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Effect of Forest Road Types on Salivary Cortisol, Blood Lactate and Heart Rate during Walking Exercise

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Abstract

This study investigated changes in salivary cortisol, lactic acid, and heart rate along the route during walking exercise in a forest environment for the purpose of reducing stress. Walking exercise in a forest environment was conducted on a Hill Type (Distance: 800m, Average slope 25°, Altitude 112m) and Step Type (Distance: 800m, Average slope 25°, Altitude 114m) routes for 10 female college students in their 20s. The subjects were asked to walk at a speed of 60 bpm. The resulting changes in salivary cortisol, lactate, and average heart rate during exercise were compared and analyzed using Repeated Measurement two-way ANOVA, and the maximum heart rate during exercise and average heart rate at rest were compared and analyzed using paired t-test, and the following results were obtained. First, there was no significant difference in salivary cortisol depending on the type and period of the forest, but it tended to gradually decrease. Second, there was a significant difference in lactic acid depending on the type and period, and it was higher in Step Type. Third, there was a significant difference in the average heart rate during exercise, and it was higher in Step Type. Fourth, there was a significant difference in maximum heart rate during exercise, and it was higher in Step Type. Fifth, there was no significant difference in average heart rate during rest. In summary, walking exercise in a forest environment can be effective for stress reduction for female college students in their 20s, but it appears that forest routes should be selected according to physical strength level, and walking exercise in a forest environment for long periods of time is not recommended. For this purpose, it is suggested that it is appropriate to select the Hill Type route.

Keywords: *Forest Walking Exercise, Stress, Salivary Cortisol, Blood Lactate, Heart Rate.*

1. INTRODUCTION

College students experience stress due to situations where they must adapt to society's demands for credit completion and competition, time management, employment, satisfaction with college, forming interpersonal relationships in a new environment, anxiety about the future, environmental and social changes, and emotional maturity. There is a high possibility of experiencing [1]. Stress caused by this environment is known to be a

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key factor in the development of diseases that cause deterioration of health and various health problems when exposed to high intensity, frequent frequency, and long periods of time [2].

There are differences between male and female college students in how they resolve stressful situations. Compared to male college students, female college students seem to cope passively with stress, showing that they are more vulnerable to stressful situations than men [3,4]. Accordingly, college students need social attention and coping skills to reduce stress.

Recently, an increasing number of people are trying to relieve their fatigue in natural environments in order to comfort their tired minds and bodies and prevent rapidly increasing diseases [5]. Among these, the forest environment is a valuable environmental resource containing a variety of healing elements, and is defined as an activity that enhances the human body's immunity and improves health by utilizing natural elements such as scent and scenery. It is reported that phytoncide, a volatile organic compound encountered in the atmosphere of a forest environment, stabilizes the autonomic nervous system and relieves stress [6-10]. In addition, light walking exercise of less than moderate intensity is suggested as an effective way to respond to stress [11].

In this way, forest walking exercise combined with the natural environment refers to walking in a place with a multidimensional environment, and ground conditions and slopes vary accordingly [12]. Due to this environment, the intensity of walking in the forest varies depending on the terrain conditions, and as it involves uphill movement, physical strength factors such as muscle strength and muscular endurance are required [13-15].

In addition, because walking in a forest environment is a physical activity that cannot be abandoned midway, it is very important to perform it within the range of physical strength [16]. Although the forest environment's positive effects on the human body have been proven, there is still insufficient consistency to support physiological effects compared to psychological effects [17], and healing activities using the natural environment are implemented. Research based on the topography of the location is lacking.

Therefore, in this study, it seems necessary to select an appropriate route for forest walking exercise to reduce stress, and investigate changes in the stress hormone cortisol, blood lactic acid, and heart rate to provide basic knowledge in selecting an appropriate route.

2.EXPERIMENTS

2.1 Subject

The subjects of this study were 10female college students in their 20s who voluntarily expressed their intention to participate and filled out a consent form. Research procedures were explained to the subjects based on bioethics and safety laws. While participating in the study, participants were instructed to abstain from moderate to high-intensity physical exercise and alcohol consumption. participants were informed that they could give up at any time during the experiment, and the characteristics of the study subjects are shown in <Table 1>.

Table 1. Characteristics of research subjects

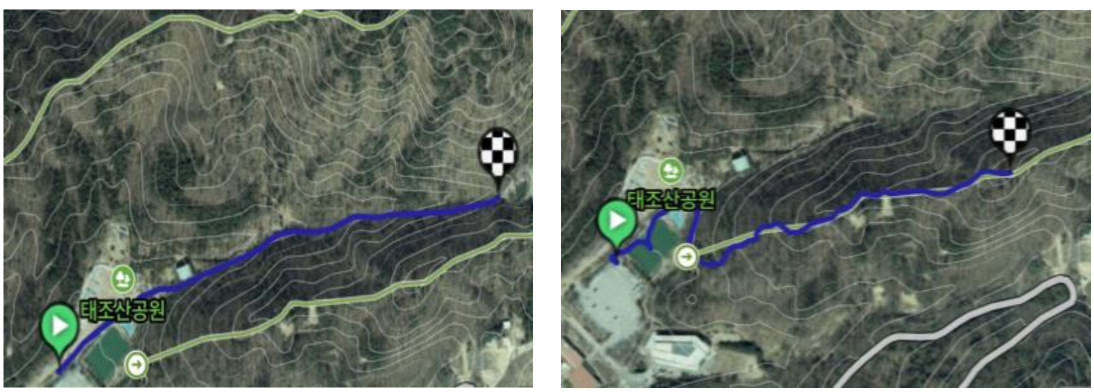
Age (year)	Weight (kg)	Height (cm)	Muscle Mass (kg)	Body Fat (%)	BMI (Kg/m^2)
21.60±1.07	56.98±5.47	162.35±5.75	22.90±2.18	26.47±3.33	21.58±1.44

2.2 Experimental Procedure

Body composition was measured 1week before the Exercise, and Randomized Crossover distributed according to the suggested forest road type (2). A break of at least 3days was provided between Exercise.

2.3 Walking Exercise Method Depending on the Type of Forest Road

The forest road types conducted in this study study were Hill-Yype (HT) and Step-Type (ST), with a distance of 800m, an average slope of 25°, and the altitude of the HT was 112m, and the altitude of the ST was 114m. The walking speed during exercise was set at 60bpm using the acoustic feedback of a metronome (Frozen Ape Pte, Singapore), and the Forest Road information is shown in <Figure 1>.



<Hill-type forest road> <Step-type forest road>

Figure 1. Forest road information

2.4 Salivary Cortisol Measurement

Salivary cortisol (SA) was measured and analyzed by enzyme immunoassay using an ELISA Kit (ALPCO diagnostics, USA) [18]. Saliva that naturally accumulates in the mouth was collected 4times in a conical tube Before Exercise, After Walking Exercise, 5minutes, and 10 minutes after Walking Exercise according to the shape of the Forest Road. It was stored frozen at -80°C or below until analysis and submitted to an analysis agency. Before starting exercise, they rinsed their mouths with cold water and refrained from using gum or drugs that could affect saliva concentration.

2.5 Blood Lactate Measurement

Blood lactate (LA) was measured four times in total: Before Exercise, After Walking Exercise, 5 minutes, and 10 minutes after walking exercise according to the type of Forest Road. If the pre-exercise measurement showed more than 2mmol, rest for 30minutes and then re-measure, and the experiment was conducted only if it was less than 2mmol. Before measurement, after disinfection with an alcohol swab, the ear lobe was punched using a puncure combined with Lacet, and 3-5μL of whole blood was applied to a strip connected to a portable lactic acid analyzer (Arkray, Japan) and analyzed.

2.6 Heart Rate Measurement

The Maximum Heart Rate (HR) during walking exercise according to the type of wirelessly assigned forest Type, the Average HR from the starting point to 400m, the average HR from 400m to 800m, and the average HR while resting were measured. For this purpose, a wireless HR sensor (Polar, Finland) was placed on the Xiphoid Process of the chest and measurements were made using Polar Beat Software (ver. 3.3.3, Polar Electro).

2.7 Static Analysis

The data collected in the study was used to calculate the average and standard deviation of all variables using the statistical program IBM SPSS statistics (ver22.0). SC, LA according to forest road type (2) and period (4), and average HR during exercise according to forest road type (2) and period (3) were analyzed using Repeated Measurement two-way ANOVA. If significant differences occurred, post-hoc was conducted using the bonferroni method. The maximum HR during walking and the average HR at rest according to the type of forest road were analyzed using a paired t-test. The statistical significance level was set at α=.05.

3.RESULTS

3.1 Changes in Salivary Cortisol

Repeated measurement two-way analysis of SC and post-hoc results of SC during walking exercise according to forest road type and period are shown in <Table 2>. There was no significant difference in SC depending on forest road type (*p*=. 844). There was no significant difference depending on the measurement period (*p*=.258), and the interaction effect did not show a significant difference (*p*=.663).

Table 2. Changes in salivary cortisol(ug/dL)

Type	BeforeWorking Exercise	After Working Exercise	Rest 5Min	Rest 10Min		F	p
Hill Type	0.51±0.37	0.35±0.14	0.37±0.18	0.34±0.19	Type	0.41	.844
					time	1.424	0.258
Step Type	0.45±0.27	0.34±0.10	0.38±0.14	0.36±0.16	(T)x(t)	0.534	0.663

3.2 Changes in Blood Lactate

The results of two-way variate analysis and post-hoc verification of repeated measurements of LA during walking exercise according to forest road type and period are shown in <Table 2>. There was a significant difference in LA depending on the type of forest road (*p*<.05). As a result of post-hoc, it was found to be high on the ST after exercise (*p*<.05) and after 10 minutes of rest (*p*<.05). Significant differences also appeared depending on the measurement period (*p*<.001). As a result of the post-hoc, a significant difference was found immediately before and after exercise on the HT forest path (*p*<.05), and a significant difference was also found just before and after exercise on the ST (*p*<.05). There was also a significant difference in the interaction effect (*p*<.01).

Table 3. Changes in blood lactate(mmol)

Type	Before Working Exercise	After Working Exercise	Rest 5Min	Rest 10Min		F	p
Uphill Type	1.80±0.44	3.20±1.08*	2.97±1.24	2.37±0.68	Type	6.776	0.29$^{\int}$
Step Type	1.70±0.30	5.27±2.86$^{\int *}$	5.03±3.55	4.50±2.45$^{\int}$	time	11.297	.000***
					(T)x(t)	5.533	.044*

3.3 Average Heart Rate during Exercise

The results of repeated measurement two-way variate analysis of the average HR during walking exercise according to the type of forest road are shown in <Table 4>. There was a significant difference in the average HR during exercise depending on the type (p<.01), and a higher HR was found in the ST at the 400m point. A significant difference appeared depending on the period (p<.001). As a result of post-hoc, it was found to be higher at the 400m and 800m points compared to the stable time in HT, and gradually increased. In Step Type, it was higher at the 400m point compared to when it was stable.

Table 4. Average heart rate during exercise(bpm)

Type	Rest	400m Point	800m Point		F	p
Hill Type	86.30±13.33	139.80±13.59***	162.00±13.15***	Type	16.266	.003$^{\int}$
Step Type	86.32±13.32	165.90±12.48$^{\int ***}$	170.10±10.62	time	342.487	.000***
				(T)x(t)	23.576	.000

3.4 Maximum Heart Rate during Exercise

The paired t-test results of Maximum HR during walking exercise according to the type of forest road are shown in <Table 5>. There was a significant difference in Maximum HR during exercise depending on the type of forest road (p<.01), and it was higher on the ST.

Table 5. Maximum heart rate during exercise(bpm)

Type	Hill Type	Step Type	t	*p*
M±SD	165.60±13.06	177.70±2.27	-3.315	.009**

3.5 Average Heart Rate during Rest

The paired t-test results of the average HR at rest during walking exercise according to the type of forest road are shown in <Table 6>. There was no significant difference in maximum HR during exercise depending on the type of forest road (p=.069).

Table 6. Average heart rate during rest(bpm)

Type	Hill Type	Step Type	t	*p*
M±SD	98.50±14.03	107.800±10.50	-2.066	.069

4.DISCUSSION

Even the same stress can help improve an individual's capabilities depending on how they deal with it [19], so this study investigated stress indicators and exercise based on exercise combined with walking in a forest environment, which is known to be effective in reducing stress, among female college students. We would like to discuss the results of the intensity index. When the human body is exposed to stress, Corticotrophin-Releasing Factor (CRF) is secreted from the hypothalamus, which in turn secretes drenocorticotropic hormone (ACTC) from the anterior pituitary gland.

This causes cortisol to be secreted from the adrenal cortex. SC is a representative stress hormone, and its secretion increases when exposed to stress. If it continues, it causes various physiological and psychological problems [20-22]. Recently, the number of people trying to relieve such stress in natural environments is increasing, but the intensity of exercise when walking in a forest environment varies depending on the terrain conditions. In addition, since it is an activity that requires consideration of the individual's physical strength level as the goal is to walk for a long period of time at a relatively low intensity to minimize the accumulation of fatigue, giving up midway is impossible, an appropriate route must be selected [5, 13, 16].

The results of this study showed that there was no significant difference in SC depending on the type of forest road, but it tended to gradually decrease over time. This suggests that walking in a forest environment is considered an effective way to manage stress by partially aligning with studies that report a decrease in cortisol levels compared to urban activities like walking through the woods or enjoying scenic views [23].

LA serves as an indicator of the relative effort level during exercise, and when the removal rate of pyruvate in anaerobic metabolic processes becomes lower than the production rate, it starts to accumulate [24,25]. LA can be produced even under adequate aerobic conditions and acts as a precursor for gluconeogenesis [26]. In this study, LA showed significant differences based on the type of forest Road and was notably higher in ST immediately and 10 minutes after exercise. LA is generated during both rest and exercise, with the rate of LA production increasing proportionally to the intensity during exercise [26].

In this study, it was observed that the walking exercise was conducted at a higher intensity in ST compared to HT, indicating that the intensity of physical activity in a forest environment varies depending on the incline of the Road, aligning with previous reports suggesting that perceived intensity is higher on HT compared to ST, which is consistent with the findings of this study [27].

However, despite being indoors, it was reported that phytoncide acid emitted in forest environments was effective in LA removal in middle-aged women [28]. Significant differences following a 10-minute exposure in a forest environment were not evident in this study but showed a tendency to decrease. This is believed to be due to the choice of static recovery method post-exercise cessation. LA removal can reach 52.53% through static recovery, while dynamic recovery at 35% Vo_2Max intensity was deemed effective in reducing LA [29, 30]. Based on these results, it is suggested that during forest walking activities, maintaining a lower exercise intensity akin to HT could be possible, and dynamic recovery might be effective during mid-activity rests.

HR increases with the intensity and duration of exercise due to activities of the sympathetic nervous system, mechanical stimuli from muscle contractions, among other factors [31-33]. Significant differences were observed in the maximum HR during exercise in this study, and average heart rate during exercise also showed significant differences based on the trail type. ST exhibited higher rates, particularly at the 400m mark, likely due to the higher exercise intensity associated with ST, similar to lactate levels.

5. CONCLUSION

This study analyzed changes in SC, LA, and HR according to the forest walking exercise route among female college students in their 20s during forest walking exercise to reduce stress, and obtained the following results. First, SC did not show a significant difference depending on the type of forest road, nor did it show a significant difference depending on the measurement period, but it tended to gradually decrease compared to the resting time. Second, significant differences in LA appeared depending on the form, and significant differences also appeared depending on the period.

It was found to be higher in the ST immediately after exercise and 10 minutes after rest. Third, the average HR during exercise showed significant differences depending on the type and period, and an interaction effect was also observed. It was found to be higher on ST. Fourth, there was a significant difference in maximum HR during exercise, and it was higher in the ST. Fifth, there was no significant difference in average HR during rest. However, additional research with a larger sample size and examining SC, LA, and HR responses during long-term forest walking exercise seems necessary.

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REFERENCES

[1] J. S. Park, “Mediating effect of acceptance in relationship between university life stress and satisfaction with life,” Journal of Stress Research, Vol. 23, No.1, pp. 1-8, March 2015.
DOI: https://doi.org/10.17547/kjsr.2015.23.1.1

[2] S. J. Lee, J. H. Lee, M. Gillen, and Krause, N, “Job stress and work-related musculoskeletal symptoms among intensive careunit nurses: A comparison between job demand-control andeffort-reward imbalance models,” American Journal of Industrial Medicine, Vol. 57, No.2, pp. 214-221, February 2014.
DOI: http://dx.doi.org/10.1002/ajim.22274

[3] S. H. Lee, “The Relationship between Coping Style for Stress and Emotional Eating Behavior by Gender Difference,” Journal of the Koran Society of Food Culture. Vol. 33, No.1, pp. 11-17, March 2018.
DOI: https://doi.org/10.7318/KJFC/2018.33.1.11

[4] G. S. Shin, and M. K. Cho, “Influencing Factors on Perceived Stress among Female College Students in South Korea,” Crisisonomy,Vol. 16, No,12, pp. 123-132, 2020.
DOI: https://doi.org/10.14251/crisisonomy. 2020.16.12.123

[5] B. W. Min, and Y. H. Park, “Research on subsidy guidelines for healing forest activation,” Proc. Korean Soc. Environ. Ecol. Con, Vol. 27, No. 1, pp. 55-56, 2017.

[6] C. Song, H. Ikei, M. Kobayashi, T. Miura, , M. Taue, T. Kagawa, and Y. Miyazaki, “Effect of forest walking on autonomic nervous system activity in middle-aged hypertensive individuals: A pilot study,” International Journal of Environmental Research and Public Health, Vol. 12, No. 3, pp. 2687-2699, March 2015.
DOI: https://doi.org/10.3390/ijerph120302687

[7] J. Lee, Y. Tsunetsugu, N. Takayama, B. J. Park, Q. Li, C. Song, and Y. Miyazaki, "Influence of forest therapy on cardiovascular relaxation in young adults," Evidence-based Complementary and Alternative Medicine, 2014.
DOI: https://doi.org/10.1155/2014/834360

[8] C. P. Yu, C. M. Lin, M. J. Tsai, Y. C. Tsai, and C. Y. Chen, "Effects of short forest bathing program on autonomic nervous system activity and mood states in middle-aged and elderly individuals," International Journal of Environmental Research and Public Health, Vol. 14, No. 8, pp. 897, August 2017.
DOI: https://doi.org/10.3390/ijerph14080897

[9] J. H. Choi, H. J. Kim, C.S. Shin, P. S. Yeon, and J. S. Lee, "The Effect of 12 - Week Forest Walking on Functional Fitness, Self - Efficacy, and Stress in the Middle - Aged Women," Korean Insitute of Forest Recreation and Welfare, Vol. 20, No. 3, pp. 27-38, September 2016.
DOI :10.34272/forest.2016.20.3.003

[10] J. Y. Hong, and J. H. Lee, "Analysis on Activities of Forest Healing Program in Healing Forests," The Journal of Korean institute of Forest Recreation, Vol. 22, No. 4, pp. 1-9, December 2018.
DOI :10.34272/forest.2018.22.4.001

[11] S. K. Lee, "Effects of Walking Exercise on Stress Reduction," Journal of The Health Care and Life Science, Vol. 7, No. 2, pp. 111-114, 2019.

[12] W. D. McArdle, F. I. Katch, V. L. and Katch, "Exercise physiology: Energy, nutrition, and human performance," Philadelphia: Lippincott Williams & Wilkins, February 2001.
DOI: https://doi.org/10.1016/s0031-9406(10)61985-2

[13] K. W. Kim, Y. K. Sim, J. B. Lee, and Y. C. Kim, "Study on the Design Techniques of Health Paths in Mountain Resorts Considering Visitors' Age-related Exercise Abilities," Korean Forest Society, N/A, pp. 150-152, 2000.

[14] C. J. Seo, and Y. W. Ko," Study to Development an Energy Consumption Program and an Exercise Intensity by Climbing Courses in Bulgapsan of Fifties` Male and Female," The Korean Journal of Growth and Development, Vol. 18, No. 4, pp. 307-313, 2010.

[15] W. Müller, H. W, U. Pramann , and M. Scheele, "Mensch beweg Dich!," so stärken Sie Ihr Bindegewebe. Zabert-Sandmann, 2001.

[16] J. W. Lee, B. J. Park, and Y. H. Choi, "A Study on Exercise Load of Trails in Chirisan National Park," Korean Journal of Environment and Ecology, Vol. 13, No. 4, pp. 348-353, 2000.

[17] V. F. Gladwell, D. K. Brown, J. L. Barton, M. P. Tarvainen, P. Kuoppa, J. Pretty, and G. R. H. Sandercock, "The effects of views of nature on autonomic control," European journal of applied physiology,Vol. 112, pp. 3379-3386, September 2012.
DOI: https://doi.org/10.1007/s00421-012-2318-8

[18] S. Izawa, K. Kim, T. Akimoto, N. Ahn, H. Lee, and K. Suzuki, "Effects of cold environment exposure and cold acclimatization on exercise-induced salivary cortisol response," Wilderness & Environmental Medicine, Vol. 20, No. 3, pp. 239-243, September 2009.
DOI: https://doi.org/10.1580/07-weme-or-123r2.1

[19] J. S. Kang, G. J. Jang, and M. H. Lee, "Stress status classification based on EEG signals," The Journal of The institute of Internet, Broadcasting and Communication," Vol. 16, No. 3, pp. 103-108, Jun 2016.
DOI:https://doi.org/10.7236/JIIBC.2016.16.5.99

[20] B. W. Chang, and J. Y. Dong, "The Difference According to the Long Time Resistive Exercise Intensities on Stress Hormone Response to Men," Korean Society of Sport Psychology, Vol. 20, No.3, pp. 201-210, 2009.

[21] H. H. Ji, and H. S. Jo, "Effects of Music Therapy on Subjective Stress Response, Salivary Cortisol, and Fatigue for Intensive Care Nurses," Korean Journal of Health Promotion, Vol. 17, No. 2, pp. 119-127, June 2017.
DOI:http://dx.doi.org/10.15384/kjhp.2017.17.2.119

[22] E. Moustaka, M. Maria, and T. C. Constantinidis, "Measuring occupational stress and HRA axis dysregulation among healthy workers by salivary cortisol levels," British Journal of Medicine and Medical Research, Vol. 6, No. 11, pp. 1040-1051, January 2015.
DOI: https://doi.org/10.9734/bjmmr/2015/15530

[23] B. J. Park, and Y. MIYAZAKI, "Physiological effects of viewing forest landscapes: Results of field tests in Atsugi city, Japan," Journal of Korean Society of Forest Science, Vol. 97, No. 6, pp. 634-640, Octorber 2008.

[24] J. Denton, and J. B. Cronin, "Kinematic, kinetic, and blood lactate profiles of continuous and intraset rest loading schemes," The Journal of Strength & Conditioning Research, Vol. 20, No. 3, pp. 528-534, August 2006.
DOI: https://doi.org/10.1519/00124278-200608000-00012

[25] R. Dotan, "Reverse lactate threshold: a novel single-session approach to reliable high-resolution estimation of the anaerobic threshold," International Journal of Sports Physiology and Performance, Vol. 7, No. 2, pp. 141-151, June 2012.
DOI: https://doi.org/10.1123/ijspp.7.2.141

[26] K. J. Kim, "Scientific Analysis andApplication of New Paradigm of LactateThreshold," Journal of coaching development, Vol. 23, No. 3, pp. 78-79, September 2020.
DOI : 10.47684/jcd.2020.09.22.3.72

[27] W. J. Lee, and B. J. Park, "Management Guideline of Trail in National Park Using Analysis of Excercise Load - At Soraksan Nat'l Park and Kyeryongsan Nat'l Park-," Korean Society of Environment and Ecology. Vol. 11, No. 4 : pp. 469-479, 1998.

[28] J. U. Min, "Effects of Phytoncide-rich Indoor Exercise on Blood Lipid Profiles, Brain Wave and Antioxidant Capacity Changes of Middle-aged Woman," The Korean Journal of Sport, Vol. 21, No. 1, pp. 397-406, March 2023.
DOI : https://doi.org/10.46669/kss.2023.21.1.034

[29] S. H. Yoo, Y. S. Jee, C. H. Jee, J. H. Yu, W. H. Lee, and D. S. Park, "Effects of Three RecoveryMethods on Blood Lactate and Median FrequencyAfter Wingate test," The Journal of KoreanAlliance of Martial Arts. Vol. 11, No. 3, pp. 223-234, Decemvber 2009.
DOI : 10.35277/kama.2009.11.3.223

[30] M. Spencer, B. Dawson, C.Goodman, B.Dascombe, and D. Bishop, "Performance andmetabolism in repeated sprint exercise: effect ofrecovery intensity," European journal of appliedphysiology, Vol. 103, No. 5, pp. 545-552, April 2008.
DOI : 10.1007/s00421-008-0749-z

[31] J. Brill, A. C. Perry, L. Parker, A. Robinson, and K.Burnett, "Dose-response effect ofwalking exercise on weight loss. How muchis enough?," International Journal of Obesity, Vol. 26, No. 11, pp. 1484-1493, MAY 2002.
DOI: https://doi.org/10.1038/sj.ijo.0802133

[32] S. K. Powers, E. T. Howley, and J. Quindry, "Exercise physiology: Theory and application to fitness and performance," New York, NY: McGraw-Hill, pp. 640, 2007.

[33] P. E. Alcaraz, J. Sánchez-Lorente, and A. J. Blazevich, "Physical performance andcardiovascular responses to an acute bout ofheavy resistance circuit training versustraditional strength training," The Journal ofStrength & Conditioning Research, Vol. 22, No. 3, pp. 667-671, MAY 2008.
DOI: https://doi.org/10.1519/jsc.0b013e31816a588f