J Int Acad Phys Ther Res 2011; 2(2): 267-343
ISSN 2092-8475
www.iaptr.org
http://dx.doi.org/10.5854/JIAPTR.2011.2.2.301

The Effect of Treadmill Training with Elastic Bands on the Chest Expansion and Pulmonary Functions of Young Adults

Sang Wan Lim[a], Kyo Chul Seo[b]

[a]Pohang College, Pohang; [b]Graduate school of Daegu University, Daegu, Korea

Received : 29 April 2011
Accepted : 16 September 2011

Address for correspondence
Sang Wan Lim, PT, Ph.D
Department of Physical Therapy, Pohang College, 55 Jukcheon-dong, Buk-gu, Pohang, Korea
Tel: 82-54-245-1218
E-mail: swlim@pohang.ac.kr

The purpose of this study was an determine whether elastic band on treadmill training might effect the chest expansion and pulmonary function of the 20's men. 40 subjects with experimental group(male: 20) and control group(male: 20) was participated in experiment. During four weeks, each group participated thirty minutes for three times per week. Subjects were assessed using pre-value and post-value measurement chest length(chest length for resting, chest expansion) and pulmonary function(forced vital capacity, forced expiratory volume at one second, FEV1/FVC, peak expiratory flow, vital capacity, tidal volume, expiratory reserve volume, inspiratory reserve volume) by the CardioTouch 3000S(BIONET, USA). These findings suggest that experimental group can be used to improve chest expansion, pulmonary function than control group. In comparison of both groups, post-test was more improved in experimental group. In conclusion, experimental group helped improving function of pulmonary volume and respiratory muscle, and thus it indicates that the functions will be more improved through the continued respiratory exercise program.

Key words: *Elastic Band; Treadmill Training; Pulmonary Function*

INTRODUCTION

One of the largest hopes of humans as well as the root of happiness that is ultimately pursued by humans is living long healthily. Today, the average life span of humans is being extended since mortality rates due to infectious diseases and other diseases are decreasing thanks to epoch-making development of medicine and accordingly, interest in health is increasing because humans' desire for longevity(1). However, modern people's health is greatly threatened as the vital resistance of their bodies is decreasing due to the development of material civilization and increased ages, cardiac disorders and pulmonary disease are greatly increasing and they do not exercise sufficiently due to their busy daily life(2). In Korea too, adult diseases due to insufficient exercise are in a rapidly increasing trend because of excessive nutrition supply and automation as a result of economic growth(3).

The ultimate objective of sports science is maximizing the effect of exercise to improve the ability to perform exercise. Therefore, regular exercise performed every day shows the effects of benefits in health and normal human development and this has been proved in the physical and psychological aspects(4). Now, the fact that those who perform regular and active physical activities can enjoy good quality life is being accepted as a clear fact. Furthermore, America College of Sporets Medicine (ACSM) reported that exercise reduces even mortality rates and the occurrence of coronary artery diseases, hypertension, obesity, stroke, type 2 diabetes, osteoporosis, colorectal cancer, breast cancer, prostatic cancer and lung cancer(5).

Many experimental and epidemiological evidences have been reported indicating that regular aerobic exercise improves risk factors such as cholesterol, hypertension, blood sugar, etc. and enhances the functions of the heart and blood vessels to prevent or delay the progress of cardiovascular diseases such as coronary artery diseases(6). Methods to show the effects of aerobic exercise on cardiopulmonary functions and circulatory functions(7), while increasing aerobic abilities in a short time includes treadmill training, bicycle training, training by going up stairs and resistance exercise using elastic bands(8, 9, 10).

In particular, treadmill training has been mainly used in various kinds of experiments because of its advantages in that exercise loads can be adjusted by changing rotating speeds or gradients and thus not only exercise loads can be accurately figured out but also the same load can be imposed in the case of repeated measurement(11). Furthermore, there are reports indicating that regular treadmill training is effective in reducing the onset ratios of cardiovascular diseases(12) and that treadmill exercise uses many muscles and thus its exercise loads are large and therefore, it increased physical abilities through cardiopulmonary function exercise and systemic exercise, and reported that treadmill exercise with gradually increasing speeds increased heart rates and ventilation increased in normal persons(1).

Besides, resistance exercise includes exercise using dumbbells, barbells and weight training machines, elastic band exercise and underwater rehabilitation exercise and since the intensity of these exercises can be freely adjusted in line with muscle power or physical strength, these are tools that are widely used as kinesitherapy for sport trauma and disorders. Of them, the resistance exercise using elastic bands not only increases the range of motion of joints without giving burdens to joints or muscles but also is effective in increasing flexibility and muscle power and thus it can be said to be very effective for the development of functional movements in all persons including males, females, elderly persons and young people(13). The most important feature of elastic band training is that the sizes of loads can be freely adjusted and the direction of loads can be adjusted to all directions in 360°. The strength of bands can be freely adjusted with the color of bands, the width of bands held and the method to tie bands. The training uses the resistance of bands as loads and the resistance is determined by the degree to which the bands are pulled.

In particular, this is effective for increasing muscle power when this is done by elderly persons since the gravity given by elastic bands is not too large(14). Elastic band exercise showed effects mainly when it was performed by elderly persons(15, 16, 17), diabetes patients(18), rheumarthritis patients(19), those with ankle joint injuries due to strain(20) and chronic low back pain patients(21).

Thus far, aerobic exercise using treadmill training has been applied to diverse subjects and many study results have been shown including many studies to improve cardiopulmonary functions. However, no study that improved cardiopulmonary functions by grafting aerobic exercise through treadmill training on resistance exercise for the chest has been reported yet. Therefore, the purpose of this study is to examine the effect of treadmill training with elastic bands worn by the chest that can be easily accessed by normal persons or cardiopulmonary disease patients on the vital capacity.

METHODS

Subjects and Period

The subjects of this study were male students of P university selected between March 7, 2011 and April 15, 2011. The subjects were randomly assigned to a group(experimental group) to wear Therabands consisting of 20 students or a group(control group) not to wear Therabands consisting of 20 students. The study subjects were those who did not have surgical pathological findings based on medical examinations and tests, understood the intent of this study and agreed to participate in this study. The physical characteristics of the study subjects are as shown in Table 1.

Procedure

The experiment was conducted 5 times a week for 6 weeks and every session of the exercise was composed of 10min of warming up exercise, 40min of main exercise and 10min of cooling down exercise. Simple stretching was performed as the warming up exercise followed by treadmill training as the main exercise and simple stretching again as the cooling down exercise in order of precedence. The experimental group used Therabands, The Hygenic Co. USA as elastic bands. The elastic band was worn in the region of the xiphisternum in a sitting position(22) and tightened to reduce the circumference of the chest of the subject by 2.5% while giving a room on the upper area to the extent that a hand could go between the band and the chest. Then, using a treadmill as an aerobic exerciser(11), exercise was performed maintaining the speed of the subject at 4km/h on the treadmill(23).

Measurement of chest expansion

In order to measure the extent to which the chest is expanded during breathing, the chest circumference was measured using a tape measure. At each experimental position, the legs were straightened and the head and the trunk were maintained to make a straight line. After making the region of the chest circumference, a tape measure was placed to horizontally pass the junction of the xiphisternum and the mesosternum to measure chest circumferences during the rest when stabilized breathing is done, during deep inspiration and during deep expiration and the degree of chest expansion was calculated by deducting the value measured at the maximum expiration from the value measured at the maximum inspiration(24).

Vital capacity measurement

Vital capacities were measures at each position of the subject using a CardioTouch 3000S(BIONET, USA). For accurate measurement, sufficient explanations and demonstrations were provided so that the patients could understand before conducting the measurement. Based on the nature of the experimental group and the control group, rubber mouse pieces that can completely cover the mouth were used and the nose was pinched so that no air would go into or come out through the nose during the measurement. To measure pulmonary functions, the vital capacity(VC), the tidal volume(TV) at normal times, the inspiratory reserve volume(IRV), the expiratory reserve volume(ERV) and the inspiratory capacity(IC) were measured.

Data Analysis

In this study, data from 20 subjects in the experimental group and 20 subjects in the control group were analyzed. The measured data were analyzed using the SPSS win 12.0 program. The mean values and standard deviations of measured value by variable were calculated and differences in the measured values of breathing functions before and after the experiment between the experimental group and control group were compared by conducting paired t-tests. In order to explain the differences between the experimental group and control group, independent t-tests were conducted. Statistical significance level α was set to .05.

RESULTS

General Characteristics of the Study Subjects

The general characteristics of the study subjects were measured from 40 subjects in the experimental group and 40 subjects in the control group out of the 60 entire male subjects. The mean age of the experimental group was 21.60±1.30 years and that of the control group was 20.37±.51 years. The mean height of the experimental group was 175.70±6.90cm, and that of the control group was 172.72±5.45cm. The mean weight of the experimental group was 72.20±13.43kg and that of the control group was 61.50±4.42kg. In the test of differences in homogeneity between the experimental group and control group, there was no significant difference (Table 1).

Table 1. General characteristics of subjects

	Experimental	Control	P
Age(years)	21.60±1.30	20.37±.51	.86
Height(㎝)	175.70±6.90	176.72±5.45	.35
Weight(㎏)	72.20±13.43	61.50±4.42	.33

*p<.05

Comparison of chest expansion between before and after the experiment in the experimental group and the control group

When chest expansion between before and after the experiment in the experimental group was compared with that in the control group, it was shown that although the chest was expanded in both groups, during the rest, inspiration and expiration, there were significant differences in the experimental group($p<.05$) while there was no significant difference in the control group($p>.05$)(Table 2).

Table 2. A comparisons of chest expansion between pre and post value for experimentals and controls (cm)

		pre-test	post-test	t	p
Rest	Experimentals	94.00±4.13	97.45±5.76	4.62	.02*
	Controls	94.72±5.56	95.00±4.42	1.69	.11
DI	Experimentals	94.20±1.40	98.27±1.80	2.04	.02*
	Controls	95.72±1.71	97.31±1.00	1.54	.21
DE	Experimentals	94.20±1.32	95.90±1.74	2.10	.04*
	Controls	93.27±1.78	94.30±1.17	1.64	.21

*p<.05, DI: Deep Inspiratory, DE: Deep Expiratory

When changes in differences between the experimental group and the control group between before and after the experiment were compared, before the experiment, significant differences were shown during the rest and expiration(p<.05), while no significant difference was shown during inspiration(p>.05). After the experiment, significant differences were shown during the rest and inspiration(p<.05), while no significant difference was shown during expiration(p>.05)(Table 3).

Table 3. A comparison of chest expansion within groups in experimantals and controls (cm)

	pre-test		p	post-test		p
	Experimentals	Controls		Experimentals	Controls	
Rest	94.00±4.13	94.72±5.56	.01*	97.45±5.76	95.00±4.42	.01*
DI	94.20±1.40	95.72±1.71	.14	98.27±1.80	97.31±1.00	.04*
DE	94.20±1.32	93.27±1.78	.01*	95.90±1.74	94.30±1.17	.00*

*p<.05

Comparison of pulmonary functions between before and after the experiment in the experimental group and the control group

Based on the result of comparison of pulmonary functions between before and after the treadmill training in the experimental group and in the control group, although the functions were improved in both groups, in the experimental group, there were significant differences in all of TV, IRV, ERV, IC, VC(p<.05) while in the control group, there were significant differences in only IRV and ERV(p<.05) and no difference in TV, IC and VC(p>.05)(Table 4). When changes between before and after the experiment in the experimental group were compared with those in the control group, between the experiment, significant differences were shown in IRV and ERV(p<.05) while no difference was shown in TV, IC and VC(p>.05). After the experiment, significant differences were shown in TV, IRV, ERV and VC(p<.05) while no difference was shown in IC(p>.05)(Table 5).

Table 4. A comparisons of pulmonary function between pre and post value for experimentals and controls (ℓ)

		pre-test	post-test	t	p
TV	Experimentals	.57±.11	.68±5.76	2.62	.02*
	Controls	.63±.22	.69±4.42	1.69	.52
IRV	Experimentals	2.02±.51	2.39±.79	2.12	.02*
	Controls	1.89±.62	2.19±.65	3.22	.01*
ERV	Experimentals	2.29±.57	4.33±.46	2.10	.00*
	Controls	2.29±.14	3.46±.49	2.64	.00*
IC	Experimentals	5.85±.91	6.35±.67	2.55	.00*
	Controls	5.35±1.01	5.54±1.08	.92	.42
VC	Experimentals	6.42±.96	7.03±.74	2.75	.00*
	Controls	5.96±.96	6.19±1.03	1.03	.17

*p<.05, VC: vital capacity, TV: tidal volume, IRV: inspiratory reserve volume, ERV: expiratory reserve volume, IC: inspiratory capacity

Table 5. A comparison of pulmonary function within groups in experimantals and controls (cm)

	pre-test		p	post-test		p
	Experimentals	Controls		Experimentals	Controls	
TV	.57±.11	.63±.22	.17	.68±5.76	.69±4.42	.01*
IRV	2.02±.51	1.89±.62	.01*	2.39±.79	2.19±.65	.04*
ERV	2.29±.57	2.29±.14	.01*	4.33±.46	3.46±.49	.00*
IC	5.85±.91	5.35±1.01	.24	6.35±.67	5.54±1.08	.09
VC	6.42±.96	5.96±.96	.11	7.03±.74	6.19±1.03	.04*

*p<.05

DISCUSSION

Recently, it has been reported that regular exercise for long periods of time would bring about physiological and biochemical changes in human blood and hearts to improve the ability to produce energy and the ability for physical activities(25). They reported associations between pulmonary functions and exercise indicating that regular aerobic exercise affects the improvement of pulmonary functions and that compared to the ventilation when humans are at stable states, cardiopulmonary functions are promoted when exercise has begun.

In this study, among the subjects who were male university students in their 20's, the experimental group performed treadmill exercise wearing elastic bands on the chest. After the experimental group and the control group performed treadmill training for four weeks, it was attempted to figure out the effect of the exercise on respiratory functions through changes in the sizes of their chests, their vital capacities, tidal volumes at normal times, maximum expiratory speeds, inspiratory reserve volumes and expiratory reserve volumes.

Chest elastic bands for treatment outcomes were attached centering on the xiphisternum as a position to maximize the chest's ability to expand. Since walking speeds during treadmill training in a range of 3-6.5km/h were judged to be the most ideal values for active mass and the oxygen intake amount of the exercise, in this study, walking speed was determined as 4km/h(23). It was reported that, to be effective, the period of breathing treatment should by 4-12 weeks and training should be performed 2-5 times a week for 20-30min a time(26). In order to achieve the objective of this study, the experiment was conducted 5 times a week for four weeks so that the experiment would not affect other treatment programs when the subjects visited the hospital. The period was set to 4 weeks considering hospital visiting periods and this was consistent with the report in a study by Pyun et al. indicating that breathing kinesitherapy should be conducted at least for four weeks(27). Gozal et al. reported that the power of the respiratory muscles might decrease quickly when respiratory training has been stopped as shown in the experiment and this it is thought that more continuous exercise programs are necessary and that more studies should be conducted on more continuous effects by testing pulmonary functions again when a certain time has passed after stopping respiratory system physical therapy(28).

In this study, the experimental group and the control group performed treadmill training while the subjects in the experimental group were wearing elastic bands on their chests and the results of comparison of chest expansion and pulmonary functions were analyzed. Based on the results of comparison of chest expansion, although there were changes in chest expansion in both the experimental group and the control group, significant changes occurred in the experimental group. The significant changes occurred because the treadmill training with elastic bands worn on the chest directly affected the chest wall and the diaphragm and chest volumes could be increased through resistance muscle power training of inspiratory muscles for ventilation functions. This seems to be a finding that lung volumes, inspiratory muscles and expiratory muscles were improved through treadmill training with elastic bands.

The measurement of vital capacities shows indicators that reflect reserved abilities for ventilation and the patient is instructed to breathe as usual and then inspire maximally and expire slowly regardless of time as completely as possible to measure the vital capacity, inspiratory capacity, expiratory reserve volume, inspiratory reserve volume and tidal volume at normal times(29). Test results are generally considered normal if they are within ±20% of estimated normal values considering the gender, age, height and weight of the patient(30).

Lee et al. reported that in cervical spine injury patients, vital capacities increased while belly bands were used compared to when no belly band was worn(22). They reported that in this case, the degrees of compression should be to the extent that the waist circumference is reduced by 2.5% and 10% in a standing position and lying position respectively to improve the respiratory functions of cervical spine injury patients. Maloney reported that when quadriplegia patients wore belly bands during pulmonary function tests, their vital capacities, inspiratory volumes and expiratory volumes significantly increased compared to when they did not wear any belly bands(31). This report is considered to support the results of this study since considerable changes in pulmonary functions appeared when elastic bands were worn through this study.

Based on the results of this study, treadmill training with elastic bands directly affected chest movements and thus different changes in chest and pulmonary functions appeared. It is considered that the partial resistance against the movements of respiratory muscles resulting from the elastic band worn on the chest greatly affected chest expansion and pulmonary functions. Therefore, since treadmill training is frequently used in clinics as a therapeutic method, it is considered that if elastic bands worn on the chest is grafted on treadmill training through these data, better treatment effects will appear.

CONCLUSION

In this study, 40 healthy male university students were divided into an experimental group to gear elastic bands consisting of 20 students and a control group consisting of 20 students and their chest expansion(at rest, during deep inspiration, during deep expiration) and pulmonary functions (maximum expiratory rate, VC, TV at normal times, IC, ERV and IRV) were compared through treadmill training for four weeks and based on the results, the experimental group showed larger changes in chest expansion and pulmonary functions as elastic bands affected the movements of respiratory muscles. Therefore, treadmill training with elastic bands worn on the chest give more helps to the improvement of pulmonary functions such as lung capacities and volumes and it is considered that if continuous treadmill training with elastic bands is clinically applied to treadmill training, it will further contribute to the improvement of the efficiency of respiration.

REFERENCES

1. Kim K. Effects of endurance on cardiopulmonary function according to the exercise intensity. Korea Sport Research 2009; 17(6): 433–440.
2. Lakka TA, Venalarinen, JM, Raurama R. Relation of leisure–time physical activity and cardio respiratory fitness to the risk of acute myocardial infarction in men. N Engl J Med 1994; 330: 1549–1554.
3. Hwang HS, Choi HN, Jo YC. An Analysis to serum lipids , skin fold thickness, glucose and in elementary school students. Korea Journal of Physical Education 1994; 33(1): 411–423.
4. Lippincott W, Steven JK. Fox's Physiological Basis for Exercise and Sport, 6/E. McGraw–Hill Companies, Inc. 2002.
5. ACSM. ACSM's Guidelines for Exercise Testing and Prescription. Philadelphia, 2002.
6. ACSM. Exercise for patients with coronary disease. Med Sci sports Exerc 1994; 26(3): 1–5.
7. McArdle WD, Katch FI, Katch VL. Exercise physiology. Lea & Febiger, Philadelphia 1981; 21(16): 50–265.
8. Metz KF, AlexanderJ F. Estimation of maximal oxygen intake from sub–maximal work parameters. Res Q Exerc Sport 1971; 42: 187–198.
9. Astrand PO, Rhyming IB. A nomogram for calculation of aerobic capacity from pulse rate during submaximal work. J Appl Physio 1997; 7: 218–221.
10. Jung SD, Park JJ, Yang JH. Effects of elastic band exercise on functional fitness and physical activity Levels in older women. Korea Journal of Physical Education 2009; 48(6): 689–701.
11. Yun KS, Lee KO, Kim JY. The kinematic and kinetic analysis of treadmill gait with various inclination and speed. The Journal of Korea Society of Aerobic Exercise 2001; 5(1): 49–68.
12. Booth FW, Gordon SE, Carson CJ. Waging war on modern chronic disease: primary prevention through exercise biology(eds). J Appl Physio 2000; 88(2): 774–787.
13. Kim JD, Bae YH, Cha KS. The Scientific and Clinical Application of Elastic Resistance. Daehanmedia 2004.
14. Alan EM, Robert T, Janet KW. Efficacy of a home–based training program for older adults using elastic tubing. Eur J Appl Physiol 1994; 69(4): 316–320.
15. Kim HK. Effects of knee muscle power strengthening using thera–band on th balance control ability in the elderly. Dankook University 2003.
16. Jung AR. Effects of resistance exercise on improvement of muscular strength and endurance. Kookmin University 2004.
17. Lee YS. A study on the effects of exercise program using thera–band on the physical strength and the balance sensation relevant to health "Targeting aged men residing in the elderly nursing facilities". Dongguk University 2003.
18. Jung JH. The effects of aerobic exercise and muscle strengthen exercise of elderly patients with diabetes mellitus. Chungnam National University 2004.
19. Lee EN. Effects of brisk walking & muscle strengthening exercise using thera–band on pain, fatigue, physical function, and disease activity in patients with rheumatoid arthritis. Korean Aced Soc Rehabil Nurs 2001; 4(1): 84–93.
20. Seo JS. The effects of thera–band stretching exercise on range of motion and strength of the patients with ankle sprain. Kookmin University 2005.
21. Park HS. The effects of abdominal muscle strengthening exercise using elastic thera–band on range of motion and strength of the patients with chronic low back pain comparing before the electronic therapy and after th electronic therapy. Dankook University 2003.
22. Lee JH, Park CY, Jun JS. A study on the effect of time lapse after position change and abdominal band on pulmonary function in the cervical cord injuries. KAUTPT 1997; 4(3): 17–33.
23. Han SY. The Effect of forward walking and backward walking on quadriceps muscles with treadmill

inclination: surface electromyographic analysis. KAUTPT. 2005; 12(1): 63-70.
24. Lee JH, Kwon YJ, Kim K. The effects of chest expansion and pulmonary function of stroke patients after breathing exercise. J Kor Soc Phys Ther 2009; 21(3): 25-32.
25. Duffaux B, Assana G, Hollman W. The delayed effects of prolonged physical exercise and physical training on cholesterol level. Eur J Appl 1982; 48: 25-29.
26. British Thoracic Society Standards of Care Subcommittee on Pulmonary Rehabilitation. Pulmonary rehabilitation. Thorax 2001; 56(11): 827-834.
27. Pyun SB, Kwon HK, Kim KH. Improved pulmonary function in the cervical cord injured after respiratory muscle training. Korea Academy of Rehabilitation Medicine. 1994; 18(2): 302-310.
28. Gozal D, Thiriet P. Respiratory muscle training in neuromuscular disease: long-term effects on strength and load perception. Med Sci Sports Exerc 1999; 31(11): 1522-1527.
29. D'Angelo ED, Agostoni E. Statics of the chest wall. In roussos c, PT eds.(The thorax. 2nd ed., Dekker) New York 1995; 457-493.
30. Han YC. Clinical Respiratory. Komoonsa 1996.
31. Maloney PF. Pulmonary function in quadriplegia: effects of a corset. Arch Phys Med Rehabil 1979; 60: 261-265.