Impacts of Korean Somatotype in Energy Consumption and Hormone Changes During Treadmill Gait -Around University Students-

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Purpose: This study is executed to examine the effects of Korean somatotype on energy consumption and hormone changes during treadmill gait.

Methods: The objects of study were a total of 70 university students in their 20s and 30s divided into 7 groups according to somatotype with 10 members each, 4 groups of male (M1, M2, M3, M4) and 3 groups of female (F1, F2, F3).

Results: In case of male groups, there was a significant difference in VO2 and VCO2 between group M1, M2 and M3 ($p<0.05$). There was also a meaningful difference between Phase1 and Phase2, Phase3 and Phase4 in a phase ($p<0.01$). In case of female groups, there was a meaningful difference in VO2 between F1 and F2, F3 ($p<0.01$). There was also a significant difference between Phase1 and Phase2, Phase3 and Phase4 in a phase ($p<0.01$). There was no significant difference in VCO2 among them, but there was a significant difference in it between Phase1 and Phase2, Phase3 and Phase4 ($p<0.01$). There was equally no significant difference in the concentration of adrenaline and nor-adrenaline among both male and female groups, but such concentration showed meaningful difference before and after exercise ($p<0.01$).

Conclusion: Energy consumption differs according to somatotype. There is a difference in hormone change, indicating that somatotype has effects on the physiological change. Therefore, in future exercise should be executed in more diverse conditions to further study somatotype with energy consumption and the correlations of hormone change.

Key Words: Adrenaline, Energy consumption, Nor-adrenaline, Somatotype

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I. Introduction

A somatotype of a human being shows the characteristics of overall physique and offers information on growth and maturity.[1] Moreover; it is a tool to describe easily and simply an overall physique as the shape and component of body regardless of the size.[2]

A somatotype depends on the cultural difference between other races.[3] It is very diverse according to the growth period. Difference in the somatotype of each country may be affected by the national factor rather than by a physical activity.[4] This should be dealt with in the study on biology of aging.[5]

Changes in the metabolism can be identified by the results got from the walking on a treadmill. Walking, rhythmic walking and joint kinematics except for maximal hip flexion and knee joint extension is similar to each other in treadmill and level walking, and but the metabolic demand of treadmill walking is 23% more than level walking.[6] Treadmill and level walking are bio-mechanically similar to each other but early fatigue or physiological change should be considered in walking re-training. This due to the fact that metabolic consumption of treadmill is larger than one of level walking.[7]

VOmax is one of the representative indexes for the energy consumption. An ectomorph shows the highest values of respiratory exchange ratio, oxygen ventilatory equivalent, plasma lactate accumulation (the last step of exercise) and the lowest VO2max.[8] VO2max has a significantly mutuality with the inside diameter of a left ventricular (LV) end-diastolic, end-diastolic volume and LV mass. It may expect maximum aerobic capacity from the measurement value of a body, the size of the heart and functional abilities.[9] Also, most of the ways to measure the efficiency of endurance training have used VO2max as an outcome variable. However, VO2max does not show only cardiorespiratory fitness for endurance.[10] It has been regarded as the most representative indicator of endurance exercise capacity.[11] So, VO2 during exercise has been frequently used for the purpose of deciding the intensity of the exercise in various endurance sports.[12]

Catecholamine is one of the major indexes to enable us to identify the physiological changes in the human body. On one occasion, it was reported that the athletes had no significant change of catecholamine according to the increase of exercise speed in treadmill walking. They complained muscular pain at 90% intensity in maximum speed.[13] The concentration of average heart rate, blood lactate and glucose, blood adrenaline and nor-adrenaline is higher at high temperature.[14] The concentration of adrenaline and nor-adrenaline was remarkably increased as a result of making the male and female with a coronary artery disease walk for 6 minutes.[15] Gomez-Merino et al.[16] mentioned that the concentration of blood nor-adrenaline was significantly increased after 3 weeks of battle training of an army and on the other hand, the one of adrenaline was not changed. Also, increased catecholamine promotes glycogen breakdown and induces the production of free fatty acid from an adipose tissue at the initial stage of exercise by activating lipase.[17]

As we examined above, the researcher reflects that it needs studies using the somatometry data of Korean adults male and female and researches under various conditions for mutual relationship between a somatotype and exercise because there is difference on the analysis of blood and respiratory gas according to a somatotype.

Ⅱ. Methods

1. Subjects

This study was researched for 30 females and 40 males who are from Yongin University, Korea. They are in good physical health without a musculoskelectal disease, a neurological disease or other skin diseases. They are in their 20s and 30s. Before the experiment, the experimental details and the purpose were sufficiently explained to all the subjects. Their physical characteristics were finely measured, after getting in advance their written experiment participation consents. Then, they participated in the experiment.

2. Experimental methods

1) Classification of Somatotype by a Group

A somatotype was transformed. It was classified into M1, M2, M3, and M4 for males and F1, F2, F3 for females based on 5th Korean Body Measurement Investigation Business Report executed by the Korean Agency for Technology and Standards[18] according to the object of this study. The subscripts of each groups signifies that the larger the number, the larger the physique. That is, the subjects in the group M1 and F1 have the smallest physique. The body dimensions of a group were measured by the same well-trained measurer who measured for another group in accordance with the recommended standards of ISAK Manual[19] using Martin's Anthropometer. Males whose heights were lesser than 163 cm and females whose heights were lesser than 152 cm were ruled out from the subjects. 40 men in total were selected from 117 men by choosing 10 men fit for the various conditions in each group, while 30 women in total were selected from 96 women by choosing 10 women fit for various conditions in each group.

The criteria used for males were height, chest circumference and waist circumference and criteria used or females were height, chest circumference and hip circumference. 10 subjects who have all the above 3 conditions were selected for each group (Table 1).

2) Setting Phases & Data Collection Phase

1~2 min., 6~7 min., 9~10 min. and 14~15 min. were set as Phase 1, Phase 2, Phase 3 and Phase 4 respectively. VO2 and VCO2 for this study were drawn as an average in each phase(for 1 minute). And the concentration of adrenaline and nor-adrenaline for this study was analyzed by drawing a blood sample before and after walking.

3. Setup or Study on Energy Consumption and Hormonal Change

This study adjusted the zero point of a measuring instrument (quark b2, COSMED, USA) using the gases including 16% of Oxygen (O_2) and 5% of Carbon Dioxide (CO_2) before

Table 1. Criteria of somatotype classification (unit: Cm)

Group					
M	M1	163≤height≤167	83≤chest girth≤104	68≤waist girth≤89	
	M2	168≤height≤172	83.6≤chest girth≤107	68.6≤waist girth≤92	
	M3	173≤height≤177	84≤chest girth≤110	69≤waist girth≤95	
	M4	178≤height≤182	86.6≤chest girth≤101	71≤waist girth≤86	
F	F1	152≤height≤157	77≤chest girth≤89		83≤hip girth≤98
	F2	156≤height≤162	78≤chest girth≤92		83.6≤hip girth≤99
	F3	163≤height≤167	80≤chest girth≤89		86≤hip girth≤95

M: male
F: female

analyzing the respiratory gas. Height and weight were recorded and then the respiratory gas was analyzed using a mask during treadmill walking (QUASTAR 4.0, H/P/cosmos, Germany). VO2 and VCO2 were analyzed by filtering the analyzed respiratory gas in the unit of 1 minute after analyzing. Adrenaline and Nor-adrenaline were analyzed by a 1340 electrochemical detector (Microplate 860) manufactured by Bio-Red after drawing a blood sample before and after walking. Dhydroxybenzylamine made by Sigma was used for the standardization of work before analyzing them, and 100 microgram of 0.1 N was immediately drawn after shaking for 10 minutes and the flow was analyzed for 1.1 μl/min with 200 psi in 0.65 v.

4. Data Analysis

This study was done between a group and a section using SPSS 12.0. and parametric statistics were used after verification of normality. To analyze the changes in energy consumption, repeated measured two way ANOVA was used for identifying the differences in the four phases depending on the four types of somatotypes in men and in the three phases depending on the three types of somatotypes in women, and LSD was used for the post-hoc. To understand the hormonal change before and after exercise, two-way (4RG × 2RM) ANOVA and two-way (3RG × 2RM) ANOVA were used.

Table 2. Change within phase and differences among groups of VO2 and VCO2 (unit : ml/kg/min)

	Group	N	Phase 1	Phase 2	Phase 3	Phase 4
Male VO2	M1	10	545.78±161.03	617.00±162.30	601.80±165.05	606.31±179.44
	M2	10	528.29±214.94	574.07±298.70	568.46±289.73	598.67±271.25
	M3	10	790.08±234.80	853.88±173.3	902.25±216.46	875.11±236.37
	M4	10	744.95±255.89	806.57±274.54	782.32±286.30	794.91±261.30
Male VCO2	M1	10	465.30±196.38	531.78±212.95	532.46±214.75	534.32±225.34
	M2	10	443.77±214.20	494.59±298.59	512.36±301.69	536.77±278.94
	M3	10	836.55±339.47	862.57±204.15	939.53±246.16	916.20±261.03
	M4	10	650.36±285.50	707.62±303.90	709.70±312.06	722.77±310.46
Female VO2	F1	10	327.46±96.00	354.93±79.80	367.08±65.32	365.45±74.41
	F2	10	432.53±115.03	447.42±107.80	473.29±90.08	458.22±88.84
	F3	10	430.81±66.40	524.24±80.00	504.29±63.18	505.78±77.28
Female VCO2	F1	10	310.56±141.07	360.90±154.45	375.56±130.86	376.16±152.44
	F2	10	377.13±76.84	411.88±74.50	457.93±85.07	439.33±89.32
	F3	10	407.62±117.62	508.82±144.62	509.69±133.59	512.68±131.80

Values are showed mean±S.D

Table 3. The result of repeated measure two-way ANOVA in change within phase and differences among groups of VO2 and VCO2

	Source of variance	SS	DF	MS	F	p	post-hoc
Male VO2	Ⅰ	1852560.1	3	617520.02	2.96	0.04*	AB,C
	Ⅱ	96016.40	3	32005.47	7.80	0.00†	a,bcd
	Ⅰ-Ⅱ	20282.93	9	2253.66	0.55	0.84	ns
Male VCO2	Ⅰ	2987409.4	3	995803.14	3.68	0.02*	AB,C
	Ⅱ	125985.89	3	41995.30	8.26	0.00†	a,bcd
	Ⅰ-Ⅱ	17423.75	9	1935.97	0.38	0.94	ns
Female VO2	Ⅰ	402980.24	2	201490.12	9.20	0.00†	E,FG
	Ⅱ	21583.48	3	17194.49	7.26	0.00†	a,bcd
	Ⅰ-Ⅱ	18602.27	6	3100.38	1.31	0.26	ns
Female VCO2	Ⅰ	332390.48	2	166195.24	3.19	0.06	ns
	Ⅱ	130461.59	3	43487.20	16.08	0.00†	a,bcd
	Ⅰ-Ⅱ	14681.06	6	2446.84	0.90	0.50	ns

ns : none significant
* p<0.05
† p<0.01
I : group
II : phase
I-II : group versus phase
A: M1, B: M2, C:M3, D: M4, E: F1, F: F2, G: F3
a: phase1, b: phase2, c: phase3, d: phase4

III. Results

1. Change in Energy Consumption

In the case of male groups, there was a significant difference in VO2 and VCO2 between group M1, M2 and M3 ($p<0.05$), and there was also a meaningful difference between Phase1 and Phase2, Phase3 and Phase4 in a phase ($p<0.01$)(Table 2, 3). In the case of female groups, there was a meaningful difference in VO2 between F1 and F2, F3 ($p<0.01$), and there was also a significant difference between Phase1 and Phase2, Phase3 and Phase4 in a phase ($p<0.01$). There was no significant difference in VCO2 among them, but there was a significant difference in it between Phase1 and Phase2, Phase3 and Phase4 ($p<0.01$) (Table 2, 3).

2. Hormonal Change

There was equally no significant difference in the concentration of adrenaline and nor-adrenaline among both the male and female groups, but such concentration showed meaningful differences before and after exercise ($p<0.01$)(Table 4, 5).

IV. Discussion

Related studies have highlighted interests in the cardiopulmonary physical therapy and they are now in increase. Exercise increases the VO2max and the exercise duration of the patients with a coronary artery disease or a ventricular dysfunction as well as a normal person.[20]

And VCO2 becomes 970～1085 ml·min^{-1} during the exercise with 75% of VO2max for the patients with left atrial dysfunction.[21] Energy consumption is the highest at a slope of about 12° under the conditions of same walking duration and speed. It was higher on a slope than on a level ground.[22] There was a significant difference in VO2max between somatotypes after aerobic exercise. Meso-ecto and meso somatotypes showed the largest increase in aerobic capacity.[23] This study also discovered that VO2 of group M3 with a greater height and heavier weight was significantly larger than the one of M1 and M2 with relatively a smaller height and lesser weight ($p<0.05$). One of F2 and F3 was meaningfully larger than the one of F1 ($p<0.01$). It agreed with the study of Bolonchuk et al.[8] that VO2

Table 4. Change of adrenaline and nor-adrenaline in pre and post exercise (unit : pg/ml)

	Group	N	pre-exercise	post-exercise
Male adrenaline	M1	10	6.15±0.91	10.59±0.75
	M2	10	5.83±0.75	11.11±0.70
	M3	10	5.80±0.67	11.11±0.94
	M4	10	6.22±0.71	11.16±0.84
Male nor-adrenaline	M1	10	44.47±10.61	57.30±1.67
	M2	10	40.83±0.75	57.47±1.83
	M3	10	40.80±0.67	56.20±2.66
	M4	10	41.22±0.71	57.11±1.47
Female adrenaline	F1	10	5.59±0.74	10.89±0.58
	F2	10	5.64±1.15	10.82±0.59
	F3	10	6.31±0.76	11.03±0.83
Female nor-adrenaline	F1	10	40.59±0.74	57.06±1.53
	F2	10	40.64±1.15	57.65±2.89
	F3	10	41.31±0.76	57.02±1.43

Values are showed mean±S.D

of an ecto somatotype is the lowest among ecto, meso and pyknic somatotypes. It also agreed with the study of Chaouachi et al.[23] that VO2 of a person with a large muscle area and a massive physique is larger than the one of a person with a shorter and smaller somatotype. In the mean time, Yoo KT[24] said that compound exercise training mixed with aerobic exercise with resistance exercise is more effective in order to improve physical fitness and walking ability of hemiplegia than with only aerobic exercise.

It is important to note the hormonal changes depending on the age and gender. The glucose level of the experimental group to which adrenaline was injected during exercise increased

Table 5. The result of repeated measure two-way ANOVA in adrenaline and nor-adrenaline change

	Source of variance	SS	DF	MS	F	p	post-hoc
Male adrenaline	I	1.10	3	0.37	0.70	0.56	ns
	II	498.45	1	498.45	686.24	0.00†	a,b
	I - II	2.51	3	0.84	1.15	0.34	ns
Male nor-adrenaline	I	62.60	3	20.87	1.14	0.35	ns
	II	4616.85	1	4616.85	327.10	0.00†	a,b
	I - II	41.12	3	13.71	0.97	0.42	
Female adrenaline	I	2.57	2	1.28	1.87	0.17	ns
	II	384.51	1	384.51	663.16	0.00†	a,b
	I - II	0.94	2	0.47	0.81	0.46	
Female nor-adrenaline	I	1.47	2	0.74	0.29	0.75	ns
	II	4031.78	1	4031.78	1603.82	0.00†	a,b
	I - II	4.35	2	2.18	0.87	0.43	

†: $p<0.01$
I: group
II: phase
I-II: group versus phase
a: pre-exercise, b: post-exercise
ns: none significant

compared to a control group. There was no difference on glycogenolysis and degradation product-glucose 6 phosphate. This result was due to the increase in adrenaline which decreased the ability to use glucose in a body. Accordingly, they insisted that adrenaline does not increase glucose 6 phosphate and glycogen breakdown.[25] Also, adrenaline significantly inhibits the inflow of glucose into the muscles promoted by insulin. Moreover, meaningful increase in adrenaline can cause the early fatigue of muscle by inhibiting the inflow of glucose into the muscles.[26] Takeyama et al.[27] insisted that the concentration of nor-adrenaline is decreased under a stable condition by constant exercise. On the other hand, Gomez-Merino et al.[16] insisted that the concentration is increased. To the contrary, Pullinen et al.[28] insisted that the concentrations of adrenaline and nor-adrenaline increased by exercise but repeated exercise decreases the concentration. The secretion of adrenaline and nor-adrenaline depends in the postural change, psychological stimulus, exercise intensity and duration. That is, the concentration of blood nor-adrenaline starts increasing from a exercise intensity equivalent to 50% of VO2max and the concentration of blood adrenaline starts increasing from a exercise intensity equivalent to 75% of VO2max. Ronsen et al.[29] reported that the concentration of adrenaline and nor-adrenaline lagrgely increased at short intervals than at long intervals under the same experiment and conditions. So, this study agreed with the study of Radke[15] that the concentration of catecholamine is increased by the duration of exercise. Also, it could also be discovered that these two hormones increased after submaximal treadmill exercise and treadmill walking. This agreed with the study of Fernhall et al.[30] that the concentration of catecholamine was significantly increased immediately after submaximal treadmill exercise. Although studies relating to respiration and hormone depending on somatotypes were searched extensively, they seemed to be lacking. So, it is regretful that any direct comparison with data in this study is difficult.

If researches for dynamic balance ability,[31] change in the muscle activity of old people,[32] correlation of curved walking ability with straight walking ability,[33] aerobic and graduated treadmill exercise decreases blood glucose levels,[34] the relationship between strength balance and joint position sense[35] related with Korean somatotype are continued, it may bring exciting results. In addition, this study selected a small number group of students based on the Size Korea 5th Version. If the range of age could however, be diversified based on the Size; Korea 6th Version has been recently introduced. Additional experiments could be carried out with the expanded number of men and women. Those findings could become great valuable data to represent the Korean somatotype.

This was studied to understand the influence that a somatotype affects the changes in energy metabolism and hormones during the treadmill exercise. According to the above results, it could be found out that there were changes in the energy consumption and hormones in accordance with a somatotype at a constant speed treadmill exercise. Considering the results of this study and many study reports, it is certain that a somatotype affects a human activity. Therefore, appropriate treatment according to the somatotypes of patients or athletes should be considered in future by practicing, examining and analyzing several exercises under more systemic and varied conditions.

Author Contributions

Research design : Min KO
Acquisition of data : Kim BK, Lee SH
Analysis and interpretation of data : Kim, JK
Drafting of the manuscript : Choi YR
Administrative, technical, and material support : Kim TW
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