Gastroesophageal Reflux Disease in Push Up and Sit Up Exercise

BJ Waleleng, D Takaendengan, N Tendean W

Division of Gastroentero-hepatology, Faculty of Medicine, University of Sam Ratulangi
Prof. dr. RD Kandaou Hospital, Manado

ABSTRACT

Background: *Several factors involve in GERD are hypotension of Lower Esophageal Sphincter (LES), Transient Lower Esophageal Sphincter (TLES) relaxation, delayed gastric emptying and esophageal hiatal hernia. Bent over and supine position like push up and sit up exercise in this study, are known as trigger factors for GERD which can cause hypotension of the LES, TLES relaxation and transdiaphragmatic pressure resulted in increased diaphragmatic nerves activation.*

Aim*: The purpose of this study was to investigate the occurrence of GERD in push up and sit up exercise.*

Materials and Methods: *This is an experimental study; subjects were healthy male aged 18-21 years. Patients data were collected after fulfilling the selection criteria as described in the study protocol. ÷² analysis or Fischer's exact test analysis was applied to determine the statistical significance of difference between push up and sit up. There were 30 subjects in the study, 15 subjects in push up group and 15 subjects in sit up group.*

Result*: Three subjects (10%) were dropped out and 27 subjects (90%) were endoscopied. In the sit up group, 13 subjects (87%) were endoscopied, 9 subjects (70%) had normal endoscopy and 4 subjects (30%) had mucosal breaks. In push up group, 14 subjects (93%) were endoscopied, 6 subjects (43%) had normal endoscopy and 8 subjects (57%) had mucosal breaks. There was no significant difference between push up and sit up group with ÷² analysis or Fischer's exact test (p = 0.322).*

Conclusion*: There was more likely GERD in push up group than in sit up group, but the difference was not significant.*

Keywords*: push up exercise; sit up exercise, gastroesophageal reflux disease (GERD)*

INTRODUCTION

Gastroesophageal reflux disease (GERD) is the flow back of gastric contents into the distal esophagus and exposes the esophageal mucosa to gastric fluid and can arise gastrointestinal symptoms.[1] This condition is the consequence of anatomical and physiological disorder involved in antireflux mechanism in esophagus and gaster. Basically, gastrointestinal reflux is a normal physiological process which happens for about 1 hour daily in normal individual. The reflux does not occur continuously due to anatomical barrier, which consist of lower esophageal sphincter (LES), crural diaphragm and phrenoesophageal ligament.[2]

The condition has high incidence rates in the West. In the last few years, expert's attention to GERD has been increasing. In Taiwan, Malaysia and Japan, it was reported that patients with GERD accounted for 13.4-16.3%. At Cipto Mangunkusumo hospital Jakarta, Syam, et al reported that there was an increased prevalence of GERD from 5.7% in 1997 to 25.18 in 2002 (mean 13.13%).[3,4]

The pathogenesis of GERD is complex and multifactorial. Some factors underlying this process is hypotension of LES, transient lower esophageal sphincter relaxation (TLESR), delayed gastric emptying and the presence of esophageal hiatal hernia.[2,5] There are several factors which affect LES tension. Factors which can increase LES tension are drugs such as á-adrenergik agonist, antacides, cholinergic agonists,metoclopramide, prostaglandin F2, high protein diet. Factors which decrease LES tension are estrogen, progesteron, anticholinergic agents, barbiturat, calcium antagonists, caffeine, diazepam, dopamin, meperidin, prostaglandin, theophyllin, mint, chocolate, ethanol and fats.[2] Another theory is LES relaxation phenomenon which does not preceded swallowing process which is called TLESR. The TLESR process can happen spontaneously or is

associated with gastric distention by pharyngeal stimulation through vagal reflex.[6] Esophageal hiatal hernia can cause pressure in phrenoesophageal ligament and affects normal antireflux mechanism, and affects gastric emptying functionality. Size or width of hernia is correlated with severity of esophagitis.[2]

Bending position and supine is the trigger of GERD, in which with such position there will be hypotension of LES and relaxation of TLES. In addition, transdiaphragmatic pressure has a role in increasing activation of diaphragmatic innervations. Bending position and supine are routinely and regularly conducted in sports activity such as push up and sit up exercise which enhance special components of fitness, avoidance of excessive fats deposition, back bone and joints become flexible and easy to move, and the muscles tense, strong and have high endurance.[2,5]

Sports exercises also develop mental fitness and increasing confidence. But many people never reach targeted fitness level due to complication of the conducted sport.[7,8] Push up and sit up exercise which are some sports for stretching and endurance of muscles, is defined as ability of muscle to do repetitive contraction with emphasis in quantity which can be executed, with sit up, there will be increased pressure in the abdomen which resulted in strong abdominal muscles. High pressure in abdomen will support the upper body and balance of back bone. Push up was designed to strengthen and fasten the upper body, mainly muscles of chest and triceps. Both sports use standard from Canadian Standardized Test of Fitness.[9]

OBJECTIVES

The objective of the study were to know how many cases of GERD would be triggered by push up and sit up exercise and to know the difference between push up and sit up as exercise triggers of GERD

METHODS

This is an experimental study, conducted at RD Kandou hospital Manado on March to May 2006. Study subjects were requested to have push up or sit up exercise to see whether there were any GERD symptoms. Endoscopy was performed at the endoscopy ward at RD Kandou Hospital. Clinical evaluation in this study was conducted at the end of the first month and end of the second month. At the end of the study, after 2 months of sport, endoscopy was performed. Subjects were SPN students, which consist of healthy male subjects aged 18-21 years old who matched the inclusion criteria. Sample size was 30 subjects, which were divided randomly in 2 groups (15 in push up group and 15 in sit up group).

Table 1. Modified Savary-Miller classification of reflux esophagitis[10]

Grade	Classification
I	Single or multiple erosions, on a single fold: erosions May be erythematous or erythemato-exudative
II	Multiple erosions affecting more than one longitudinal fold: erosions may be confluent
III	Circumferential erosion
IV	Ulcer(s), stricture(s)
V	Columnar epithelium in community with Z-line, non-circular, star-shaped or circumferential (Barrett's esophagus)

Inclusion criteria

Healthy students according to Health Regulation No. 23, 1992,[11] proven by anamnesis and physical examination. Subjects must have ideal body weight according to normal body mass index, and willing to participate in the study by signing the informed consent, and obey the rules and procedures of the study.

Exclussion criteria

The subjects were excluded if they had been suffered from GERD, scleroderma, gastrinoma (Zolinger-Ellison Syndrome), post operative conditions Heller's esophagogastric myotomi, or were using H_2 agonists, PPI, corticosteroids, alcohol, á-adrenergic agonists, antacids, cholinergic agonists,meto chlopramide, prostaglandin F_2, estrogen/progesterone, anticholinergic agents, barbiturate, calcium antagonists, diazepam, dopamine, meperidin, theophylin, mint, chocolate, ethanol, and fats; or were having diet high in protein, caffeine or in stress condition, and were involved in other kind of sports such as weight lifting, athletics and biking.

RESULTS

Basic characteristics

There were 30 subjects consist of 15 subjects in push up group and 15 subjects in sit up group. There were three subjects dropped out, who consist of one subject who was not cooperative during endoscopy and two subjects with severe thrombocytopenia when endoscopy was conducted. After the study, we had eight subjects aged 18 years old, 11 subjects aged 19 years old, 10 subjects aged 20 years old, and one subject aged 21 years old.

Mean of push up and sit up exercise

During the study quantity of push up was 20.7-31.79/ minute with mean 26.24/minute and sit up was 26.2-38.4/minute with mean 32.3/minute

Distribution according to subjective complaints

Subjective complaints were consisted of gastrointestinal tracts symptoms in 19 subjects (44.19%), Symptoms of muscles, skin and bone in 9 subjects (20.92%), respiratory tract in 8 subjects (18.61%), head and neck in 3 subjects (6.98%), urinary tract in 2 subjects (4.65%) and other complaints in 2 subjects (4.65%).

Detailed subjective complaints were epigastric pain in 4 subjects, nausea in 2 subjects, dizziness when stood up in 2 subjects, diffuse abdominal pain in 5 subjects, headache in 1 subject, dysuria in 1 subject, coughing and nasal secretion in 7 subjects, wounded arm with pus in 1 subject, itching when sweating in 1 subject, nasal bleeding in 1 subject, left upper quadrant abdominal pain in 3 subjects, flank pain in 1 subject, fever in 3 subjects, swollen and tender legs in 2 subjects, chest pain in 1 subject, right upper quadrant abdominal pain in 1 subject, sore throat and dysphagia in 1 subject, excessive defecation after much eating in 2 subjects, loss of appetite in 1 subject, cramps all over the body in 1 subject, bone pain in the feet in 1 subject. These complaints began on day 9 after push up or sit up until the end of study and when endoscopy was conducted 2 subjects were admitted to hospital due to fever and laboratory evaluation revealed severe thrombocytopenia 36,000/mm^3 and 24,000/mm^3, respectively.

Table 2. Characteristics of patient

Characteristic	N = 30
Age (years old)	
18	8 (27%)
19	11 (37%)
20	20 (33%)
21	1 (3%)
Exercise	
Push up	14 (46.7%)
Sit up	13 (43.3%)
Quantity(per minute)	
Push up	20.7 – 31.79
Sit up	26.2 – 38.4
Mean push up	26.24
Mean sit up	32.3
Subjective complaints	
Gastrointestina; tract symptoms	19 (44.19%)
Skin, muscle and bone	9 (20.92%)
Respiratory tract	8 (18.61)
Head and neck	3 (6.98%)
Urinary track	2 (4.65%)
Other complaints	2 (4.65%)

Distribution According to Endoscopic Evaluation

There were 15 subjects with normal endoscopy and 12 subjects with esophagitis in various grades. In push up group, there were six subjects with normal endoscopy, while in eight subjects there were esophagitis in various grades. In sit up group, there were 9 subjects with normal endoscopy, while in four subjects there were esophagitis in various grades.

In push up group, there were eight subjects with esophagitis in various grades, which consist of esophagitis grade 0-I in 1 subject, grade I in 1 subject, grade I-II in 2 subjects, grade II in 4 subjects. In sit up group there were four subjects with esophagitis in various grade, which consist of esophagitis grade 0-I in one subject, grade I in two subjects and grade I-II in one subject.

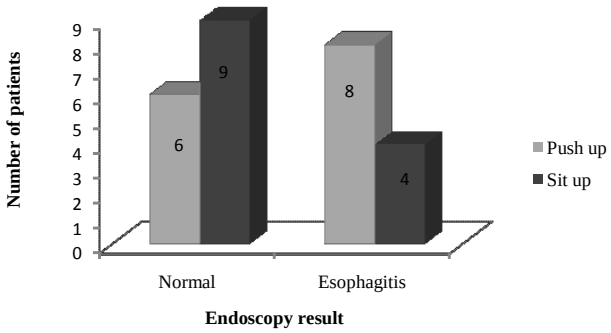

Figure 1. Distribution of samples according to result of endoscopy

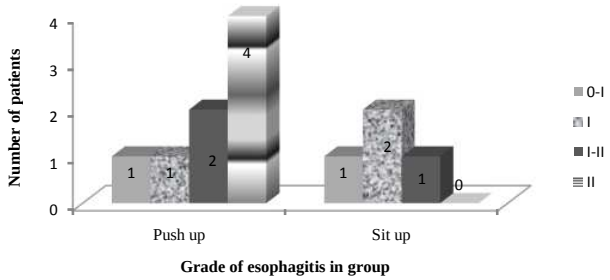

Figure 2. Distribution of samples according to endoscopic evaluation

Table 3. Occurrences of GERD in push up and sit up exercise groups

	Push up	Sit up	Total
Positive	8 (57.1%)	4 (30.8%)	12
Negative	6 (42.9%)	9 (69.2%)	15
Total	14	13	27

$X^2 = 0.981$; df (degree of freedom) = 1; p = 0.322

DISCUSSION

Gastroesophageal reflux disease (GERD) is reflux of gastric contents into esophagus and resulted in clinical symptoms, which are triggered by food, bending position and supine, also due to esophageal pH less than 4.[1,2,5] Gastric acid problems like GERD in the last few years have began receiving many attention from the experts. GERD is one of the frequently found upper intestinal tract disease and the prevalence in Indonesia tend to increase.[1,12] The pathogenesis of GERD is complex and multifactorial.[2,5] Some factors underlying this process is LES hypotension, relaxation of TLES, delayed gastric emptying and the presence of esophageal hiatal hernia. In bending position and supine there will be hypotension of LES and relaxation of TLES. In addition, transdiaphragmatic pressure has a role in increasing activation of diaphragmatic innervation.[2,5]

The clinical course of esophageal reflux disease is differentiated based on the presence of esophagitis (GERD) or absence of mucosal damage (NERD). NERD group generally have atypical symptoms while GERD group have typical symptoms such as heartburn, postural regurgitation, dysphagia with odinophagia.[12,13] After exposed with gastric contents, esophageal mucosa will develop symptoms, which will become erosion in the form of single patchy lesion. Gastric contents exposure continuing for a long period of time and in large quantity will cause extensive mucosal damage in the form of large confluent lesion. In some patients, the healing of large confluent lesion will result in a scar and will end up in a stricture. The final result of a large confluent lesion which does not heal is the formation of Barrett's esophagus, which is the trigger of carcinoma.[1,14]

In this study, there were 30 subjects, which consisted of 15 subjects in sit up group and 15 subjects in push up group. The mean age group was 19.5 years old. Age 18-21 years old involved in this study was standardized according to Canadian Standardized Test of Fitness in which age 18-21 is the age group to gain optimal results from sit up or push up. In this study we got low body mass index (BMI) in 3 subjects (10%), i.e. age 18 years in 2 subjects (66.7%) and age 20 years in 1 subject (33.3%), normal BMI in 87%, i.e. 18 years in 5 subjects (19.2%), age 19 years in 11 subjects (42.3%), age 20 years in 9 subjects (34.7%) and age 21 years in 1 subject (3.8%), and high BMI in 3%, i.e. in age18 years in 1 subject (100%) with mean BMI 20,515,419 kg/m^2. In this study, we found subjective complaints started from day 9 after conducted push up or sit up exercise until the end of the study. In this study, we found that almost all subjects had normal BMI with mean BMI 20,515,419 kg/m^2. Although there were subjects with high body mass index (BMI) but that did not affect activity of push up or sit up exercise. Until recently, it is not known how far the factors such as genetic, race, body weight or BMI, alcohol and fatty foods have a role in increasing the prevalence of GERD.[12] The typical symptoms of GERD such as heart burn, postural regurgitation, dysphagia with odinophagia are the most frequently found.[2,5] In this study there were various subjective complaints after push up or sit up, involving gastrointestinal tract, respiratory tract, urinary tract, skin, muscle and bone symptoms and other complaints, with the most frequent complaints were in gastrointestinal tract such as nausea, epigastric pain, vomiting, loss of appetite and excessive defecation (diarrhea). These are typical symptoms of GERD. Other subjective complaints involving the respiratory tract, urinary tract, skin, muscle, and bone were due to physical factors. The exhaustion resulted in diminished immunity, thus, facilitates the mild to severe viral infection.

Push up or sit up is a sports activity for muscles stretching and endurance which is conducted repetitively with emphasis in quantity.[9] In this study the quantity of sit up was 26-38/minute with mean 32.3/minute and quantity of push up was 21-32/minute with mean 26.24/minute. According to Canadian Standardized Fitness Test, quantity of sit up /minute is excellent if ≥ 48/minute, above average if 42-47/minute, average 38-41/minute and under average if 33-37/minute and bad if can only reach ≤ 32 x/minute. While for push up, quantity/minute is excellent if ≥ 39 x/minute, above average if 29-38 /minute, average if 23-28/minute, below average if 18-22/minute, and bad if can only reach ≤ 17 x /minute.[9] In this study the quantity of sit up were vary, i.e. bad to average with mean 32.3/minute categorized as bad, while for push up were also vary, i.e. below average to above average with mean 26.24/minute categorized as average. The mean sit up was classified as bad and mean push up was classified as average because this exercise was depended on physical and mental fitness. Food, rest, and mental status/stress determined physical fitness. In this study, subjects were burdened with heavy schedules with high stress level.

Diagnosis of GERD is confirmed based on clinical symptoms and other supportive examination, including endoscopy, histopathology, double contrast, 24 hours esophageal pH-metry, Bernstein test, and esophageal manometry.[2,5] Endoscopy is an invasive procedure to directly visualize the gastrointestinal tract and peritoneal cave by using the fibreoptic technique. This is the gold standard for diagnosis of GERD, i.e. by finding mucosal break in esophagus with sensitivity of 90-95%. To judge the severity of mucosal break in endoscopy the Modified Savary-Miller Classification was used.[10]

In this study, 3 subjects (10%) were dropped out and 27 subjects (90%) were endoscopied. Three dropped out subjects were consisting of 1 subject (33.3%) who was non-cooperative during endoscopy and two subjects (66.7%) with severe thrombocytopenia due to viral infection. Among 27 subjects endoscopied there were 15 subjects (56%) with normal endoscopy and 12 subjects (44%) with mucosal break in esophagus. There were 15 subjects in sit up group, 13 subjects (87%) were endoscopied and two subjects (13%) were dropped out. There were 15 subjects push up group, 14 subjects (93%) were endoscopied, and 1 subject (7%) was dropped out. In sit up group, there were 13 subjects endoscopied, in which nine subjects (70%) had normal endoscopy, and four subjects (30%) had mucosal break in esophagus. While in push up group, there were 14 subjects endoscopied, in which six subjects (43%) had normal endoscopy, and eight subjects (57%) had mucosal break in esophagus. In sit up group, from four subjects with mucosal break (esophagitis), there was one subject (25%) with esophagitis grade 0-1, 2 subjects (50%) with esophagitis grade 1 and 1 subject (25%) with esophagitis grade 1-2. In push up group, from 8 subjects with mucosal break, there was 1 subject (12.5%) with esophagitis grade 0-1, 1 subject (12.5%) with esophagitis grade 1 and 2 subjects (25%) with esophagitis grade 1-2 and 4 subjects (50%) with esophagitis grade 2. Some factors which play role in GERD is position, supine or bending, and these position were associated with sit up and push up.[15,16,17] The triggering of GERD due to these position is the result of the presence of abdominal effect pressure especially maximal transdiaphragmatic pressure, the presence of increased exposure of gastric acid into esophagus and pharyngeal stimulation induced by relaxation of LES together with inhibition of crural diaphragm.[18-27] In addition, the change of body postural position which resulted in gravitational change delay the esophageal clearance. There is also increased intra-abdominal pressure induced by valsava maneuver, so there will flow back of gastric refluxant to esophagus due to pressure against lower esophageal junction sphincter.[28-32]

÷2 analysis or Fischer exact test analysis, which were conducted to see the relationship between sit up and push up exercise and the occurrence of GERD, showed that there was no significant difference statistically between the occurrence of GERD in push up group and the occurrence of GERD in sit up group.

CONCLUSION

From this study, it was concluded that gastroesophageal reflux disease could be found in push up or sit up exercise. GERD is more likely in push up than sit up exercise but there was no significant difference between these two groups statistically.

Recommendation

Further studies with larger samples are needed. Push up or sit up needs time to develop GERD, so further studies on GERD in the future need longer duration of study. Although there was no statistically significant difference between those two groups in this study, the procedure to perform push up or sit up is suggested to be standardized according to operational definition from the Canadian Standardized Fitness.

REFERENCES

1. Manan C. Penyakit refluks gastroesofageal-esofagitis refluks pengobatan masa kini. Dalam: Setiati S, Alwi I, Kasjmir YI, Atmakusuma D, Lydia A, Syam AF (Eds). Current Diagnosis and Treatment in Internal Medicine 2001. Pusat Informasi dan Penerbitan FKUI Jakarta 2001.h.1-7.
2. Ogorek CP. Gastroesofageal reflux disease. In: Fauci AS, Braunwald E, Isselbacher KJ, et al (Eds). Harrison's Principles of Internal Medicine. 15th ed. Mc Graw-Hill, New York 2001.p.1642-9.
3. Kelompok Studi GERD Indonesia. Konsensus Nasional Penatalaksanaan Penyakit Refluks Gastroesofageal di Indonesia. Perkumpulan Gastroenterologi Indonesia 2004.
4. Rani AA. Gastroesophageal reflux disease (GERD) and non-erosive relux disease (NERD). Dalam: Setiati S, Alwi I, Simadibrata M, Sari NK (Eds). Pertemuan Ilmiah Tahunan Ilmu Penyakit Dalam 2004. Pusat Informasi dan Penerbitan FKUI Jakarta 2004.h.1-8.
5. Goyal RK. Disease of esophagus. In: Fauci AS, Braunwald E, Isselbacher KJ, et al (Eds). Harrison's Principles of Internal Medicine. 15th ed. Mc Graw-Hill, New York 2001.p.1642-9.
6. Hirsch DP, Tytgat GN. Boeckxstaens GE. Review article: Transient lower oesophageal sphincter relaxations - a pharmacological target for gastroesophageal reflux disease? Aliment Pharmacol Ther 2002;16;17-26.
7. Alter MJ. Beberapa instruksi bagi 311 jenis stretching dengan ilustrasi gambar. Dalam: Jamal Habib (Ed). 300 teknik stretching sport. Ed 1. PT Raja Gryffindor Persada Jakarta 2003.h.191-202.
8. Donovan G, Namara JM, Peter Gianoli. Pemeliharaan tulang punggung. Dalam: Sumosardjono S. Koreksi gerakan senam yang membahayakan. Ed 1. PT Raja Grafindo Persada Jakarta 2001.h.28-60.
9. Banister EW, Mekjavic IB, Asmundson RC, Ward R. Measurement of muscular endurance. In: Laboratory experiments in human structure and function. West Publ Co. Minneapolis/St Paul 1993.p.172-81.
10. Sonnenberg A. Epidemiologic aspect in the occurrence and natural history of gastroesophageal reflux disease. In: Fass R. GERD/Dyspepsia: Hot Topics. Hanley & Belfus USA 2004.p.1-22.
11. Soejoeti SZ. Konsep sehat, sakit dan penyakit dalam konteks sosial budaya. Cermin Dunia Kedokteran 2005;149:49-52.
12. Perhimpunan Dokter Spesialis Penyakit Dalam Indonesia. Konsensus Nasional: Penatalaksanaan Penyakit GERD. Halo Internis. Edisi 5 Juni-Agustus 2005.
13. Aulia C. Prevalence of non-erosive reflux disease in Pondok Indah hospital: A preliminary study. Acta Medica Indonesiana 2005;37:79-81.
14. Tutuian R, Vela MF, Shay SS, Castell DO. Multichannel intraluminal impedance in esophageal function testing and

gastroesophageal reflux monitoring. J Clin Gastroenterol 2003;37(3):206-15.
15. Rai AM, Orlando RC. Gastroesophageal reflux disease. Curr Opin Gastroenterol 2000;16:351-9.
16. Legget JJ, Johnston BT, Mils M, Gamble J, Heaney LG. Prevalence of gastroesophageal reflux in difficult asthma. Chest 2000;127(4):1227-31.
17. Vandenplas Y. Hassl E. Mechanisms of gastroesophageal reflux and gastroesophageal reflux disease. J Pediatric Gastroenterol Nutr 2002;35:119-36.
18. Dent J, Dodds WJ, Friedman RH, et al. Mechanism of gastroesophageal reflux in recumbent asymptomatic human subjects. J Clin Invest 1980;65:256-67.
19. Chail M. Gastroesophageal reflux disease in the elderly. In: Clinical geriatric. Gastroenterology 2004;12(4):39-45.
20. Singh P, Taylor RH, Colin-Jones DG. Simultaneous two level oesophageal pH monitoring in healthy controls and patients with esophagitis: comparison between two positions. Gut 1994;35(3):304-8.
21. Pandolfino JE, Bianchi LK, Lee TJ, Hirano I, Kahrilas PJ. Esophagogaastric junction morphology predicts susceptibility to exercise-induced reflux. Am J Gastroenterol 2004;99(8):1430-6.
22. Hilman DR, Markos J, Finucane KE. Effect of abdominal compression on maximum transdiaphragmatic pressure. J Appl Physiol 1990;68(6):2296-304.
23. Straathof JW, Ringers J, Lamers CB, Masclea AA. Provocation of transient lower esophageal sphincter relaxations by gastric distension with air. Am J Gastroenterol 2001;96(8);2317-23.
24. Van Lunteren E, Haxhiu MA, Cherniack NS, Goldman MD. Differential costal and crural diaphragm compensation for posture changes. J Appl Physiol 1985;58(6):1895-900.
25. Doods WJ, Hogan WJ, Miller WN, Steff JJ, Arndorfer RC, Lydon SB. Effect of increased intrabdominal pressure on lower esophageal sphincter pressure. Am J Dig Dis 1975;20(4):298-308.
26. Grillner S, Nilsson J, Thorstensson A. Intra-abdominal pressure change during natural movements in man. Acta Physiol Scand 1978;103(3):275-83.
27. Freidin N, Mittal RK, McCallum RW. Does body posture affect the incidence and mechanism of gastro-oesophageal reflux?. Gut 1991;32(2):133-6.
28. Collings KL, Pratt FP, Stanley SR, Bemben M, Miner P.B. Esophageal reflux in conditioned runners, cyclists, and weightlifters. Official Journal of The American College of Sports Medicine 2003.p.730-5.
29. Emerenziani S, Zhang X, Blondeau K, Silny J, et al. Gastric fullness, physical activity, and proximal extent of gastroesophageal reflux. Am J Gastroenterol 2005;100:1251-6.
30. Marshall REK, Anggiansah A, Anggiansah CL, Owen WA, Owen WJ. Esophageal body length, lower esophageal sphincter length, position, and pressure in health and disease. Disease of the Esophagus 1999;12:297-302.
31. Hodges W, Gandevia SC. Changes in intra-abdominal pressure during postural and respiratory activation of the human diaphragm. J Apl Physiol 2000;89:967-76.
32. Van Niuewenhoven MA, Brummer RJM, Brouns F. Gastrointestinal function during exercise: comparison of water, sports drink, and sports drink with caffeine. J Apl Physiol 2000;89:1079-85.