JACOBS PUBLISHERS

OPEN ACCESS

Jacobs Journal of Sports Medicine

Research article

The Effect of Core Muscle Strength Training on Lung Function Middle and Long Distance Athletes

Worasit Seaburin[1], Parichat Rirermkul[2], Ashira Hiruntrakul[3*]

[1] *Branch of Sport Science, Faculty of Science and technology, LoeiRajabhat University, Thailand*

[2] *Sports Science Research Section, Sports Science Centre, Sports Authoruty of Thailand*

[3] *Branch of Sport Science, Faculty of Apply Science and Engineer, KhonKaenUniverity, NongKhai Campus, Thailand*

**Corresponding author: Ashira Hiruntrakul, Branch of Sport Science, Faculty of Apply Science and Engineer, KhonKaenUniverity, NongKhai Campus, Thailand, Email: hashir@kku.ac.th*

Received: 08-22-2016

Accepted: 09-20-2016

Published: 09-29-2016

Abstract

The respiratory muscle training is a form of lung functions' development. However, the main breathing muscle training is quite difficult because the breathing muscle is tiny and its position is complex which is harder to do the training. The core muscles are the accessory muscles in respiratory system. The muscles are bigger and easier to design training. The objective of this study is to determine the effects of core muscle strength training on lung function of the middle and the long distance athletes after the 12-week training. The 34 participants in this study as trainees were divided into groups to practice athletics which are a core muscles strength training group and a control group that practice only athletics The fitness and lung function parameter were measured before training in week 8, week 10, and week 12. The data obtained from the samples were statistical analized with the Repeated Measure one-way ANOVA, whereas, the data comparing between samples were analyzed with the two-way ANOVA at a significance level of 0.05. The results showed that when comparing the data within the control group, there were higher rates of the maximum voluntary ventilation (MVV) (186.65 ± 17.78, 168.54 ± 28.70 l/min), the force vital capacity (FVC) (4.46 ± 0.56, 4.15 ± 0.55 l), the average length chest wallat rest and inhalation (84.44 ± 3.80, 81.12 ± 3.84 and 88.82 ± 3.86, 85.18 ± 3.96 cm.), respectively. In addition, we found that the oxygen consumption in the experimental group had increased higher since week 8 (39.46 ± 4.28, 43.49 ± 3.77 ml/kg/min). In Conclusion, after the 12 weeks of the core muscles strength, the respiratory rate, ventilation, work of breathing, lung volume and the oxygen consumption were improved better according to the training program.

Keywords: Lung Function; Core Muscle Strength Training

Introduction

The middle and the long distance athlates require a physical performance, muscle function in both the anaerobic and aerobic form. The performance of the athlete, running middle distance and long distance by lung and heart, is associated with respiratory and circulatory systems. Respiration is one of the important components of physical fitness. The supply of oxygen to the muscles to the blood and excrete waste to keep my balance acidic - pH of blood is constant. Oxygen is approximately 250 ml/min but when a hard workout. It can take more oxygen to 30 times in order to supply enough oxygen for metabolism, absorption is increased and the elimination of the oxygen out in the general rate of oxygen is increased three fold to exercise, Light or vigorous exercise 8-12 times (2-3 liters / minute), but if the athlete performance in oxygen consumption is higher than normal. During heavy exercise the rate may be increased up to 16-20 times (4-5 L / min). The rate of oxygen consumption will vary according to the intensity of the workout. The most important part is the breathing muscles that help breathing, consisted of a group of muscles, including the diaphragm muscle, intercostals muscle which acts on the breath include quiet inspiratory, forces breathing and deep inspiratory and the muscles on the exhale. Expiratory muscles contain relaxed expiratory and forces expiratory by the respiratory muscles, the abdominal muscles are the most important issue. The contraction of this muscle makes rib knit together Body and curved increased pressure in the abdomen. Push up on the diaphragm muscle. This muscle performed in children such as coughing and vomiting or while exercising in a continuous and very heavy. Lung function will change when training. Therefore, those who practice it will change the respiratory rate, ventilation, work of breathing, lung capacity, the ability to spread the gas, oxygen transport. However, the respiratory muscle training is quite difficult. Especially for the main muscle used in breathing, which are the muscles are small and are in a position to train even harder. The trunk muscles are muscles sticking in the ribs and chest. Muscles are easier to design training. So strength training, muscular body is likely to affect pulmonary function. It is necessary to develop the capacity of the physical fitness of athletes another way.

Objective

The objective of this study is to determine the effects of core muscle strength training on lung function of the middle and the long distance athletes after the 12-week training.

Material and Methods

The participants of this research study were the 34 middle and long distance athletes, aged 19-24 years. All of the participants have been approved by the Human Research Ethics Committee, KhonKaen University. The middle and long distance athlete as the participants are healthy and disease free as they will have a barrier to exercise with the body mass index ranged from 18.5 to 25.0 kg/m2. The exclusion criteria underlying disease related to the respiratory system and the injuries that can not be trained.

Volunteers signed a consent form and were messured for the following imformation; Parameter measured length chest by tape, pulmonary function tests using spirometer (Pony FX Spirometer complete, C09062-01-99)for the maximum voluntary ventilation (MVV), the force vital capacity (FVC.), the forced expiratory volume in the first second (FEV1) and the FEV1/FVC%, The oxygen consumption test was messured using Astrand and Ryhming approach with bike work MONARK, 820E; and heart rate monitor (Polar, F6 Denim Stone) was tested for totally four times before the trial, week 8, week 10, and week 12. The participants were divided into two groups of 17 by means of a simple grouping (randomly assignment) which were the control group and the experimental group practicing athletics alone. Athletics exercises with core muscle strength training.

Position	Week 1-3		Week 4-6		Week 7-9		Week 10-12	
	time	set	time	set	time	set	time	set
Sit up	10	3	10	4	12	3	12	4
Front Plank	10	3	10	4	12	3	12	4
Side Bench	10	3	10	4	12	3	12	4
Crunches	10	3	10	4	12	3	12	4
Push up	10	3	10	4	12	3	12	4
Lateral Bridge	10	3	10	4	12	3	12	4
Back extension	10	3	10	4	12	3	12	4
Leg rise	10	3	10	4	12	3	12	4

Table 1. Core muscle strength training program.

Data Analysis

This research used data analysis with statistical methods by using SPSS compare the difference of the average of their ability to breathe. The samples were collected before and after the week 8, 10, and 12 with Repeated Measure One-way ANOVA and the difference in the ability to breathe was compared. The data obtained from the samples were collected before and after the week 8, 10, and 12 with Two-way ANOVA at a significance level of 0.05.

Results

The objective of this study was to determine the effects of strength training on the lung function after the 12-weeks training of the 34 middle and long distance athletes, aged 19-24 years. The results of the study were as follows.

Table 2 shows that when comparing between the experiment and control groups; the difference of the comparison was not statistically significant at the 0.05 level of the average age, weight, height, BMI, percent body fat, and resting heart rate before training. When considering the data within the group, it was found that the average age, weight, height, BMI, percent body fat and heart rate at rest before training, week 8, week 10, and week 12 were not different with statistical significance .05

Table 3 illustrates the comparison between the experiment and the control groups. The comparing results found that the average length chest at rest, maximum length chest, capable of maximum oxygen consumption, and lung capacity before training were not different at the statistical significance .05. However, There was changing at week 8, week 10, and week 12 of the trial, the average length chest resting experiment group (84.44 ± 3.80, 84.29 ± 4.05, 83.71 ± 4.19) and control group (81.12 ± 3.84, 80.47 ± 3.62, 80.38 ± 3.28) and while breath

Parameters	Before	Week 8	Week 10	Week 12
Age(years)				
Experiment group	20.88 ± 0.70	20.98 ± 0.70	21.08 ± 0.70	21.18 ± 0.70
Control group	20.71 ± 0.77	20.91 ± 0.77	21.01 ± 0.77	21.11 ± 0.77
Weight (kg.)				
Experiment group	63.08 ± 6.10	62.89 ± 5.90	62.95 ± 5.86	61.72 ± 4.29
Control group	59.54 ± 5.05	59.08 ± 5.48	59.02 ± 5.49	58.88 ± 5.22
Height (cm.)				
Experiment group	170.47 ± 4.49	170.47 ± 4.49	170.47 ± 4.49	170.47 ± 4.49
Control group	169.44 ± 5.12	169.44 ± 5.12	169.44 ± 5.12	169.44 ± 5.12
BMI (kg/m^2)				
Experiment group	21.69 ± 1.77	21.63 ± 1.73	21.65 ± 1.70	21.23 ± 1.22
Control group	20.74 ± 1.51	20.57 ± 1.56	20.55 ± 1.55	20.50 ± 1.46
% Fat				
Experiment group	16.42 ± 3.55	16.71 ± 4.05	16.46 ± 4.20	16.41 ± 4.08
Control group	16.60 ± 2.88	16.55 ± 3.38	16.88 ± 3.26	16.68 ± 3.06
Resting heart rate (beat/min)				
Experiment group	75.65 ± 10.94	77.06 ± 7.18	72.53 ± 4.90	72.29 ± 4.50
Control group	77.41 ± 12.16	76.76 ± 12.15	72.24 ± 11.56	70.35 ± 9.70

Table 2. Basic characteristic data: Control group (N=17) and Experiment group (N=17)

Parameters	Before	Week 8	Week 10	Week 12
Resting chest length (cm.)				
Experiment group	83.38 ± 3.35	84.44 ± 3.80†	84.29 ± 4.05†	83.71 ± 4.19†
Control group	81.35 ± 3.24	81.12 ± 3.84	80.47 ± 3.62	80.38 ± 3.28
Maximum chest length (cm.)				
Experiment group	87.44 ± 4.05	88.82 ± 3.86†	89.29 ± 4.04†	88.56 ± 4.05†
Control group	84.90 ± 3.67	85.18 ± 3.96	85.21 ± 3.82	85.06 ± 3.79
VO_{2max} (ml/kg/min)				
Experiment group	39.46 ± 4.28	41.85 ± 3.40	43.49 ± 3.77*	47.08 ± 3.80*
Control group	40.89 ± 6.92	42.96 ± 7.64	41.70 ± 6.80	44.31 ± 5.59*
Lung capacity (l)				
Experiment group	3.57 ± 0.64	3.76 ± 0.48	3.83 ± 0.43	3.84 ± 0.42
Control group	3.37 ±0.49	3.46 ± 0.42	3.58 ± 0.41	3.53 ± 0.33

* average after training different significantly from before training $p < 0.05$.

† average of the experiment group different significantly from control group $p < 0.05$.

Table 3. Physical fitness parameters

ing fully experiment group (88.82 ± 3.86, 89.29 ± 4.04, 88.56 ± 4.05) and control group (85.18 ± 3.96, 85.21 ± 3.82, 85.06 ± 3.79) were higher.

The comparison winthin the control group was different with the statistically significance .05; but the ability in using oxygen up, and lung capacity in week 8, week 10, and week 12 was not different. When comparing the average within the group, the average length chest at rest while breathing fully before training in week 8, and week 10, and week 12 did not differ with the statistical significance .05. However, it was found that the ability of maximum oxygen consumption was higher with statistical significance at 0.05 in week 10 and week 12, experiment group compared to before training (39.46 ± 4.28, 43.49 ± 3.77, 47.08 ± 3.80). For the control group, the average length chest at rest, while breathing fully, and lung capacity before training, week 8, week 10, and week 12 were not different, statistically significant at .05. On the other hand, there was the differences in maximum oxygen capacity found increased significantly at .05 at in week 12, compared to before training (40.89 ± 6.92, 44.31 ± 5.59)

Table 4 displays the comparison between the experimental group and the control group in the ability to breathe maximum voluntary ventilation (MVV) before training, week 8, and week 10.

The result found that there was no difference statistically significant at .05. At week 12, the MVV was high. The difference is statistically significant at .05 in the experimental group and the control group (186.65 ± 17.78, 168.54 ± 28.70) respectively,

while the FVC (Forced Vital Capacity) before training, week 8, week 10. , and 12 weeks were not significantly different .05 between the treatment and the control groups.

At Week 12, the FVC increased significantly at the level of 0.05 in the experimental group and the control group (4.46 ± 0.56, 4.15 ± 0.55), respectively. When comparing the average FEV 1 (Forced Expiratory Volume in. one second) before training, week 8, week 10, and week 12, there were no differences were statistically significant at 0.05. When comparing to the average FEV 1 / FVC% before training, a week. 8, week 10, and week 12, the result showed no difference statistically significant at .05.; the average rates of FEFmax (PEF) before training weeks 8 weeks 10 and week 12 were no difference statistically significant at .05.

The comparision of the ability of breathe maximum voluntary ventilation (MVV) before training, week 8, week 10, and week 12 of treatment found that there was higher significance level of 0.05, as well as the control group of the FVC

Parameters	**Before**	**Week 8**	**Week 10**	**Week 12**
MVV (l/min)				
Experiment group	165.48 ± 15.35	179.44 ± 15.55*	185.85 ± 16.27*	186.65 ± 17.78*†
Control group	160.21 ± 27.20	167.71 ± 28.76*	170.24 ± 28.96*	168.54 ± 28.70*
FVC (l)				
Experiment group	4.46 ± 0.51	4.43 ± 0.53*	4.36 ± 0.53*	4.46 ± 0.56*†
Control group	4.26 ± 0.50	4.12 ± 0.52	4.01 ± 0.54*	4.15 ± 0.55
FEV1 (l)				
Experiment group	3.87 ± 0.40	3.84 ± 0.42	3.78 ± 0.43	3.90 ± 0.48*
Control group	3.73 ± 0.50	3.63 ± 0.52	3.50 ± 0.48*	3.62 ± 0.53*
FEV1 /FVC%				
Experiment group	86.71 ± 5.52	86.59 ± 5.11	86.76 ± 5.18	87.35 ± 5.23*
Control group	87.13 ± 5.23	87.47 ± 5.48	86.59 ± 4.29	86.82 ± 6.58
$FEF_{25-75\%}$ (l/min)				
Experiment group	4.44 ± 1.02	4.33 ± 0.97	4.28 ± 1.04	4.49 ± 1.16
Control group	4.32 ± 1.11	4.43 ± 1.22	4.14 ± 1.14	4.19 ± 1.31
FEF_{max}(PEF) (l/min)				
Experiment group	9.57 ± 1.17	10.30 ± 1.30*	10.54 ± 1.20*	11.00 ± 1.48*
Control group	8.92 ± 2.04	9.59 ± 1.62	9.50 ± 1.50	10.13 ± 1.68*

***** average after training different significantly from before training $p < 0.05$.

† average of the experiment group different significantly from control group $p < 0.05$

Table 4. Lung function parameters

(Forced Vital Capacity), the volume of air blown out was as same as the full after inhaling fully before training, week 8, week 10, and week 12 experimental group and the control group showed a different significance level of 0.05. Likewise, when comparing the groups of the FEV 1 (Forced Expiratory Volume in one second.), the volume of air blown out was faster in the second one before training and 12 weeks of treatment; it showed that the increase is statistically significant at 0.05 (3.87 ± 0.40, 3.90 ± 0.48). At the meanwhile, the control group decreased significantly at.05, comparing to the previous practice, week 10, and week 12 (3.73 ± 0.50, 3.50 ± 0.48, 3.62 ± 0.53), respectively, when. Compare the inside of the FEV 1 / FVC% is the percentage of the volume of air blown out in the first second to the volume of air blown into force as soon as possible.

It reveals that the experimental group had increased significantly between both groups before training and Week 12 (86.71 ± 5.52, 87.35 ± 5.23), while the control group showed no differences statistically significant at .05 The results of the FEFmax (PEF) before training, week 8, week 10, and week 12 found that the increase is statistically significant at the .05, while the control group showed an increasing statistically significant at the 0.05 level of the before and week 12 (8.92 ± 2.04, 10.13 ± 1.68)

Discussion

This research study focuses on the investitgation of the effects of core strength training on the lung function after 12 weeks were carried out among the 34 middle and long distance athletes aged between 19-24 years. The participants were divided into groups with randomly assignment experimental train as usual with the training program with core strength training and control group. The training took only three days a week for 12 weeks to compare the different results of the pulmonary function between the treatment and control groups. The results of training found that at week 8 and week 10, mean pulmonary function (MVV, FVC, FEV1, FVE1 / FVC, PEF, FEF25-75%) did not differ statistically significant at the 0.05 level due to the time required. In a few studies Athletes who train regularly have to rely on oxygen and nutrients to the muscles adequately. Thus, the work of muscles, while middle distance runner, a mixed work requires physical work in a way does not use oxygen. Oxygen together Rehearsals for the production of the two energy systems of the body can produce energy and adequate demand by required strength, endurance and muscle strength, as well as the ability of the nervous system, muscles and the circulatory system. According to the performance of the athlete, running middle distance and long distance, the athletes who want to add more oxygen respond by increasing the function of the respiratory system and heart. The increased amount of oxygen results on muscle function increases; and as an athlete who trained well in the short term may have any changed because of the dysfunction of the lung. The duration of training in pulmonary function should be extended and continued for at least 12 weeks or three months to see the results changing for the better application with Legg and Cruz [1] in which the study investigated the effects of the shoulder back pocket that affects pulmonary function into two groups: one bag with strap chest strap and the bag with two straps, chest strap The results showed that the mean FVC, FEV1, FEV1 / FVC, and PEF were not statistically different. Stephanie J. et al [2] studied the effect of the intensity of respiratory muscle training on lung function and the ability to work with people who were healthy. The training took three days a week for eight week and there was no significant difference statistically consistent with Hathairat Sikom and colleagues [3] who studied the effects of practicing qigong together with an elastic band around the chest on lung function in people. Among the seniors aged between 60-80 years, the 30 people of them have found that the average lung function six weeks the three groups was not different with any statistical significance.

In week 12, the researchers found that the MVV and the FVC were different with statistical significance between the experimental groups more than the control group. The experimental group strength training, muscular body affects the ability to breathe. The specific strength training needs to be considered choosing the exercise that causes stiffness and strength in the muscles used in sports coaching as well as the acting on a set number of times and weights used in practice in accordance with the highest quality strength training to create a positive effect on muscles. It is very important to prepare the body to be properly basic steps of the principles and methods of training runs from light to heavy. By gradually increasing the intensity up gradually on the basis of ability levels gradually. It was developed to increase sequentially the resistance training to strengthen the muscles as well as require a foundation by defining a small proportion of heavy or hard to train relative to the amount of time and number of copies [4,5] in strength training, muscular body while practicing the breath; Breathing - exhaling regularly and continuously deep inspiration, Increasing carbon dioxide and increasing the amount of oxygen in a body, and Breathing deeply from the abdomen through the movement of the diaphragm to stimulate the nerve pairs 10. In addition, the experimental group, the strength of the core, called power zone when the administration is giving strength, muscular body and forced breath. Breathing is forced (forced breathing; hyperpnea) breathing this way. The volume of air that flows out to be increased more than a breath can be stimuated by cranial nerve 10. The state wants to breathe in the air to leave the lungs as much volume as the state with the use of force or exercise more. As a result, breathing in the desired pattern of airflow through the lungs rather than the exception in accordance with Stephanie J. et al [2] who studied the effect of the intensity of respiratory muscle training on pulmonary function and ability, as well as, Hathairutand colleagues [3] who studied the effects of practicing qigong together with an elastic band around the chest on pulmonary function in the elderly. The Pulmonary function test (MVV, FVC, FEV1, FEV1 / FVC) and three groups of training weeks 6 and 12 were monitored. The results showed, after the 12 week, the average MVV between the control group and the experimental group was different significantly at the 0.05 level in the breathing rhythm into the muscles active process diaphragm and the muscles between the ribs outside the need to work more in order to reduce the pressure inside the lungs, breasts. Intrapulmonary pressure is less than atmospheric pressure so that the air flows into the lungs. While exhaling mechanism is in the muscle contraction and relaxation of the muscles of the rib. Ribs and sternum, lower level lower diaphragm loosen the pressure of the chest cavity and lungs inflated lungs deflate the air are expelled from the lungs; the stomach will flatten down on the strength of the muscle. The samples training regulary will result in better ventilation. Increased durability of the muscles used for breathing. The muscles used in breathing are very strong, especially the diaphragm and the muscles between the ribs consistent with the study of Barnas et al. [6] on the expansion of the wall of the chest by straining chest at the ribs and. Belly of the volunteers were 6 Results showed that the increase of the expansion phase of the breasts.

The comparison within the group reveals that the MVV, FEV1 and FEFmax (PEF) increase of the experimental group and the control group before training, week 8, week 10, and week 12 are different with statistical significance at the 0.05 level, since both groups are athletes running middle distance and long distance training about the durability of the respiratory and circulatory disorders by affecting the ability to breathe. There is no difference between the groups at week 12 because the exercises used to train the muscles could help them breathe. Breathing techniques are applied to the body, especially the muscles to be strong exhaling the body core muscle groups. It also found that respiratory muscle training can increase their ability to breathe. Reducing dyspnea and increased ability to exercise a level nearly maximum [7] mechanism helps explain the strength of the respiratory muscles, chest muscles, diaphragm and rib muscles seized outside a structural change by increasing muscle mass increased respiratory muscle strength [8]. It is consistent with the study on the effects of respiratory muscle training with a weighted differently with heart rate during exercise and perception of fatigue. He found that respiratory muscle strength increases [9].

The research study also found that the resting length chest and maximum length chest with the difference between the experimental and the control group at week 12 were significantly the level of 0.05 to strength training. Trunk muscles affect the length of the chest while breathing at rest and with increasing size. The expansion of the chest rise after being trained for such expansion may result from respiratory muscles. Similarly, Kendall, McCreary and Provance [10], said that the change of the respiratory muscles and the breasts that grow as a result of muscle strength increased. The strength can generate breathing while forced inspiration helps lift the breasts in front - back. This is consistent with the findings of Minoguchi, Shibuya, Miyagawa et al, [11] that the effect of stretching the chest muscles and respiratory muscle training was investigated and found that stretching the chest can make the breasts grow more muscle training, breathing and movement of the upper limbs (Upper extremity movement) to twist your body (Trunk rotation), Technical ventilated (Ventilatory movement strategies) and increase mobility can be used to increase the expansion of the chest [12]. It can be said that the expansion of the chest increased as a result of respiratory muscle strength increased. Additionally, the muscles surrounding the airways in the body is associated with breathing in and out

It is also found that the ability to use up oxygen in the experimental group increased from week 10 higher than before training. While the control group changes at week 12 showed that increasing the strength of the trunk muscles, resulting in changes in the way of their ability to use oxygen maximum, which could be a result of the measures chest enlargement to include lung capacity improved when the trunk muscles strength uniformly affect breathing muscles with greater strength, particularly the diaphragm and the muscles between the ribs. This result shows that the core muscles affect the length of the chest, according to the theory of strength training of the muscles. The practice is found to change significantly as muscles grow larger in size determined by the cross-sectional area. And tightness of muscles is key corresponds to Charoen [5] who noted that weight training exercise that follows the rules of use and do not use (Law of use and disuse) to train the muscles to work against. The results of the training is to increase muscular strength, endurance, more in line with Fox and Mathews [13] and Heyward [14] stated that the physiological changes resulting from weight training. And training with resistance is the shape of the muscles, nervous system biochemistry increase CP and ATP also grow [15] said, what is the point of the toning of muscle fibers resulting. Strength training is coming from. The hypertrophy of muscle fibers is the result of increasing the size of a small fiber (Myofibrils) as well as muscle or other words. Increasing the number of actin and myosin serves as a source of strength in the muscle contraction. The size of the muscle fibers has been developed with the size and strength increases with strength training is required.

Conclusion

The effect of core muscle strength training on lung function in the middle and long distance athletes after training 12 weeks showed that strength training of the trunk muscles, resulting in the MVV, FVC higher compared to the control group. And it is found that the FEV1, FEV1/FVC% and FEFmax (PEF) are higher compared within the group. Moreover, strength training for muscular body has resulted in the average resting and maximum length chest, including the oxygen consumption, were higher as well. It is based on the hypothesis that the lung function is changed when training. Thus, the practice will change respiratory rate, ventilation, work of breathing, lung volume, and time spent in training lung function should take a longer period to at least 12 weeks or three months. It is necessary to develop the capacity of the physical fitness of athletes another way. The further studies required to work on the further physiological changes. They subjects of the study can be the different types of sports and other activities that affect the control training on pulmonary function.

References

1. Legg S. and Cruz, C. Influence of backpack straps on pulmonary function. Ergonomics. 1999, 31(3):349-353.

2. Stephanie JE, and Viswanath BU. Effect of inspiratory muscle training intensities on pulmonary function and work capacity in people who are healthy: a randomized controlled trial; 2011, 91(6): 894-905.

3. Sikom H, Pataropatt V, and Roungthai R. Effects of Tai Chi Exercise with Elastic Chest Wall Restriction upon Pulmonary Function in the Elderly. Kamphaengsean Acad. J. 2010, 8(2): 64-79.

4. Paulette B. Strength training for Coaches. Illinois: Leisure Press. 1991.

5. Krabuanpatana C. Weight training. Bangkok: Department of sport science, Faculty of Education Kasetsart University; 2001.

6. Barnas M and JA. Agility and Conditioning of the San Francisco. 49ers strength and conditioning. 1996, 18(4): 10-16.

7. Watsford ML, and Murphy AJ. The effects of respiratory muscle training on exercise in older women. J. Aging Phys. Act. 2008, 16(3): 245-260.

8. Ramirez-Sarmiento A, Orozco-Levi M, Guell R, Barreiro E, Hernandez N. et al. Inspiratory muscle training in patients with chronic obstructive pulmonary disease: Structural adaptation and physiologic outcomes. Am. J. Respir. Crit. Care Med. 2002, 166(11): 1491-1497.

9. Gething AD, Passfield L, and Davies B. The effects of different inspiratory muscle training intensities on exercising heart rate and perceived exertion. Eur. J. Appl. Physiol. 2004, 92(1-2): 50-55.

10. Kendall FP, McCreary EK, and Provance PG. Muscles, testing and function: With Posture and pain. Baltimore, Md: Williams & Wilkins; 1993.

11. Minoguchi H, Shibuya M, Miyagawa T, Kokubu F, Yamada M. et al. Cross-over-comparison between respiratory muscle-stretch-gymnastics-and-inspiratory-muscle-training.Intern Med. 2002, 41(10): 805-12.

12. Frownfelter DM M. Facilitating ventilation patterns and breathing strategies. In: Frownfelter D, Dean E, eds. Cardiovascular and Pulmonary Physical Therapy Evidence and Practice, 4th edition. St. Louis, MO: Mosby & Elsevier Health Sciences: Chapter 23. 2006, 377-403.

13. Fox EL and DK M. The Physiological Bases of Physical Education and Athletics. 3rd edition, Philadelphia: Saunders college Publishing; 1981.

14. Heyward VH. Advanced fitness assessment & exercise prescription. 2nd edition. Champaign, IL: Human Kinetics; 1991.

15. Krabuanpatana C. Elastic training. Bangkok: Grand Sport Group Co.Ltd, Thailand, 2008.