ALEXANDRE MIGUEL GUERRA CORDEIRO

THE EFFECT OF THORACIC MANIPULATION ON PULMONARY FUNCTION IN SWIMMING ATHLETES

Thesis Advisor: Prof. Rodrigo Ruivo

Universidade Lusófona de Humanidades e Tecnologias

Faculdade de Educação Física e Desporto

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President: Professor Doutor António Palmeira, PhD
Arguing: Professor Raquel Madeira, PhD
Dissertation Advisor: Professor Rodrigo Ruivo, PhD

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Resumo

Objectivo: A presente dissertação de mestrado teve como principal objetivo analisar o efeito da manipulação da coluna torácica (MCT) na função pulmonar em atletas de natação durante um período de 30 minutos.

Método: Numa primeira fase, foi elaborada uma revisão sistemática de literatura (RSL) com base em estudos do tipo randomized controlled trial (RCT) e clinical trial e, numa segunda fase, foi realizado um estudo experimental crossover com o objectivo de analisar se existem diferenças após a realização de uma sessão de MCT durante um período de 30 minutos em 21 atletas de natação federados divididos em dois grupos (Intervenção *vs* Controlo), com idades compreendidas entre os 16 - 24 (M = 18.62 ± 2.40). Após o washout de duas semanas fez-se o crossover dos grupos.

Resultados: Na RSL foram seleccionados 4 artigos, sendo dois RCT que estudaram as variáveis dependentes capacidade vital forçada (CVF) e volume expiratório forçado no primeiro segundo (VEF_1) e onde mostraram efeitos significativos nos dois grupos e dois quasi-experimentais que estudaram as variáveis dependentes CVF, VEF_1 e ventilação voluntária máxima (VVM) e em que estes estudos não apresentaram diferenças significativas comparando os dois grupos. Os resultados do estudo experimental demonstraram que não houve diferenças significativas nas variáveis CVF e VEF_1, entre os grupos, no entanto, o mesmo não aconteceu com o VVM, em que se verificaram valores estatísticamente significativos diminuidos.

Conclusão: Os resultados dos estudos analisados na RSL não são unânimes. Dois estudos referem que existem efeitos benéficos na MCT, no sentido de melhorar as funções pulmonares, mas outros dois estudos analisados não referem qualquer alteração nestas funções. À semelhança de dois estudos da RSL, o estudo de intervenção também não produziu nenhum efeito nas variáveis CVF e VEF_1, pelo contrário, houve uma diminuição nos valores da VVM sendo as suas diferenças significativas. É necessário por isso, mais investigação nesta área, pois ela encontra-se limitada pela quantidade de estudos existentes, assim como uma intervenção de maior duração com follow-up para se poder tirar conclusões mais fidedignas.

Palavras-chave: Manipulação da coluna torácica, Alta velocidade baixa amplitude, Baixa velocidade mobilização articular.

Abstract

Objective: The main objective of this master's thesis was to analyze the effect of thoracic spinal manipulation (TSM) on lung function in swimming athletes during a 30-minute period.

Method: In a first phase, a systematic literature review (SLR) was developed based on randomized controlled trial (RCT) and clinical trial studies and, in a second phase, an experimental crossover study was carried out with the objective to analyze if there are differences after a 30-minute TSM session in 21 federated swimming athletes divided into two groups (Intervention *vs* Control), aged 16 - 24 (M = 18.62 ± 2.40). After the washout of two weeks the crossover of the groups was made.

Results: In the SLR, 4 articles were selected being two RCT that studied forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) and where they did show significant results in the two groups and two quasi-experimental that studied the dependent variables FVC, FEV_1 and maximal voluntary ventilation (MVV) and in which these studies did not show a significant increase comparing the two groups. The results of the experimental study showed that there were no significant differences in the FVC and FEV_1 variables between the groups, however, the same did not occur with the MVV, in which there were statistically significant decreased values.

Conclusion: The results of the studies analyzed in the RSL are not unanimous. Two studies reports that there are beneficial effects on TSM in the sense of improving lung function, but the other two studies analyzed do not report any change in these functions. Similarly, to two studies of RSL, the intervention study also had no effect on the FVC and FEV_1 variables, on the contrary, there was a decrease in the values of the MVV being their significant differences. Therefore, more research in this area is necessary, since it is limited by the number of existing studies, as well as a longer follow-up intervention with a view to obtaining more reliable conclusions.

Key words: Thoracic spine manipulation, High velocity low amplitude, Low velocity joint mobilization.

Abbreviations

ATS – American Thoracic Society

BMI – Body mass index

BTPS - Body temperature (i.e. 37˚C), ambient pressure, saturated with water vapors

CG – Control group

CO2 – Carbon dioxide

FEV_1 - Forced expiratory volume in one second

FEV_1_C - Forced expiratory volume in one second in the control group

FEV_1_I - Forced expiratory volume in one second in the intervention group

FVC - Forced vital capacity

FVC_C - Forced vital capacity in the control group

FVC_I - Forced vital capacity in the intervention group

FRC - Functional residual capacity

HVLA – High velocity low amplitude

IG – Intervention group

L.min-1 - Liters per minute

LVJM - Low velocity joint mobilization

MVV – Maximal voluntary ventilation

MVV_C – Maximal voluntary ventilation in the control group

MVV_I – Maximal voluntary ventilation in the intervention group

O2 – Oxygen

PEF - Peak expiratory flow

PFTs - Pulmonary function tests

PNS - Parasympathetic nervous system

RCT – Randomized controlled trial

ROM – Range of motion

RV - Residual volume

SNS – Sympathetic nervous system

TLC - Total lung capacity

TSM – Thoracic spine manipulation

VC - Vital capacity

VO_2max - maximal oxygen uptake

WHO – World health organization

Definitions

1. Peak expiratory flow (PEF): Highest flow achieved from a maximum forced expiratory maneuver started without hesitation from a position of maximal lung inflation (Miller, 2005).

2. Forced expiratory volume in one second (FEV_1): The maximum volume of air exhaled in the first second of a forced expiration from a position of full inspiration, expressed in liters at BTPS (Miller, 2005).

3. Forced vital capacity (FVC): The total volume of air exhaled with a maximal forced expiratory effort after a full inspiration (Miller, 2005).

4. Functional residual capacity (FRC): The volume of air in the lungs following normal expiration (Ranu, Wilde, & Madden, 2011).

5. Maximal voluntary ventilation (MVV): The maximum volume of air a subject can breathe over a specified period of time (12 to 15 seconds for normal subjects). It is expressed in L.min-1 at BTPS (Miller, 2005).

6. Residual volume (RV): The amount of air remaining in the lungs after a maximal expiration (Ranu, Wilde, & Madden, 2011).

7. Total lung capacity (TLC): The total volume of air in the lungs after a maximal inspiration (Ranu, Wilde, & Madden, 2011).

8. Vital capacity (VC): The maximum volume of air that can be expelled after a maximum inspiration (Miller, 2005).

9. VO_2max: The highest rate at which oxygen can be taken up and utilized by the body during severe exercises (Ibikunle,& Enumah, 2016).

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Chapter I
General Introduction

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 (Walser, Meserve, & Boucher, 2009).

Shin and Lee (2016) reported that a number of different methods have been studied for improving respiratory function, including pulmonary rehabilitation, medicine therapy and spinal manipulation therapy.

TSM is proposed to increase joint mobility which could exert a positive influence on chest wall compliance and pulmonary function, a theory which has been previously investigated in those with respiratory system limitations such as chronic obstructive pulmonary disease and asthma (Jeffrey et al., 1998; Bockenhauer et al., 2002; Dougherty et al., 2011). Also, few studies have analyzed the effects that TSM may have on respiratory function at rest in healthy adults (Shin & Lee, 2016; Wall, Peiffer, Losco, & Hebert, 2016). However, these effects were only measured in the period immediately after treatment (Engel & Vemulpad, 2007; Santos et al., 2015; Shin & Lee, 2016) and over an extended time frame of 30 minutes (Wall et al., 2016), meaning that the duration of these potential effects remains virtually unknown by the few studies still performed.

There are no studies in the sporting context, therefore, the objective of the experimental study was to analyze the influence of a single TSM session on FVC, FEV_1 and MVV over a time frame of 30 minutes in swimming athletes, where elite level athletes constantly seek methods to enhance performance and where the respiratory system is considered a rate limited factor.

Organization of the dissertation

The dissertation is organized in two chapters. The first chapter reports a systematic review of literature, which sought to identify studies that analyzed the effect of thoracic spine manipulation on pulmonary function in healthy individuals. The second chapter corresponds to an experimental article whose objective is to analyze the effect of thoracic manipulation on pulmonary function in swimming athletes.

Chapter II

Manuscript I - The effect of thoracic spine manipulation on pulmonary function in healthy individuals - Systematic review of literature

Resumo

Introdução: A terapia de manipulação vertebral tem sido usada há centenas de anos e é comumente realizada por fisioterapeutas, osteopatas, quiropráticos e médicos, tendo sido sugerida como uma intervenção terapêutica com potencial para melhorar a função respiratória. Com a maioria da literatura a avaliar indivíduos com limitações existentes do sistema respiratório, como doença pulmonar obstrutiva crónica e asma, poucos estudos examinaram o impacto que esta terapêutica pode ter, mais especificamente a manipulação da coluna torácica (MCT), sobre a função respiratória em adultos saudáveis.

Objectivo: O objetivo desta revisão sistemática foi analisar o efeito da MCT na função respiratória em adultos saudáveis.

Método: Para a revisão sistemática de literatura (RSL) foi efectuada uma pesquisa com base em estudos do tipo "randomized controlled trial" e "clinical trial", seguindo a abordagem do modelo PICOS (*participants, intervention, control, outcomes e study design*), na base de dados electrónica PubMed/MEDLINE e Google Scholar entre Fevereiro e Março de 2018.

Resultados: Foram seleccionados quatro artigos para leitura integral. Foram excluídos 3362 artigos tendo em conta os critérios de elegibilidade descritos no método. Dos resultados que integram a RSL, dois apontam para a importância do efeito positivo da MCT na função respiratória e os outros dois estudos não revelam qualquer efeito.

Conclusão: Os resultados dos estudos analisados não são unânimes. Dois estudos referem que existem efeitos benéficos na MCT, no sentido de melhorar as funções pulmonares, mas os outros dois estudos analisados não referem qualquer alteração nestas funções. No entanto, é necessário mais investigação nesta área, pois ela encontra-se limitada pela quantidade de estudos existentes.

Palavras-chave: Manipulação da coluna torácica, Alta velocidade baixa amplitude, Baixa velocidade mobilização articular.

Abstract

Introduction: Vertebral manipulation therapy has been used for hundreds of years and is commonly performed by physiotherapists, osteopaths, chiropractors and physicians, and has been suggested as a therapeutic intervention with potential to improve respiratory function. With most literature evaluating individuals with existing limitations of the respiratory system, such as chronic obstructive pulmonary disease and asthma, few studies have examined the impact that this therapy, more specifically the thoracic spine manipulation (TSM), may have on respiratory function in healthy adults.
Objective: The objective of this systematic review was to analyze the effect of TSM on respiratory function in healthy adults.
Method: A systematic review of the literature (SRL) was carried out based on "randomized controlled trial" and "clinical trial" studies, following the PICOS (*participants, intervention, control, outcomes and study design*), in the electronic database PubMed/MEDLINE and Google Scholar between February and March 2018.
Results: Four articles were selected for reading comprehension. 3362 articles were excluded considering the eligibility criteria described in the method. From the results that integrate the SRL, two point to the importance of the positive effect of MCT on respiratory function in healthy adults and the other two studies do not reveal any effect.
Conclusion: The results of the studies analyzed are not unanimous. Two studies report that there are beneficial effects on TSM in the sense of improving lung function, but the other two studies do not report any change in these functions. However, further research is needed in this area, as it is limited by the number of studies available.

Key words: Thoracic spine manipulation, High velocity low amplitude, Low velocity joint mobilization.

1 – Introduction

Spinal manipulation therapy has been used for hundreds of years and it is commonly performed by physical therapists, osteopaths, chiropractors and medical practitioners (Campbell et Snodgrass, 2010). The published research investigating the effectiveness of thoracic spine manipulation (TSM) that involves high velocity thrusts with either a long or short lever-arm, usually aimed at reducing pain and improving range of motion (Ernst, Edin, & Harkness, 2001), has been growing since the beginning of the 2000s, where they were applied mostly for treatment of musculoskeletal conditions (Walser, Meserve, & Boucher, 2009).

Shin and Lee (2016) reported that a number of different methods have been studied for improving respiratory function, including pulmonary rehabilitation, medicine therapy and spinal manipulation therapy.

TSM is proposed to increase joint mobility which could exert a positive influence on chest wall compliance and pulmonary function, a theory which has been previously investigated in those with respiratory system limitations such as chronic obstructive pulmonary disease and asthma (Jeffrey et al., 1998; Bockenhauer et al., 2002; Dougherty et al., 2011). Also, few studies have analyzed the effects that TSM may have on respiratory function at rest in healthy adults (Shin & Lee, 2016; Wall, Peiffer, Losco, & Hebert, 2016). However, these effects were only measured in the period immediately after treatment (Engel & Vemulpad, 2007; Santos et al., 2015; Shin & Lee, 2016) and over an extended time frame of 30 minutes (Wall et al., 2016), meaning that the duration of these potential effects remains virtually unknown.

Reduction in lung function, may be due to thoracic spine motion and costochondral joint restriction might affect the functions of respiratory system (Ghaffar, Sajjad, & Rasul, 2016). When hypomobility of the joint is identified, joint mobilization techniques are applied, so that may influence in improving lung function (Ghaffar et al., 2016).

Studies also say that chest wall restriction, reduces the ability of the chest wall to expand during inhalation and results in decreases in lung capacity (Klineberg et al., 1981; Scheidt et al., 1981; Noord et al., 1986) and exercise performance (O’Donnell et al., 2000; Coast & Cline, 2004).

Decreased lung volumes at rest result in rapid shallow breathing during exercise (O’Donnell et al., 2000; Coast & Cline, 2004), as well as Coast and Cline (2004)

expressed a decrease in the maximal oxygen uptake (VO_2max), maximal exercise time and maximum minute ventilation (MVV).

Gonzalez, Coast, Lawler and Welch (1999), also found decreased spirometric values, resulting from restriction of the thoracic wall of 8, 11 and 10 percent in forced vital capacity (FVC), forced expiratory volume (FEV_1) in one second and MVV, respectively. Their results corroborate with the work by Cline, Coast, and Arnall (1999), which reported decreases of 12 and 14 percent in FVC and FEV_1, respectively.

From a clinical perspective, besides chest wall and the structures associated with it are potential regions for therapeutic interventions, this can be explained by the zygapophyseal thoracic joints as an important source of local and referred pain, the role of thoracic curvature in determining general spinal posture, the influence of movement patterns in other regions of the spine and shoulder waist and also because as we grow older, residual volume (RV) increases, FVC decreases, chest wall distension decreases and diaphragm strength capacity also decreases (Schiller, 2001).

According to Miller et al. (2005), pulmonary function tests (PFTs) are non-invasive tests and show us how the lungs are working, like for example, FVC is one of the most relevant data of spirometry, which is the volume provided over expiration created as forcefully and completely as possible initiated from full inspiration and the FEV_1, which is the volume delivered in the first second of an FVC maneuver, both expressed in liters at body temperature and ambient pressure saturated with water vapour (BTPS).

The MVV is the maximum volume of air a subject can breathe over a specified period of time (12 - 15 seconds for normal subjects). It is expressed in L.min-1 at BTPS.

Also, according to Miller et al. (2005), there are two types of disorders that can cause problems in the circulation of air inside and outside the lungs:

Obstructive: This is when the air has difficulty getting out of the lungs due to the resistance. This causes a decrease in airflow.

Restrictive: This is when the chest muscles cannot expand enough. This causes problems with the airflow.

PFTs can be done with 2 methods:

Spirometry: A spirometer is a device with a mouthpiece hooked up to a small electronic machine.

Plethysmography: You sit or stand inside an air-tight box that looks like a short, square telephone booth to do the tests.

Despite the existence of some literature that evidence the beneficial effects of the TSM on pulmonary function in healthy adults, studies on this subject are still scarce. In an attempt to broaden the knowledge about the scientific evidence of the studies investigating the relationship between the variables mentioned above, a systematic review of the literature was carried out, which had as its starting point the following question: What is the evidence of the action of TMS on lung function?

1.1 - Objectives

The objective of this systematic review of literature (SRL) was to make a systematic review of randomized controlled trials and clinical trials in order to better analyze the effect of TSM on pulmonary function in healthy individuals.

2 – Method

2.1 - Eligibility criteria

This research was constructed based on the PICOS (*Population/Patient Problem, Intervention, Comparison, Outcomes, and Study Design)* model, referenced and recommended by the PRISMA guidelines (Liberati et al., 2009).

The studies potentially relevant to be included in this SLR were obtained by reading the titles, abstracts and the full text whenever the abstract was not enlightening.

The choice was based on those that relate the application of manual therapy to the thoracic spine and the resulting effects from that on pulmonary function before and after the intervention, in dates between January 2000 and March 2018.

We included only RCT and quasi-experimental studies.

We also included studies that evaluated the variables proposed using spirometry validated instrument.

Meta-analyzes, systematic reviews, conference abstracts, dissertations and theses were excluded from this review, the first because they already bring together studies related to the subject, the seconds for not gathering a level of evidence pertinent to a review.

We also excluded studies that the title was not related to the matter and studies performed outside the age limit (16 to 40 years), as well as those that did not clearly define all procedures of the study design and methods.

Types of studies

Randomized controlled trials (RCT) and clinical trials (CT) studying the effects of TSM on pulmonary function. Limits were imposed for language and only Portuguese, English and French articles were analyzed.

Types of participants

This research looked at studies that included healthy participants of both genders and with ages between 16 and 40 years old.

Types of intervention

Trials comparing the effects of TSM on pulmonary function in an intervention group, with or without a control group.

Types of outcomes measures

Trials where at least, the following outcomes were studied: FVC and FEV_1.

Studies where MVV was studied are also included in this review.

2.2 - Information sources

This search was applied to PubMed/MEDLINE and Google Scholar. The articles must have been published within the past 18 years in a peer-reviewed journal.

2.3 – Research strategy

The search strategy and inclusion criteria, followed the PICOS approach (Liberati et al., 2009). By this model, some alternatives to the keywords were defined in order to avoid bias in the search results (Table 1).

We used the following search terms to search all trials registers and databases and the combinations "OR"/"AND" were used as follows: manual therapy OR thoracic mobilization OR manipulation OR spinal AND pulmonary function OR respiratory function OR spirometry.

At PubMed/MEDLINE we activated the following filters: Article types - Clinical Trial, Randomized Controlled Trial; Publication dates - 2000/01/01 to 2018/03/31; Ages - Adolescent: 13 - 18 years, Adult: 19 - 44 years.

Table 1 - Definition of keywords used in the PICOS model for research

Population /Patient /Problem	Intervention	Comparison/ Control	Outcomes	Study Design
Adult Adolescent	Manual therapy Thoracic mobilization Manipulation Spinal		Pulmonary function Respiratory function Spirometry	Randomized controlled trial Clinical trial

2.4 - Study selection

One reviewer independently selected articles/trials for inclusion, assessed the validity of included trials and extracted data. If there was uncertainty, a second reviewer was consulted.

The following criteria were then used to determine which studies would be included or excluded for this review.

2.5 - Data collection process

The data were collected by the author, applying a table based on the review Irvine and Taylor (2009) that was created using Excel software (Table 2). These authors divided the table into five columns: *Study, Participants, Experimental / Control Intervention* and *Outcome measures* used to expose results. In the present systematic review, some columns were added, in order to complete the information in the table that shows the data of the articles under analysis.

A column with the *Type of study* and another column with the qualitative evaluation (risk of bias - PEDro and LOE scales) of the articles was added.

Finally, a column with a brief summary of the *Conclusions* of the authors of each article was placed.

2.6 - Risk of bias

In order to qualitatively evaluate the selected articles and consequent risk of bias, the PEDro scale (Physiotherapy Evidence Database) were used for articles that presented a RCT and the Oxford Center for Evidence - Based Medicine 2011 Levels of

Evidence scale (LOE), for the studies that presented the type of quasi-experimental design, being evaluated by the investigator.

The PEDro scale is composed by 11 criteria (eight related to internal validity, two related to statistical information and one related to external validity) and was developed to evaluate the methodological quality of the studies inserted in the above mentioned database. The criterion - *Therapist blinding* - was not counted because, due to the methodology of the intervention, this cannot be guaranteed. The criteria used are shown in Table 3.

LOE were based on the guidelines of the Oxford Center for Evidence - Based Medicine. This institution aims to develop and promote health-related issues through scientific evidence. The evidence is divided into five levels, numbered 1 through 5 which are shown in Table 4.

It should be noted that the articles were neither selected nor excluded on the basis of this qualitative evaluation, although the classification obtained is taken into account in the interpretation of the results.

3 - Results

3.1 - Study selection

Through the search strategy, the inclusion/exclusion criteria and after the application of the filters described in the method, the initial survey identified 3366 references. 3 duplicate studies were removed. After the removal of duplicates, 3363 studies were selected for review of titles and abstracts, of which 3357 were excluded because they did not meet the inclusion criteria. Two studies were excluded based on eligibility criteria after full reading. In this way, four studies were included in this systematic review of the literature. The process of selecting studies is presented in Figure 1.

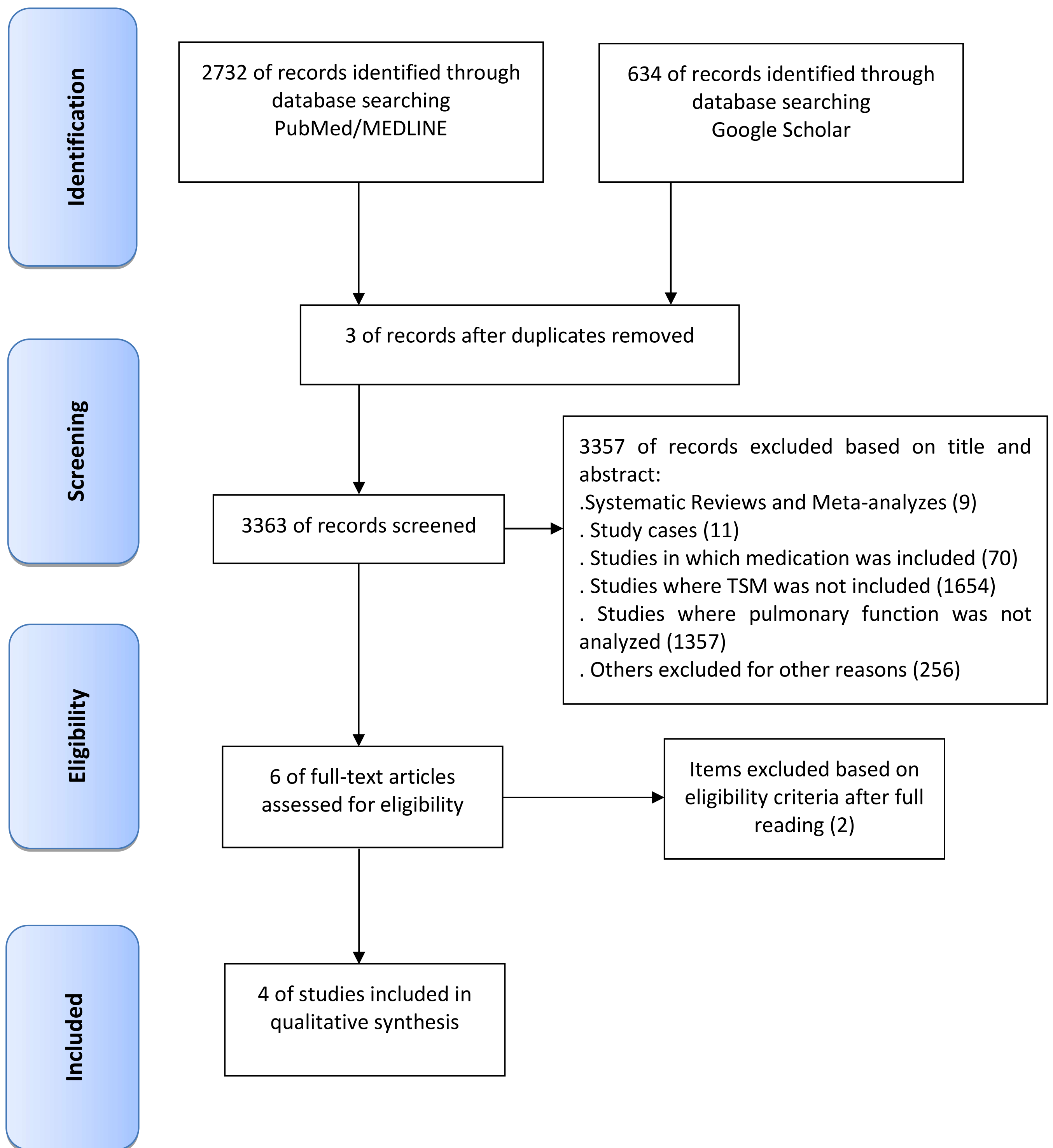

Figure 1 - Flowchart of study selection process for review.

3.2 - Study characteristics

Evaluation of the methodological quality of the studies

Table 3 and Table 4 shows the results of the methodological quality for each criterion evaluated by the PEDro and LOE scales respectively. The methodological quality of the two studies analyzed (Engel & Vemulpad, 2007; Shin & Lee, 2016) was 9 out of 10 possible points on PEDro scale. The limitation in both studies was the inability to "blind" the therapist's participation, for this reason, it must be considered that this requirement is not applied (N/A). It is also not referenced whether the Assessor was blind or not.

On the other hand, the methodological quality of the two studies analyzed (Santos et al., 2015; Wall et al., 2016) in a LOE scale from 1 to 5 was 2b.

Intervention

The duration of the intervention on Santos et al. (2015), Shin and Lee (2016) and Wall et al. (2016) studies was just a single session of manual therapy, while Engel and Vemulpad (2007) underwent six sessions of interventions over a 4-week period for each participant.

The power analysis of the sample was reported in only one of the studies (Wall et al., 2016). Of the four studies included in this systematic review, only two did not describe the recruitment strategies participants (Engel & Vemulpad, 2007; Santos et al., 2015) and the remaining two described that the participants were recruited from a university campus (Wall et al., 2016; Shin & Lee, 2016).

On Engel and Vemulpad (2007) study, there are three intervention groups, where the one with manual therapy only, had soft tissue therapy with spinal and rib manipulation administered to their lower cervical, upper and middle thoracic spines and associated ribs. Each participant underwent six manual therapy sessions over a 4-week period. Spirometry measurements were taken one minute before and one minute after each intervention.

Santos et al. (2015), on the other hand, applied TSM only to the sixth thoracic vertebra in conjunction with a muscle energy technique that stretches the pectoral muscles and measured at baseline and five minutes after the intervention.

Shin and Lee (2016) did not specify which region or regions where thoracic manipulation occurred, only referring to what occurs in the thoracic region with reduced

mobility. The respiratory function tests were performed at baseline and reassessed immediately after TSM.

On the study by Wall et al. (2016), TSM were applied at the upper level (T1-T3), mid (T4-T7) and lower (T8-T12) thoracic spine and the respiratory function tests measured at baseline and 1 minute, 10 minutes, 20 minutes and 30 minutes following the thoracic manual therapy intervention.

Primary outcomes

In all studies the primary outcome assessed was FVC and FEV_1. Santos et al. (2015) and Wall et al. (2016) studies, also evaluated the MVV parameter.

Table 2 - Characteristics of included studies (n = 4). Description of features, results and conclusions of selected articles

Study	**Type of study**	**Participants and age (years)**	**Intervention**		**PEDro scale**	**LOE scale**	**Aims and measures**	**Study results**
			Experimental	Control				
Wall et al (2016)	Quasi-experimental	n = 20; 23 ± 3.9	Manual therapy	No group added		2b	Analyze FVC; FEV_1; MVV after TSM	Manual therapy does not alter pulmonary function FVC/FEV_1 ratio was 0.84 (p = 0.07). No statistically significant difference shown also on MVV
Santos et al (2015)	Quasi-experimental	n = 30; 20.8 ± 1.9	Manual therapy	No group added		2b	Analyze FVC; FEV_1; MVV after TSM	No statistically significant difference shown on FVC (p = 0.50), FEV_1 (p = 0.12) and MVV (p = 0.15)
Shin & Lee (2016)	RCT	n = 15; 21.2 ± 2.1 n = 15; 22.5 ± 4.8	TSM	Control group (No-TSM)	9		Analyze FVC; FEV_1 after TSM	Experimental group showed FVC ($p < 0.05$) and FEV_1 ($p < 0.05$). Control group showed no difference after the intervention
Engel & Vemulpad (2007)	RCT	n = 20; 18 - 28	3 groups: Exercise; Manual therapy; Manual therapy & Exercise. Each participant underwent 6 sessions of interventions over a 4-week period.	Control group	9		Analyze FVC; FEV_1 after TSM	Only the manual therapy group showed a significant increase in FVC ($p < 0.00$) and FEV_1 (p = 0.00)

TSM, Thoracic Spine Manipulation; FVC, Forced Vital Capacity; FEV_1, Forced Expiratory Volume in one second; MVV, Maximal Voluntary Ventilation; RCT, Randomized Control Trial; *p*, p-value.

Table 3 - Quality PEDro scores of included studies

Study	Journal	Impact Factor	Eligibility criteria	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding	< 15% dropouts	Intention-to-treat analysis	Between-group difference reported	Point estimate and variability reported	Total (0 to 10)
Shin & Lee (2016)	Journal of Physical Therapy Science	---	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Yes	9
Engel & Vemulpad (2007)	Journal of Manipulative and Physiological Therapeutics	1.59	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Yes	9

Table 4 - Qualitative Analysis of the Bias Risk of Levels of Evidence

Study	Journal	Journal Impact factor_2017	LOE (1 a 5)
Wall et al (2016)	Scientific Reports	4.25	2b
Santos et al (2015)	Arq. Ciênc. Saúde UNIPAR	---	2b

3.3 - Syntheses of results

A randomized control trial by Engel and Vemulpad (2007) explored the effect of combining manual therapy with exercise on respiratory function in normal individuals. This study reported that participants who received manual therapy showed a significant increase in FVC ($p < 0.00$) and FEV_1 ($p = 0.00$) in respiratory function compared to the control group which reported no change in FVC or FEV_1. They concluded that manual therapy appeared to increase the respiratory function in normal individuals, although they acknowledge that generalizability was limited by the small sample size (n = 20).

Santos et al. (2015) study consisted of 30 volunteers and the results show that there was no significant difference for FVC ($p = 0.50$), for FEV_1 ($p = 0.12$) and for MVV ($p = 0.15$).

Shin and Lee (2016) show us that after the intervention, the FVC and FEV_1 were significantly increased in the experimental group ($p < 0.05$). However, the control group showed no difference after the intervention. Differences between the 2 groups in pre and post-intervention FVC and FEV_1 were significant.

Wall et al. (2016) on the other hand, tell us that the standard deviation (SD) FVC/FEV_1 ratio was 0.84 ($p = 0.07$) as well as MVV shows no significant difference. So, there were no statistically significant changes in the pulmonary function measures at any time point following the manual therapy intervention.

4 - Discussion

4.1 - Summary of evidence

Overall, the evidence is not sufficient robust to determine the effectiveness of TSM in pulmonary function, because of the four studies that measured the FVC and FEV_1 parameters, two of them (Engel & Vemulpad, 2007; Shin & Lee, 2016) show statistically significant increases, while the other two do not present statistically significant results (Santos et al., 2015; Wall et al., 2016). In these last two studies, the MVV parameter was also measured and similarly, there were no significant results.

It has been previously proposed that manipulative therapy may enhance joint mobility and subsequently, enhance static and/or dynamic lung function (Engel & Vemulpad, 2007).

Spinal manipulation is a manual treatment in which a vertebral set is passively manipulated, to promote the normal arc of the vertebra, improving joint mobility, as

described by Vernon and Mrozek (2005) in his findings, in which the improvement of the mobility of the vertebra thoracic cavity after the thrust maneuver in the thoracic spine occurred.

According to Makofsky et al. (2007), during mobilization/manipulation, the capsulo-ligamentary tissues of a joint are mechanically stretched and a major goal of these techniques is to improve the extensibility of restricted capsulo-ligamentous tissue; Secondarily, the level of activation of the joint mechanoreceptors is affected and the articular mobilization has demonstrated improvement in the physiological and accessory movements for the hypomobility of structures.

Henley, Ivins, Mills, Wen and Benjamin (2008) proposed that manipulation therapy promotes autonomic activity, causing associated vasodilation, smooth muscle relaxation and increased blood flow, leading to improved range of motion, decreased pain perception, and/or changes in the tissue. It would seem reasonable to consider manipulation therapy as an adjunctive therapeutic approach to increase thoracic mobility, reduce the work of breathing and manage pain.

Miller, Bulbulian, Sherwood and Kovach (2000) showed that increasing thoracic joint mobility improves lung function in the short term in normal individuals.

Although the results do not fully support the use of TSM to improve lung function in healthy adults, alternative approaches to manual therapy may produce different results as seen in this review. Therefore, future research efforts in this area should examine the effects of different techniques of manual therapy and treatment protocols, whether in healthy individuals or in impaired populations, as well as in the context of enhancing aerobic performance in sports where the respiratory system considered a rate limited factor.

4.2 - Limitations

We identified as main limitations of our study: the systematic review was conducted almost entirely by an investigator, which may have conditioned the research strategy; only the PubMed/MEDLINE and Google Scholar databases were searched, so by extending the search to other databases, other eligible studies could be identified.

5 - Conclusion

As would be expected from a relatively recent area of scientific knowledge, methodological limitations are evident in studies in this context. The results of the studies analyzed are not unanimous. Two studies reported that there are beneficial

effects on TSM in the sense of improving lung function, but the other two studies did not report any change in these functions. These make it difficult to state the most frequent frequency, type and duration of intervention and draw conclusions about their effectiveness or no effectiveness for this population.

Despite these results, manual therapy and in particular TSM has been analyzed in other parameters, namely in cardiovascular function, inflammatory markers, neuroendocrine function, autonomic nervous system response, increased range of motion, spinal stiffness among others and the results have been promising, so, the effects of this type of manual therapy on pulmonary function are encouraging, but future studies with rigorous study designs are required.

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Chapter III

Manuscript II - The effect of thoracic spine manipulation on pulmonary function in swimming athletes

Resumo

Objectivo: O objetivo deste estudo foi analisar o efeito da manipulação da coluna torácica (MCT) na capacidade vital forçada (CVF), volume expiratório forçado no primeiro segundo (VEF_1) e ventilação voluntária máxima (VVM) em atletas de natação durante um período de 30 minutos medido em 5 momentos de avaliação.

Método: Realizou-se um estudo aleatorizado controlado crossover, que consistiu em 21 atletas federados de natação (11 do género masculino), divididos em dois grupos (Intervenção *vs* Controlo), com idades compreendidas entre os 16 - 24 anos (M = 18.62 ± 2.40), onde a CVF, VEF_1 e VVM foram medidos em 5 momentos de avaliação: baseline e, 1 minuto, 10 minutos, 20 minutos e 30 minutos após a intervenção da MCT. Após o washout de duas semanas, fez-se o crossover dos grupos.

Resultados: No grupo de intervenção não foram observadas diferenças significativas na CVF ($p = 0.35$) e VEF_1 ($p = 0.25$) em qualquer dos 5 momentos de avaliação, no entanto, o mesmo não aconteceu com a VVM ($p = 0.02$), onde se verificou uma redução estatísticamente significativa entre a baseline e aos 10 e 30 minutos.

Conclusão: Os resultados demonstraram que a MCT não produziu nenhum efeito significativo nas variáveis CVF e VEF_1, enquanto na VVM se registou uma diminuição nos valores no grupo de intervenção. Sendo este um estudo pioneiro na área do desporto, será necessário por isso, mais investigação para se poder retirar conclusões mais fidedignas.

Palavras-chave: Manipulação da coluna torácica, Alta velocidade baixa amplitude, Baixa velocidade mobilização articular.

Abstract

Objective: The objective of this study was to analyze the effect of thoracic spinal manipulation (TSM) on forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and maximal voluntary ventilation (MVV) in swimming athletes during a 30-minute period measured in 5 evaluation moments.

Method: A randomized controlled crossover study was performed, consisting of 21 federated swimming athletes (11 male), divided into two groups (Intervention *vs* Control), aged 16 - 24 (M = 18.62 ± 2.40), where FVC, FEV_1 and MVV were measured in 5 evaluation moments: at baseline and, 1 minute, 10 minutes, 20 minutes and 30 minutes following the TSM intervention. After the washout of two weeks, the crossover of the groups was made.

Results: In the intervention group, no significant differences were observed in FVC ($p = 0.35$) and FEV_1 ($p = 0.25$) in any of the 5 evaluation moments, however, the same did not occur with MVV ($p = 0.02$), where there was a statistically significant reduction between baseline and at 10 and 30 minutes.

Conclusion: The results showed that TSM had no significant effect on the FVC and FEV_1 variables, while, in the MVV there was a decrease in values in the intervention group. As this is a pioneering study in the field of sport, more research will therefore be needed to draw more reliable conclusions.

Key words: Thoracic spine manipulation, High velocity low amplitude, Low velocity joint mobilization.

1- 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 (Walser, Meserve, & Boucher, 2009).

Shin and Lee (2016) reported that a number of different methods have been studied for improving respiratory function, including pulmonary rehabilitation, medicine therapy and spinal manipulation therapy.

Regarding the functions of respiratory system, it is assumed that a reduction in lung function, may be due to limited thoracic spine motion and costochondral joint restriction. When hypomobility of the joint is identified, joint mobilization techniques are applied, so that may improve lung function (Ghaffar, Sajjad, & Rasul, 2016).

An experimental body of evidence exists indicating that spinal manipulation could affect the nervous system by activating paraspinal sensory neurons during the maneuver itself and/or by altering spinal biomechanics. Biomechanical changes which follow the manipulation would, in turn, modulate paravertebral sensory neuron signals. As a short-lasting, dynamic mechanical stimulus, spinal manipulation may take advantage of two signalling characteristics of the nervous system: (1) inherent high-frequency signalling properties of dynamically sensitive primary afferent neurons and (2) response properties of postsynaptic neurons (Huisman, Speksnijder & Wijer, 2013).

TSM is proposed to increase joint mobility which could exert a positive influence on chest wall compliance and pulmonary function, a theory which has been previously investigated in those with respiratory system limitations such as chronic obstructive pulmonary disease and asthma (Jeffrey et al., 1998; Bockenhauer et al., 2002; Dougherty et al., 2011).

Decreased lung volumes at rest result in rapid shallow breathing during exercise, as well as expressed a decrease in the maximal oxygen uptake (VO_2max), maximal exercise time and maximal voluntary ventilation (MVV) (O'Donnell et al., 2000; Coast & Cline, 2004).

Gonzalez, Coast, Lawler and Welch (1999), also found decreased spirometric values, resulting from restriction of the thoracic wall of 8, 11 and 10 percent in forced

vital capacity (FVC), forced expiratory volume in one second (FEV_1) and MVV, respectively. Their results corroborate with the work by Cline, Coast and Arnall (1999), which reported decreases of 12 and 14 percent in FVC and FEV_1, respectively.

Previous studies that analyzed the effects of TSM at rest in healthy adults, observed that there were no significant differences in respiratory functions (Santos et al., 2015; Wall, Peiffer, Losco & Hebert, 2016), on the other hand, Engel & Vemulpad (2007) and Shin & Lee (2016) studies observed that there were significant differences in their results. The effects of TSM were only measured in the period immediately after treatment (Engel & Vemulpad, 2007; Santos et al., 2015; Shin & Lee, 2016) and over an extended time frame of 30 minutes (Wall et al., 2016), meaning that the duration of these potential effects remains virtually unknown by the few studies still performed.

To see how the lungs are working, it can be used pulmonary function tests (PFTs), that are non-invasive tests. In this spirometric tests, FVC and FEV_1 are two of the most relevant data of spirometry that can be measured. FVC is the volume provided over expiration created as forcefully and completely as possible initiated from full inspiration and the FEV_1 is the volume delivered in the first second of an FVC maneuver, both expressed in liters at body temperature and ambient pressure saturated with water vapour (BTPS).The MVV is the maximum volume of air a subject can breathe over a specified period of time (12 to 15 seconds for normal subjects) and it is expressed in L.min-1 at BTPS (Miller et al., 2005).

The interpretation of pulmonary function tests (PFTs) requires knowledge of respiratory physiology and the guidelines for performing and interpreting PFTs have been published by the European Respiratory Society (ERS) and American Thoracic Society (ATS).

It has been observed that there are no studies in the context of sports activities, for this reason, additional research is required to explore the effects of TSM, where elite level athletes constantly seek methods to improve performance, where the respiratory system is considered a limited rate factor.

1.1- Objectives

Following the model applied by Wall et al. (2016), the objective of this study was to analyze the influence of a single TSM session on FVC, FEV_1 and MVV over a time frame of 30 minutes in swimming athletes.

2 - Methods

2.1 - Study design and Power analysis

It is a randomized control trial (RCT) crossover study, with the participation of 24 individuals. The minimum level of clinically important change in FVC and FEV_1 is estimated to be 12% (Pellegrino et al., 2005). Based on previous research (Lazovic et al., 2015), we assumed the baseline mean (standard deviation) FVC value would be 6.0 (± 0.9) liters 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.

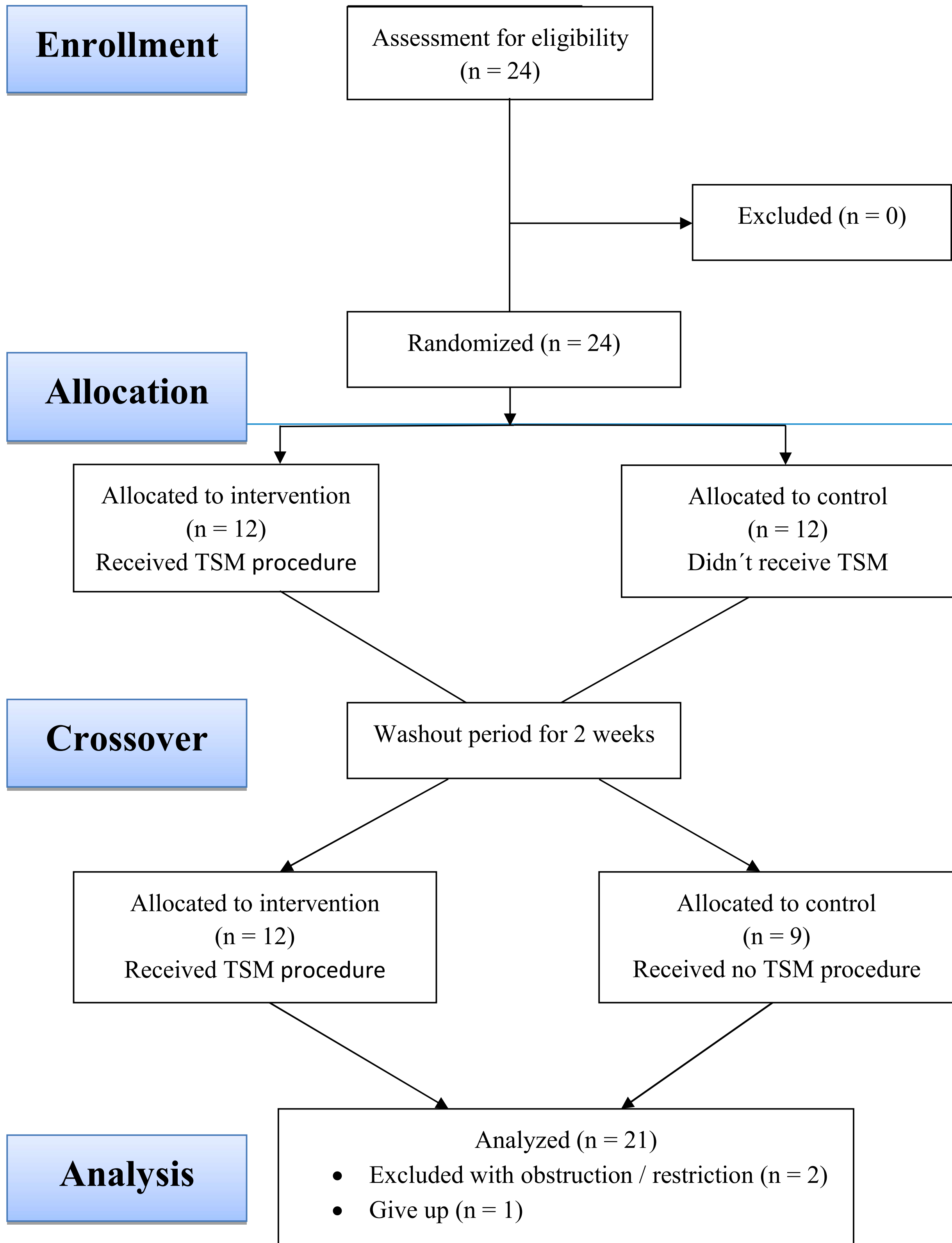


Figure 2 - Flowchart of study selection process for review

2.2 - Participants

The participants were recruited at the "Clube de Campismo Luz e Vida" and at the "Clube de Instrução e Recreio do Laranjeiro" where the study took place in two separate occasions.

The sample consisted of 24junior and senior swimmers' federated athletes of both genders (11 males), with frequent participation in competitions of 200 meters or more national level (participation in national championships), for at least 3 years and train at least 3 times a week.

Figure 2 is a diagram of retention and randomization throughout the study, where we can visualize the 3 drop outs occurred, for that reason we analyzed 21 athletes.

Table 5 shows a summary of the anthropometric characteristics, namely for a central tendency measure: the mean and two dispersion measures and the standard deviation.

All the collections were performed individually and on an equal basis, without interference from other swimmers, in any of the studied variables.

The participants were invited to a briefing on participation in the study. For those who accept and agree to participate, they must sign an informed consent (see Appendix I and II) and a questionnaire relating to personal, health and nutritional data (see Appendix III).

All procedures were performed according to the Declaration of Helsinki.

Confidentiality and anonymity are guaranteed, stored in a computer with password, being the investigator the responsible person for that.

The study participants were clearly instructed about the basic sequence of their portion of the research study.

Data collection for the participants took place over the course of a two-month window, from May 7 through June 30 of 2018.

Table 5 - Anthropometric Characteristics (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

Abbreviations: BMI, Body Mass Index

2.3 - Randomization

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) (Shin & Lee, 2016).

For the selection of the sample, the following inclusion criteria were respected: to be aged between 16 and 30 years; who have a normal BMI, that is, between 18.5 and 24.9 kg/m2 (inclusive).

The following exclusion criteria were used: individuals with cardiorespiratory disease (cardiovascular risk categorization, medical indication of respiratory pathology), cognitive or physical disabilities, osteopathic/chiropractor treatment in the 4 weeks prior to the study, thoracic scoliosis greater than 25º, previous sternum/clavicle/rib/vertebra fracture for at least 1 year previous, which do not meet the general considerations for lung testing requirements according to (Miller et al., 2005), pregnancy or menstruation.

2.4 - Instruments

Respiratory function tests were performed using a professional portable spirometer (Medikro Pro) validated according to the ATS and ERS criteria (Miller et al., 2005). Medikro Pro spirometer uses the new Medikro Calibration Free Technology (Medikro CFT). Medikro CFT allows for precise, and calibration free, spirometry testing. The Medikro Pro spirometer system continuously monitors ambient conditions to ensure automated and constant calibration of the spirometry system.
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 (2016) and NANHES III data was used.

All the above 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%.

An osteopathy table of brand Multiphysio was used to guarantee the perfect execution of the thoracic manipulation.

In the calculation of the 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.

There were no changes in athlete´s anthropometric measurements during the study and this collection of data was always attended by the author of this dissertation and with the participation of other technician experienced in the matter.

2.5- Procedures

The 24 participants were divided into 2 groups, 12 participants in the IG and 12 participants in the CG.

The intervention phase of the study was performed by an osteopath with 8 years of experience in the TSM technique.

All participants in the intervention group completed a single experimental session which involved PFTs (FVC; FEV_1 and MVV) that were measured at baseline (b) and 1 minute, 10 minutes, 20 minutes and 30 minutes following the TSM intervention that implicate two manual therapy techniques applied in standardized fashion: 1) High velocity low amplitude (HVLA) thrust manipulation and 2) Low velocity joint mobilization (LVJM).

The subject lay supine with the arms crossed over the chest and hands passed around the shoulder. The thoracic spine is in neutral position. The hand of the osteopath contacted with a neutral hand position, 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 high-velocity low amplitude technique downward toward the couch and in a cephalad direction was applied. A cracking or popping sound accompanied all manipulations. 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 2 attempts were performed on each participant. Further details of the HVLA technique is available at Masaracchio, Cleland, Hellman and Hagins (2013) and Cleland et al. (2005) studies. Following the thrust manipulations, it was performed LVJM, rotatory, grade 4 joint mobilizations to the thoracic spine 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 10 mobilizations to the left and 10 mobilizations to the right (Maitland, 2005, p.332-333).

The CG received only the positioning of the osteopath's hands on the participant's body in the same position with only light touch without performing any maneuver, without reduction, or push or joint noise. PFTs (FVC; FEV_1 and MVV) were also measured at baseline (b) and 1 minute, 10 minutes, 20 minutes and 30 minutes following this light touch.

Participants underwent the PFTs 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 FEV_1 could be measured. These measures were completed in triplicate, allowing one minute between efforts, with the best results used for analysis. Sixty seconds after completing the third PFTs, participants were required to complete a single MVV maneuver for 15 seconds. During this period, the participant remained in the study room.

At this stage, two athletes were excluded from the study because they presented obstruction/restriction in the spirometry test.

Subsequently, there was a washout period of 2 weeks, after which the crossover was done for the groups and the intervention performed again (at this point, one athlete gave up for professional reasons), being transmitted to the athletes during this period, not to vary their normal daily routine.

2.6- Statistical analysis

Data analysis and statistical analyzes (descriptive and inference) were performed using IBM SPSS Statistics 24 (SPSS, Inc., Chicago, IL, USA). The variables used were

Age, Weight, Height, BMI, FVC, FEV_1, and MVV, all a continuous quantitative nature, except the first that is of a discrete quantitative nature.

In the second part of our analysis, we added a new variable called group, which allows us to distinguish the intervention group from the control group, which is of an ordinal qualitative nature.

The variables FVC, FEV_1 and MVV were later divided into two groups, for the intervention group and the control group, and each group was again divided into 5 parts, that is, baseline, 1 minute, 10 minutes, 20 minutes and 30 minutes respectively.

The ANOVA inferential test evaluates the hypothesis of means between different groups, in our case, the measurements in the different periods of times are the same. The rejection of the null hypothesis in favor of the alternative hypothesis indicates that these differences are due to the factor (or factors), which had statistically significant effects on the participants' results. Performing the ANOVA test for repeated measures requires assumptions, one of which is the sphericity test. In this case, it is expected that there is heterogeneity between the variances, that is, if there is variability between the measurements made to the same individual in a given time interval.

Variables were assessed for normality using the Kolmogorov Smirnov test and the Shapiro Wilk test. We concluded that the variables followed normal distribution with the level of significance of 0.05. For the remaining tests the level of significance was the same.

3 - Results

Twenty-four healthy volunteers participated in this study. There were complications encountered with ventilation function measurements of data in two subjects, reporting obstruction/restriction results in the ventilation function on the spirometry results, whether in any of the 5 evaluation moments and one athlete did not complete the study. Data from these three subjects were excluded from data analysis. Therefore, data from 21 subjects were analyzed. Table 6 shows the anthropometric statistics, namely for the mean, the standard deviation and the two dispersion measures respectively.

Table 6 - Anthropometric Statistics

		Age	Weight	Height	BMI
N	Valid	21	21	21	21
	Missing	0	0	0	0
Mean		18.62	65.47	170.71	22.41
Median		18.00	66.00	170.00	22.00
Std. Deviation		2.39	8.70	7.47	2.10
Minimum		16	54.00	159.00	18.50
Maximum		24	88.00	186.00	27.80

We will now describe the results of the variables FVC, FEV_1, MVV and then the analysis comparing the groups to see if there are any significant differences.

FVC_I (Intervention)

The mean FVC_I results obtained at the five evaluation moments (before the intervention and after 1, 10, 20 and 30 minutes) at the time of the intervention are represented in Table 7 and were submitted to ANOVA for repeated measures.

Table 7 - Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FVC_I_B	21	2.60	6.59	4.64	1.04
FVC_I_1	21	3.50	6.48	4.74	0.94
FVC_I_10	21	3.26	6.49	4.62	0.96
FVC_I_20	21	3.28	6.55	4.74	0.90
FVC_I_30	21	2.48	6.84	4.65	1.04

Table 8 - Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	0.14	36.91	9	0.00	0.53	0.60	0.25

For ANOVA, sphericity assumptions were not met, as can be seen in Table 8 ($\chi^2_{(9)} = 36.91$, $p < 0.00$).

In this way, the Greenhouse-Geisser correction was used, and no significant differences were observed between the five moments (F = 1.09, p = 0.35). The four versions of the F statistic come to the same conclusion. Since the critical level (Sig.) is greater than 0.05, we do not reject the hypothesis of equality of means and thus conclude that the mean in the 5 times in the athletes is the same (Table 9). As there are no significant differences, we do not perform any multiple *post-hoc* comparison tests.

Table 9 - Tests of Within - Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	0.29	4	0.07	1.09	0.37
	Greenhouse-Geisser	0.29	2.13	0.13	1.09	0.35
	Huynh-Feldt	0.29	2.40	0.12	1.09	0.35
	Lower-bound	0.29	1.00	0.29	1.09	0.31

FEV_1_I (Intervention)

The mean FEV_1_I results obtained at the five evaluation moments (before the intervention and after 1, 10, 20 and 30 minutes) at the time of the intervention are represented in Table 10 and were submitted to ANOVA for repeated measures.

Table 10 - Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FEV_1_I_B	21	2.05	5.28	3.91	0.82
FEV_1_I_1	21	2.41	5.53	3.86	0.76
FEV_1_I_10	21	2.80	5.39	3.77	0.70
FEV_1_I_20	21	2.79	5.40	3.81	0.71
FEV_1_I_30	21	2.11	5.26	3.80	0.75

Table 11 - Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	0.22	27.93	9	0.00	0.58	0.66	0.25

As we want to test if there is variability between the measurements, for this we will use the sphericity test, one of the assumptions of the ANOVA test and verify that the assumptions of sphericity have not been fulfilled, as we can see in Table 11 ($\chi^2_{(9)}$ = 27.93, $p < 0.00$).

In this way, the Greenhouse-Geisser correction was used, and no significant differences were observed between the five moments (F = 1.44, p = 0.25). The four versions of the F statistic come to the same conclusion. Since the critical level (Sig.) is greater than 0.05, we do not reject the hypothesis of equality of means and thus conclude that the mean in the 5 times in the athletes is the same (Table 12). As there are no significant differences, we do not perform any multiple *post-hoc* comparison tests.

Table 12 - Tests of Within - Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	0.23	4	0.06	1.44	0.23
	Greenhouse-Geisser	0.23	2.31	0.09	1.44	0.25
	Huynh-Feldt	0.23	2.63	0.09	1.44	0.24
	Lower-bound	0.23	1.00	0.23	1.44	0.24

MVV_I (Intervention)

The mean MVV_I results obtained at the five evaluation moments (before the intervention and after 1, 10, 20 and 30 minutes) at the time of the intervention are represented in Table 13 and were submitted to ANOVA for repeated measures.

Table 13 - Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
MVV_I_B	21	17.46	171.40	85.99	35.35
MVV_I_1	21	17.80	174.79	82.46	34.30
MVV_I_10	21	25.40	145.84	79.29	30.74
MVV_I_20	21	36.27	154.54	80.89	33.19
MVV_I_30	21	19.87	147.94	76.24	33.40

Table 14 - Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	0.55	10.86	9	0.28	0.79	0.95	0.25

Since we want to test for variability between measurements, we will use the sphericity test, one of the ANOVA test conditions, and verify that the sphericity assumptions have been fulfilled, as can be seen in Table 14.

The Mauchly test indicated that the sphericity principle was met ($\chi^2_{(9)} = 10.86$, $p = 0.28$). The results of ANOVA (Table 15) show the presence of significant differences (F = 3.02, $p = 0.02$).

Table 15 - Tests of Within - Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	1106.56	4	276.64	3.02	0.02
	Greenhouse-Geisser	1106.56	3.17	349.01	3.02	0.03
	Huynh-Feldt	1106.56	3.83	288.36	3.02	0.02
	Lower-bound	1106.56	1.00	1106.56	3.02	0.09

As there are significant differences we will perform a *post hoc* statistical test (Table 16) and verify where these differences exist.

The test to be performed is the multiple comparison test that compares the pairs of measurements that were made and signals the differences.

Table 16 - Pairwise Comparisons

(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	3.53	2.99	0.25	-2.70	9.77
	3	6.70	2.65	0.02	1.16	12.24
	4	5.10	3.53	0.16	-2.27	12.47
	5	9.75	3.39	0.00	2.68	16.82
2	1	-3.53	2.99	0.25	-9.77	2.70
	3	3.16	2.58	0.23	-2.23	8.56
	4	1.56	3.53	0.66	-5.81	8.94
	5	6.22	3.16	0.06	-0.38	12.83
3	1	-6.70	2.65	0.02	-12.24	-1.16
	2	-3.16	2.58	0.23	-8.56	2.23
	4	-1.60	2.30	0.49	-6.40	3.19
	5	3.05	2.25	0.19	-1.65	7.75
4	1	-5.10	3.53	0.16	-12.47	2.27
	2	-1.56	3.53	0.66	-8.94	5.81
	3	1.60	2.30	0.49	-3.19	6.40
	5	4.65	2.70	0.10	-0.99	10.30
5	1	-9.75	3.39	0.00	-16.82	-2.68
	2	-6.22	3.16	0.06	-12.83	0.38
	3	-3.05	2.25	0.19	-7.75	1.65
	4	-4.65	2.70	0.10	-10.30	0.99

We can verify that the pairs that present significant differences are: 1 with 3 and 1 with 5, this means that between MVV_I_B with MVV_I_10 ($p = 0.02$) and MVV_I_B with MVV_I_30 ($p = 0.00$) there is a level of significance lower than 0.05 respectively (Table 16).

FVC_C (Control)

The mean FVC_C results obtained at the five evaluation moments (before the intervention and after 1, 10, 20 and 30 minutes) at the time of intervention in the control group are represented in Table 17 and were submitted to ANOVA for repeated measures.

Table 17 - Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FVC_C_B	21	3.32	6.33	4.52	1.00
FVC_C_1	21	2.35	6.37	4.54	1.03
FVC_C_10	21	2.20	6.35	4.38	1.10
FVC_C_20	21	1.94	6.45	4.35	1.12
FVC_C_30	21	2.99	6.45	4.39	1.05

Table 18 - Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	0.19	29.87	9	0.00	0.70	0.82	0.25

As we want to test if there is variability between the measurements, for this we will use the sphericity test, one of the assumptions of the ANOVA test and verify that the assumptions of sphericity have not been fulfilled, as can be seen in Table 18 ($\chi^2_{(9)} = 29.87$, $p < 0.00$).

In this way, the Greenhouse-Geisser correction was used, and no significant differences were observed between the five moments (F = 2.52, p = 0.07). The four versions of the F statistic come to the same conclusion. Since the critical level (Sig.) is greater than 0.05, we do not reject the hypothesis of equality of means and thus conclude that the mean in the 5 times in the athletes is the same (Table 19). As there are no significant differences, we do not perform any multiple *post-hoc* comparison tests.

Table 19 - Tests of Within - Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	0.67	4	0.17	2.52	0.04
	Greenhouse-Geisser	0.67	2.80	0.24	2.52	0.07
	Huynh-Feldt	0.67	3.31	0.20	2.52	0.05
	Lower-bound	0.67	1.00	0.67	2.52	0.12

FEV_1_C (Control)

The mean FEV_1_C results obtained at the five evaluation moments (before the intervention and after 1, 10, 20 and 30 minutes) at the time of intervention in the control group are represented in Table 20 and were submitted to ANOVA for repeated measures.

Table 20 - Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FEV_1_C_B	21	3.02	5.52	3.81	0.72
FEV_1_C_1	21	1.99	5.23	3.76	0.77
FEV_1_C_10	21	2.14	5.19	3.67	0.80
FEV_1_C_20	21	1.94	5.34	3.64	0.80
FEV_1_C_30	21	2.42	5.26	3.65	0.76

Table 21 - Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	0.42	15.68	9	0.07	0.73	0.87	0.25

Since we want to test for variability between measurements, we will use the sphericity test, one of the ANOVA test attempts, and verify that the sphericity assumptions have been fulfilled, as we can see in Table 21.

The Mauchly test indicated that the sphericity principle was met ($\chi^2_{(9)} = 15.68$, $p = 0.07$). The results of ANOVA (Table 22) show the presence of significant differences ($F = 3.46$, $p = 0.01$).

Table 22 – Tests of Within - Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	0.47	4	0.12	3.46	0.01
	Greenhouse-Geisser	0.47	2.94	0.16	3.46	0.02
	Huynh-Feldt	0.47	3.51	0.13	3.46	0.01
	Lower-bound	0.47	1.00	0.47	3.46	0.07

As there are significant differences we will perform a *post hoc* statistical test (Table 23) and verify where these differences exist.

The test to be performed is the multiple comparison test that compares the pairs of measurements that were made and signals the differences.

Table 23 - Pairwise Comparisons

(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	0.05	0.06	0.43	-0.08	0.18
	3	0.14	0.05	0.02	0.02	0.25
	4	0.17	0.07	0.02	0.02	0.31
	5	0.16	0.06	0.01	0.03	0.28
2	1	-0.05	0.06	0.43	-0.18	0.08
	3	0.09	0.05	0.12	-0.02	0.20
	4	0.12	0.06	0.07	-0.01	0.25
	5	0.11	0.06	0.11	-0.02	0.25
3	1	-0.14	0.05	0.02	-0.25	-0.02
	2	-0.09	0.05	0.12	-0.20	0.02
	4	0.03	0.03	0.44	-0.05	0.11
	5	0.02	0.03	0.55	-0.05	0.10
4	1	-0.17	0.07	0.02	-0.31	-0.02
	2	-0.12	0.06	0.07	-0.25	0.01
	3	-0.03	0.03	0.44	-0.11	0.05
	5	-0.00	0.04	0.88	-0.10	0.09
5	1	-0.16	0.06	0.01	-0.28	-0.03
	2	-0.11	0.06	0.11	-0.25	0.02
	3	-0.02	0.03	0.55	-0.10	0.05
	4	0.00	0.04	0.88	-0.09	0.10

We can verify that the pairs that present significant differences are: 1 with 3, 1 with 4 and 1 with 5, this means that between FEV_1_C_B with FEV_1_C_10 ($p = 0.02$), FEV_1_C_B with FEV_1_C_20 ($p = 0.02$) and FEV_1_C_B with FEV_1_C_30 ($p = 0.01$) there is a level of significance lower than 0.05 respectively (Table 23).

MVV_C (Control)

The mean MVV_C results obtained at the five evaluation moments (before the intervention and after 1, 10, 20 and 30 minutes) at the time of intervention in the control group are represented in Table 24 and were submitted to ANOVA for repeated measures.

Table 24 - Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
MVV_C_B	21	49.32	162.79	84.89	32.41
MVV_C_1	21	43.90	142.82	80.84	26.58
MVV_C_10	21	24.75	149.52	82.44	33.06
MVV_C_20	21	25.30	156.03	78.70	34.36
MVV_C_30	21	20.89	154.11	81.28	34.75

Table 25 - Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	Df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	0.39	17.05	9	0.04	0.73	0.87	0.25

As we want to test if there is variability between the measurements, for this we will use the sphericity test, one of the ANOVA test attempts and verify that the sphericity assumptions were not fulfilled, as we can see in Table 25 ($\chi^2_{(9)} = 17.05$, $p < 0.04$).

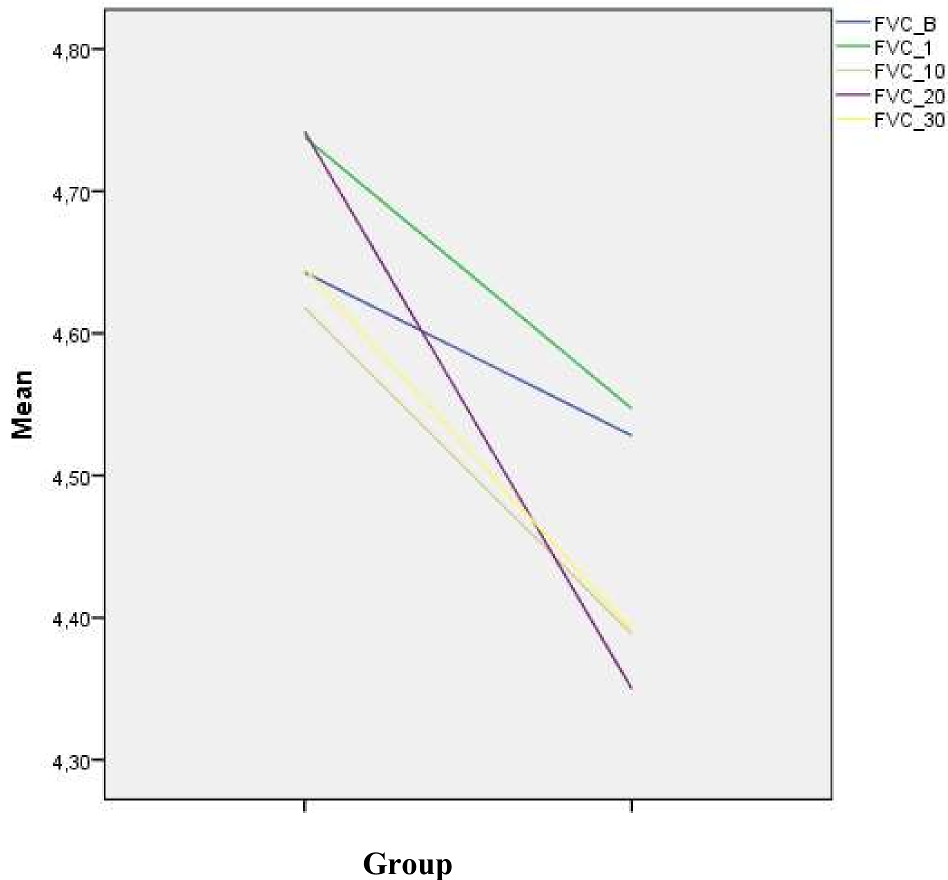
In this way, the Greenhouse-Geisser correction was used, and no significant differences were observed between the five moments (F = 1.24, $p = 0.30$). The four versions of the F statistic come to the same conclusion. Since the critical level (Sig.) is greater than 0.05, we do not reject the hypothesis of equality of means and thus conclude that the mean in the 5 times in the athletes is the same (Table 26). As there are no significant differences, we do not perform any multiple *post-hoc* comparison tests.

Table 26 - Tests of Within - Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	432.66	4	108.16	1.24	0.29
	Greenhouse-Geisser	432.66	2.93	147.42	1.24	0.30
	Huynh-Feldt	432.66	3.49	123.81	1.24	0.30
	Lower-bound	432.66	1.00	432.66	1.24	0.27

FVC between the two groups

Analysis comparing the groups to see if there are any significant changes, shows that non-parallel lines are indicative of interaction. There seems to be interaction between measurements FVC_1, FVC_10 and FVC_30 in the different groups (Figure 3).



Group

Figure 3 - FVC between the two groups - Line chart

Table 27 - Tests of Within-Subjects Effects – FVC between the two groups

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	0.52	4	0.13	1.99	0.09
	Greenhouse-Geisser	0.52	2.94	0.18	1.99	0.11
	Huynh-Feldt	0.52	3.27	0.16	1.99	0.11
	Lower-bound	0.52	1.00	0.52	1.99	0.16
Time* Group	Sphericity Assumed	0.43	4	0.10	1.64	0.16
	Greenhouse-Geisser	0.43	2.94	0.14	1.64	0.18
	Huynh-Feldt	0.43	3.27	0.13	1.64	0.17
	Lower-bound	0.43	1.00	0.43	1.64	0.20

We can observe that there are no significant differences in the measurements in the different groups, that of the intervention and that of the control, since the level of significance is higher than 0.05, even for any test performed (Table 27).

We assume that the sphericity hypothesis was not rejected.

Table 28 - Tests of Between-Subjects Effects – FVC between the two groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	4365.10	1	4365.10	881.55	0.00
Group	2.93	1	2.93	0.59	0.44

We can observe that *p-value* = 0.44 < 0.05 does not reject H0, again we observe that there are no differences in FVC between groups here (Table 28).

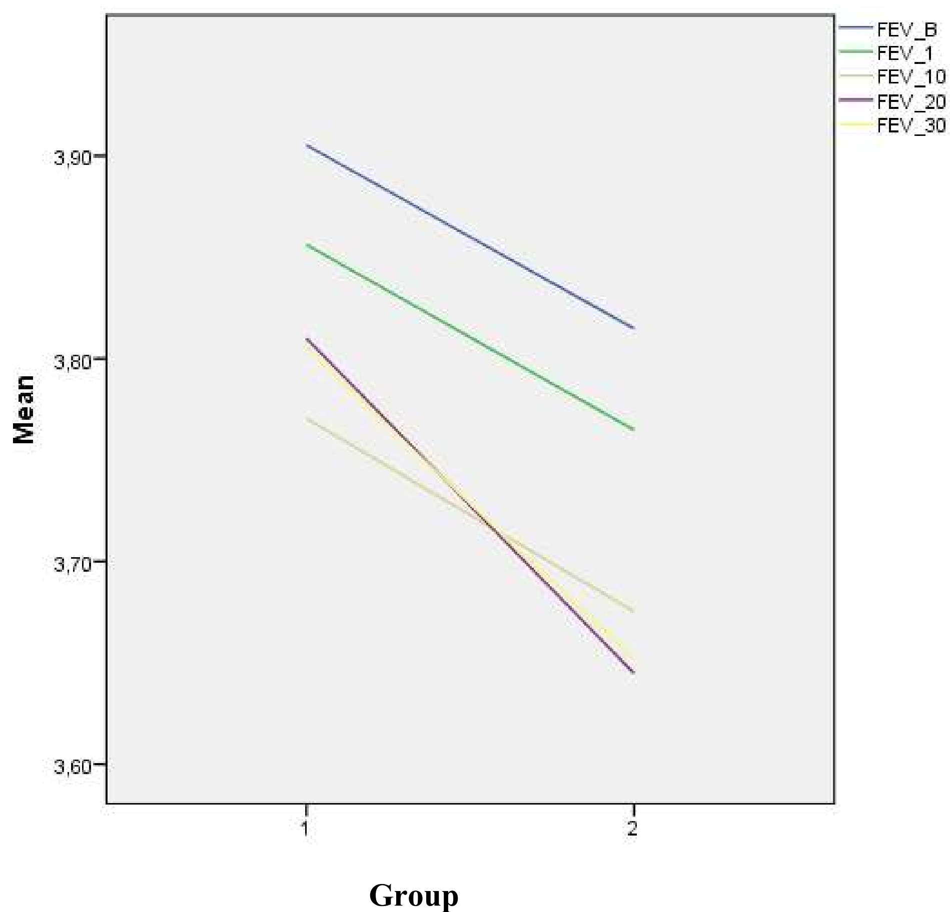


Figure 4 - FEV_1 between the two groups - Line chart

In Figure 4 we can observe that there is interaction between FEV_1_20 and FEV_1_30 measurement times.

Table 29 - Multivariate Tests for FEV_1

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.24	2.91	4.00	37.00	0.03
	Wilks' Lambda	0.76	2.91	4.00	37.00	0.03
	Hotelling's Trace	0.31	2.91	4.00	37.00	0.03
	Roy's Largest	0.31	2.91	4.00	37.00	0.03
Time * Group	Pillai's Trace	0.03	0.37	4.00	37.00	0.82
	Wilks' Lambda	0.96	0.37	4.00	37.00	0.82
	Hotelling's Trace	0.04	0.37	4.00	37.00	0.82
	Roy's Largest	0.04	0.37	4.00	37.00	0.82

We can observe here that Time is significant but between groups it is not (Table 29).

Table 30 - Tests of Within-Subjects Effects – FEV_1between the two groups

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	0.65	4	0.16	4.37	0.00
	Greenhouse-Geisser	0.65	2.90	0.22	4.37	0.00
	Huynh-Feldt	0.65	3.24	0.20	4.37	0.00
	Lower-bound	0.65	1.00	0.65	4.37	0.04
Time * Group	Sphericity Assumed	0.05	4	0.01	0.38	0.82
	Greenhouse-Geisser	0.05	2.90	0.02	0.38	0.76
	Huynh-Feldt	0.05	3.24	0.01	0.38	0.78
	Lower-bound	0.05	1.00	0.05	0.38	0.54

We can observe that Time is significant but between the groups does not seem to have any statistical significance (Table 30).

Table 31 - Tests of Between-Subjects Effects - FEV_1 between the two groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	2984.40	1	2984.40	1083.02	0.00
Group	0.74	1	0.74	0.27	0.60

We can see that Intervention and Control, groups are not statistically significant because *p-value* is greater than 0.05, so H0 is not rejected, so measurements between groups are similar (Table 31).

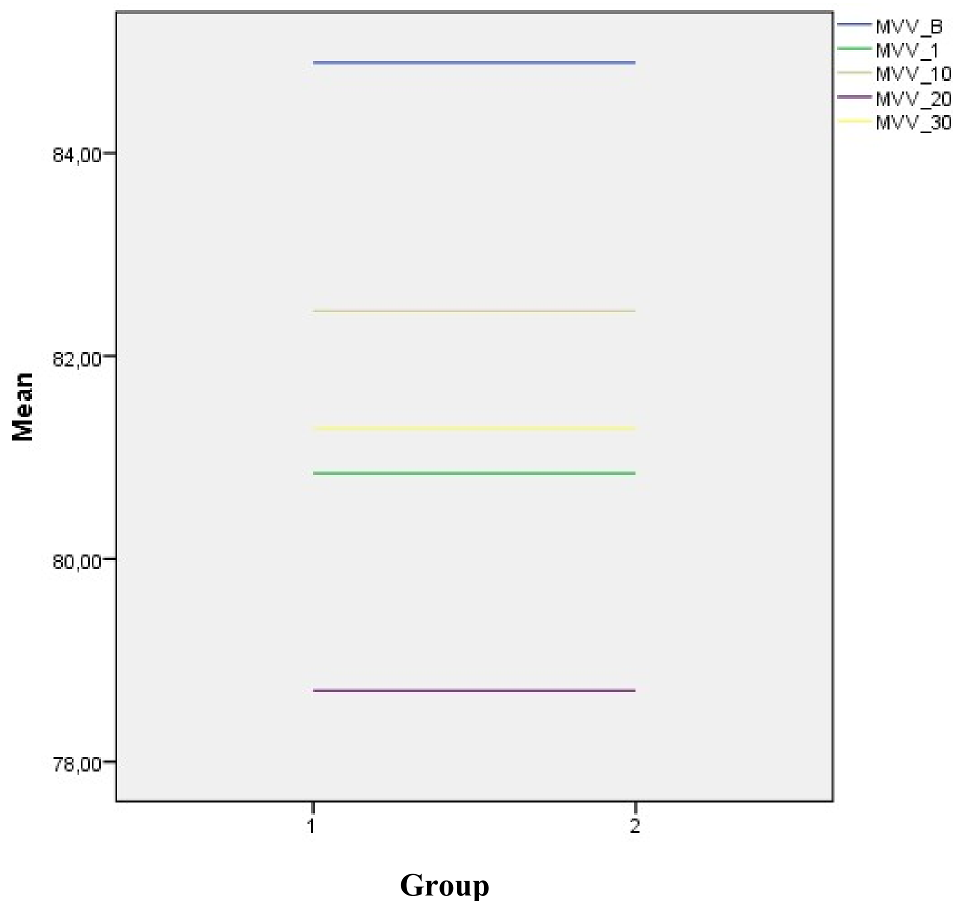


Figure 5 - MVV between the two groups - Line chart

In Figure 5 we can observe that parallel lines indicate that there is no interaction.

Table 32 - Tests of Within-Subjects Effects – MVV between the two groups

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	865.32	4	216.33	2.49	0.04
	Greenhouse-Geisser	865.32	2.93	294.84	2.49	0.06
	Huynh-Feldt	865.32	3.27	264.49	2.49	0.05
	Lower-bound	865.32	1.00	865.32	2.49	0.12
Time * Group	Sphericity Assumed	0.00	4	0.00	0.00	1.00
	Greenhouse-Geisser	0.00	2.93	0.00	0.00	1.00
	Huynh-Feldt	0.00	3.27	0.00	0.00	1.00
	Lower-bound	0.00	1.00	0.00	0.00	1.00

We can verify that there is an interaction between Time but not between groups (Table 32).

Table 33 - Tests of Between-Subjects Effects – MVV between the two groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	1399394.51	1	1399394.51	286.04	0.00
Group	0.00	1	0.00	0.00	1.00

Again, there is no interaction between groups because *p-value* is greater than 0.05 (Table 33).

4 - Discussion

This study analyzes the effect of a single TSM session on FVC, FEV_1 and MVV in swimming athletes during a 30-minute period measured in 5 evaluation moments.

Theoretically, an increase in the PFTs, could improve the athlete's performance, being also previously proposed that manipulative therapy may enhance joint mobility and subsequently, enhance static and/or dynamic lung function (Engel & Vemulpad, 2007). In line with this, an increase in athlete's performance to occur with this type of TSM techniques, 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 was no statistically significant for FVC ($p = 0.35$) and FEV_1 ($p = 0.25$) in any of the 5 evaluation moments. With the MVV ($p = 0.02$) there was a statistically significant reduction between baseline and at 10 and 30 minutes, this may be due to the fact of this test requires effort and coordination on the part of the athlete in doing so, and for that reason, there may have been some fatigue during the five moments of evaluation (Miller et al., 2005). With our study, we conclude that there were no significant differences between the obtained results in the two groups. These findings are in line with Santos et al. (2015) study, although there was only one moment of evaluation, the results also showed that there was no significant difference for FVC ($p = 0.50$), for FEV_1 ($p = 0.12$) and MVV ($p = 0.15$).

Similar results were observed on the Wall et al. (2016) study and tell us that there were no statistically significant changes in the pulmonary function measures at any time point following the manual therapy intervention. The standard deviation (SD) FVC/FEV_1 ratio was 0.84 ($p = 0.07$) as well as MVV shows no significant difference.

However, it is not unanimous in the literature that TSM may not influence some of the pulmonary functions measurements, since the Engel and Vemulpad (2007) study reported significant increase in FVC ($p < 0.00$) and FEV_1 ($p = 0.00$) in healthy participants who received nonspecific HVLA of the lower cervical and thoracic spine, and the posterior articulations of the associated ribs, compared to the control group which reported no change in FVC or FEV_1. Importantly, these findings were only reported immediately following the sixth manual therapy session during an intervention

consisting of six sessions over a four-week period. They concluded that manual therapy appeared to increase the respiratory function in normal individuals.

Similarly, the study by Shin and Lee (2016) investigated the effects of TSM on a single session in healthy participants who received HVLA in the thoracic spine, showed that after the intervention, FVC and FEV_1 were significantly increased in the experimental group ($p < 0.05$). However, the control group showed no difference after the intervention. Differences between the 2 groups in pre and post-intervention FVC and FEV_1 were significant.

While the current study results do not support the use of TSM for enhancing pulmonary function in swimming athletes, future research efforts in this area should examine the effects of different manual therapy techniques and treatment protocols, with more complex approaches, indicating the use of other techniques aimed e.g., at diaphragm activation and/or accessory muscle stretching, as well as in other type of aerobic sports.

4.1 – Limitations

The intervention in the current study consisted of only one manual therapy treatment. It is possible that additional treatments may favorably impact pulmonary function, as was demonstrated in the Engel and Vemulpad (2007). A further limitation is the effect of the thoracic manual therapy treatment was only measured up to 30-minutes post treatment; and the potential for longer term effect on pulmonary function is unknown.

The pressure and velocity of the manual therapy were not measured. However, the same osteopath performed the techniques, hence, we assumed that there was consistency and no substantial difference among the TSM techniques used in this study.

We did not consider the existence of a well-recognized circadian rhythm in lung function being exposed by Medarov, Pavlov and Rossoff (2008), who demonstrated in 4756 spirometrics of healthy individuals, data of FEV_1, FVC and FEV_1/FVC and peak expiratory flow (PEF) were statistically significant of diurnal variations for the four variables, the lowest average observed in the interval of 12:00 - 12:59 in the afternoon, the highest mean values were identified in the afternoon from 15:00 - 15:59 and 16:00 - 16:59, two other smaller peaks from 8:00 - 8:59 and 11:00 - 11:59 in which this is a point to be investigated in future research, since these intervals were not considered

during the spirometry evaluation of this sample, although the circadian rhythm is recognized by the researchers.

We did not measure myofascial restrictions on the athletes.

5 - Conclusion

After the results of the various statistical tests applied to the two groups, we can affirm that there is no significant influence of these TSM techniques for the FVC_I and FEV_1_I intervention group. On the other hand, statistically significant decrease changes were observed in the MVV_I intervention group. Further research with a longer duration and longer follow-up periods are advisable in order to obtain more reliable conclusions.

Right to privacy and informed consent.

The author declares that no participant data appear in this dissertation.

Competing interests

The author declares that he has no competing interests.

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7 - Appendix

Apêndice I - Consentimento Informado

Mestrando: Alexandre Cordeiro **Contacto telefónico:** 926 185 688

Orientador da Dissertação: Professor Rodrigo Ruivo

Eu ____, declaro que autorizo que os meus dados, referentes à intervenção feita, sejam utilizados na elaboração de um estudo científico (dissertação) referente ao 2º ano do Mestrado em Exercício e Bem-Estar, para apresentação na Universidade Lusófona de Humanidades e Tecnologias.

Toda a informação será tratada confidencialmente, omitindo todos os meus dados pessoais – nome, morada, número de telefone ou qualquer outro tipo de informação que possa permitir a minha identificação. Os dados recolhidos serão utilizados exclusivamente para a realização deste estudo.

Foi-me explicado de forma satisfatória, o objetivo do estudo, bem como todos os seus procedimentos.

Foi-me explicado que tenho o direito de colocar, agora e durante o desenvolvimento do estudo, qualquer questão sobre este, a investigação ou os métodos a utilizar.

Tenho disponibilidade para pertencer a este estudo participando na avaliação requerida.

Fui também informado que sou livre de recusar a utilização dos meus dados clínicos neste estudo, bem como o direito de desistir deste em qualquer fase, sem ser prejudicado.

Foi-me explicado que a minha participação não irá privar-me de receber todos os cuidados de saúde necessários à minha condição.

Assinatura do utente ou responsável legal:

____

Assinatura do mestrando: ____

Data: ________________________

Para qualquer questão contactar o investigador do estudo.

Apêndice II - Consentimento Informado

Mestrando: Alexandre Cordeiro **Contacto telefónico:** 926 185 688

Orientador da Dissertação: Professor Rodrigo Ruivo

1. No âmbito do estudo de investigação da dissertação de mestrado supracitada, foi solicitada a minha autorização para participação do meu filho;
2. Fui informado de que o estudo visa avaliar a função respiratória após intervenção de duas técnicas manipulativas dirigidas à coluna torácica com a respectiva medição através de espirometria;
3. Fui informado previamente que o meu filho responderá a um questionário de saúde no âmbito de validar a sua participação no estudo.
4. Eu entendo que os resultados deste estudo poderão vir a ser publicados, sendo que a identidade do meu filho não será revelada. Todas as informações e dados recolhidos serão mantidos sigilosos.
5. Eventuais questões que se me coloquem, no que diz respeito ao estudo ou à participação do meu filho no mesmo, serão respondidas pelo investigador, antes ou depois deste meu consentimento;
6. Declaro que li a informação referida nos pontos anteriores.
7. Em qualquer momento do estudo posso desistir da participação.

Assinatura _______________________________ Data: ___________________

Nome do filho ____

8. Eu certifico que expliquei ao adolescente supracitado a natureza e o objectivo associados à participação no estudo, tendo respondido a todas as questões que me foram colocadas e testemunhado a assinatura.
9. Eu providenciei uma cópia deste formulário para o participante neste estudo.

Assinatura _______________________________________ Data: __________________

(Aluno de Mestrado: Alexandre Cordeiro)

Para qualquer questão contactar o investigador do estudo.

Appendix III - Health questionnaire

Dados Pessoais

Data: _____/_____/_____

Nome: ____

Género: M ( ) F ( ) Estado Civil: ________________________

Idade: ______ Data de nascimento: _____/_____/______

Morada: ____

Código Postal: ______ - ______ Localidade: _______________________________

Telemóvel/Telefone: ____

Profissão: ____

Local de Trabalho: ____

Dados Vitais e Características Antropométricas

Peso: ________ Kg Altura: _______ cm

IMC: __________________ (a preencher pelo Investigador)

Principais Problemas/Queixas (Indique-nos qual/quais os seus principais problemas, ou qual é o seu quadro clínico e estado de saúde actual):

____

____

____

____

____

____

____

Medicação

Está a tomar alguma medicação? SIM ☐ NÃO ☐

Se SIM, que medicação está a tomar e com queintuito?__________________________

____

Tratamentos Prévios

Realiza ou já realizou Osteopatia, Quiropráxia e/ou Fisioterapia? SIM ☐ NÃO ☐

Se SIM, porque razão e à quanto tempo?

____

____

Realiza ou já realizou outro tipo de tratamentos? SIM ☐ NÃO ☐

Se SIM, porque razão e à quanto tempo?

____

__________ ____

Assinale com um X se apresenta algum dos seguintes factores?

Fístulas cutâneas	☐	Náusea ou vómitos	☐	Feridas infectadas	☐
Osteoporose	☐	Tuberculose	☐	Micose cutânea	☐
Úlceras da pele	☐	Muito debilitado/a	☐	Febre	☐
Queimaduras graves	☐	Alcoolismo	☐	Tabagismo	☐
Gravidez	☐	Menstruação	☐	Nenhuma	☐

Problemas (Assinale com um X se tem ou não problemas em cada um destes itens e se responder que SIM, indique especificamente quais são esses problemas):

PROBLEMAS	SIM	NÃO	Quais?
Cardíacos (problemas de coração)			
Tensão Arterial (Tensão Alta, Tensão Baixa)			
Renais (problemas de rins)			
Problemas do Aparelho Digestivo			
Problemas do Aparelho Respiratório			
Deficiência cognitiva e/ou Física (escoliose, ...)			
Ginecológicos			
Circulatórios			
Traumatismos			
Fracturas			
Cirurgias			
Próteses			
Tonturas/Vertigens			

Outras Observações: