Schultz A. B, McGann T. S, Callaghan S. J, & Lockie R. G. (2015). Effects of Preventative Ankle Taping on Planned Change-of-Direction and Reactive Agility Performance and Ankle Muscle Activity in Basketballers. *J Sports Sci Med*, *14(4),* 864-876.

Kang, W. K. (2018). Effects of Stepper Exercise on Physical Fitness and Blood Lipids in Pre-and Post-Menopausal Obese Women. *Korean Alliance for Health, Physical Education, Recreation, And Dance, 57(6),* 273-283.

Kim, C. S. (2021). Exercise Science and COVID-19. *Korean Society of Exercise Physiology*, *30(1),* 1-2.

Kim, K. M., Shin, J. J., Park, H. M. & Lee, D. Y. (2014). The effect of thigh muscle activity for stair walking and stepper strengthening exercise in university students. *Korea Academia-Industrial cooperation Society Journal 40(2),* 936-939.

Kim, T. W., Kim, E. H., Kwon, M. S. (2007). The Effect of Walking Speed on Joints of Lower Extremity in Obese Adult. *Korean Journal of Sport Science, 18(3),* 18-26.

Kim, Y. J., Wang, C. S. & Kim, E. K. (2016). Measurement of Energy Expenditure Through Treadmill-based Walking and Self-selected Hallway Walking of College Students: Using Indirect Calorimeter and Accelerometer. *Journal of community nutrition, 21(6),* 520-532.

Kim, Y. P. (2021). Untact and Exercise Science Accelerated by Coronavirus Infection-19 (COVID-19). *Korean Society of Exercise Physiology, 30(2),* 129-130.

Korea Centers for Disease Control and Prevention. (2021). Coronavirus Infection-19(COVID-19) in October. Retrieved November 11, 2021, from http://mohw.go.kr

Lee, H. K. (2009). Physiological Responses according to Walking with Nordic Poles or Hand Weights on Treadmill. *Korean Association of Certified Exercise Professionals*, *11(2)* 9-17.

Lee, J. H., Lee, S. W., & Yoon, Y. J. (2021). The Relationship between South Korean Baby Boomer's Physical Activity, Sedentary time, and Subjective Health Level in COVID-19 Pandemic. *The Korean Journal of Physical Education, 60(3)* 89-102.

Moon, G. S., & Choi, J. Y. (2014). The Study of Effect on the Functional Insole during stair descent for Elderly women. *The Korean Society of Sports Science, 23(2),* 1507-1516.

Paffenbarger-Jr, R. S., Blair, S. N., Lee, I. M., & Hyde, R. T. (1993). Measurement of physical activity to assess health effects in free-living populations. *Med Sci Sports Exerc, 25(1)*, 60-70.

Qiu, S., Cai, X., Schumann, U., Velders, M., Sun, Z., & Steinacker, J. M. (2014). Impact of Walking on Glycemic Control and Other Cardiovascular Risk Factors in Type 2 Diabetes*: A Meta-analysis*. *PloS One*, *9(10),* 109767.

Roy, M. S. (2001). Serious stair injuries can be prevented by improved stair design. *Applied Ergonomics*. *32(2),* 135-139.

Slater L. V & Hart J. M. (2017). Muscle Activation Patterns During Different Squat Techniques. *J Strength Cond Res, 31(3),* 667-676

Song, Y. K., Jeon, Y. K. & Seo, S. H. (2017). Understanding of Lactate. *Korea Institute of Sport Science*, *28(1),* 1-10.

Sung, B. J., Heo, M. H. & Lee, J. B. (2020). Analysis of the Energy Consumption and Exercise Effect of Middle-aged Men and Women in Horseback Riding Simulator. *Korean Society for Wellness*, *15(46),* 419-430.

Teixeira-Salmela, L. F., Olney, S. J., Nadeau, S., & Brouwer, B. (1999). Muscle strengthening and physical conditioning to reduce impairment and disability in chronic stroke survivors. *Arch Phys Med Rehabil*. *80(10)*, 1211-1218.

Zeni, A. I., Hoffman, M. D., & Clifford, P. S. (1996). Energy expenditure with indoor exercise machines. *Journal of the American Medical Association*, *275(18),* 1424-1427.