Rev Andal Med Deporte. 2021; **14(2)**: *65-69*

Junta de Andalucía
Consejería de Educación y Deporte

Revista Andaluza de
**Medicina del Deporte**

https://ws072.juntadeandalucia.es/ojs

Original

# The effect of thoracic manipulation on pulmonary function in swimmers

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ARTICLE INFORMATION: Received 10 January 2020, accepted 11 March 2020, online 11 March 2020

ABSTRACT

*Objective:* Spinal manipulation has been used to improve respiratory function in healthy individuals. However, it has been observed that there are no studies in the context of sports activities. The objective of this study was to analyse the effect of thoracic spinal manipulation on forced vital capacity, forced expiratory volume in one second and maximal voluntary ventilation in swimmers.
*Method:* A randomized controlled crossover study consisting of 21 swimmers, divided into two groups (Intervention *vs* Control), aged 16 – 24y, where forced vital capacity, forced expiratory volume in one second and maximal voluntary ventilation were measured in five evaluation moments: at baseline and, 1 minute, 10 minutes, 20 minutes and 30 minutes following the thoracic spinal manipulation procedures.
*Results:* ANOVA tests showed no statistically significant differences for forced vital capacity ($p$ = 0.35) and forced expiratory volume in one second ($p$ = 0.25) among the five evaluation moments. With the maximal voluntary ventilation there was a statistically significant ($p$ = 0.02) reduction, observed between baseline (86.00 litres) and at 10 minutes (79.29 litres) and 30 minutes (76.24 litres). No significant differences were observed between the results of intervention and control groups.
*Conclusions:* In the current study no significant differences were observed in pulmonary function after thoracic spinal manipulation. Future research efforts should examine the effects of different manual therapy techniques and treatment protocols.
*Keywords:* Thoracic spine manipulation; Pulmonary function; High velocity low amplitude manipulation; Low velocity joint mobilization.

## Efecto de la manipulación torácica en la función pulmonar de nadadores

RESUMEN

*Objetivo:* La manipulación espinal se ha utilizado para mejorar la función respiratoria en individuos sanos. Sin embargo, se ha observado que no hay estudios en el contexto de las actividades deportivas. El objetivo de este estudio fue analizar el efecto de la manipulación de la columna torácica en la capacidad vital forzada, el volumen espiratorio forzado en el primer segundo y la ventilación voluntaria máxima en nadadores.
*Método:* Un estudio cruzado controlado aleatorio que consta de 21 nadadores, divididos en dos grupos (Intervención *vs* Control), de 16 a 24 años, donde se midieron la capacidad vital forzada, el volumen espiratorio forzado en el primer segundo y la ventilación voluntaria máxima en cinco momentos de evaluación: al inicio y, 1 minuto, 10 minutos, 20 minutos y 30 minutos después de los procedimientos de la manipulación de la columna torácica.
*Resultados:* Las pruebas ANOVA no mostraron diferencias estadísticamente significativas para la capacidad vital forzada ($p$ = 0.35) y el volumen espiratorio forzado en el primer segundo ($p$ = 0.25) entre los cinco momentos de evaluación. Con la ventilación voluntaria máxima hubo una reducción estadísticamente significativa ($p$ = 0.02), observada entre lo inicio (86.00 litros) y a los 10 minutos (79.29 litros) y 30 minutos (76.24 litros). No se observaron diferencias significativas entre los resultados de los grupos de intervención y control.
*Conclusiones:* En el presente estudio, no se observaron diferencias significativas en la función pulmonar después de la manipulación de la columna torácica. Futuros estudios de investigación deberían examinar los efectos de diferentes técnicas de terapia manual y protocolos de tratamiento.
*Palabras clave:* Manipulación columna torácica; Función pulmonar; Manipulación de alta velocidad y baja amplitud; Movilización articular de baja velocidad.

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https://doi.org/10.33155/j.ramd.2020.03.005

## Efeito da manipulação torácica na função pulmonar em nadadores

RESUMO

*Objetivo:* A manipulação da coluna vertebral tem sido utilizada para melhorar a função respiratória em indivíduos saudáveis. No entanto, observou-se que não existem estudos no contexto de atividades desportivas. O objetivo deste estudo foi analisar o efeito da manipulação da coluna torácica na capacidade vital forçada, volume expiratório forçado no primeiro segundo e ventilação voluntária máxima em nadadores.
*Método:* Estudo aleatorizado controlado cruzado composto por 21 nadadores, divididos em dois grupos (Intervenção *vs* Controlo), com idades entre 16 e 24 anos, onde a capacidade vital forçada, volume expiratório forçado no primeiro segundo e ventilação voluntária máxima foram medidos em cinco momentos de avaliação: no início e, 1 minuto, 10 minutos, 20 minutos e 30 minutos após os procedimentos da manipulação da coluna torácica.
*Resultados:* Os testes ANOVA não mostraram diferenças estatisticamente significativas para a capacidade vital forçada ($p$ = 0.35) e volume expiratório forçado no primeiro segundo ($p$ = 0.25) entre os cinco momentos da avaliação. Com a ventilação voluntária máxima houve uma redução estatisticamente significante ($p$ = 0.02), observada entre o início (86.00 litros) e as medições aos 10 minutos (79.29 litros) e 30 minutos (76.24 litros). Não foram observadas diferenças significativas entre os resultados dos grupos intervenção e controlo.
*Conclusões:* No presente estudo, não foram observadas diferenças significativas na função pulmonar após a manipulação da coluna torácica. Futuras pesquisas devem examinar os efeitos de diferentes técnicas de terapia manual e protocolos de tratamento.

*Palavras-chave:* Manipulação coluna torácica; Função pulmonar; Manipulação de alta velocidade e baixa amplitude; Mobilização articular de baixa velocidade.

### Introduction

Spinal manipulation therapy has been used for hundreds of years and it is commonly performed by physical therapists, osteopaths, chiropractors and medical practitioners. The published research investigating the effectiveness of thoracic spine manipulation (TSM) has been growing since the beginning of the 2000s, where different techniques were applied mostly for treatment of musculoskeletal conditions.[1]

There are studies in individuals with limitations of the respiratory system, such as chronic obstructive pulmonary disease and asthma, in which TSM is suggested to increase joint mobility with a positive influence on chest wall compliance and lung function.[2-4] The chest mobilization is also believed to improve pulmonary ventilation and gas exchange.[5]

To see how the lungs are working, pulmonary function tests (PFT) like forced vital capacity (FVC), forced expiratory volume in one second (FEV1) and maximal voluntary ventilation (MVV) are three non-invasive most relevant data in spirometry that can be measured.

It has been observed that there are not so many studies in the context of sports that explore the effects of TSM. Considering this and since elite level athletes constantly seek methods to improve performance, where the respiratory system is considered a limited rate factor, additional research is required to explore the effects of TSM. Thus, the aim of this study was to analyse the influence of a single TSM session on FVC, FEV1 and MVV over a time frame of 30 minutes in swimmers.

### Methods

#### *Trial design*

It was a randomized control trial crossover study. Participants were randomly assigned to receive either the TSM or no TSM procedures. Allocation to groups was randomized and concealed from all participants, with each participant selecting a sealed envelope from a set of prepared envelopes. Each envelop had a group number written inside. Number 1 assigned participants to the intervention group (IG) and number 2 assigned participants to the control group (CG).

#### *Participants*

Participants were recruited from two swimming clubs, where the study was conducted.

The sample consisted of 24 junior and senior swimmers of both genders (11 males), caucasians, with frequent participation in national level competitions, with a minimum of 3-year experience. The inclusion criteria were to be aged between 16 and 30 years, those who meet the general considerations for lung testing requirements,[6] while the exclusion criteria used were individuals with cardiorespiratory disease, osteopathic/chiropractor treatment in the four weeks prior to the study, previous sternum/clavicle/rib/vertebra fracture in the last twelve months.

The participants were invited to a briefing before participation in this study. Those who accepted and agreed to participate, signed an informed consent and answered a questionnaire about personal and health data. For participants under 18 parental consent was obtained.

The study was approved by the Research Ethics Committee of our University, in Lisbon, in accordance with the Declaration of Helsinki. Confidentiality and anonymity were guaranteed, stored in a computer with password, the principal author being the responsible person for that.

Of the 24 healthy volunteers participated in this study, there were complications encountered in two subjects reporting *obstruction/restriction* on the spirometry results and one athlete did not complete the study. Data analysis from these three subjects were excluded. Therefore, data from 21 subjects were analysed (see Figure 1). Their anthropometric characteristics are summarized in Table 1. Data collection were performed individually and on an equal basis, without interference from other swimmers, over a two-month period.

**Table 1.** Anthropometric Characteristics of the participants (n = 21)

| | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|
| Age (years) | 16 | 24 | 18.62 | 2.40 |
| Body weight (kg) | 54 | 88 | 65.48 | 8.71 |
| Body height (cm) | 159 | 186 | 170.71 | 7.47 |
| BMI (kg/m2) | 18.5 | 27.8 | 22.42 | 2.11 |

BMI: body mass index; SD: standard deviation.

#### *Procedures*

PFT was performed by a cardiopneumology technician with a professional portable spirometer Medikro Pro, Product Code: M9488 (Medikro Oy, Finland), validated according to the American Thoracic Society and European Thoracic Society criteria.[6] All data were determined via the Medikro Spirometry Software version 3.1-03. The recommended reference values are in accordance with the reference equations proposed by Dias, Oliveira, Bárbara, Cardoso and Gomes[7] and the third National Health and Nutrition Examination Survey (NHANES III) data was used.

All measurements were carried out under standard environmental conditions, enabling comfort temperature (between 18°C and 24°C) and a relative atmospheric humidity of 50% to 70%.

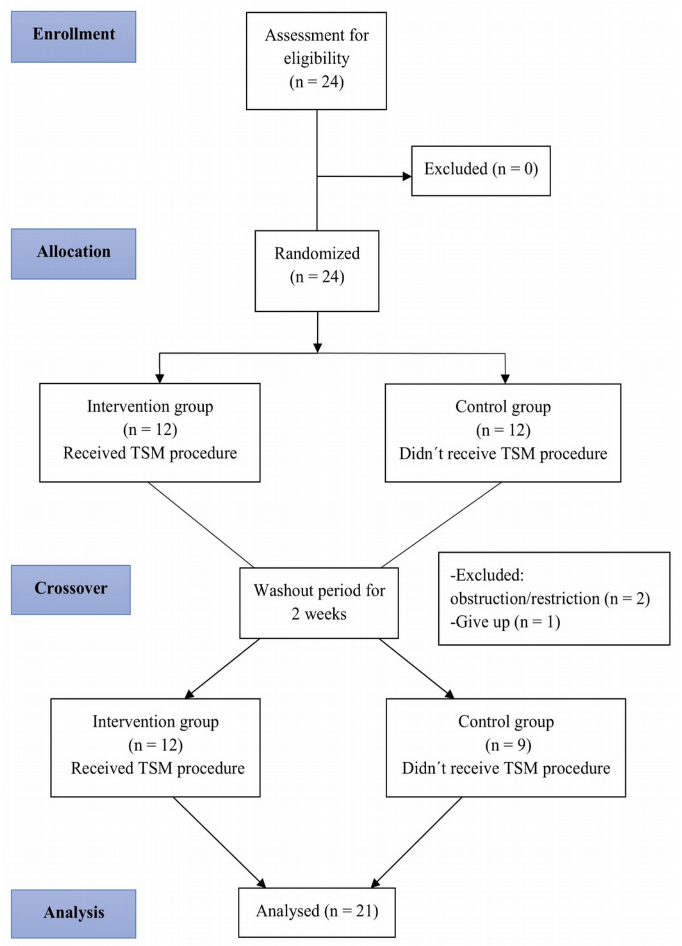


**Figure 1.** Flowchart of study selection process for review

In the calculation of the body mass index (BMI), a balance (Seca 877, Hamburg, Germany) and a stadiometer (Seca 217, Hamburg, Germany) were used for measurement.

All measurements were taken with the participants wearing only underwear.

The 24 participants were randomly divided into two groups, 12 in the IG and 12 in the CG.

All participants in the IG completed a single experimental session which involved PFT (FVC; FEV1; MVV) that were measured as follows: at baseline (before TSM intervention) and: at 1st minute, 10th minute, 20th minute and 30th minute following the TSM intervention that implicated two manual therapy techniques applied in standardized fashion: 1) High velocity low amplitude (HVLA) thrust manipulation[8,9] and 2) Low velocity joint mobilization (LVJM).[10]

An osteopath with nine years of experience performed the TSM techniques.

For HVLA, the subject laid supine with the arms crossed over the chest and hands passed around his shoulder. The osteopath with his hand in a neutral position contacted first over the spinous process of T1-T4, then over T5-T8 and finally over T9-T12. The other hand stabilized the head, neck, and upper thoracic spine of the participant. Gently, flexion of the thoracic spine was introduced until slight tension was palpated in the tissues at the osteopath contact point. Then, a HVLA technique downward toward the table and in a cephalad direction was applied. If no popping sound was heard on the first attempt, the osteopath repositioned the participant and performed a second HVLA thrust manipulation. A maximum of two attempts were performed on each participant (Figure 2a). Then it was performed LVJM rotatory grade four joint mobilizations to the thoracic and costovertebral joints. With the participant seated and with hands placed on the contralateral shoulder, the osteopath placed their hand on the costovertebral joint and rotated the participant toward end-range. Each participant received one set of ten mobilizations to the left and ten mobilizations to the right (Figure 2b).

The CG received only light touch without performing any manoeuvre, without reduction, or push or joint noise and PFT were performed in the same manner as in the IG.

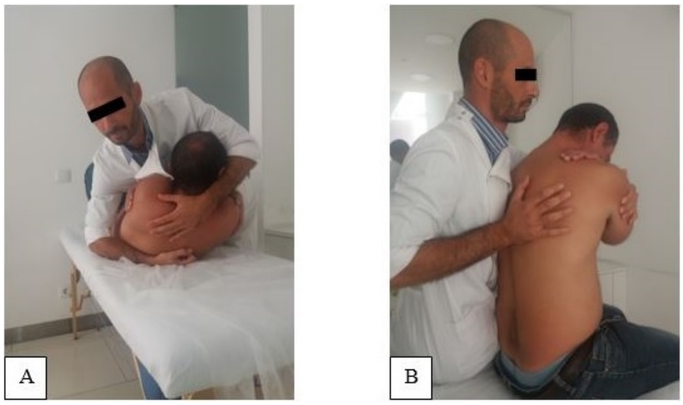


**Figure 2.** A: High velocity low amplitude technique. B: Low velocity joint mobilization technique.

Participants underwent the PFT in standing position, wearing a nose clip. During this, they were instructed to breathe normally into the spirometer for 30 seconds, sealed their lips around the mouthpiece, after which they were instructed to inspire maximally and then maximally expire as forceful as possible for six seconds so that FVC and FEV1 could be measured. Measures were completed in triplicate, allowing one minute between efforts, with the best results used for analysis. One minute after, participants completed a single MVV manoeuvre for 15 seconds.

Two athletes were excluded from the study because they presented obstruction/restriction in the spirometry measurements. Subsequently, there was a washout period of two weeks, after which the crossover was done for the groups and the intervention performed again (at this point, one athlete quitted the study for professional reasons).

*Statistical analysis*

For FVC and FEV1, 12% is estimated to be the minimum level of clinically important change.[11] To calculate the sample size, we used G*Power software (version 3.1.9.2, Heinrich-Heine-University, Düsseldorf, Germany). Based on previous research,[12] we assumed the baseline mean (standard deviation) FVC value would be 6.0 (± 0.9) litres with a correlation between measures of 0.3. Considering an alpha level of 0.05, recruiting 21 participants would provide 90% power to detect a 12% change in FVC.

Variables were assessed for normality using the Kolmogorov Smirnov test and the Shapiro Wilk test. We concluded that the variables followed normal distribution at the level of significance of 0.05. Therefore, a General Linear Model *ANOVA* for repeated measures was used to compare the values of both groups in the five evaluation moments.

Statistical analyses were performed using IBM SPSS Statistics 24 (SPSS, Inc., Chicago, IL, USA).

## Results

The *ANOVA* tests for repeated measures, after applying the Greenhouse-Geisser correction, showed no statistically significant differences in the results obtained in the five moments for FVC ($F$ = 1.093, $p$ = 0.35) and for FEV1 ($F$ = 1.440, $p$ = 0.25) (see Table 2). With respect to MVV, significant differences were found ($F$ = 3.029, $p$ = 0.033), with the significant differences occurring between Baseline and ten minutes and between Baseline and 30 minutes, in

**Table 2.** Means, standard deviations, confidence intervals, ANOVA results and effect size for forced vital capacity, forced expiratory volume in one second and maximal voluntary ventilation in the five evaluation moments

| | Time | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline | | 1 minute | | 10 minutes | | 20 minutes | | 30 minutes | | | | |
| | *M (SD)* | *CI 95%* | *M (SD)* | *CI 95%* | *M (SD)* | *CI 95%* | *M (SD)* | *CI 95%* | *M (SD)* | *CI 95%* | *F* | *p* | $\eta^2$ |
| FVC | 4.64 (1.04) | 4.17 - 5.12 | 4.74 (0.94) | 4.31 - 5.17 | 4.62 (0.96) | 4.18 - 5.05 | 4.74 (0.90) | 4.33 - 5.15 | 4.65 (1.04) | 4.17 - 5.12 | 1.093 | 0.348 | 0.052 |
| FEV1 | 3.91 (0.82) | 3.53 - 4.28 | 3.86 (0.76) | 3.51 - 4.20 | 3.77 0(0.70) | 3.45 – 4.09 | 3.81 (0.71) | 3.49 – 4.13 | 3.80 (0.75) | 3.46 – 4.15 | 1.440 | 0.247 | 0.067 |
| MVV | 86.00 (35.36) | 69.90 – 102.09 | 82.46 (34.31) | 66.85 – 98.08 | 79.29 (30.74) | 65.30 – 93.29 | 80.90 (32.20) | 65.78 – 96.01 | 76.24 (33.40) | 61.04 – 91.45 | 3.029 | 0.033 | 0.132 |

FVC: forced vital capacity; FEV1: forced expiratory volume in one second; MVV: maximal voluntary ventilation; $\eta^2$ : partial Eta squared.

both cases the baseline value (86.00 litres) being significantly higher than those after ten minutes (79.29 litres) and after 30 minutes (76.24 litres).

A paired-samples *t*-test was performed to compare the results obtained by each participant in FVC, FEV1 and MVV in the five moments, in the intervention and control situations. With two exceptions, FVC after one minute and after 20 minutes, all the other measurements did not show any significant difference, and all the correlations between the two moments were strong, positive and significant at the 0.01 level.

## Discussion

This study analysed the effect of a single TSM session on FVC, FEV1 and MVV in swimmers during a 30-minute period measured in five evaluation moments, one to establish baseline and four subsequent moments, after 1, 10, 20 and 30 minutes.

Decreased lung volumes at rest result in rapid shallow breathing during exercise, which can be expressed in a decrease in the maximal oxygen uptake ($VO_2$max) where is considered to be an important performance-influencing factor,[13] a decrease in the maximal exercise time and MVV.[14,15] Theoretically, an increase in the PFT could mean an improve in the athlete's performance and so, if TSM techniques could improve the lung function, this could be very valuable if applied immediately before a swimming competition or as part of the athlete's training in the short, medium or long-term performance improvement. However, the main finding from our study showed that there were no statistically significant differences occurred among the five moments in FVC and FEV1, therefore no significant improvement was found. On the other hand, with the MVV there was a statistically significant reduction that can be due to the fact that this test requires effort and coordination by the athletes when performing it, and for this reason, there may have been some fatigue during the five moments of evaluation.[6]

This type of results is not unanimous in the literature, and contrary to our results, Engel and Vemulpad[16] reported significant increase in FVC and FEV1 in healthy participants who received nonspecific HVLA of the lower cervical and thoracic spine and the posterior articulations of the associated ribs. However, it should be noted that these findings were only reported immediately following the sixth manual therapy session during an intervention consisting of six sessions over a 4-week period.

Similarly, Shin and Lee[17] investigated the effects of TSM in a single session in healthy participants who received HVLA in the thoracic spine and showed that after the intervention, FVC and FEV1 were also significantly increased in the experimental group, (FVC increased by 0.2 litres and FEV1 by 0.1 litres) while the control group showed no difference. On the other hand, Wall et al.[18] indicated no statistically significant changes in the pulmonary function measures at any time point following the manual therapy intervention, and so did Santos et al.[19] in a study with 30 volunteers, where the results showed no significant difference, in FVC, FEV1 and MVV.

In conclusion, although we were seeking for acute improvement in swimmer´s performance, our results did not quite support our expectations.

Some limitations must be referred. Myofascial restrictions, pressure, and velocity of the TSM techniques on the participants were assumed to be identical, since they were all performed by the same osteopath, but actually they were not measured. Also, our intervention consisted of only one manual therapy intervention, and it is possible that additional interventions may favourably impact pulmonary function.

Future research should examine the effects of these and other manual therapy techniques with more complex approaches, e.g., diaphragm activation and/or accessory muscle stretching, not only in swimming but also in other type of sports, and if possible, with a longer follow-up evaluation, in order to obtain more reliable conclusions.

**Authotship.** All the authors have intellectually contributed to the development of the study, assume responsibility for its content and also agree with the definitive version of the article. **Conflicts of interest.** The authors have no conflicts of interest to declare. **Funding.** No grants or funding sources. **Acknowledgements.** Special thanks to all athletes, to Mr. João Saúde, Mr. Carlos Costa, Dr. Carlos Lopes and Professor Manuela Rodrigues. **Provenance and peer review.** Not commissioned; externally peer reviewed. **Ethical Responsabilities.** *Protection of individuals and animals:* The authors declare that the conducted procedures met the ethical standards of the responsible committee on human experimentation of the World Medical Association and the Declaration of Helsinki . *Confidentiality:* The authors are responsible for following the protocols established by their respective healthcare centers for accessing data from medical records for performing this type of publication in order to conduct research/dissemination for the community. *Privacy:* The authors declare no patient data appear in this article.

## References

1. Walser F, Meserve B, Boucher T. The effectiveness of thoracic spine manipulation for the management of musculoskeletal conditions: a systematic review and meta-analysis of randomized clinical trials. J Man Manip Ther. 2009;17(4):237-46.
2. Balon J, Aker PD, Crowther ER, Danielson C, Cox PG, O'Shaughnessy D, et al. A comparison of active and simulated chiropractic manipulation as adjunctive treatment for childhood asthma. N Engl J Med. 1998;339(15):1013–20.
3. Bockenhauer S, Julliard K, Lo K. Quantifiable effects of osteopathic manipulative techniques on patients with chronic asthma. J Am Osteopath Assoc. 2002;102(7):371-5.
4. Dougherty P, Engel R, Vemulpad S, Burke J. Spinal manipulative therapy for elderly patients with chronic obstructive pulmonary disease: a case series. J Manip Physiol Ther. 2011;34(6):413–7.
5. Leelarungrayub D. Chest Mobilization Techniques for Improving Ventilation and Gas Exchange in Chronic Lung Disease. Chronic Obstructive Pulmonary Disease - Current Concepts and Practice [Internet]. InTech; 2012.
6. Miller R, Crapo R, Hankinson J, Brusasco V, Burgos F, Casaburi R, et al. General considerations for lung function testing. Eur Respir J. 2005;26(1):153–61.
7. Dias H, Oliveira A, Bárbara C, Cardoso J, Gomes E. Programa Nacional para as Doenças Respiratórias - Critérios da Qualidade Para a Realização de uma Espirometria Direção-

Geral Da Saúde, 2016;1–30. [consulted on november 2018]: Available at https://www.dgs.pt/documentos-em-discussao-publica/criterios-da-qualidade-para-a-realizacao-de-uma-espirometria-em-discussao-publica-pdf.aspx.

8. Masaracchio M, Cleland A, Hellman M, Hagins M. Short-term combined effects of thoracic spine thrust manipulation and cervical spine nonthrust manipulation in individuals with mechanical neck pain: a randomized clinical trial. J Orthop Sport Phys. 2013;43(
9. Cleland J, John M, Childs D, Mcrae M, Palmer J, Stowell T. Immediate effects of thoracic manipulation in patients with neck pain: a randomized clinical trial. Man Ther. 2005;10(2):127–35.
10. Maitland G, Hengeveld E, Banks K, English K, editors. Maitland's vertebral manipulation. 7th ed. Elsevier Butterworth Heinemann; London. 2005. p. 332-3.
11. Pellegrino R, Viegi G, Brusasco V, Crapo R, Burgos F, Casaburi R, et al. Interpretative strategies for lung function tests. Eur Respir J. 2005;26(5):948–68.
12. Lazovic B, Mazic S, Suzic-Lazic J, Djelic M, Djordjevic-Saranovic S, Durmic T, et al. Respiratory adaptations in different types of sport. Eur Rev Med Pharmaco 2015;19(12):2269–74.
13. Fernandes R, Keskinen K, Colaço P, Querido A, Machado L, Morais P, et al. Time limit at V̇O2max velocity in elite crawl swimmers. Int J Sports Med. 2008;29(2):145–50.
14. O'Donnell E, Hong H, Webb A. Respiratory sensation during chest wall restriction and dead space loading in exercising men. J Appl Physiol. 2000;88(5):1859–69.
15. Coast J, Cline C. The effect of chest wall restriction on exercise capacity. Respirology. 2004;9(2):197–203.
16. Engel R, Vemulpad S. The effect of combining manual therapy with exercise on the respiratory function of normal individuals: a randomized control trial. J Manip Physiol Ther. 2007;30(7):509–13.
17. Shin C, Lee W. The immediate effects of spinal thoracic manipulation on respiratory functions. J Phys Ther Sc. 2016;28(9):2547–9.
18. Wall A, Peiffer J, Losco B, Hebert J. The effect of manual therapy on pulmonary function in healthy adults. Sci Rep. 2016;6:33244.
19. Santos A, Santos A, Carli J, Rocha P, Previatti K. Influência das técnicas de terapia manual osteopática na função respiratória. Arq Cienc Sau. 2015;19(3):191-7.