



Original Article

Effect of complex training on carbon monoxide, cardiorespiratory function, and body mass among college students at the initial stage of stopping smoking

SEUNGSUK KIM, PhD¹⁾

¹⁾ Department of Sports and Health Management, Mokwon University: Daejeon 302-729, Republic of Korea

Abstract. [Purpose] This study aimed to analyze the effects of complex training on carbon monoxide, cardiorespiratory function, and body mass among college students with the highest smoking rate among all age group. [Subjects and Methods] A total of 40 college students voluntarily participated in this study. All subjects smoked and were randomly divided into two groups: the experimental group (N=20) and the control group (N=20). The experimental group underwent complex training (30 min of training five times a week for 12 weeks) while the control group did not participate in such training. The complex training consisted of two parts: aerobic exercise (walking and running) and resistance exercise (weight training). [Results] Two-way ANOVA with repeated measures revealed significant interactions among CO, VO₂max, HRmax, VEmax, body fat, and skeletal muscle mass, indicating that the changes were significantly different among groups. [Conclusion] A 12 week of complex physical exercise program would be an effective way to support a stop-smoking campaign as it quickly eliminates CO from the body and improves cardiorespiratory function and body condition.

Key words: Complex training, Cardiorespiratory function, Smoking

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INTRODUCTION

In January 2015, the Korean government initiated a stop-smoking campaign as a means to enhance the overall health of the Korean people. The campaign increased cigarette cost and turned public places such as restaurants, bars, and coffee shops into non-smoking area. As a result of the stop-smoking campaign, the adult smoking rate decreased from 43.1% in 2014 to 39.9% in 2015 indicating the approach of a smoking rate below 30%, which would be a first in the history of official smoking statistics¹⁾. However, the smoking rate has not decreased as markedly in college students. The smoking rate among college students in Korea is 23.2%, well above the average reported by the Organization for Economic Cooperation and Development (OECD) of 20.7%²⁾. This discrepancy may be due to a change in college students once they reach the age at which they can buy cigarettes legally.

Cigarettes contain over 5,000 types of toxic or carcinogenic compounds including carbon monoxide (CO), nicotine, and tar. CO has a high capacity to chemically combine with hemoglobin (Hb), thereby resulting in an elevation of the carboxy-hemoglobin (COHb) level thereby impairing the oxygen transportation activity of blood and resulting in polycythemia³⁾. In addition, CO decreases the oxygen level in blood resulting in damage to blood vessels and it has been associated with an increase in blood cholesterol, atherosclerosis, lung cancer, and colorectal cancer^{4, 5)}. Typically, smokers have lower values for various bronchial resiliency indicators including forced vital capacity (FVC), forced volume for 1 second (FEV₁), and

Corresponding author. Seung Suk Kim (E-mail: 1166sskim@daum.net)

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Table 1. Changes in carbon monoxide, cardiorespiratory function, and body composition

Items	Group	Pre	Post
Carbon monoxide (ppm)	Exercise	18.6 ± 3.4	0.3 ± 1.7*
	Control	17.3 ± 2.6	0.5 ± 2.5
VO ₂ max (ml/kg/min)	Exercise	38.8 ± 4.3	43 ± 2.7*
	Control	37.9 ± 3.7	38.3 ± 3.9
HRmax (beat/min)	Exercise	185.8 ± 4.5	195.8 ± 2.6*
	Control	187.6 ± 3.3	189.2 ± 3.1
VEmax (l/min)	Exercise	64.3 ± 1.6	69.6 ± 1.6*
	Control	65.1 ± 2.3	66.1 ± 2.6
Body fat (%)	Exercise	26.8 ± 2.6	19.6 ± 2.1*
	Control	25.2 ± 1.6	27.6 ± 2.6
Skeletal muscle (kg)	Exercise	32.5 ± 2.6	35.9 ± 2.3*
	Control	33.2 ± 0.7	33.2 ± 1.6

Values are expressed as mean ± SD. Significantly different ($p < 0.05$) between pre- and post-complex exercise training program.

forced expiratory flow (FEF) than those of non-smokers⁶). Moreover, the amount smoked is positively related to the body mass index (BMI) and abdominal obesity^{7, 8}). Therefore, smokers' abdominal circumference and abdominal obesity measures tend to be greater than those of non-smokers^{7, 8}). As college students have the highest smoking rate among all age groups^{1, 2}), this study aimed to analyze the effect of complex training on exhalation CO level, cardiorespiratory function, and body mass in college students who were stopping smoking.

SUBJECTS AND METHODS

A total of 40 male college students voluntarily participated in this study. All subjects had been smoking for more than 1 year. Students diagnosed with a respiratory ailment by a doctor or who previously participated in a stop-smoking program were excluded from the study. The subjects were randomly divided into two groups: the experimental group (N=20; age=20.2 ± 0.3 yrs; height=176.5 ± 2.7 cm; weight=78.4 ± 2.6 kg) and the control group (N=20; age=20.9 ± 0.3 yrs; height=175.7 ± 1.7 cm; weight=79.2 ± 2.0 kg). All subjects had a 12 week of nonsmoking period from the beginning of the experiment. The experimental group underwent complex training while the control group did not participate in such training. All subjects were informed of the content and purpose of the experiment and all provided written informed consent (Mokwon University) before participating in the study.

Subjects' exhalation CO level, maximum oxygen uptake (VO₂max), maximum heart rate (HRmax), maximum ventilation (VEmax), body fat content (%), and skeletal muscle mass were measured at the start and end of the study. Exhalation CO level was measured to the nearest parts per million (ppm) as previously reported⁹) by using a CO measuring instrument (Micro Co., Rochester, Kent, England). For reference, CO levels were categorized into five stages: stage 1 (non-smoker, 0–6 ppm), stage 2 (risky, 7–10 ppm), stage 3 (smoker, 11–15 ppm), stage 4 (habitual smoker, 16–25 ppm), and stage 5 (addictive smoker, 26–35 ppm) as previously described⁹).

Exercise tolerance was estimated by using the Bruce protocol. Briefly, the protocol begins with an initial treadmill speed of 1.7 miles per hour (mph), which is then increased by 0.8 mph every 3 min; in addition, the initial gradient of 10% is increased by 2% every 3 min. Subject's VO₂max, HRmax, and VEmax were estimated by using a breath-by-breath respiration analysis gas analyzer assembly (Quark b2; Cosmed, Rome, Italy), which was operated in peak mode.

Body composition determined from body fat content (%) and skeletal muscle mass (kg) values was estimated by using bioelectrical impedance analysis equipment (InBody J20, Bio-Space, Seoul, Korea).

The complex training program included participation in physical exercise for 30 min five times a week for 12 weeks at the fitness center of D university. The complex training program consisted of two parts: aerobic exercise (walking and running) and resistance exercise (weight training). Aerobic exercise was performed until the subject attained 50–70% of their HRmax. To accurately assess exercise intensity, subject heart rate was monitored during exercise with a portable recordable HR monitor (Polar Electro, Technogym, Finland). Weight training was performed until 70% of a subject's one repetition maximum (1RM) was attained, with the 1RM values calculated by using Brzycki's equation¹⁰). Table 1 summarizes the complex training program.

All experiments were reviewed and approved by the Institutional Review Board of Daegu University. The data obtained were processed by using SPSS 20.0 version (IBM, Armonk, NY, USA). Mean and standard deviation values of the two groups were calculated and two-way ANOVA with repeated measures was conducted to examine differences between the groups and between measurement times. Values of $p < 0.05$ were considered statistically significant.

RESULTS

The two-way ANOVA with repeated measures showed significant interactions ($p < 0.05$) among CO, VO₂max, HRmax, VEmax, body fat content, skeletal muscle mass, and waist: hip ratio; thus, indicating that the changes were significantly different between the groups.

DISCUSSION

The Korean government has been attempting to decrease the adult smoking rate below 29% by implementing new policies, such as raising the cost of cigarettes and placing graphic health warnings on cigarette packages¹). Despite these policies, the smoking rate of college students, in particular, has not been decreasing as much as other groups^{1, 2}). There are many health concerns related to smoking. One, in particular, is CO, which has a high affinity to chemically combine with Hb, thereby impairing the oxygen transportation capacity of smokers' blood, as well as affecting cardiorespiratory function and blood pressure^{3, 11, 12}). Smokers tend to have approximately 10% lower oxygen transportation capacity than non-smokers¹³). In addition, the associated higher level of carboxyhemoglobin increases the possibility developing coronary artery disease, cerebral infarction, chronic obstructive lung disease, and lung cancer^{14, 15}). On that basis, this study aimed to analyze the effects of participation in complex training on CO, cardiorespiratory function, and body mass among college students who were at the initial stage of stopping smoking. The results of this study show that exhalation CO levels decreased in both the experiment and control groups. Notably, the exhalation CO level of the experiment group significantly decreased from stage 4 (habitual smoker, CO level 16–25 ppm) to stage 1 (non-smoker, CO level 0–6 ppm). The control group also had a decreased exhalation CO level; however, the experimental group had a greater CO decrease. Complex training assisted in achieving this result by increasing blood circulation, transport of oxygen, heartbeat, respiration volume, pulmonary circulation, and perspiration. In addition, the experimental group showed significant increases in VO₂max, HRmax, and VEmax indicating multiple effects of the complex training program. In contrast, the control group did not show such increases. The results of this study are consistent with those in previous studies. Rode and Shephard¹⁶) examined the effect of smoking and abstinence from cigarette on the oxygen cost associated with hyperventilation. The hyperventilation oxygen cost was measured twice, immediately following smoking and after one day of abstinence from cigarettes¹⁶). After abstinence, the hyperventilation oxygen cost was 13–79% lower than that before abstinence¹⁶). Byun¹⁷) reported that 8 weeks of a combined exercise training program significantly improved VO₂max, body composition, and, in particular, body fat content among current smokers. Nam and Kang¹⁸) analyzed changes in CO level in two groups over a 12 week period. They¹⁸) found that those abstaining from cigarettes and exercising had a greater decrease of CO level than those abstaining from cigarettes but not exercising.

The results of the present study also showed changes in body fat (%), waist: hip ratio, and skeletal muscle mass (kg). The body fat content (%) decreased and skeletal muscle mass (kg) increased only in the experiment group. These results are consistent with those in previous studies^{19, 20}). Those studies^{19, 20}) suggested that complex physical exercise increases basal metabolism by developing skeletal muscles and such exercise also reduces obesity, diabetes, and many other chronic diseases. In addition, development of skeletal muscles reflects associated increases in mitochondria, oxidative enzymes, muscle capillaries, and muscle blood flow rate^{19, 20}). In conclusion, a complex physical exercise program would be an effective way to support a stop-smoking program as it can quickly eliminate CO from the body and improve cardiorespiratory functions and body mass. Therefore, this study provided practical data establishing the effective exercise program for people who are stopping smoking and want to improve their health (e.g., cardiorespiratory function, and body mass). However, this study only focused on male college students. Thus, future study needs to include diverse personal characteristics, such as age and gender.

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