Case Report

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체중조절을 위한 3주간 계단 오르기의 효과

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Effects of Three-Week Stair Climbing Exercise for Weight Control: A Case Series Study

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This study is designed to check whether everyday-life stair climbing, which is a low-cost and readily accessible form of exercise, is effective for reducing overweight of sedentary people in various health indicators. We selected four overweight people and measured body weight, body fat percentage, muscle quantity, pulmonary function, lower-extremity strength and volume of thigh muscle and fat. After 3-week exercise of climbing stairs in more than 5 minutes twice a day, same procedures were taken. Body weight was reduced by 3.35 kg on average (standard deviation [SD], 0.79), and body fat mass by 2.53 kg (SD, 1.36). Lower extremity strength improved about 5%, and slight loss of thigh fat (right 3.2%; left 13.4%) was observed. However, pulmonary function and muscle quantity did not grow significantly. Although only four people may not be representative as targets, but it is suggested that stair climbing has sufficient utility as an easily accessible exercise.

Keywords: Exercise, Overweight, Sedentary lifestyle, Lower extremity, Pulmonary function tests

Introduction

Obesity is a condition that substantially raises their risk of morbidity from hypertension, dyslipidemia, type 2 diabetes, coronary heart disease, etc[1)]. The majority of obese persons who develop atherosclerotic cardiovascular disease typically have a clustering of risk factors for metabolic syndrome[2)]. In 2010, overweight and obesity were estimated to cause 3–4 million deaths worldwide[3)]. In Korea, like other developed countries, the number of obesity population has been gradually increasing, which led to the prevalence of 31% in adult population (35%–36% in male, 25%–27% in female) since 2007[4)].

It is well known that reducing body fat is essential for treating

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obesity, which is achieved by continuous daily diet and exercise. There have been many studies about the effective ways to exercise for relieving obesity. Some of them claim that aerobic exercise such as walking and cycling is proper for obesity, while other claims strength exercise can help reducing body fat[5-7].

Stair climbing is a low-cost, inconspicuous, and readily accessible form of exercise which is associated with a reduced mortality in populations[8]. Despite these features, stair climbing as an exercise modality for resolving or reducing obesity has not been considered so far, while it is already useful tools for rehabilitating and enhancing lower limb power[9,10]. This study has been designed to check whether sequent, everyday-life stair climbing can be effective for the sedentary people in various health indicators.

Case Report

We selected four overweight people, who volunteered and have no other underlying condition, and informed consent was obtained from all of the subjects and the rights of the subjects were protected. The characteristics of the subjects are shown (Table 1).

We used Physical Activity Readiness Questionnaire to rule out unsuitable participants. We measured their body weight, body fat percentage, and muscle quantity via InBody. And we tested their pulmonary function by PFT, lower-extremity strength by Isokinetics (De Queen, AR, USA), volume of thigh muscle and fat by thigh computed tomography (CT). And after the 3-week exercise of stair climbing in more than 5 minutes twice a day, same procedures were taken. Participants were supposed to climb stairs of their apartments and workplaces without rest, and the interval between climbing or the method of going back down was arbitrary. There was no exercise instructor especially assigned.

Table 1. Physical characteristics of the subjects

Variable	A	B	C	D
Age (yr)	36	37	33	58
Sex	Female	Male	Female	Female
PAR-Q	–	–	–	–
Height (cm)	154	174	167	149
Weight (kg)	72.3	88.9	73.9	67.0
Body mass index (kg/m^2)	30.5	29.4	26.5	30.6
Body fat mass (%)	31.6	26.5	28.6	26.6
Muscle quantity (kg)	22.2	35.2	24.6	21.8
Pulmonary function tests				
FVC (L)	3.03	4.94	4.79	3.15
FEV_1 (L)	2.53	3.90	3.99	2.54
Volume of muscle and fat (by CT)				
Thigh muscle (Rt, mm^2)	11,158.42	16,890.19	9,815.86	10,003.57
Thigh muscle (Lt, mm^2)	10,850.97	17,492.72	10,171.19	9,955.67
Thigh fat (Rt, mm^2)	13,900.71	10,294.79	12,375.07	8,669.50
Thigh fat (Lt, mm^2)	13,857.45	9,450.47	12,737.36	8,774.56
Lower-extremity strength by Biodex				
Peak torque (60/sec, Rt, extension)	73.400	197.900	85.100	65.400
Peak torque (60/sec, Rt, flexion)	40.600	77.000	37.900	41.900
Peak torque (60/sec, Lt, extension)	56.200	206.800	51.100	57.400
Peak torque (60/sec, Lt, flexion)	45.300	75.900	19.200	41.500
Peak torque (180/sec, Rt, extension)	52.600	129.700	70.400	50.000
Peak torque (180/sec, Rt, flexion)	19.200	59.000	36.100	29.400
Peak torque (180/sec, Lt, extension)	41.000	139.900	64.200	45.500
Peak torque (180/sec, Lt, flexion)	23.000	52.500	32.700	34.300

PAR-Q: Physical Activity Readiness Questionnaire, FVC: forced vital capacity, FEV_1: forced expiratory volume in 1 second, CT: computed tomography, Rt: right thigh, Lt: left thigh.

The Seoul National University-Boramae Hospital Institutional Review Board approved this study.

1. Assessing obesity

We measured their body weight, and body fat percentage, and muscle quantity was assessed with eight-polar bioelectrical impedance (InBody 3.0, Biospace, Seoul, Korea).

2. Assessing pulmonary function

Pulmonary Function Test was performed using standard laboratory techniques according to guidelines by the American Thoracic Society. The vital capacity and its subdivisions were measured from a slow exhalation with a rolling seal spirometer (Sensormedics 2800, SensorMedics Co., Yorba Linda, CA, USA). Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) were obtained from forced expiration into the spirometer.

3. Assessing lower limb muscle strength

We measured the peak torque of extensor and flexor at knee joint via Biodex (Shirley, NY, USA) measuring right and left respectively in load speed 60 degree/sec and 180 degree/sec with extension and flexion five times and 10 times respectively.

4. Assessing thigh muscle and fat quantity

CT was used to measure cross-sectional area of mid-thigh bone, muscle, and fat tissue and to characterize muscle attenuation. With the subject supine, a 10-mm cross-sectional scan of both legs was obtained, located at the midpoint between the anterior iliac crest and the patella. In image analysis, area of bone, adipose tissue, and skeletal muscle were measured by selecting the following regions of interest, defined by the following attenuation values: ≥200 Hounsfield units (HU) for bone, −20 to −190 HU for adipose tissue, and 0−100 HU for muscle; mean muscle attenuation was determined from all pixels within this range.

5. Results

After 3-week exercise, the changes of subjects are shown (Table 2). The body weight of the four participants was reduced by 3.35 kg on average (SD, 0.79), and body fat mass by 2.53 kg

Table 2. Changes of subjects (average)

Variable	Before (A)	After (B)	Difference (SD)	Rate of change*
Weight (kg)	75.52	72.18	−3.35 (0.79)	−4.44
Body fat mass (%)	28.32	25.80	−2.52 (1.36)	−8.91
Muscle quantity (kg)	25.95	25.70	−0.25 (0.57)	−0.96
Pulmonary function tests				
FVC (L)	3.98	3.87	−0.11 (0.43)	−2.64
FEV_1 (L)	3.24	3.19	−0.05 (0.21)	−1.54
Volume of muscle and fat (by CT)				
Thigh muscle (Rt, mm^2)	11,967.01	11,941.32	−25.69 (159.5)	−0.21
Thigh muscle (Lt, mm^2)	12,117.63	11,925.29	−192.34 (244.2)	−1.59
Thigh fat (Rt, mm^2)	11,310.01	10,944.63	−365.38 (788.1)	−3.23
Thigh fat (Lt, mm^2)	11,204.96	9,698.05	−1,506.91 (982.6)	−13.45
Lower-extremity strength by Biodex				
Peak torque (60/sec, Rt, extension)	105.45	110.60	5.15 (17.54)	4.88
Peak torque (60/sec, Rt, flexion)	49.35	58.58	9.22 (8.66)	18.69
Peak torque (60/sec, Lt, extension)	92.88	97.78	4.90 (25.00)	5.28
Peak torque (60/sec, Lt, flexion)	45.48	52.38	6.90 (10.67)	15.17
Peak torque (180/sec, Rt, extension)	75.68	77.25	1.58 (12.97)	2.08
Peak torque (180/sec, Rt, flexion)	35.93	44.03	8.10 (9.01)	22.55
Peak torque (180/sec, Lt, extension)	72.65	74.10	1.45 (15.57)	2.00
Peak torque (180/sec, Lt, flexion)	35.63	40.60	4.98 (8.37)	13.96

SD: standard deviation, FVC: forced vital capacity, FEV_1: forced expiratory volume in 1 second, CT: computed tomography, Rt: right thigh, Lt: left thigh.
*Change rate=(B−A)/A×100.

(SD, 1.36). The slight loss of thigh fat (right thigh, 3.2%; left thigh, 13.4%) was confirmed by thigh CT, and strength of lower extremities was improved about 5%. However, the thigh muscle did not change significantly and FVC and FEV_1 were reduced by 2.6% and 1.5%, respectively. Although it seems that pulmonary functions of participants have decreased on average, the decrease results from that of one of four participants (subject C), which may be due to insufficient compliance in the test. And participants reported their pulmonary function to be improved subjectively, and no side effect or harm were reported due to the exercise.

Discussion

It has been already implied that stair climbing have close relationship with muscle strength or pulmonary function, the key factors of controlling overweight and obesity. There have been many studies about stair climbing as a test of muscle capacity or pulmonary function[8]. We, however, focused on the aspects of stair climbing as a modality improving physical function in itself. We performed a study before, in which we selected one male and one female subjects in their forties, measured their blood pressure, heart rate and oxygen saturation, let them climb up the 108 stairs in a subway station having no turn in 1 minute, and took same measurement. As a result, blood pressure of the male subject did not change significantly from 129/88 mm Hg to 122/71 mm Hg, whereas heartrate increased from 80/min to 106/min, and blood pressure of the female subject changed from 105/67 mm Hg to 115/78 mm Hg, heartrate from 69/min to 90/min. So, we could observe 60%−90% of maximum heartrate for the age, and infer that continuing stair climbing could be a proper form of aerobic exercise. After that, this study has been designed to check further effect of stair climbing in various health indicators, and it has the significance in inspecting direct relationships of those indicators.

But it might be jumping to the conclusion that climbing stairs has ‘proved’ to be effective for the weight loss only based on this study because of some limitations. Our study has intrinsic limitation in the fact that it is merely ‘case study.’ Only four people as a target may not be representative. As a matter of fact, this sample size cannot have statistical significance even with non-parametric test like Wilcoxon signed-rank test ($p>0.12$), and in order to assure statistical significance we require at least a sample size of 6 or more in Wilcoxon signed-rank test. In addition, the nutrition of subjects was not so strictly controlled that the possibility may not be ruled out that changes of indicator were affected by the diet. In fact, no significant growth of thigh muscle can be regarded as the effect of exercise alone not followed by adequate protein ingestion. In further study, homogenous group or the larger number of subjects will be needed for inspecting more sophisticated relationship. And still stricter diet control has to be introduced.

In our study, participants consist of the office worker, the housewives, one of whom became overweight after the childbirth, and all of them have sedentary life style in common. They have little extra physical activity except irregular leisure time of 1−2 times a month. But continuous climbing stairs for 3 weeks in daily life offers them benefits like losing body weight, strengthening of lower extremity and losing of thigh fat without separated physical activity. Despite all the limitations of this study, it can be suggested that stair climbing can be an effective way to lose weight for the people who have sedentary life style.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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