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Review

The Effectiveness of Pump Techniques and Pompages: A Systematic Review

Carla Vanti, Matteo Golfari, Giacomo Pellegrini, Alice Panizzolo, Luca Turone, Silvia Giagio and Paolo Pillastrini *

Department of Biomedical and Neuromotor Sciences (DIBINEM), Alma Mater Studiorum, University of Bologna, 40138 Bologna, Italy; carla.vanti@unibo.it (C.V.); golfarim@gmail.com (M.G.); giacomo.pellegrini@gmail.com (G.P.); alice.panizzolo1@gmail.com (A.P.); lucaturone@gmail.com (L.T.); silviagiagio@gmail.com (S.G.)

* Correspondence: paolo.pillastrini@unibo.it; Tel.: +39-051-2142496; Fax: +39-051-2142609

Featured Application: Singular studies suggested some effectiveness of pump techniques; however, the differences for population, modalities, dosage, and outcome measures do not allow definite conclusions.

Abstract: Background: Osteopathic manual procedures called pump techniques include thoracic, abdominal, and pedal pumps. Similar techniques, called pompages, are also addressed to joints and muscles. Despite their widespread use, no systematic review has been published on their effectiveness. (2) Methods: CINAHL, Cochrane Controlled Trials Register, ISI Web of Science, PEDro, PubMed, and Scopus databases were searched until July 2020. Randomized Controlled Trials (RCTs) on adults were included. Subjective (e.g., pain, physical function) and objective (e.g., pulmonary function, blood collection) outcomes were considered. The Risk of Bias tool (RoB 2) and the GRADE instrument were used to evaluate the quality of evidence. (3) Results: 25 RCTs were included: 20 concerning the pump techniques and five concerning pompages. Due to the extensive heterogeneity of such studies, it was not possible to perform a meta-analysis. The risk of bias resulted from moderate to high and the quality of the evidence was from very low to high. Singular studies suggested some effectiveness of pump techniques on pain and length of hospitalization. Pompage seems also to help improve walking distance and balance. (4) Conclusions: Although several studies have been published on manual pump techniques, the differences for population, modalities, dosage, and outcome measures do not allow definite conclusions of their effectiveness.

Keywords: osteopathy; manipulation; manual therapy; physical therapy

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1. Introduction

Osteopathic manual techniques were first proposed by A. Taylor Still to correct somatic dysfunctions, increase blood and lymphatic flow and improve the individual's self-healing capacity [1]. Starting from these bases, in 1920, C. Earl Miller developed a manual technique called "thoracic pump technique", aiming to improve lymphatic flow via intrathoracic pressure changes [2]. By the manipulation of this lymphatic pump, Dr. Miller speculated that an increased lymphatic circulation of the entire body could be provoked [3]. A number of other lymphatic pump techniques have been developed and investigated since Dr. Miller's time [4]. Some ancient lymphatic pump techniques already in use are abdominal and pelvic pumps and pedal pumps [5].

Other authors deepened the pump techniques, expanding their focus and studying their effects on connective tissues. In the 1970s, Angus Cathie studied the relationship between spinal mechanics and respiratory dynamics and between the fascia and venous, lymphatic and lacunar circulation [6]. The fascia was considered as an integrated system;

therefore, a fascial restriction can be potentially extended to distant areas of the body and can provoke stress/malfunction on any structure that is enveloped by the fascia itself [7,8].

Based on the studies of Dr. Cathie, another variation of pump techniques was developed in France. In the 1980s, the physical therapist Marcel Bienfait proposed a technique called pompage and widened its use [9,10]. Recently, pompages have been further modified and updated according to the most recent developments in treating the connective tissues [11].

Globally, pump techniques aim at promoting the relaxation and elongation of soft tissues and fascia [12–14], reducing intra-fascial thickening and adhesions, decreasing joint load [15,16], reactivating joint metabolism, facilitating circulation, and finally, reducing pain and normalizing muscular tone [17–19]. More specifically, the lymphatic pump techniques are designed to facilitate venous, lymphatic and lacunar circulation, with an action mediated by the alternation of pressure/traction and decompression/relaxation [20].

Lymphatic pump techniques are carried out in two phases. In the first phase (pressure/traction), the clinician applies a tension reaching the "barrier" or limit of the physiological elasticity of the fascia, without causing defense reactions by the patient. This tensioning must therefore be painless, but at the same time, it must not be too light to adequately stimulate the fascial tissue [21]. In the second phase (decompression/relaxation), the clinician allows the fascia to return to the initial position without stopping the movement [22,23].

The alternation of these two phases is rhythmic; the frequency can be slow (e.g., suboccipital release, pectoral traction, doming of the diaphragm, and rib raising), at medium speed—20/30 cycles per minute (e.g., release of the thoracic inlet, abdominal or pelvic lymphatic pump), or at high speed—110/120 cycles per minute (e.g., thoracic lymphatic pump, and pumps applied to peripheral areas). Pompage techniques addressed to joints and muscles are generally slower, and a further phase of maintaining the tension is added [23].

These different modalities and frequencies depend on the treated area and the characteristics of the tissues addressed by each technique. The alternation of rhythmic pressures and decompressions can be applied on the joints (joint/articular pump), the muscles (muscular pump), the abdominal area (abdominal pump), the feet and the lower limbs (pedal pump), or on the patient's chest (thoracic pump) [24,25]. The pump techniques are generally well tolerated and can be used easily and safely in many clinical presentations. Currently, both the American osteopathic pump techniques and French pompages are performed as a part of a wider family of pump techniques.

Despite the widespread use of these manual procedures in clinical practice by osteopaths and physical therapists, their effectiveness was not deeply studied. Narrative reviews were published in 2007 [26], 2011 [27], 2014 [28], 2016 [29], and 2020 [30]. However, no systematic review was conducted, including risk of bias (RoB) and quality of the evidence assessment.

This systematic review aims to investigate the effectiveness of pump techniques and pompages in adults on subjective (e.g., pain, physical function) and objective (e.g., pulmonary function) outcomes.

2. Materials and Methods

We followed the Cochrane Handbook for Systematic Reviews of Intervention as our methodological guidance [31]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for the reporting was used [32]. The protocol was registered in PROSPERO database (CRD42020180002).

2.1. Data Sources and Searches

The following databases were searched: MEDLINE, Cochrane Controlled Trials Register, PEDro, CINAHL, Scopus, and ISI Web of Science. Searches were conducted by the two authors (M.G., G.P.) up to July 2020.

The search in the individual databases was given by the union of various combinations of specific keywords: "lymphatic"/"abdominal"/"thoracic"/"pedal"/"muscular"/"technique/"osteopathic "/" pump "; "pompage" and adapted for each database. The specific search strategy for MEDLINE is reported in the Supplement 1.

Randomized Controlled Trials (RCTs) published in all languages were eligible for inclusion. A reference list of identified articles was also checked for any relevance together with other grey literature sources.

2.2. Studies Selection

2.2.1. Types of Studies

The search was limited only to full-text RCTs. Unpublished studies (e.g., conference abstracts; trial protocols) were excluded.

2.2.2. Types of Participants

We included only RCTs on adults ($\geq$18 years old) of any sex. Studies on animals were also excluded.

2.2.3. Types of Interventions

RCTs describing the intervention as different types of pump techniques (e.g., articular pump, lymphatic pump, abdominal pump, thoracic pump, pedal pump, thoracic lymphatic pump) and pompages were included.

2.2.4. Types of Comparator (s)/Control

We included RCTs where the treatment with pump techniques was compared with placebo, no intervention, any other types of physical therapy intervention (e.g., Exercise; Manual Therapy; Relaxation; Biofeedback; Physical Modalities; Taping; Orthosis; Dry Needling; Acupuncture; Cognitive-Behavioral Therapy; Multidisciplinary Rehabilitation) or other interventions such as pharmacotherapies or surgery.

2.2.5. Types of Outcome Measures

Pain intensity measured with a Numerical Rating Scale (NRS) or a Visual Analogue Scale (VAS); blood collection; lung functions by FEV1, FVC, FEV1/FVC, oxygenation, residual lung volume, expiratory flow peak, Tiffeneau index; length of hospitalization were considered as primary outcomes.

Additional outcomes were: Range of Motion—ROM (measured, for example, with tape or goniometer); Global Perceived Effect (measured, for example, with Global Rating of Change); Quality of Life (measured, for example, with SF-36 or Euro-QoL); Change in Neurological function (measured, for example, with neurodynamic tests, neurological examination, or other measures as pressure pain, thermal or vibration threshold or H-reflex); Psychological condition (measured, for example, with Fear-avoidance, Catastrophizing, Kinesiophobia, Pain Self-Efficacy, Anxiety or Depression Questionnaires); Treatment adherence and Adverse events.

2.3. Data Extraction and Quality Assessment

Search results were collected and imported to EndNote V.X9 (Clarivate Analytics, Philadelphia, PA, USA). Duplicates were automatically removed [33]. Two independent reviewers (M.G., G.P.) performed the review process using Rayyan QRCI online software (Rayyan Systems Inc., Cambridge, MA, USA) [34]. This consisted of two levels of screening: title and abstract review and full-text review. In case of disagreement, conflicts were resolved by a third author (C.V.).

Two reviewers (M.G., G.P.) independently extracted the following data: Total number of participants; Number of participants of treatment and control groups; Mean age of participants; Proportion of males/females; Mean/median pain duration; Taking drugs; Mean Pain intensity; Mean Physical functioning; Type of treatment; Treatment dosage (number

of times the intervention was delivered; number and duration of sessions; total duration of the program; intensity or dose); Type of control; Primary measure used to recording each outcome; Means and standard deviations of each outcome at post-intervention for all treatment groups; Measurement scales/questionnaires and their direction for each outcome; Number of adverse events in study group and control group; Type of adverse events; Year of publication; Publication language; Country of publication; Setting. Study authors were contacted to obtain important missing data.

2.4. Risk of Bias Assessment

Two authors (A.P., L.T.) independently assessed the RoB through the Revised Cochrane risk-of-bias tool for RCTs (RoB 2) [31,35]. A RoB graph was created through RobVis visualization tool [36].

To assess the certainty of evidence for the main outcomes, two authors (A.P., L.T.) used the GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) approach classifying evidence as high, moderate, low, or very low quality based on considerations of RoB, consistency, directness, precision, and publication bias [37]. In case of disagreement, a third author (C.V.) was consulted.

2.5. Data Synthesis and Analysis

A descriptive summary of the results of the included studies was provided, commenting on the difference between treatments. The treatment effect was measured for each study using the mean differences. Whenever possible, the data were synthesized using meta-analysis.

3. Results

3.1. Overall Results

3673 studies were identified with the database search. Through other searches, a further 66 studies were added. After removing duplicates and excluding by title and abstract, 106 studies were eligible to be assessed by full-text reading to verify the eligibility for inclusion in this systematic review. Eighty-one articles were excluded for various reasons (Supplement 2), with 25 studies available for qualitative synthesis [37–61] (Figure 1).

Among these studies, 20 analyzed pump techniques [37–56], and five concerned pompages [57–61]. The included studies were published from 1968 to 2019 and conducted in the USA [38–41,43–50,54–56], Brazil [57,58,60,61], Italy [51,52,59], Egypt [37], Poland [53], and India [42]; the total number of patients who completed the assessments was 1632.

The treatment techniques used in the studies were osteopathic pump and pompage techniques. In 20 studies, thoracic lymphatic techniques were applied together with other techniques, such as pedal pump, abdominal pump, and sternal pump [37–56]. In five studies, pompages were used [57–61]. The duration of the treatments ranged from one day to seven weeks and the duration of each treatment ranged from two to 50 min. The interventions with which the pump techniques were compared were no treatment [37,52], light touch [44–48,50,54,56,57], conventional rehabilitation [38,41,42,51,53,55,61], vaccination [39,40] stretching [58], muscle-tension headache program and electrotherapy program [59], and educational lectures [60]. Primary outcomes were pain intensity, lung functions, blood count cell, and length of hospitalization. Secondary outcome measures were ROM and psychological condition.

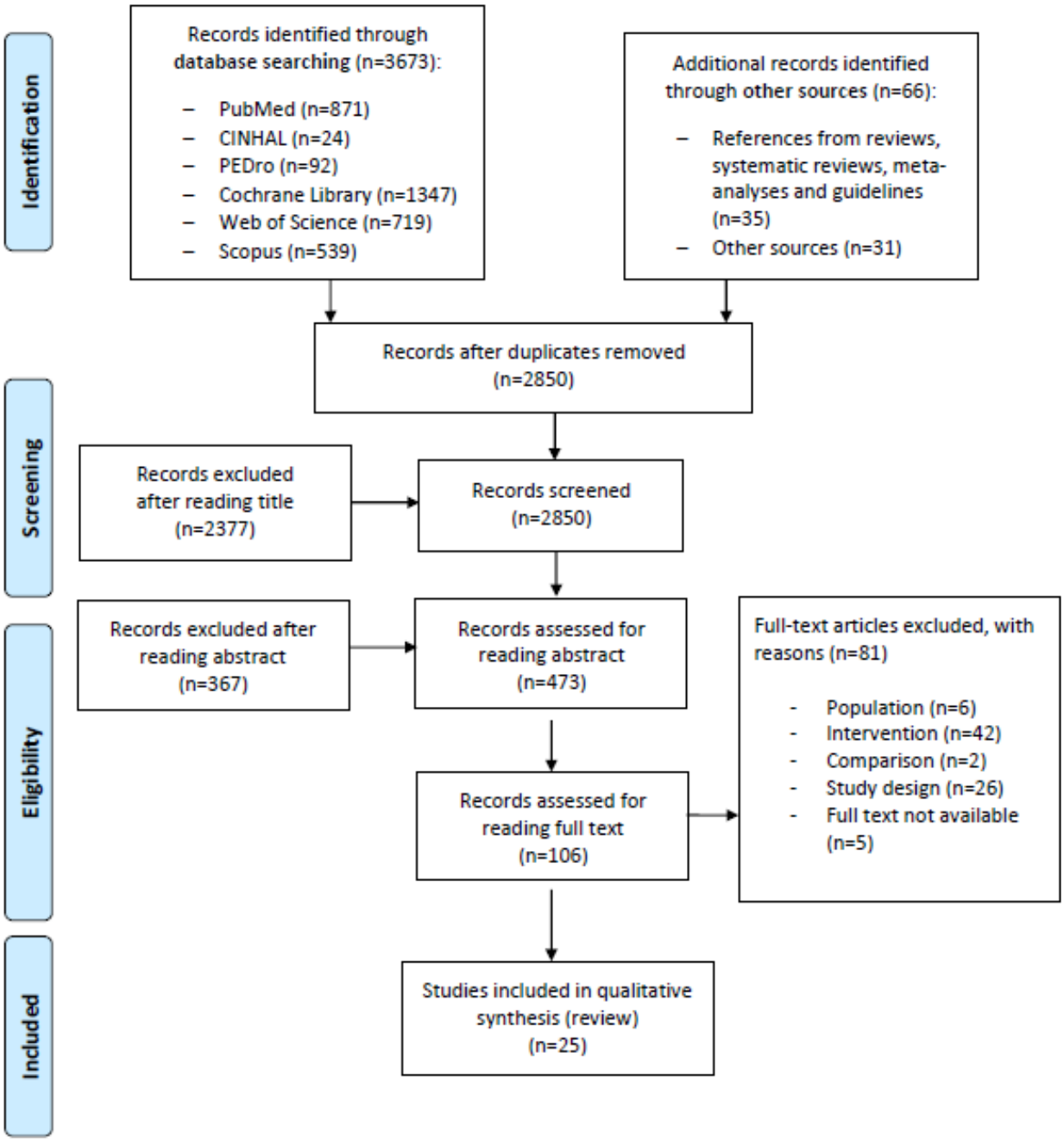

Figure 1. Flow chart of study selection.

3.2. Quantitative Synthesis

We could only carry out one meta-analysis on two studies [51,53] similar for participants, interventions, comparison and outcomes. Nevertheless, due to the extensive heterogeneity (Chi2 = 9.97, I2 = 90%) of the included studies, meta-analysis was not reported and only a qualitative synthesis with a summary of the available evidence was conducted.

3.3. Qualitative Synthesis

The characteristics and results of the included studies are synthesized in Tables 1 and 2.

Table 1. Characteristics of the studies on pump techniques.

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Abdelfattah A. et al. [37] (2018) Egypt	Healthy subjects	– Thoracic trauma – Inflammatory or systemic diseases – Malignancy osteoporosis – Autoimmune diseases	45 subjects randomly assigned to 3 equal groups: **Group A** → Osteopathic Manipulative Therapy- OMT (n = 15) **Group B** → OMT treatment (n = 15) **Control group** → No treatment (n = 15)	**Number of sessions**: 12 session (3 × 4 weeks) **Time of each session:** 2 min **Group A** → Sternal pump and sternal recoil techniques **Group B** → Thoracic lymphatic pump and splenic pump techniques **Control group** → did not receive any manipulative techniques	**Follow up**: at baseline and post-treatment Absolute CD4+ count	The multiple pairwise comparison tests revealed the significant increase in the CD4 post-treatment compared with pretreatment in Group B only. Regarding between subject effects, multiple pairwise comparisons revealed that there was a significant increase in favor to Group B compared to Group A and C at post-treatment.
Allen T.W. et al. [38] (1967) USA	Hospitalized patients with signs and symptoms of lower respiratory tract disease (pneumonia, bronchitis, emphysema, bronchial asthma, and bronchiectasis)	Not specified	16 subject who accepted therapy for their particular condition: **Treatment group** → Thoracic Pump + standard therapy (n = 6) **Control group** → Standard therapy (n = 10)	**Number of sessions:** 3 session for day (for 4 to 5 days) **Time of each session**: 5 min **Treatment group** → Thoracic pump + bronchodilators, antibiotics, expectorants, sedatives, and parenteral fluids **Control group** → bronchodilators, antibiotics, expectorants, sedatives, and parenteral fluids	**Follow up:** at baseline and 5 days later – Vital capacity – Pulmonary function	In the control group of 10 patients, an increase in vital capacity was observed in 6 patients, a decrease was noted in 3, and no change was observed in 1. In the experimental group, 5 patients had an increase in vital capacity; none had a decrease. Other measurements of pulmonary function were usually improved in both groups.
Breithaupt T. et al. [39] (2001) USA	Healthy subjects (elderly adults and young adults)	Contraindications to influenza vaccine	97 subjects: 36 young adults and 61 elderly adults volunteered: **Treatment group** → Thoracic lymphatic pumping **Control group** → No thoracic lymphatic pumping	**Number of sessions:** 5 sessions (1 per day) **Time of each session:** 5 min **Treatment group** → – Thoracic lymphatic pumping to younger subject – Thoracic lymphatic pumping to elderly subject **Control group** → – No thoracic lymphatic pumping to younger subject – No thoracic lymphatic pumping to elderly subject	**Follow up:** at baseline and post-vaccination Titers of anti-influenza serum antibodies	Among the older subjects of both groups, 13 (72%) of 18 of the positive responders had a twofold or fourfold antibody increase on vaccination, while with the younger subjects, 13 (72%) of 18 of the positive responders had an eightfold or greater antibody increase on vaccination. Thoracic lymphatic pumping did not appear to change the quantity or quality of the immune response.

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Jackson K. et al. [40] (1998) USA	Healthy subjects	– Previous hepatitis B infection or known exposure – Previous hepatitis B vaccination – Pregnancy – Use of corticosteroids, cytotoxic drugs or immune-suppressants. – Subject with contraindications for the vaccine. – Subject with recent broken or damaged ribs or other upper thoracic injury. – Bone cancer	39 subjects randomly assigned to 2 groups: **Treatment group** → Vaccination + Osteopathic Manipulative Therapy (n = 20) **Control group** → Vaccination (n = 19)	**Number of sessions:** 3 sessions a week (for 2 weeks) **Time of each session:** 7 min **Treatment group** Vaccination + Patient-assisted active lymphatic pump + passive lymphatic pump + splenic pump **Control group** → Only vaccination	**Follow up:** at baseline and post-vaccination/manipulation and after week 5, 6, 7, 8, 13, 18, 25, 31, 34 Hepatitis B antibody	50% of subjects in the treatment group achieved titer of 374 mlU/mL. The control groups' subjects had positive antibody responses in 16% of subjects. At all follow-ups starting from the sixth week, the average anti-hepatitis B titer was higher in the treatment group than in the control group.
Lorenzo S. et al. [41] (2019) USA	Healthy subjects	– Disorders or open wounds precluding skin contact – Fasciitis or fascial tears – Muscle strains or inflammation – Neoplasia – Bone fracture – Osteomyelitis – Osteopenia – Osteoporosis – Coagulation problems – Deep vein thrombosis – Adrenal disease/syndromes – Current respiratory disorders (including COPD and asthma) – Immunosuppressive syndromes – Radiation or chemotherapy within the past 3 years – Lupus and other autoimmune disease	53 subject randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy (OMT) (n = 28) **Control group** → Standard Pulmonary Rehabilitation (SPR) (n = 25)	**Number of sessions:** 1 session a week (for 6 weeks) **Time of each session:** 30 min **Treatment group** → Protocol OMT: 4 techniques: rib raising, doming of the diaphragm, thoracic lymphatic pump and thoracic high velocity, low amplitude (HVLA) technique **Control group** → Protocol SPR: rest, saline nebulizer, tapotement and pursed-lip breathing	**Follow up:** at baseline and post-treatment every weeks (for 6 weeks) Pulmonary function test: – Forced Expiratory Volume (FEV) – Forced Vital Capacity (FVC) – FEV/FVC ratio	In the OMT group, rib raising yielded the highest positive mean(SD) change of 0.001 (0.136) L in FEV, and 0.052 (0.183) L in FVC, followed by lymphatic pump, with a change of 0.080 (0.169) L in FEV and −0.031 (0.229) L in FVC. In the SPR group, pursed-lip breathing yielded the highest positive mean (SD) change of 0.101 (0.278) L in FEV and 0.031 (0.179) L in FVC, followed by tapotement with a change of 0.045 (0.229) L in FEV and 0.061 (0.239) L in FVC. Saline treatment significantly decreases lung function. All other treatments did not result in any significant change in lung function.

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Mascarenhas S. et al. [42] (2013) India	Subjects with COPD	– Patients with COPD grade IV – Acute change in the COPD condition or exacerbation – Acute illness – Fever	50 subject randomly assigned to 2 groups: **Treatment group** → Group A (n = 25) **Control group** → Group B (n = 25)	**Number of sessions:** 1 session **Time of each session:** 15 min **Treatment group** → Thoracic lymphatic pump without activation technique + nebulization **Control group** → Nebulization	**Follow up:** at baseline and post-treatment Pulmonary function tests: – Vital Capacity (VC) – Forced Expiratory Volume in the 1st second (FEV1) – Forced Vital Capacity (FVC) – FEV1/FVC ratio – Forced Expiratory Flow (FEF)	There were significant improvements in the VC, FEV1, FVC, FEV1/FVC values of both the groups. The FEF values showed significant improvements in experimental group as compared to control group. The means of the difference between the pre- and post-values of both the groups showed no statistical significance.
Newberry M. et al. [43] (2011) USA	HIV-positive subjects aged between 18 and 65 years who had not undergone antiretroviral therapy (ART) for the past 12 months	– Medical conditions that would limit a subject's ability to participate in this study as defined by his physician and verified by physical examination, recreational drug use, and prescription of systemic steroids. – Women	18 subject randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy (OMT) group (n = 9) **Control group** → Conversation with the researcher (n = 9)	**Number of sessions:** 1 session **Time of each session:** 15 min **Treatment group** → Myofascial release of the thoracic inlet + pectoral traction + rib raising + thoracic pump + abdominal pump **Control group** → Remained in a seated position and engaged in conversation with the search staff	**Follow up:** at baseline and 2, 5, 10, 15, 30, and 45 min intervals after completion of the respective protocols Complete white blood cell counts and differentialwhite blood cell counts	No significant difference between groups emerged concerning neutrophil, eosinophil, and monocyte count. An optimal time interval for measurement of white blood cell change across the 5 cell types was not determined. However, p values for the 30 min interval were consistently below 0.18 for neutrophils, eosinophils and monocytes.
Noll D.R. et al. [44] (1999) USA	– Subject aged 60 or older – Radiologic diagnosis of pneumonia – Two clinical findings consistent with a diagnosis of pneumonia	– Lung abscess – Bronchiectasis – Tuberculosis – Lung cancer – Acute fractures or metastatic bone disease	21 subject randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy (n = 11) **Control group** → Randomly assigned in "light touch group" or "no-touch group" (n = 10)	**Number of sessions:** twice a days (on Monday through Friday) and once each weekend **Time of each session:** 15 min **Treatment group** → Bilateral paraspinal muscle inhibition + bilateral rib raising + diaphragmatic myofascial release + condylar decompression + cervical soft tissue technique + bilateral myofascial release to the anterior thoracic inlet + thoracic lymphatic pump + conventional medical care **Control group** → —Light touch group: Light touch + conventional medical care - No-touch group: only conventional medical care	**Follow up:** at baseline and post-treatment – Fever – Duration of leukocytosis – Duration of total antibiotic treatment – Length of hospital stay	The duration of fever was not statistically different for the treatment and control group. The mean duration of leukocytosis, intravenous antibiotic treatment and length of stay were shorter for the treatment group; these measures did not reach statistical significance

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Noll D.R. et al. [45] (2000) USA	Subjects with new pulmonary infiltrate on chest X-ray (consistent with a diagnosis of pneumonia) and at least two other clinical findings consistent with acute pneumonia (fever, leukocytosis, new cough, and acute change in mental status)	– Lung abscess – Tuberculosis – Lung cancer – Acute rib or vertebral bone fractures – Metastatic disease of the bones	58 subject randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy (n = 28) **Control group** → Sham treatments (n = 30)	**Number of sessions:** twice a days (7 days a week until a study end point was reached) **Time of each session:** 15 min **Treatment group** → Bilateral paraspinal inhibition + bilateral rib raising + diaphragmatic myofascial release + condylar decompression + soft tissue technique + myofascial release + anterior thoracic inlet myofascial release + thoracic lymphatic pump **Control group** → Standardized light touch protocol treatment	**Follow up:** at baseline and day 3 and day 5 – Fever – Duration of total antibiotic treatment – Length of hospital stay in hospitalized elderly patients with pneumonia – Leukocyte Count	There were no significant differences between groups for the mean number of shifts with a recorded fever. Results of the duration of antibiotic treatment and length of hospital stay was significantly shorter in the treatment group. There were no significant differences between groups for mean white blood cell count on days 1, 3, or 5. However, there was a significant difference in the rate of change in the white blood counts between days 1 and 3. By day 5, these differences in the change in white blood cell counts were no longer statistically significant.
Noll D.R. et al. [46] (2004) USA	Subject aged 65 years and older from two community nursing homes	– Nursing home residents with an acute illness, hypersensitivity to the influenza vaccine, or allergy to egg – Home residents unable to cooperate with study protocol treatments – Home residents with acute vertebral or rib fractures, cancer, splenomegaly or history of splenectomy, or at high risk for pathologic fractures	14 subject randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy (n = 7) **Control group** → Sham protocol (n = 7)	**Number of sessions:** 3 times weekly for 2 weeks and then twice weekly for 2 more weeks **Time of each session:** 15 min **Treatment group** → Phase 1: the operator treated each patient's specific somatic dysfunction found on structural examination, by choosing among muscle energy, counterstrain, myofascial, direct, or articulatory techniques treated. Phase 2: paraspinal muscle inhibition+ rib raising to the paraspinal muscles + thoracic inlet myofascial release + abdominal diaphragm myofascial release + thoracic lymphatic pump + splenic pump **Control group** → Phase 1: the operator took several minutes to purposefully and systematically auscultate participant's heart and lungs. Phase 2: light touch + soft massage	**Follow up:** at baseline and post-treatment – Perceived success of the received protocol – Identification of the protocol (active vs. sham)	The groups were not significantly different in reporting the health benefits and adverse effects associated with treatments, nor in their reporting of the enjoyment of treatments and their willingness to recommend these treatments to others. The responses of those participants with Mini-Mental Status Exam (MMSE) scores in the "normal" range indicate uncertainty about the group assignment. Of the 3 participants in the treatment group with MMSE scores greater than 23, 1 incorrectly believed he received a sham treatment, and 2 correctly believed they received OMT. Of the 4 participants in the control group with MMSE scores greater than 23, 1 incorrectly believed he received OMT, and 3 were unsure of group assignment.

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Noll D.R. et al. [47] (2008) USA	– Aged 65 years or older – Had airflow obstruction (FEV1/FVC ratio < 70%)	– Unstable medical condition, acute bronchitis, pneumonia, or an exacerbation of Chronic Obstructive Pulmonary Disease (COPD) – Unable to perform the pulmonary function testing because of cognitive or physical impairments – If they had received osteopathic or chiropractic manipulation in the 4 weeks before the study – If they had thoracic spinal scoliosis greater than 25 degrees, substantial chest wall deformity, or acute rib or vertebral fracture	35 subject randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy (OMT) protocol (n = 18) **Control group** → Sham protocol (n = 17)	Number of session: 1 session **Time of each session:** 20 min **Treatment group** → Soft Tissue + rib raising + abdominal diaphragm myofascial release + suboccipital decompression + thoracic inlet + myofascial release + pectoral traction + thoracic lymphatic pump **Control group** → Light touch applied to the same anatomic regions as in the OMT group	**Follow up:** at baseline and post-treatment Pulmonary function test: – Forced Expiratory Volume in the 1st second (FEV1) – Forced vital capacity (FVC) – FEV/FVC – Forced expiratory flow (FEF) – Expiratory reserve volume (ERV) – Residual volume (RV) – Total lung capacity (TLC) – RV/TLC	Compared with the sham group, the OMT group showed a statistically significant decrease in the forced expiratory flow at 25% and 50% of vital capacity and at the midexpiratory phase; the expiratory reserve volume; and airway resistance. The OMT group also had a statistically significant increase in the residual volume, total lung capacity, and the ratio of those values compared with the sham group. Most subjects (82%,OMT group; 65%, sham group) reported breathing better after receiving their treatment. Only 53% of subjects in the OMT group and 41% in the sham group correctly guessed their group assignment.

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Noll D.R. et al. [48] (2010) USA	– Subjects aged ≥ 50 years newly hospitalized with pneumonia – New pulmonary infiltrate on chest X-ray – All least two of the following: new or increased cough, fever ≥ 38 °C, pleuritic chest pain, new physical findings on chest examination, respiratory rate ≥ 25 breaths/min, deteriorating mental or functional status, or White Blood Cell count (WBC) > 12,000 cells/mm^3	– Nosocomial pneumonia – Lung abscess – Advancing pulmonary fibrosis – Bronchiectasis – Pulmonary tuberculosis – Lung cancer – Metastatic malignancy – Uncontrolled metabolic bone diseases – Current rib or vertebral fracture – Prior pathologic fracture – Previous study participation or respiratory failure	406 subjects randomly assigned to 3 groups: Standard group → Standard care control (CCO) (n = 135); **Treatment group** → Osteopathic Manipulative Therapy (OMT) protocol (n = 135) **Control group** → Light Touch (LT) protocol (n = 136)	**Number of sessions:** Twice daily until discharge **Time of each session:** 15 min Standard group → Conventional care only (CCO): standard care control **Treatment group** → Thoracolumbar soft tissue + rib raising + diaphragm myofascial release + cervical spine soft tissue + suboccipital decompression + thoracic lymphatic pump + pedal lymphatic pump **Control group** → Light touch (LT) to the same body regions, in the same sequence, and for the same duration as the OMT protocol.	**Follow up:** at baseline and post-treatment Primary outcomes: – Hospital length of stay (LOS) – Time to clinical stability – Symptomatic and functional recovery score Secondary outcomes: – Duration of intravenous and oral antibiotics – Treatment endpoint (including death and respiratory failure 60-day hospital readmission rate) – Highest daily temperature – Highest daily respiratory rate and WBC	Intention-to-treat analysis found no significant difference between the groups for any outcome. PP analysis found a significant difference between groups in LOS. Multiple comparisons indicated a reduction in median LOS for the OMT group versus the CCO group, but not versus the LT group. Secondary outcomes of duration of intravenous antibiotics and treatment endpoint were also significantly different between groups. Duration of intravenous antibiotics and death or respiratory failure was lower for the OMT group than the CCO group, but not the LT group. There was a significant difference between the groups on treatment endpoint. Multiple comparisons indicated the treatment endpoints of death and respiratory failure were less frequent in the OMT versus the CCO group. Other outcomes were not statistically different, except respiratory rate, which was slightly lower in the OMT group than the CCO group.

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Noll D.R. et al. [49] (2013) USA	Subjects age ≥ 60 years old	– Cognitive impairment or combative behavior – Acute illness – Acute vertebral or rib fracture, or risk of pathologic fractures – Malignant cancer, splenomegaly – History of splenectomy	20 subjects randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy (OMT) (n = 10) **Control group** → Light touch (n = 10)	Number of session: 1 session **Time of each session:** 6 min **Treatment group** → Myofascial release to the thoracic inlet + splenic pump + pedal lymphatic pump **Control group** → The light touch protocol was applied to the same body areas	**Follow up:** at baseline and post-treatment Primary outcomes: Lymphocite subset panel (percentage and absolute cell numbers for CD3 cells, CD4 cells, and CD8 cells; CD4/CD8 ratio, and absolute lymphocytes). Secondary outcome: Complete blood cell count and manual white blood cell count with an automated differential	The between-group differences for the mean (standard deviation) absolute lymphocyte cell count, red blood cell count, hemoglobin level, and hematocrit measures all decreased, but the changes were not statistically significant relative to the control group. There was a statistically significant between group difference in mean change for platelet counts: counts in the OMT group decreased by a mean (standard deviation) platelets per microliter and the light touch group increased platelets per microliter.
Noll D.R. et al. [50] (2016) USA	Subject aged ≥ 50 years old who met specific criteria for pneumonia on their admission to the hospital	Not specified	387 subjects randomly assigned to 3 groups: **Treatment group** → Osteopathic Manipulative Therapy (OMT) group (n = 130) **Control group** → Sham group (n = 124) Standard group → Standard care control (CCO) (n = 133)	**Number of sessions:** twice daily for the duration of the hospital stay **Time of each session:** 20 min **Treatment group** → Thoracolumbar soft tissue + rib raising + doming of the diaphragm with myofascial release + cervical spine soft tissue + suboccipital decompression + thoracic inlet myofascial release + thoracic lymphatic pump + pedal pump. **Control group** → Light touch to the same body regions in the same sequence and duration as the OMT protocol. Standard group → Standard care control	**Follow up:** at baseline and post-treatment – Hospital length of stay (LOS) – Ventilator-dependent respiratory failure rate – In hospital mortality rate	By per-protocol analysis of the younger age subgroup, LOS was shorter for the OMT group than the light touch and CCO groups. By per-protocol analysis of the Pneumonia Severity Index (PSI) class IV subgroup, the OMT group had a shorter LOS than the CCO group and a lower ventilator-dependent respiratory failure rate than the CCO group. By intention-to-treat analysis of the older age subgroup, in-hospital mortality rates were lower for the OMT group and light touch groups than the CCO group. By intention-to-treat analysis, in hospital mortality rates in the PSI class V subgroup were lower for the OMT group than the CCO group but not the light touch group.

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Racca V. et al. [51] (2017) Italy	– Subject aged ≥ 18 years old – Consecutively admitted to cardiac rehabilitation unit after recent elective Coronary Artery Bypass Graft – Valve replacement or repair or ascending aorta surgery with sternotomy – Capable of voluntarily providing their written informed consent	– Subject who underwent heart surgery using mini-thoracotomy – Patients after heart transplantation or implantation of ventricular assistance – Diabetes mellitus – Autoimmune diseases – Altered cognitive capacitive	80 subjects randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy (OMT) program (n = 40) **Control group** → Standardized cardiorespiratory rehabilitation program alone (n = 40)	**Number of sessions:** 5 min daily sessions every week for the period of hospitalization **Time of each session:** 50 min **Treatment group** → Standardized cardiorespiratory rehabilitation + thoracic manipulation + sternal manipulation + clavicular manipulation **Control group** → Standardized cardiorespiratory rehabilitation	**Follow up:** at baseline and at the end of rehabilitation program – Functional capacity – Functional respiratory capacity (holding the breath for at least 5 s) – Submaximal functional cardiorespiratory capacity (6-min walking test) – Pain (VAS) – Anxiety and depression (Anxiety and Depression Scale) – Length of Hospitalization – Pharmacotherapies	The inspiratory volume was significantly greater in the OMT group. However, no significant differences between groups were found in the walked distance. At the end of the rehabilitation program, the reduction in perceived pain was more marked in the OMT group and the VAS score was significantly lower in OMT patients than in controls. The Hospital Anxiety and Depression Scale scores did not differ significantly between groups. Hospitalization was significantly shorter in the OMT group than in the control group. No significant differences in equivalent daily doses of analgesic, anti-inflammatory, or anxiolytic drugs were found between groups.

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Rapisarda A. et al. [52] (2015) Italy	– Male subjects aged from 20 to 40 years	– Female subjects – Younger than 20 and older 40 years of age – Subject engaged in a resistance training program – Smoking – Allergic disorders – Autoimmune: respiratory system, gastrointestinal, osteoarticular or malignant tumor, tuberculosis and general infectious diseases (bacterial and viral), including tropical diseases, diabetes, convulsion, fainting, epileptic attack, febrile episodes or flu syndromes, cardiovascular diseases, jaundice and /or hepatitis, kidney and hematologic disease – Having suffered thoracic injuries in the last six months or thoracic fractures throughout life – Suffering from anxiety or depression, not taking medications for at least two months – Splenectomy and recent surgery – Not fasting	40 subjects randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy group (n = 20) **Control group** → Sham group (n = 20)	**Number of sessions:** 1 session **Time of each session:** 10 min **Treatment group** → Direct myofascial release for the thoracic inlet + rib raising + thoracic pumping + doming of the abdominal diaphragm + abdominal pumping + pedal pumping + second thoracic pumping + direct myofascial release for the thoracic inlet **Control group** → Did not receive any treatment	**Follow up:** at baseline and post-treatment Hematic sample	The only significant value referred to monocytes was for the treated group. It can be noticed that having used the Wilcoxon test, it was detected that the number of pairs of values showing some difference (after removing zero differences) is equal to 12. The number of pairs is less than 16 minimum amount of information that allows us to consider the distribution approximately normal. The analyzed data, both for the control and for the treated group, did not indicate significant differences.

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Ratajska M. et al. [53] (2019) Poland	– Male and female subjects – Post-operative phase of cardiac surgery	Not specified	80 subject were randomly assigned to 2 groups: **Treatment group** → Miofascial release group (n = 40) **Control group** → Conventional rehabilitation group (n = 40)	**Number of sessions:** 1 time a day (from day 3 to day 6 after the surgery) **Time of each session:** 30 min **Treatment group** → Conventional rehabilitation + myofascial release technique **Control group** → PT-assisted kinesiotherapy + active exercise (breathing, coordination and walking)	**Follow up:** at baseline and day 4 and day 6 post-surgery – Pain (VAS) – Breathing difficulties (VAS) – Physical fitness (VAS) – Level of fatigue during exercise (Borg scale) – Forced Expiratory Volume in the 1st second (FEV1) – Forced vital capacity (FVC)	Treatment group compared to control group showed a significantly greater improvement in relation to: pain intensity on day 4 and on day 6 after the surgery; lower breathing difficulties on day 6 post-surgery; limiting physical fitness on day 6 post-surgery. Between day 4 and 6 post-surgery in the treatment group compared to control group, there was a significantly higher increase in FEV1 and FVC. All subject examined on day 6 following the surgery, showed a decrease in FEV1 and FVC.
Saggio G. et al. [54] (2010) USA	– Subject with no underlying medical problems – Second-year medical students at New York College of Osteopathic Medicine (NYCOM) and scheduled to take their national board examination 2 to 3 weeks after their participation in the study	– Vigorous exercise for more than 10 h per week – Immunosuppressive syndromes (human immunodeficiency virus—HIV, cancer, mononucleosis, or any other immunosuppressive syndrome not listed) – Steroid use – Radiation or chemotherapy within the past 3 years – Diagnosis of lupus, asthma, or any other autoimmune disease not stated above	25 subject randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy group (n = 12) **Control group** → Sham technique group (n = 13)	**Number of sessions:** 1 session **Time of each session:** 20 min Experimental group → Occipitoatlantal release + rib raising + thoracic pump technique **Control group** → Sitting in quiet area of the laboratory for 20 min and asking to rest calm	**Follow up:** at baseline and post-treatment SIgA levels in highly stressed individuals	The experimental group displayed a statistically significant greater increase in post-intervention sIgA levels than the control group

Table 1. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Sleszynski P. et al. [55] (1993) USA	106 subjects who underwent cholecystectomy at Olympia Fields Osteopathic Medical Center, Chicago	– More than one operation in the same day requiring a separate incision – Any incision other than subcostal – Structural deformity that would interfere with thoracic manipulation – Refused or missed more than one treatment from the unassigned group – Withdrew from the study. – A risk score of atelectasis of 10 or higher based on a predetermined scale	42 subjects randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy group (n = 21) **Control group** → Sham technique group (n = 21)	**Number of sessions:** three times daily until discharge **Time of each session:** treatment length Thoracic Lymphatic Pump → Thoracic lymphatic pump **Control group** → Incentive spirometry	**Follow up:** at baseline and post-treatment Pulmonary function test: – Forced Expiratory Volume (FEV) – Forced vital capacity (FVC)	Study patients treated with the thoracic lymphatic pump technique had an earlier recovery and quicker return toward preoperative values for FEV and FVC than patients treated with incentive spirometry.
Walkowski S. et al. [56] (2014) USA	- Healthy subjects	– Smoking – Pregnancy – Recent (within 3 months) use of corticosteroids – Cytotoxic drugs or immunosuppressants – Cardiovascular risk factors – Liver disease – Renal failure – Acute and chronic infections (including HIV) – Individuals with recent history of broken or damaged ribs or upper thoracic injury	20 subjects randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy OMT) protocol (n = 10) **Control group** → Sham treatments (n = 10)	**Number of sessions:** 1 session **Time of each session:** 7 min **Treatment group** → Lymphatic pump + splenic pump + hepatic pump **Control group** → Light touch treatment	**Follow up:** at baseline and 5 min and 30 min post-treatment – Blood collection – Levels of nitrites – C-Reactive Protein (CRP) in plasma	OMT was not able to induce a rapid modification in the levels of plasma nitrites or CRP or in the proportion or activation status of central memory, effector memory or naïve CD4 and CD8 T cells. A significant decrease in the proportion of a subpopulation of blood dendritic cells was detected in OMT patients. Significant differences were also detected in the levels of immune molecules such as IL-8,MCP-1, MIP-1a and most notably, G-CSF. Thus, OMT is able to induce a rapid change in the immunological profile of particular circulating cytokines and leukocytes.

Legend: 6MWT = Six Minute Walking Test; CCO = Standard Care Control; COPD = Chronic Obstructive Pulmonary Disease; CRP = C-Reactive Protein; ERV= Expiratory Reserve Volume; FEF= Forced Expiratory Flow; FEV = Forced Expiratory Volume; FEV1 = Forced Expiratory Volume in the 1st Second; FVC = Forced Vital Capacity; HIV = Human Immunodeficiency Virus; LOS = Length of Hospital Stay; LT = Light Touch; MMSE = Mini-Mental Status Exam; OMT = Osteopathic Manual Therapy; RV = Residual Volume; SPR = Standard Pulmonary Rehabilitation; TLC = Total Lung Capacity; VAS = Visual Analogue Scale; VC = Vital Capacity: WBC = White Blood Cell count.

Table 2. Characteristics of the studies on pompages.

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Correia M. et al. [58] (2016) Brazil	– Aged between 18 and 60 years – Diagnosed with fibromyalgia and approved by a cardiologist to practice physical activities	– Pregnancy – Undergoing another physiotherapeutic treatment – Regular practice of physical activities (assessed using the International Physical Activity Questionnaire-IPAQ)15 – Cognitive disability or other musculoskeletal disorders that would hinder the realization of proposed activities.	23 subjects randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy group (n = 13) **Control group** → Exercise group (n = 10) Sample losses totaling 15 individuals (EG, n = 7/CG, n = 8).	**Number of sessions:** 24 sessions (twice a week) **Time of each session:** 2 min **Treatment group** → Pompage + stretching + aerobic exercise **Control group** → Stretching + aerobic exercise	**Follow up:** at baseline, post-treatment, 6 and 12 weeks post-treatment. – Pain (McGill Pain – Questionnaire) – Fatigue (Chalder Fatigue Questionnaire) – Sleep quality (Sleep Inventory)	Improved only one of the pain aspects evaluated by the McGill Questionnaire (mixed aspects of pain). The results regarding fatigue and sleep quality did not show significant differences.
Fidecicchi G. et al. [59] (2008) Italy	– Chronic disabling tension headache (more than 15 days of painful symptoms per month) – Not responsive to conventional drug treatment – Consecutively referred to the Headache Center of the Department of Neuroscience of the United Hospitals of Ancona	– Epileptic seizures – Pacemakers – Pregnancy – Wounds or dermatitis in the area of application of the electrodes	16 subjects randomly assigned to 2 groups: **Treatment group** → Treatment with horizontal therapy (HT) (n = 8) **Control group** → Treatment HT with intensity current equal to 0 (sham therapy) and manual therapy (n = 8)	**Number of sessions:** 5 sessions (2 weeks) **Time of each session:** 45 min. **Treatment group** → Total body electrode program + muscle-tension headache program **Control group** → Total body electrode program (intensity equal to 0) + muscular Pompage	**Follow up:** at baseline, post-treatment and 8 weeks post-treatment – Pain (VAS) – Range of motion (ROM) in cervical flexion, extension, lateral inclination and rotation	In both groups there was a significant reduction in the maximum perceived pain and the number of episodes of headache over the weeks of treatment ($p < 0.0001$). There was a significant ROM increase in flexion (time effect: $p < 0.04$), extension ($p < 0.02$), and rotation ($p < 0.03$) in both groups.

Table 2. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Gondim I. et al. [60] (2017) Brazil	– Women aged 60 to 80 years – Diagnosis of knee osteoarthritis (OA)	– Unstable cardiovascular and/or respiratory diseases – Cognitive disorder – Knee and/or hip arthroplasty – In the last six months: lower limb surgery, corticosteroid injection in the knee and/or physiotherapy for OA – Diseases contributing to balance deficit (ankylosing spondylitis, rheumatoid arthritis, uncontrolled diabetes mellitus, neurological diseases, vestibulopathies) – Fibromyalgia.	22 subjects randomly assigned to 2 groups: **Treatment group** → FEP group (n = 11) **Control group** → Educational lectures (n = 11)	**Number of sessions:** 24 sessions (twice a week) **Time of each session:** 50 min **Treatment group** → Strengthening + balance exercises associated + knee Pompage **Control group** → Educational lectures and group dynamics	**Follow up:** at baseline and post-treatment – Pain (WOMAC) – Postural balance (BBSD) – Muscle strength (Isokinetic Dynamometer)	FEP group presented better results in pain outcomes, postural balance and muscle strength when compared to the control group. Regarding pain, there was a pain reduction in the FEP group when compared to control, however this result was not significant. The FEP group had lower levels of antero-posterior, mid-lateral and global oscillations when compared to the control group. The increase in muscle strength in the FEP group was observed in both the more symptomatic knee and in the less symptomatic knee, but these gains were not significant when compared to the groups.
Rocha T. et al. [57] (2015) Brazil	– Ex-smokers' subjects – Clinically stable (i.e., no exacerbation in the previous 6 weeks) – Aged > 60 years – Post-bronchodilator measurements of Forced Expiratory Volume In The 1st Second (FEV1) < 80% and FEV1 0.7 of Forced Vital Capacity (FVC)	– Other cardiopulmonary diseases – Body Mass Index > 30 kg/m^2 – Previous thoracic surgery – Lack of consent – Inability to understand the verbal commands necessary for the outcome assessments	20 subjects randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy group (n = 11) **Control group** → Sham technique group (n = 9)	**Number of sessions:** 6 sessions (separated by 1 to 2 days, during 2 weeks) **Time of each session:** 30 min **Treatment group** → Manual diaphragm release technique **Control group** → Light touch with the same anatomical landmarks, without exerting pressure or traction	**Follow up:** at baseline and post 1st treatment, post 6th treatment – Diaphragmatic mobility – Exercise capacity (6-Minute Walking Test—6MWT) – Maximal expiratory pressures – Abdominal and chest wall kinematics	The Manual Diaphragm Release Technique significantly improved diaphragmatic mobility over the course of treatments, with a between-group difference in cumulative improvement of 18 mm. The technique also significantly improved the 6-minute walk distance over the treatment course, with a between-group difference in improvement of 22 m. Maximal expiratory pressure and sniff nasal inspiratory pressure both showed significant benefits from the technique during the first and sixth treatments, but no cumulative benefit. The effects on other outcomes were non-significant or small.

Table 2. *Cont.*

Author	Inclusion Criteria	Exclusion Criteria	Groups	Treatment	Outcome Measures	Results (As Reported by the Authors)
Schmidt A. et al. [61] (2013) Brazil	– Clinical and spirometric diagnosis of COPD according to GOLD criteria – Age below 75 years – Body Mass Index (BMI) > 21 kg/m^2 10 – Clinically stable in the last three months	– Orthopedic and rheumatic diseases – Recent surgeries – Cognitive alterations that prevented the tests from being performed – Participants who were absent for three consecutive days or three alternate days.	5 subjects randomly assigned to 2 groups: **Treatment group** → Osteopathic Manipulative Therapy group (n = 2) **Control group** → Rehabilitation group (n = 3)	**Number of sessions:** 8 sessions (4 weeks) **Time of each session:** 50 min **Treatment group** → Posture + Pompage **Control group** → Pulmonary rehabilitation protocol	**Follow up:** at baseline and post-treatment Functional capacity (6-Minute Walking Test—6MWT)	When the two groups were compared, a significant difference was found after intervention for the 6MWT (p = 0.004). The patients of the treatment group increased the distance covered and had a better performance in the 6MWT after the intervention. On the contrary, the patients of the control group decreased the distance covered and had low performance in the 6MWT.

Legend: CG = Control Group; EG = Experimental Group; FEV1 = Forced Expiratory Volume in the 1st Second; FVC = Forced Vital Capacity; HT = Horizontal Therapy; IPAQ = International Physical Activity Questionnaire; LT = Light Touch; OA = Osteoarthritis; ROM = Range of Motion; 6MWT = Six Minute Walking Test; VAS = Visual Analogue Scale; WOMAC = Western Ontario and Mc Master University.

3.3.1. Pump Techniques Versus Light Touch

Nine studies [44–50,56] were identified comparing osteopathic pump protocol versus light touch at short-term follow-up. Outcomes assessed were pulmonary function, blood collection, and length of hospitalization.

- *Pulmonary function.* Only one study [47] assessed this outcome on patients complaining of Chronic Obstructive Pulmonary Disease (COPD). The OMT group showed a statistically significant decrease in Forced Expiratory Volume in the 1st second (FEV1), the Expiratory Reserve Volume and airway resistance. The OMT group also had a statistically significant increase in the residual volume, total lung capacity, and the ratio of those values compared with the control group.
- *Blood collection*. Two studies [49,56] assessed this outcome. No statistically significant changes emerged between the treatment groups and the control groups with regard to white and red blood cell count. In the first study [49] on subjects aged $\geq$ 60 years, an increase of platelets in the control group and a decrease in the treatment group was observed. In the second study [57] on adult males, a decreased level of monocytes was noted in both groups.
- *Length of Hospitalization.* Four studies [44,45,48,50] assessed this outcome on patients affected by pneumonia and patients operated on for heart surgery. All four studies showed no significant difference between the treatment groups and the control groups. A third group that received standard care was also compared in two studies [48,50]. In both studies, the length of hospitalization was shorter for the experimental groups than for the standard treatment groups.
- *Cognitive status.* Only one study [46] assessed this outcome on elderly subjects. In this study, comparing the subjects who responded to Mini-Mental State Examination (MMSE) in the "normal" range, no differences occurred between the treatment group and the control group.

3.3.2. Pump Techniques Versus Conventional Rehabilitation

Six studies [38,41,42,51,53,55] were identified comparing osteopathic pump protocol versus standard rehabilitation at short-term follow-up. Conventional rehabilitation included treatments such as standard pulmonary rehabilitation (tapotement, pursed-lip breathing, saline nebulizer and rest) [41], supervised and unsupervised exercise (breathing, coordination and walking) [53], nebulization [38], standard cardiorespiratory rehabilitation [51], incentive spirometry [55], and drugs (bronchodilators, antibiotics, expectorants, sedatives, and parenteral fluids) [42]. The outcomes assessed were pain, pulmonary function, and length of hospitalization.

- *Pain.* Two studies [51,53] assessed this outcome in patients operated on for heart surgery at short-term follow-up. In both studies, there was a statistically significant decrease in mean pain intensity in the treatment group compared to the control group. In the first study [51] there was also a statistically significant decrease in breathing difficulty for the treatment group compared to the control group.
- *Pulmonary function.* Four studies [38,41,42,56] were identified comparing osteopathic pump protocol versus other conservative treatments, at short-term follow-up. In the first study [38] on patients with pulmonary pathology, a statistically significant increase in FVC appeared in both groups. No significant changes emerged for other lung functions. In the second study on healthy subjects [41], osteopathic techniques were compared with standard pulmonary rehabilitation [SPR]. In the treatment group, rib-raising and lymphatic pump led to a change in FEV1 and FVC although not statistically significant. In the control group, saline treatment was associated with significant decline in lung function. All other techniques did not significantly change lung function. In the third study on patients with pulmonary pathology [42], in the treatment group an osteopathic protocol was added to a nebulization, while the control group was submitted only to nebulization. Statistically significant post-treatment improvements in FEV1, FVC, VC, and FEV1/FVC emerged in the experimental group

compared to the control group. In the fourth study [56] on patients operated on for cholecystectomy, an osteopathic pump protocol was compared with incentive spirometry. This study showed a significant increase in FVC and FEV1 in the treatment group compared to the control group at second and third postoperative days.

- *Length of Hospitalization*. Only one study in patients operated on for heart surgery [51] assessed this outcome. Hospitalization was significantly shorter for the treatment group compared with the control group.
- *Functional capacity.* Only one study in patients operated on for heart surgery [51] assessed this outcome. This study showed a statistically significant increase of walking distance for both groups, without significant difference between the treatment group and the control group.

3.3.3. Pump Techniques Added to Vaccination Versus Vaccination

Two studies [39,40] were identified comparing osteopathic pump protocol added to vaccination versus vaccination alone at short-term follow-up. The outcome assessed was blood collection.

- *Blood collection.* Two studies on healthy subjects [39,40] assessed this outcome. In the first study [39] there was no significant change in the anti-influenza immunoglobulin production in the treatment group compared to the control group. There was a significant increase in anti-influenza immunoglobulin in both groups for young subjects compared to elderly ones. In the second study [40], there was a significant increase in hepatitis B antibody in the treatment group compared to the control group at 13th week. No significant difference between the two groups emerged at the other follow-ups.

3.3.4. Pump Techniques Versus No Treatment

Two studies [37,52] were identified comparing osteopathic pump protocol versus no treatment, at short-term follow-up. Outcome assessed was blood collection.

- *Blood collection.* Two studies [37,52] assessed this outcome on healthy subjects. In the first study [37], two treatment groups (with different osteopathic pump protocols) were compared to a control group. Among the treatment groups and the control group, only the group submitted to thoracic lymphatic pump and splenic pump techniques showed a significant increase in CD4 lymphocytes.

In the second study [52], the only significant change was an increase in monocytes (white blood cells) in the treatment group compared to the control group. There were no significant changes in red blood cells.

3.3.5. Pump Techniques Versus Placebo

Saliva sampling. Only one study [54] assessed the salivary immunoglobulin A (sIgA) in highly stressed individuals. The experimental group received osteopathic protocol, whilst the control group sat relaxed in a separate area for 20 min. There was a significant increase in sIgA levels in both post-treatment groups, without any significant difference between groups.

3.3.6. Diaphragmatic Pompage (Manual Diaphragm Release Technique) Versus Light Touch

Functional capacity. Only one study [57] was identified comparing diaphragmatic pompage (Manual Diaphragm Release Technique) versus light touch in subjects with COPD, at short-term follow-up. Outcome assessed was functional capacity. This study showed a statistically significant improvement of walking distance measured with the 6-min Walking Test (6MWT) for the treatment group compared to the control group.

3.3.7. Pompages Added to Stretching and Aerobic Exercise versus Stretching and Aerobic Exercise

Pain, fatigue and sleep quality. Only one study [58] on Myofascial Pain Syndrome was identified comparing Manual Diaphragm Release Technique added to stretching and aerobic exercise versus stretching and aerobic exercise in subjects with fibromyalgia, at short-term follow-up. Outcomes assessed were pain, fatigue and sleep quality. No significant differences emerged between the groups for all outcome measures.

3.3.8. Pompages Added to Sham Tension-Type Headache Program Versus Tension-Type Headache Program

Pain and ROM. Only one study [59] was identified comparing pompages added to sham total body electrode program versus total body electrode program, in subjects with chronic disabling tension headache, at short-term follow-up. Outcomes assessed were pain and ROM. A significant increase in flexion, extension and rotation ROM appeared in both groups, with ROM normalization. Furthermore, a significant reduction in perceived pain was recorded in both groups.

3.3.9. Knee Pompage Added to Exercise Versus Educational Lectures

Pain, postural balance and muscle strength. Only one study [60] was identified comparing knee pompage added to exercise versus educational lectures in knee osteoarthritis, at short-term follow-up. Outcomes assessed were pain, postural balance and muscle strength. The treatment group presented better results in pain, postural balance and muscle strength when compared to the control group. Pain reduction was not different between the treatment group and the control group. The only significant difference between groups was about better balance improvements for the experimental group at 12 weeks follow-up. A muscle strength increase was observed in symptomatic and less symptomatic knee, for both groups.

3.3.10. Pompages Added to Postural Treatment Versus Pulmonary Rehabilitation Protocol

Functional capacity. Only one study [61] was identified comparing pompages added to postural treatment versus pulmonary rehabilitation protocol in COPD patients at short-term follow-up. Outcome assessed was functional capacity. The patients of the treatment group increased the distance covered and had a better performance in the 6MWT after the intervention. On the contrary, the patients of the control group decreased the distance covered and had low performance in the 6MWT. A statistically significant difference between groups emerged.

3.4. Adverse Effects

Concerning side effects, one participant in a study from the treatment group reported stiffness and was unable to get out of bed the morning after the first treatment while in the control group, one participant reported "a little muscle soreness in the abdomen" [46]. In a second study [47], one subject in the treatment group reported generalized muscle soreness, and another reported "a little muscle soreness in the neck", while in the control group, four instances of possible adverse effects were reported: "elevated blood pressure in the morning", (164/90 mm Hg)"mild heart palpitations", "a little [muscle] soreness", and "back was a little sore".

3.5. Risk of Bias and Quality of the Evidence Assessment

Tables 3 and 4 show the synthesis of the RoB assessment for the selected studies. Globally, the RoB of the studies on pump techniques and pompages ranges from moderate to high.

Table 3. Synthesis of the risk of bias assessment on pump techniques.

	Randomisation Process	Deviations from Intended Interventions	Missing Outcome Data	Measurement of the Outcome	Selection of the Report Result	Risk of Bias
Abdelfattah A. 2018 [37]	?	?	+	+	?	MODERATE
Allen 1967 [38]	?	?	−	−	?	HIGH
Breithaupt 2001 [39]	?	?	+	?	?	MODERATE
Jackson K. 1998 [40]	?	?	+	?	?	MODERATE
Lorenzo S. 2019 [41]	?	−	−	−	?	HIGH
Mascarenhas S. 2013 [42]	?	?	+	+	?	MODERATE
Newberry M. 2011 [43]	?	?	+	+	?	MODERATE
Noll D.R. 1999 [44]	?	?	−	−	?	HIGH
Noll D.R. 2000 [45]	?	−	+	−	?	HIGH
Noll D.R. 2004 [46]	?	?	+	?	?	MODERATE
Noll D.R. 2008 [47]	?	?	+	−	?	HIGH
Noll D.R. 2010 [48]	+	?	+	?	?	MODERATE
Noll D.R. 2013 [49]	?	?	+	?	?	MODERATE
Noll D.R. 2016 [50]	?	?	−	?	?	HIGH
Racca V. 2017 [51]	+	?	+	−	?	HIGH
Rapisarda A. 2015 [52]	?	−	−	−	?	HIGH
Ratajska M. 2019 [53]	?	−	−	−	?	HIGH
Saggio G. 2010 [54]	+	?	+	−	?	HIGH
Sleszynski P. 1993 [55]	?	?	−	?	?	HIGH
Walkowski S. 2014 [56]	+	?	+	?	?	MODERATE

The quality of evidence assessment through the GRADE instrument was made by consideration of the different comparisons between interventions explained in the previous paragraphs of the results. Tables 5 and 6 show the quality of evidence for each comparison, which ranges from very low to high.

Table 4. Synthesis of the risk of bias assessment on pump techniques.

	Randomisation Process	Deviations from Intended Interventions	Missing Outcome Data	Measurement of the Outcome	Selection of the Report Result	Risk of Bias
Correia M. 2016 [58]	?	−	−	+	?	MODERATE
Fidecicchi G. 2008 [59]	?	?	+	−	?	HIGH
Gondim I. 2017 [60]	?	−	−	+	?	MODERATE
Rocha T. 2015 [54]	+	?	+	+	?	MODERATE
Schmidt A. 2013 [61]	?	−	−	−	?	HIGH

Table 5. GRADE evaluation of the studies on pump techniques: quality of evidence and strength of recommendations.

	Quality				Summary of Findings		
Outcome (No. of Studies)	**RoB**	**Inconsistency**	**Indirectness**	**Imprecision**	**No. of Participants**	**Effect Size (SMD) with CI ***	**GRADE +**
			Pump techniques versus light touch				
Pulmonary function (Noll 2008 [47])	Not serious	Not assessable	Not serious	Serious	35	#	LOW
Blood collection (Noll 2013 [49], Walkowski 2014 [56])	Serious	Not serious	Serious	Serious	40	#	VERY LOW
Length of Hospitalization (Noll 1999 [44], Noll 2000 [45], Noll 2010 [48], Noll 2016) [50]	Not serious	Not serious	Not Serious	Not Serious	872 (21 + 58 + 406 + 387)	#	HIGH
Cognitive status (Noll 2004 [46])	Serious	Not assessable	Serious	Serious	14	#	VERY VERY LOW
			Pump techniques versus conventional rehabilitation				
Pain (Ratajska 2009 [53], Racca 2017 [51])	Not serious	Not serious	Not serious	Serious	160 (80 + 80)	#	MODERATE
Pulmonary function (Lorenzo 2019 [41], Mascarenhas 2013 [42], Allen 1968 [38], Sleszynski 1993 [55])	Not serious	Serious	Not serious	Serious	161 (53 + 50 + 16 + 42)	#	LOW
Length of Hospitalization (Racca 2017 [51])	Not serious	Not assessable	Not serious	Serious	80	#	LOW
Functional capacity (Racca 2017 [51])	Not serious	Not assessable	Not serious	Serious	80	#	LOW
			Pump techniques versus no treatment				
Blood collection (Abdelfattah 2018 [37], Rapisarda 2015 [52])	Not serious **	Serious	Serious	Serious	130 (45 + 45 + 40)	#	VERY LOW
			Pump techniques versus placebo				
Saliva sampling (Saggio 2010 [54])	Not serious	Not assessable	Serious	Serious	25	#	VERY LOW
			Pump techniques + vaccination versus vaccination				
Blood collection (Breithaupt 2001 [39], Jackson 1998 * [40])	Serious	Serious	Serious	Serious	136 (97 + 39)	#	VERY VERY LOW

Table 5. *Cont.*

Outcome (No. of Studies)	Quality				Summary of Findings		
	RoB	Inconsistency	Indirectness	Imprecision	No. of Participants	Effect Size (SMD) with CI *	GRADE +
Pump techniques versus incentive spirometry							
Pulmonary function (Sleszynski 1993 [55])	Not serious	Not assessable	Not serious	Serious	42	#	LOW

* Effect Size (SMD) with CI = Effect Size (Standardized Mean Difference with Confidence Interval). # Effect size is not reported because meta-analysis was not performed. + GRADE for the study had been calculated only for before treatment and after treatment (short-term) outcomes. ** 50% RoB moderate and 50% RoB high.

Table 6. GRADE evaluation of the studies on pompages: quality of evidence and strength of recommendations.

Outcome (No. of Studies)	Quality				Summary of Findings		
	RoB	Inconsistency	Indirectness	Imprecision	No. of Participants	Effect Size (SMD) with CI *	GRADE +
Pompage + stretching + aerobic exercise versus stretching + aerobic exercise							
Pain (Correira 2016 [58])	Not serious	Not assessable	Not serious	Serious	23	#	LOW
Fatigue (Correira 2016 [58])	Not serious	Not assessable	Not serious	Serious	23	#	LOW
Sleep quality (Correira 2016 [58])	Not serious	Not assessable	Not serious	Serious	23	#	LOW
Pompage + sham total body electrode program versus total body electrode program							
Pain (Fidecicchi 2008 [59])	Not serious	Not assessable	Not serious	Serious	16	#	LOW
ROM (Fidecicchi 2008 [59])	Not serious	Not assessable	Not serious	Serious	16	#	LOW
Knee pompage + exercise versus educational lectures							
Pain (Godmin 2017 [60])	Not serious	Not assessable	Not serious	Serious	22	#	LOW
Postural balance (Godmin 2017 [60])	Not serious	Not assessable	Not serious	Serious	22	#	LOW
Muscle strength (Godmin 2017 [60])	Not serious	Not assessable	Not serious	Serious	22	#	LOW
Manual Diaphragm Release Technique versus light touch							
Functional capacity (Rocha 2015 [57])	Serious	Not assessable	Not serious	Serious	20	#	VERY VERY LOW
Pompage + postural treatment versus pulmonary rehabilitation protocol							
Functional capacity (Schmidt 2013 [61])	Not serious	Not assessable	Not serious	Serious	5	#	LOW

* Effect Size (SMD) with CI = Effect Size (Standardized Mean Difference with Confidence Interval). # Effect size is not reported because meta-analysis was not performed. + GRADE for the study had been calculated only for before treatment and after treatment (short-term) outcomes.

Effect size is not reported because meta-analysis was not performed. For the indirectness domain, we considered that the population generally investigated by clinical studies is not healthy, therefore the studies carried out on healthy subjects were rated as "serious": Concerning the inconsistency domain, if the results were not statistically significant, we rated inconsistency as "serious".

4. Discussion

This review aimed to investigate the effectiveness of pump techniques and pompages on subjective parameters (e.g., pain, physical function) and objective parameters (lung function, blood count cell, length of hospitalization) on adults.

The results of this review showed that pump techniques and pompages were applied in a wide spectrum of populations and using very different outcome measures. The studies on pump techniques were conducted both on healthy, young or elderly subjects, and in different clinical conditions as COPD, pneumonia, other pulmonary diseases, and patients submitted by surgery. The studies on pompages were done on pulmonary diseases, tension-type headache, fibromyalgia, and knee osteoarthritis.

All studies combined various pump techniques or added these techniques to other treatments, with different procedures. In example, the treatment performed by Noll and colleagues [48] included thoraco-lumbar soft tissue treatment, rib raising, diaphragm doming, cervical soft tissue treatment, suboccipital decompression, inlet relaxation, together with thoracic lymphatic pump and pedal pump. Instead, Racca and colleagues [51] performed chest wall and diaphragm manipulation, combined with manual compressions on the sternal, dorsal, and clavicular areas. On the other hand, these studies respected designs similar to common clinical practice, in which pump techniques are frequently adjunct to other therapeutic procedures, through the integration of different manual techniques [30].

Significant differences also appeared in sessions' numbers, treatment length, and duration of each session: all these parameters seem to have been chosen arbitrarily. There is therefore a specific difficulty in measuring the single effects of the pump techniques with pragmatic studies, since they are usually applied within a multimodal program.

Singular studies seem to suggest a certain effectiveness of pump techniques in reducing pain and improving lung function in surgical and pulmonary diseases patients when compared to standard rehabilitation, and in reducing the length of hospitalization when compared to standard care. Only one study [47] showed worse results after having undergone thoracic pump with activation, compared to sham treatment. This specific pump technique, by facilitating the inspiration phase, may increase the residual volume and decrease the expiratory flow in old people with airflow obstruction.

No significant difference emerged when pump techniques were compared with light touch, and hematic exams results on healthy subjects were contradictory. The pompages techniques, alone or combined with exercise, seem effective in improving walking capacity in pulmonary disease and balance in knee osteoarthritis, nevertheless no significant difference emerged adding pompages techniques to stretching and exercise or sham tension-type headache program.

No serious adverse effect related to the application of pump techniques was reported in the selected studies.

These results must be taken with great caution, due to the heterogeneity of the studies and the small samples. The RoB and the quality of evidence assessment confirmed several limitations of the included studies.

A major strength of our study is an extensive search using many databases and careful consideration of all published reviews and guidelines on this topic. The selection and qualitative assessment were conducted independently by two authors. Only studies using explicit criteria for Population, Intervention, Comparison, and Outcome (PICO) were included, while studies with important missing data were excluded, minimizing the reference bias. Studies in all languages, from every country and for any year of publication were searched, thereby reducing publication bias. Nevertheless, no study showed some evidence that favored controls, and we do not exclude the possibility that other negative studies were not published. Most of the included studies did not have a published protocol, and thus it is difficult to assess reporting bias.

The most important limitation of this review is related to the differences among studies related to populations, interventions and outcome measures, which did not allow us to perform a quantitative synthesis. Seven studies came from the same author, so we cannot exclude a publication bias. Even after attempting to contact authors, we were not able to retrieve five studies (detailed in Supplement 2), and some data from other studies were not found, forcing the elimination of them.

In the absence of any previous systematic reviews on this topic, we could not compare our results with other ones. Only an indirect comparison was made with a recent systematic review that challenged the validity of treating spinal dysfunctions with spinal manipulative therapy (manipulation, mobilization or traction) to obtain physiological effects [62].

The results of this systematic review may be interesting for clinical practice, because the use of pump techniques and pompages and outcome measures concerning pain, physical activity, and pulmonary function are common in clinical settings.

The quality of RCTs in this field should be significantly improved to reduce bias in future systematic reviews, especially by better standardization of techniques and dosages. In order to measure the real effectiveness of these procedures, the effects of pump techniques and pompages should be further investigated both as single treatment and as technique combined or integrated with other standardized treatments; finally, the clinical conditions better responding to pump techniques and pompages, and the most effective dosage should also be investigated.

5. Conclusions

This systematic review suggests the effectiveness of pump techniques and pompages on pulmonary, post-surgical and musculoskeletal conditions when comparing to standard rehabilitation but not to controls like light touch. These results emerged by single studies with moderate to high RoB. The quality of evidence, from very low to high, supports these results. Further research is likely to have an important impact in the estimation of the effects of these methods.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/app11094150/s1, Supplement 1: Search strategy for MEDLINE, Supplement 2: Details on the studies excluded from this review, with reasons.

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