REVIEW

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The Effectiveness of Physiotherapy in Idiopathic or Primary Frozen Shoulder: a Systematic Review and Meta-Analysis

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SUMMARY

Objective. The objective of this work was to evaluate the effectiveness of physiotherapy in individuals affected by primary or idiopathic frozen shoulder, considering only studies that employed a randomized controlled trial.

Methods. A systematic review and meta-analysis were carried out according to PRISMA guidelines. Three bibliographic databases were searched: MEDLINE, Cochrane Library and PEDro. The minimum prerequisites for papers to be included in the systematic review were that they had to (a) employ a randomized controlled trial; (b) be published in English or Italian language. The studies were evaluated according to Cochrane Collaboration's tool for assessing risk of bias and Jadad scale.

Results. Twelve studies in systematic review and nine studies in meta-analysis were included.

Conclusions. Frozen shoulder is a condition whose therapeutic targets could change due to symptoms and stage. Rehabilitation program, particularly end-range mobilization techniques and therapeutic exercise are the most effective in reducing pain and increasing function in sub-acute phases.

KEY WORDS

Frozen shoulder; adhesive capsulitis; rehabilitation; physical therapy; rehabilitation program

INTRODUCTION

Frozen shoulder is a condition characterized by spontaneous onset of pain, ROM restriction, stiffness and limitation of glenohumeral joint (1-5). Also defined adhesive capsulitis, it is an unknown etiology disorder (primary or idiopathic frozen shoulder); when it is associated with traumas or systemic diseases, such as diabetes mellitus II type, thyroid diseases, rheumatoid arthritis etc., it is defined secondary frozen shoulder. It has an estimated incidence of 3% to 5%, particularly in females, with a high prevalence in 40 to 60 aged population and an incidence of 20% in diabetes mellitus affected population (6-7).

The term "frozen shoulder" was introduced in 1934 by Coldman, although in 1872 Duplay had already defined this disorder as scapulohumeral periarthritis; the term adhesive capsulitis was introduced by Naviesar in 1947 (8). There is no preference for handedness; rarely it occurs simultaneously bilaterally, sometimes it is reported to occur sequentially bilaterally (6), while very rarely it occur more times the same side unless there is a history of traumas or specific disease that could relapse (2,9). The right physiopathologic mechanism is not yet well-understood, but it is reported to be a chronic inflammatory process of synovium and soft tissue followed by a fibrotic picture similar to

Dupuytren's disease, due to the rise of collagen formation, myofibroblasts and fibroplasias (10); some arthroscopic and histologic studies have shown that the condition is caused by a glenohumeral capsule contracture, particularly of the coracohumeral ligament within the rotator interval (9). Another theory tells that if the immobilization due to injury and pain is kept up longer than necessary, it may lead to learned non-use, loss of cortical representation and then stiffness and pain (11).

Early diagnosis is not easy: the first symptom is the onset of a nocturnal and daily pain causing restriction in function and daily activities (1-3,5); there is a loss of both passive and active movements, particularly a loss of more than 30° in passive external rotation (2); there is weakness of supraspinatus muscle and long head biceps lack of flexibility which cause limitation in abduction (12-14). In this pathologic mechanism the capsule does not become adhered to the humerus, but the contracted capsule holds the humeral head tightly against the glenoid fossa, causing a progressive loss of the physiological movements (15). Based on this and on the absence of a significant correlation between joint space capacity and restricted ROM, some authors reported that tightness of capsule and soft tissues around bring to a proportional motion restriction, more in external rotation than internal rotation (38). Many authors divide the natural course of the disease in three stages (1-3,6,12,13,16,17): stage I (freezing or painful stage) of 3-9 months, characterized by pain and progressive reduction of function and joint mobility; stage II (*frozen stage*) of 4-12 months which may not lead to increased pain but to a strong limitation of movements and ROM particularly external rotation, frontal flexion and abduction; stage III (*thawing stage*) of 12-42 months characterized by a progressive rise and recovery of movements and ROM.

Other authors (18) reported four stages based on the arthroscopic course. Even if frozen shoulder is reported to have a spontaneous resolution within 2-3 years, some individuals could have persistent symptoms and stiffness beyond three years (20) and sometimes persistent disability (15,19,20).

The best treatment approach in this disease is largely unclear and discussed; many operative and non-operative options are reported (21). Among the operative ones, the arthroscopic capsular release is considered a safe procedure that bring a fast improvement in symptoms, then manipulation under anesthesia *(MUA)* is considered a efficacious treatment with a iatrogenic damage risk such as fractures, brachial plexus injuries, rotator cuff tears, labral tears and gleno-humeral dislocation.

Among the non operative options we report hydrodilation, a technique involving the injection of a local anesthetic into the capsule at a pressure high enough to distend and stretch the joint capsule, the *steroid* injection*,* oral therapy (particularly NSAID) and physiotherapy.

The objective of this work was to evaluate the effectiveness of physiotherapy in individuals affected by primary or idiopathic frozen shoulder, considering only studies that employed a randomized controlled trial.

MATERIALS AND METHODS

Search strategy

For this review were considered only qualitatively significant studies. Therefore, only Randomized Control Trials (RCTs) were included, meaning only those studies that involve the random assignment of participants to two types of treatment, one experimental and one control.

The minimal prerequisites for papers to be included in the systematic review and meta-analysis were that they had to (a) employ a randomized controlled trial (RCT); (b) be published in English or Italian.

A PRISMA checklist was used to carry out the review. This work was developed through systematic review and meta-analysis. Three electronic databases were searched: MEDLINE, Cochrane Library, and PEDro. The bibliographical search was performed with no temporal limitations. The following keywords were used: MEDLINE/ Cochrane Library: "Frozen Shoulder" (Mesh) OR "Adhesive Capsulitis"; (treatment) OR (exercise) OR (pain) OR (rehabilitation) OR (physiotherapy) OR (treatment rehabilitation) OR (rehabilitation treatment) OR (physiotherapy treatment) OR (treatment physiotherapy); PEDro: "Frozen Shoulder" OR "Adhesive Capsulitis".

Study selection and quality assessment

The study focused on adults (> 18 aged) with primary or idiopathic frozen shoulder or other disease with same clinical picture also named. The research has been oriented towards physiotherapy treatments, carried out either individually or in group, aimed at reducing symptoms and signs associated with frozen shoulder. We excluded studies focused on other medical therapy interventions (eg: oral therapy, steroid injections, surgery, MUA, hydrodylation) and studies focused exclusively on instrumental electronic therapy (eg. LLLT, diathermy, shockwave, ultrasounds).

Two authors independently researched the articles using the search terms and independently screened titles and abstracts according to the eligibility criteria to select relevant studies.

The quality of the included studies was assessed by using Cochrane Collaboration's tool for assessing risk of bias

by RevMan and Jadad scale by giving each article a score between 0 and 5 points.

Statistical analysis

We performed a meta-analysis using Review Manager software (RevMan, the Cochrane Collaboration). The mean difference (MD) was used as the effect size for continuous outcomes. A fixed-effect model was used, as we expected a fixed effect-size from the studies. The overall effect sizes were calculated based on the pooled proportions and 95% confidence intervals (CIs). The differences between the studies were calculated through the overall effect size (Z), with a statistical significance threshold of $p < 0.05$. The data used for statistical analysis were divided according to two points in time: first we considered the post-treatment included in the first 6 weeks (0-6 weeks) and then the results obtained at follow-up included in some specific ranges: 6-12 weeks, 12-26 weeks, 26-52 weeks, 52-104 weeks.

OUTCOME MEASURES

The primary outcomes of interest included y VAS, (visual analogic scale for pain), DASH score (Disability of Arm, Shoulder and Hand score), SPADI (Shoulder Pain and Disability index) and functioning assessed by Constant Score and ROM collected both the post-treatment outcome at 6 weeks and the follow-up outcome creating some ranges till two years follow-up.

RESULTS

Search results

The study selection process is diagrammed in **figure 1**. Total number of articles retrieved from MEDLINE, Cochrane, and PEDro was 651. We excluded 584 articles after removing duplicates and reading the titles and abstracts. Of the remaining 67 articles, after reading full-text only 12 were included. These twelve studies were all RCTs published in English language and they all met the eligibility criteria.

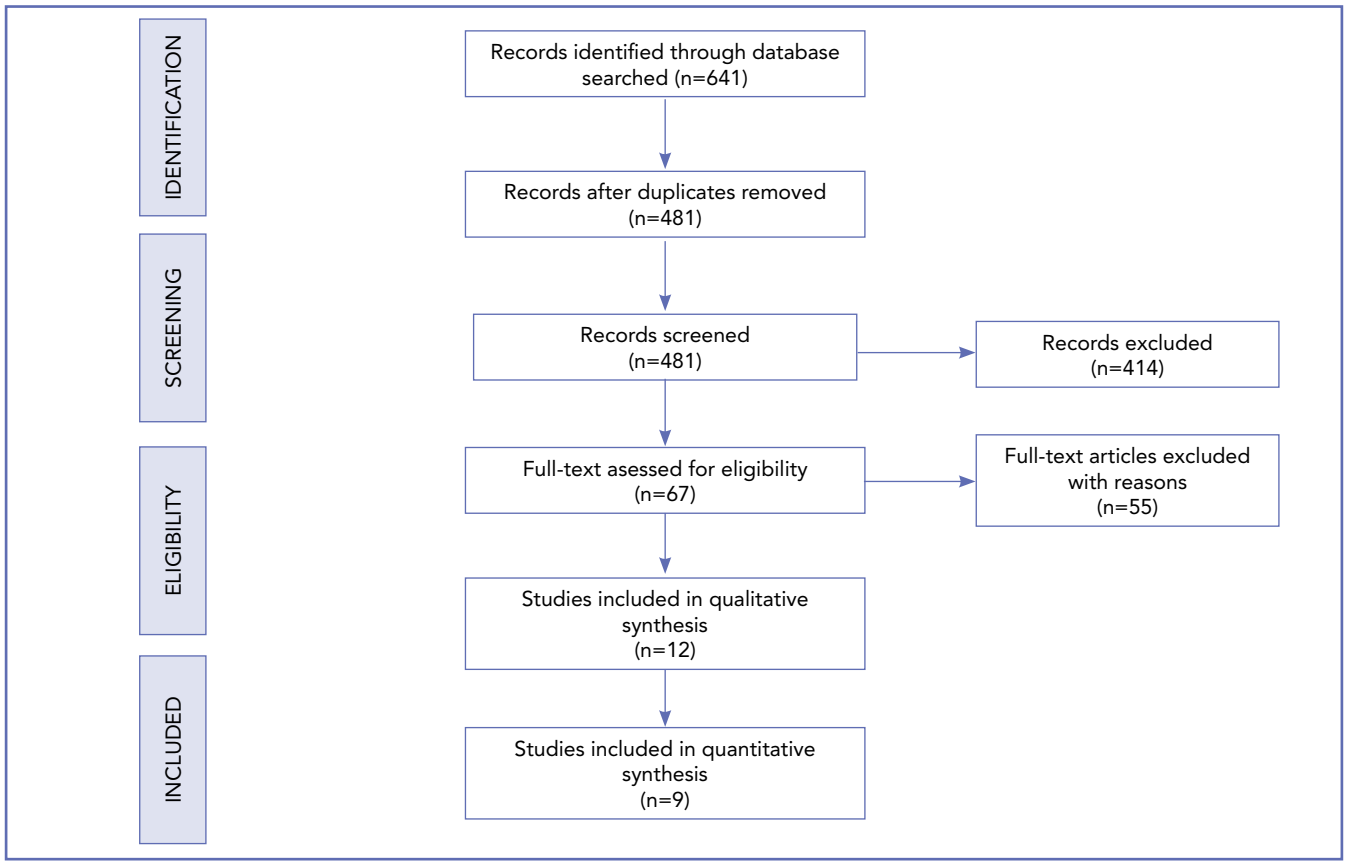

Figure 1. Flow-chart.

CHARACTERISTICS OF INCLUDED STUDIES

A summary of included studies is shown in **table I**. For each study we analyzed the following items: sample size, mean age of participants and genre, mean duration of symptoms, intervention, type and dosage of treatment for both the study and the control group, follow-up, outcomes, and Jadad score.

The twelve studies were published from 2009 to 2017 and included 568 patients: 248 were male and 320 were female. The mean age across all participants was 51,5.

Çelik e Mutlu (22) investigated the effectiveness of some mobilization techniques plus stretching and home exercises for six weeks (eighteen sessions) in thirty patients; mobilization techniques consist of low grade (I or II) rhythmic oscillations at resting position in every direction for the first two weeks and high-grade oscillations (III or IV) in end range of motion depending on the level of tolerance during the other weeks. The authors found that joint mobilizations with stretching are more effective than stretching alone in improving abduction, external rotation and function (CONSTANT SCORE) till one year follow-up.

Dundar et al. (23) recruited fifty-seven patients for twenty sessions in four weeks and studied the effectiveness of a one hour passive continuous motion (CPM) daily treatment in the experimental group; the other group had a conventional physiotherapy treatment with stretching and supervised exercises; both groups also had home exercises. They found in weeks 4 and 12 significant improvements in all parameters for both groups; however the results showed that CPM treatment provides better pain control (VAS and SPADI) at four and twelve weeks than conventional physiotherapy, but no superiority considering function (Constant Score) and ROM.

Gutiérrez et al. (24) applied in 57 patients high-degree joint mobilization techniques in posterior slide in the end range of available motion after cycle ergometer in the experimental group, and conventional physiotherapy program consisting of ultrasound and classic exercises in the control group. The authors found that gleno-humeral posterior mobilization after cycle ergometer training provides significant improvement compared with conventional treatment in short period pain (VAS), function (CONSTANT SCORE) and particularly in external rotation (ROM). No follow-up was given; besides the authors underlined the cost/effectiveness difference between the two treatments, favorable to experimental group.

Ibrahim et al. (25) investigated the efficacy of a static progressive stretch device in sixty patients for four weeks and twelve sessions; the device had to be worn 30 minutes daily, one time in the first week, twice a day in the second and third week, three times a day in the fourth week. Both groups also had a conventional treatment consisting of heat packs and manual therapy. Results showed significant differences in favour of the experimental group in mobility (ROM in active and passive abduction, external rotation) and disability (DASH) in every follow-up; in pain (VAS) they found significant differences at one year follow-up. The authors concluded recommending that static progressive stretch devices should be added to the traditional therapy regimen.

Other authors (26) evaluated the same patients of the previous study in a two years follow up (104 weeks): they confirmed significant differences favour to the experimental group in mobility and disability (DASH), however clinical differences in favour of control group were found in pain (VAS) at two year follow-up. They noticed worse values for pain in SPS group probably because patients had assiduously started using again the affected arm in daily and sports activities, reasonably exacerbating pain.

Kumar et al. (27) investigated Maitland's mobilization techniques plus supervised exercises program as Codman exercises and stretching on forty patients during a four weeks period. Mobilizations (in twelve sessions) consisted in 5 sets of passive oscillatory movements of 2/3 glides per second for 30 second in caudal and posterior-anterior glides. Control group had only supervised exercises program (in twenty sessions). Although no follow-up was given, at four weeks both groups showed statistically significant improvement in all outcomes considered (ROM, SPADI, VAS).

Furthermore, the differences between experimental group and control group was statistically significant in favour of the first one in all parameters, concluding that Maitland's mobilization techniques should be added to a supervised exercise program.

Russel et al. (9) divided seventy-five patients in three groups for six weeks: every group had home exercises, one group also had exercises in a supervised group made up by twelve stations twice a week, and another group had an individual multimodal physiotherapy depending on individual disease levels always twice a week. For this study, 6 months and 1 year follow-up were available: all groups demonstrated significant improvement, however exercise class group and individual multimodal physiotherapy group showed significant differences compared with home exercise group in function (CONSTANT SCORE and OXFORD SHOULDER SCORE), in forward elevation and external rotation and in anxiety and disability outcomes (HADS). Between exercise class group and individual multimodal physiotherapy there were significant differences favour to the first one in function but not in anxiety and depression and range of motion, concluding that a group exercise class provides

superior outcomes in relieving the signs and symptoms of frozen shoulder, but standard multimodal physiotherapy is a good alternative significantly better than exercise at home.
Yang et al. (28) divided their thirty-two patients in three groups according on whether the following criteria were achieved or not: 8° of scapular posterior tipping, 97° of humeral elevation, 39° of humeral external rotation during arm elevation. Subjects with larger shoulder kinematics in all 3 criteria were assigned to the control group, other subjects were randomly allocated in criteria-control group and criteria-intervention group The first two groups had the same standardized treatment approach: passive mid-range mobilization (MRM) techniques, stretching, physical modalities (ultrasound, shortwave diathermy and/or electrotherapy) and exercises; the criteria-intervention group received in addition to standardized treatment a specific one including end-range mobilization (ERM) techniques as described by Maitland at high grade (IV) in various directions and scapular mobilization.
The authors evaluated at 4 and 8 weeks (16 session) the following outcomes: ROM (internal and external rotation and abduction), disability (FLEX-SF) and shoulder complex kinematics through the FASTRAK motion analysis system. The final results showed that end-range intensive grade IV mobilization techniques combined with scapula mobilization techniques can be given to patients with some specific restriction criteria as less than 8° of scapular posterior tipping, 97° of humeral elevation, 39° of humeral external rotation during arm elevation.
Rawat *et al*. (29) studied a rotator cuff strengthening exercises protocol dividing their fourty-two patients in two groups: both groups had a treatment of mobilization techniques and transcutaneous electrical nerve stimulation (TENS), then the experimental group had strengthening of rotator cuff muscles including isometric and isotonic exercises. Although no follow-up was available, after twelve sessions and four weeks both groups showed improvement in pain (VAS), disability and function (SPADI and PSFS), mobility (ROM in flexion, abduction and internal and external rotation) and in secondary outcome (strength of rotator cuff muscles measured with handheld dynamometer). However, the analysis between two groups showed significant differences favour to experimental group in all parameters except forward flexion.
Akbas et al. (30) investigated the role of PNF exercises for scapula and arm in addition to home exercises in thirty-six patient. Both groups also received heat packs and ultrasound before their three weeks treatment (fifteen sessions). Specific PNF exercises consisted in D2F pattern and "hold-relax" technique for the upper arm and "repeated stretch technique" for the scapula. After treatment there were better significant differences in experimental group in night and activity pain (VAS), pain in Shoulder Pain and Disability Index (SPADI) and mobility in flexion and abduction, not in external and internal rotation.
Balci et al. (31) recruited and randomly allocated fifty-three patients in three groups: control group had a one hour standard treatment (TENS, ultrasound and heat packs), then a PNF group had in addition some PNF exercises consisting in scapular "hold-relax" technique, while a classic exercise group had in addition supervised stretching and strengthening exercises. They evaluated results after just one session and no follow up was available. Results showed immediate improvement in function (SST) and ROM in both experimental groups, improvement in pain (VAS) in PNF group and control group; no group showed good results in scapula-humeral kinematic (LSST) (**table 1**).

TRIAL QUALITY

The Cochrane collaboration's tool for assessing risk of bias was used to assess risk of bias of each study (**figure 2**). Except two studies, all articles received high risk in blinding and personnel (performance bias) due to the nature of treatment; some articles was assigned high risk in selection bias due to not right allocation concealment, and high risk or unclear risk in blinding outcome assessment (detection bias) because a missing of adequate description of blinding assessment. We also used Jadad scale to assess the quality of included studies. Five articles had a Jadad score of two points (8,23,27,30,31), five had three points (9,22,24,28,29) and two had five points (25,26). The main problems of the articles who received a low score according to Jadad scale were the impossibility of a double blind study due to nature of treatment, inadequate description of dropout and withdraws and inadequate randomization method. The quality assessments were initially completed by a single reviewer and then checked for accuracy by one other reviewer.

META-ANALYSIS OF PRIMARY OUTCOMES

Data from VAS, DASH score, SPADI, Constant Score and ROM were included in the meta-analysis.
Effectiveness of physiotherapy in pain assessed by VAS (**figure 6**). Pain was assessed by Visual Analogue Scale (VAS) with a 0-10 scale at rest or post-treatment significant results were found in experimental groups (0-6 weeks: MD -0.36 (-0.54, -0.18) p < 0,0001, 6-12 weeks: MD -0.75 (-1.04, -0.46) p < 0,0001, 12-26 weeks: MD -1.63 (-2.08, -1.19) p < 0,00001, 26-52 weeks: MD -2.03 (-2.6, -1.46), p < 0,0001). Statistical heterogeneity was found at 0-6 weeks follow-up (I^2 = 84%) but no in other follow-up (I^2 = 0%).

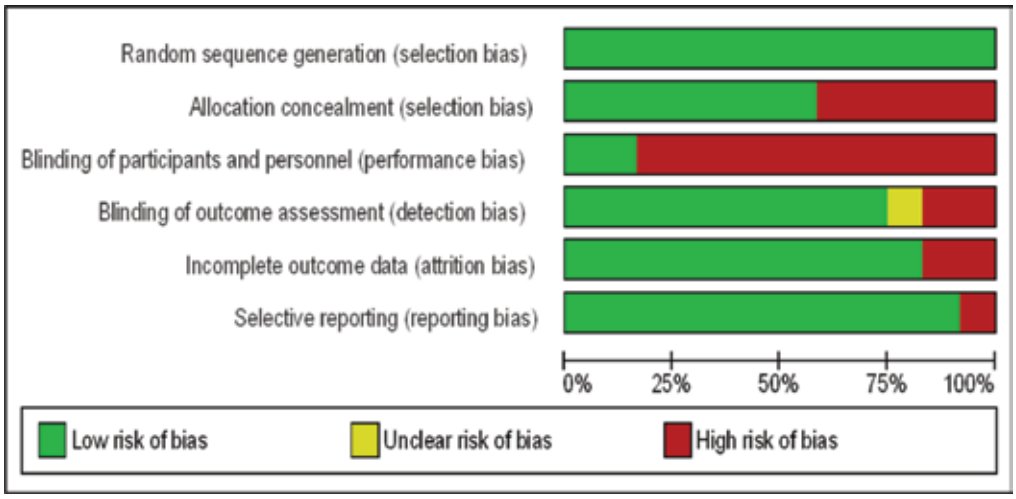

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

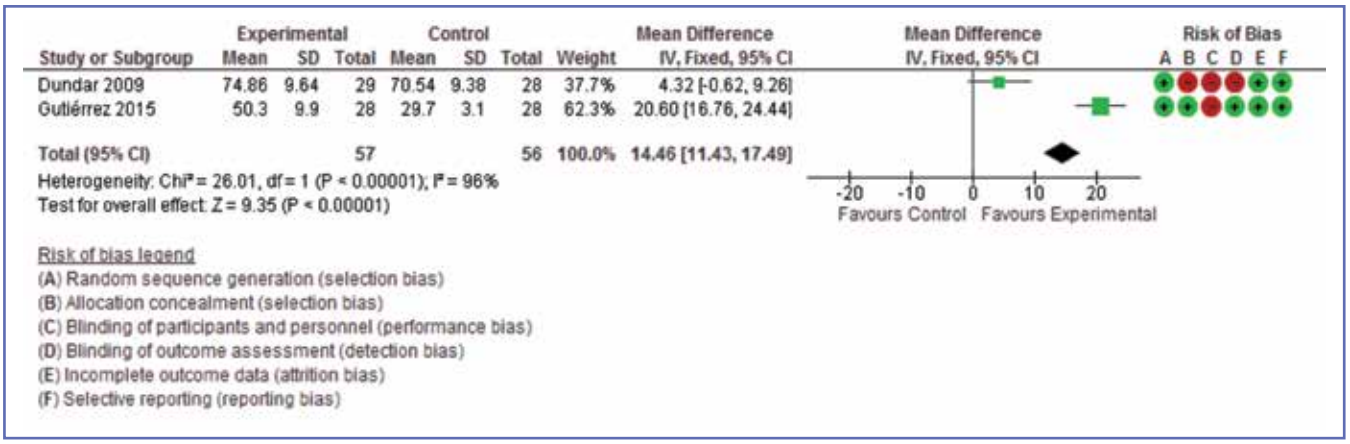

Figure 3. Forest plot. Outcome: Vas at rest/ post treatment.

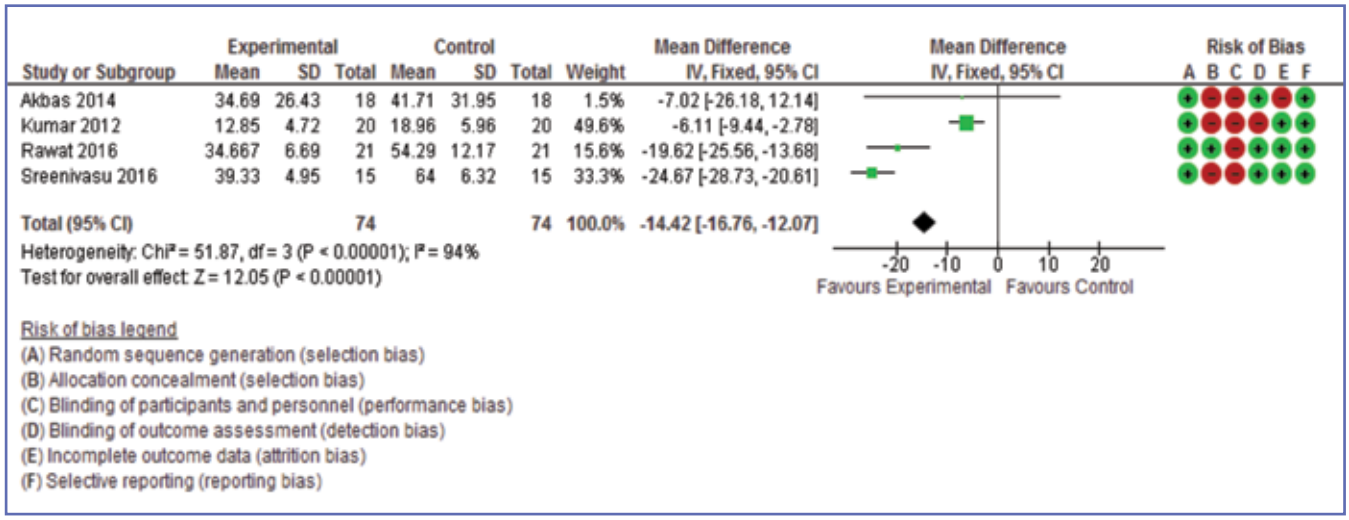

Figura 4. Forest plot. Outcome: Spadi.

Table 1. Data Extraction.

Authors	Partecipant details	Interventions (EG)	Rates of treatments	Control group (CG)	Outcome measurement toools	Follow-up	Conclusions	Jadad score
Çelik, 2016 [22]	n = 28; EG = 12 ; CG = 14 M = 8 ; F = 18 Mean age: EG = 54.2 ; CG = 54.8 M = 3 ; F = 9 MDoS (weeks): EG = 16 ± 2.2 ; CG =15.4 ± 2.0	❖ Maitland's mobilization tecniques ❖ Therapeutic Exercise (ET) ❖ Home Exercises (HE)	18 sessions (3x6 weeks)	❖ Therapeutic Exercise (ET) ❖ Home Exercises (HE)	VAS, ROM (flex., abd., e.r., i.r.), DASH, Constant Score	6/52 weeks	Joint mobilization combined with stretching exercises is better than stretching alone in improving external rotation, abduction, and function till 1 year follow-up.	3
Dundar, 2009 [23]	n = 57; EG = 29 ; CG= n = 28 M = 18 ; F = 39 Mean age: EG= 56.3 ± 7.8; CG= 57.1 ± 8.3 MDoS (months): EG = 6.3 ± 4.2 CG=5.9 ± 4.0	❖ CPM ❖ Home Exercises (HE)	20 sessions (5x4 weeks)	❖ Therapeutic Exercise (ET) ❖ Home Exercises (HE)	VAS, ROM (flex., abd., e.r., i.r.), Constant Score, SPADI	4/12 weeks	CPM provides better results in control of pain than conventional therapy at 4 and 12 weeks. No differences in function and ROM.	2
Gutiérrez, 2015 [24]	n = 57; EG = 29; CG = 28 M = 11 ; F = 46 Mean age: EG = 52.8 ± 4.7 ; CG = 53.3 ± 4.4 MDoS (months): EG = 4.9 ± 0.8; CG = - Gruppo controllo: = 5.2 ± 0.8	❖ End-Range Posterior Mobilization (ERPM) ❖ 15' cycle ergometer	10 sessions (2/3x5/6 weeks)	❖ Conventional treatment (CT) ❖ ET, US	ROM (e.r., flex., abd.), VAS, Constant Score	6 weeks	Glenohumeral posterior mobilization technique applied after training with cycle ergometer is an effective short-term technique to decrease pain and improving joint function (particularly external rotation).	3
Hussein, 2015 [26]	n = 60; EG=30; CG=30 M = 31 ; F = 29 Mean age: EG = 51.9; CG = 51.2 MDoS = NS	❖ Static Progressive Stretch (SPS) ❖ Conventional treatment (CT) ❖ HP, MT	12 sessions (3x4 weeks)	❖ Conventional treatment (CT) ❖ HP, MT	VAS, ROM (act. abd., pass. abd, e.r.), DASH.	4/12/24/52/ 104 weeks	Static progressive stretch device may be add to traditional therapy in improving pain, function and ROM till two year follow-up.	5
Kumar, 2012 [27]	n = 40; EG=20 ; CG=20 M = 26 ; F = 14 Mean age: EG = 47.9; CG = 47.1 MDoS = NS	❖ Maitland's mobilization tecniques ❖ Therapeutic Exercise (ET)	12 sessions (3 x4 weeks)	❖ Therapeutic Exercise (ET)	VAS, ROM (abd., e.r.), SPADI	4 weeks	Maitland mobilization technique combined with therapeutic exercise appeared more effective than therapeutic exercise alone in relieving pain and improving R.O.M. and function in short period.	2
Ibrahim, 2014 [25]	n = 60; EG=30; CG=30 M = 31 ; F = 29 Mean age: EG = 51.9; CG = 51.2 MDoS = NS	❖ Static Progressive Stretch (SPS) ❖ Conventional treatment (CT) ❖ HP, MT	12 sessions (3x4 weeks)	❖ Conventional treatment (CT) ❖ HP, MT	VAS, ROM (act. abd., pass. abd, e.r.), DASH.	4/12/24/52/ 104 weeks	Static progressive stretch device combined with conventionl therapy have beneficial long-term effects on ROM, pain and function . At 12-month follow-up, EG had continued to improve, while the control group had relapsed.	5
Russel, 2014 [9]	n = 75; EG1=25; EG2=25; CG=25 Mean age = 51.1 M – F ratio = 1:1,14 MdoS = 5.79 (months)	EG1 ❖ Therapeutic Exercise Group (ETG) ❖ Home Exercises (HE) EG2 ❖ Individual Multimodal Physiotherapy ❖ Home Exercises (HE)	12 sessiond (2x6 weeks)	❖ Home Exercises (HE)	ROM (flex., e.r.), Constant Score, OSS, SF-36, HADS	6/26/52 weeks	A group exercise class provides superior outcomes in relieving the signs and symptoms of frozen shoulder; multimodal physiotherapy is a good alternative and significantly better than unsupervised exercise at home.	3

Authors	Partecipant details	Interventions (EG)	Rates of treatments	Control group (CG)	Outcome measurement toools	Follow-up	Conclusions	Jadad score
Balci, 2016 [31]	n = 53; EG1=18 ; SG2 = 18; CG = 17 M = 13 ; F = 40 Mean age: EG1=56.7±7.7; EG2=58.1±8.4 CG=58.6±11.3 MDoS= NS	EG1 ❖ Scapular PNF ex. ❖ Conventional Treatment (CT)* EG2 ❖ Therapeutic Exercise (ET) ❖ Conventional treatment (CT)	1 session	❖ Conventional treatment (CT)* * CT = HP, TENS, US,	VAS, ROM (att. flex, att. abd.), SST, LSST	Post intervention	All groups showed immediate improvements in motions and function. Pain was reduced in EG1 and CG groups. No significant differences among groups were found.	2
Yang, 2012 [28]	n = 32; EG= 10; CG1 = 12; CG2 = 10 M = 10 ; F = 22 Mean age: EG = 56.8 ± 7.2; CG1= = 54.9 ± 10.3; CG2= 54.3 ±7.6 MDoS (weeks): EG= 19.6 ±12.8; CG1 = 22.4 ± 9.2; CG2 = 15.8 ± 10.7	❖ End-Range Mobilization + Scapular Mobilization ❖ Conventional Treatment (CT)**	16 sessions (2x8 weeks)	CG1: ❖ Conventional treatment (CT)** CG2: ❖ Conventional treatment (CT)** ** CT = MT, ET, US, diathermy, TENS	ROM (Abd., e.r, i.r.), FLEX-SF, "hand-behind-back" assessment, articular shoulder kinematic.	4/8 weeks	A subgroup of subjects identified from a clinical prediction who received ERM + scapular mobilization had significantly greater improvements than a criteria-control subgroup	3
Sreenivasu, 2016 [8]	n = 30; EG=15; CG=15 M = 16 ; F = 14 Mean age: EG = 52.4 ± *5.9; CG*=50.6 ± 5.7 MDoS: NS	❖ End-Range Mobilization ❖ Scapular Mobilization	16 sessions (4x4 settimane)	❖ End-Range Mobilization	- ROM (flex., est., abd., e.r., i.,r,), SPADI	4 weeks	A subgroup of patients identified from a clinical prediction who had scapular mobilization + ERM have significantly greater improvements than patients who received ERM alone.	2
Rawat, 2017 [29]	n = 42 ; EG=21; CG=21 M = 24 ; F = 18 Mean age: EG: 56.00 ± 10.42; CG=54.19 ± 8.33 MDoS (weeks): EG=5.52 ± 3.7; CG = 3.83 ± 2.2	❖ Rotator Cuff Strenghtening (RCS) ❖ Conventional Treatment (CT) ❖ GHM and SM, TENS	12 sessions (3 x4 settimane)	❖ Conventional Treatment (CT) ❖ GHM and SM, TENS	ROM (flex., Abd., e.r., i.r.), VAS, SPADI, PSFS, muscle strenght	4 weeks	Statistically significant changes in pain, function, and ROM in the group that received strengthening of rotator cuff muscles in addition to TENS and mobilization were found.	3
Akbas, 2015 [30]	n = 36; EG=18; CG=18 M = 20 ; F = 16 Mean age: EG = 53.94 ± 9.38 CG =54.81 ± 11.96 MDoS = NS	❖ PNF scapular ex. ❖ Conventional Treatment (CT) ❖ HP, US, ET	15 sessions (5x3 weeks)	❖ Conventional Treatment (CT) ❖ HP, US, ET	VAS, ROM (abd., e.r., i.r.), SPADI, postural assessment.	3 weeks	PNF exercises appears to have significant contribution to night pain and ROM in flexion and abduction in patients with frozen shoulder.	2

EG = Experimental Group; CG = Control Group; HE = Home Exercises; ET = Therapeutic Exercise; CT= Conservative Treatment;
SPS = Static Progressive Stretch; PM = Posterior mobilization; ERM = End Range Mobilization; MT = Manual Therapy; GHM = Glenohumeral mobilization; SM = Scapular Mobilization; MRM = Mid Range Mobilization; US = Ultrasounds; TENS = Transcutaneous Elecric Nerve Stimulation; RCS = Rotator Cuff Strenghtenening; PSFS = Patient-Specific Functional Scale; OSS = Oxford Shoulder Score; SF-36 = Short Form 36; HADS = Hospital Anxiety and Disability Scale; SST = Simple Shoulder Tests; LSST = Lateral Scapular Slide Test; DASH = Disabilities of the Arm, Shoulder and Hand score; VAS = Visual Analogue Scale; PNF = Proprioceptive Neuromuscular Facilitation; HP = Heat Packs; SPADI = Shoulder Pain and Disabilty Index; ROM = Range of Motion; MDoS: Mean duration of Symptoms

EFFECTIVENESS OF PHYSIOTHERAPY IN ROM

(**Figures 7,8,9,10**) Rom was assessed with a goniometry. Positive findings favour to experimental interventions have been found in ROM in passive abduction with a decrease at 6 and 52 weeks (0-6 weeks: MD 22.53 (19.93, 25.12); p < 0,00001; 6-12 weeks: MD 21.79 (17.44, 26,15), p < 0,00001; 12-26 weeks: MD 46.43 (41.32, 51.53), p < 0,00001; 26-52 weeks: MD 44.95 (39.84, 50,06), p < 0,00001) and in ROM in active abduction till 52 weeks (0-6 weeks: MD 17.50 (14.07, 20.92), p < 0,00001; 6-12 weeks: MD 73.87 (69.30, 78,43), p < 0,00001; 12-26 weeks: MD 94.00 (90.91, 97.09), p < 0,00001; 26-52 weeks: MD 94.17 (91.59, 96.74), p < 0,00001). Moderate statistical heterogeneity was found in passive abduction in 0-6 weeks (I^2 = 42%), high in 6-12 weeks (I^2 = 94%), in active abduction in 0-6 follow-up (I^2 = 94%) and no heterogeneity in long term follows-up (I^2 = 0%) both passive and active abduction. Considering ROM in passive flexion and internal rotation only short term comparison was available: the same trend favour to experimental groups was confirmed (passive flexion 0-6 weeks: MD 14.15 (10.15, 18.15), p < 0,00001; internal rotation 0-6 weeks: MD 18.22 (14.69, 21,75), p < 0,00001). High heterogeneity was found in flexion (I^2 = 91%) and internal rotation (I^2 = 86%).

Finally ROM in external rotation was considered: the intergroup analysis showed statistically significant results in experimental groups in every follow-up (0-6 weeks: MD 19.86 (18.07, 21.65) p < 0,00001; 6- weeks: MD 42.89 (40.86, 44.91), p < 0,00001; 12-26 weeks: MD 47.30 (44.58, 50.02), p < 0,00001; 26-52 weeks: MD 47.95 (45.07, 50.83), p < 0,00001). High statistical heterogeneity was found in 0-6 weeks follow-up (I^2 = 87%) and 6-12 weeks (I^2 = 98%).

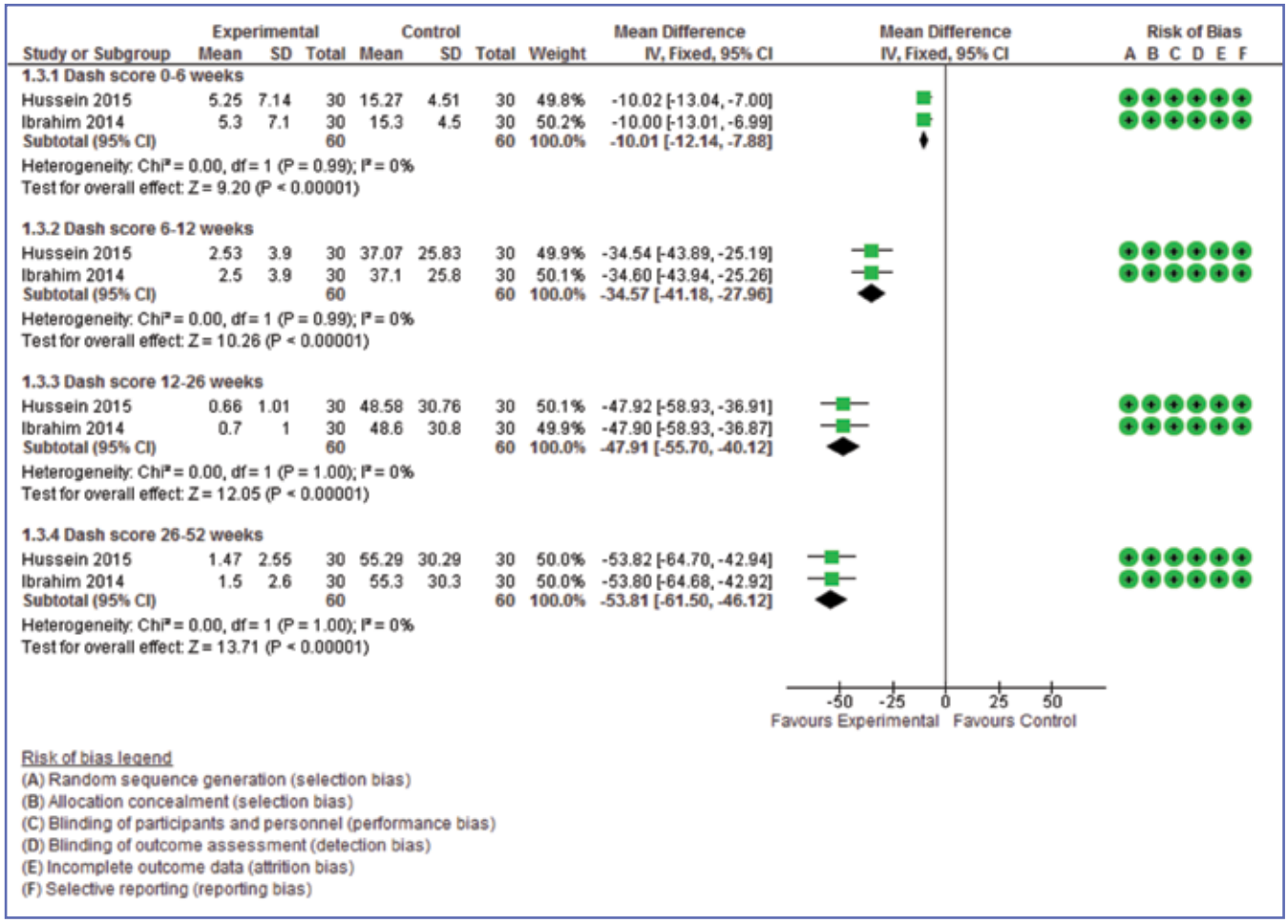

Figure 5. Forest plot. Outcome: ROM in passive abduction.

EFFECTIVENESS OF PHYSIOTHERAPY IN DASH SCORE

Statistically significant results were found in experimental group in intergroup analysis in every follow-up (0-6 weeks: MD -10.01 (-12.14, -7.88), p < 0,00001; 6-12 weeks: MD -34.57 (-41.18, -27.96); p < 0,00001, 12-26 weeks: MD -47.91 (55.70, 40.12); p < 0,00001, 26-52 weeks: MD -53.81 (-61.50, -46.12), p < 0,00001). No heterogeneity was found (I^2 = 0%).

EFFECTIVENESS OF PHYSIOTHERAPY IN SPADI

SPADI meta-analysis was available only in short term follow-up (0-6 weeks) and favour to experimental groups: MD -14,42 (-16.76, -12,07), p < 0,0001). High heterogeneity was found (I^2 = 94%).

EFFECTIVENESS OF PHYSIOTHERAPY IN CONSTANT SCORE

Constant score meta-analysis was available only in short term follow-up (0-6 weeks) and favour to experimental groups: MD 14.46 (11.43, 17.49), p < 0,00001. High heterogeneity was found (I^2 = 96%).

DISCUSSION

The frozen shoulder has been the focus of much interest in the recent scientific literature (32-39). According to this review physiotherapy seems to be recommended in individuals with primary frozen shoulder. Therapeutic exercise has demonstrated to be an effective option in all outcomes reported, from mobility to function and pain (9,22-24,27,29,30).

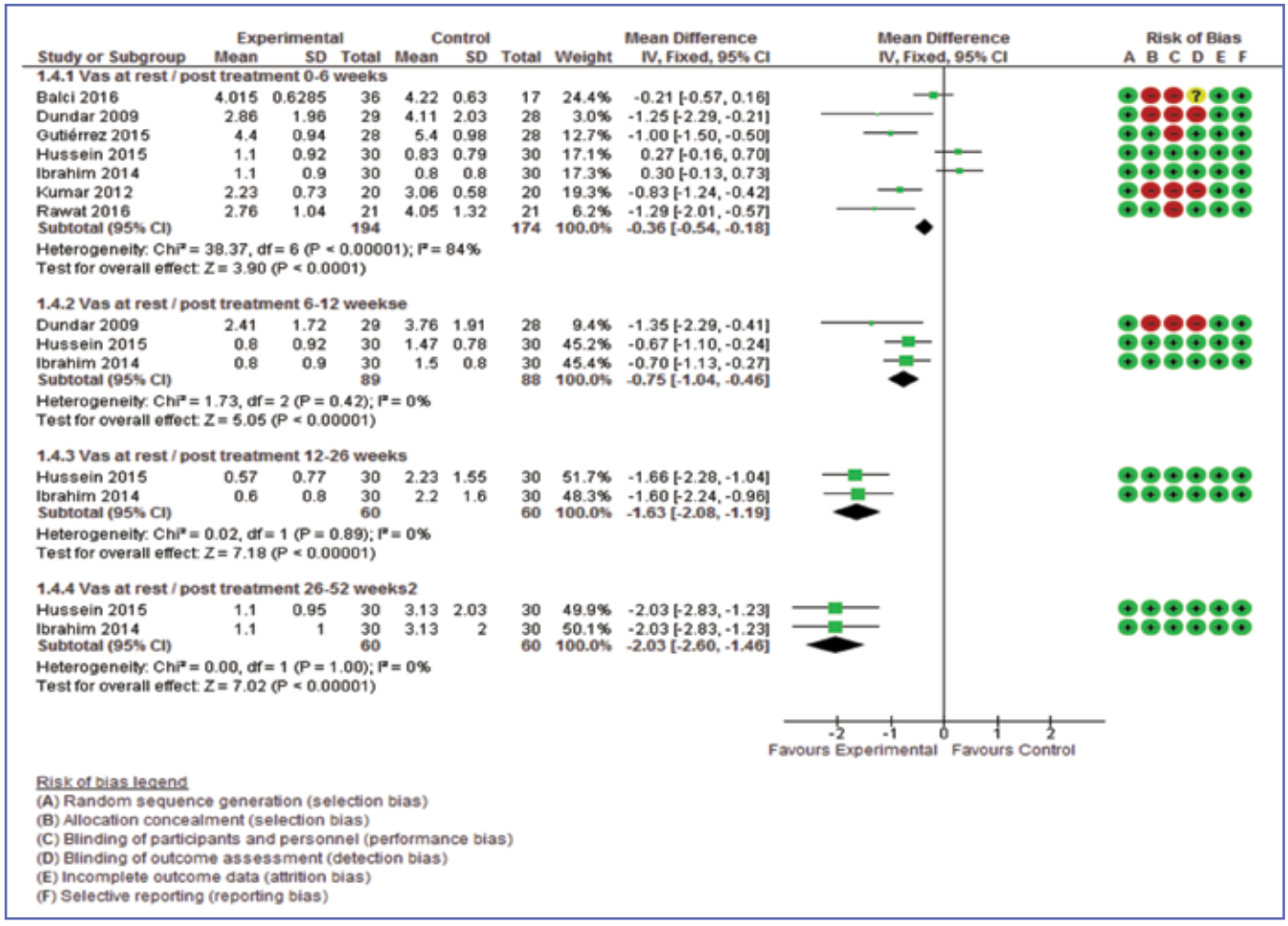

Figure 6. Forest plot. Outcome: ROM in active abduction.

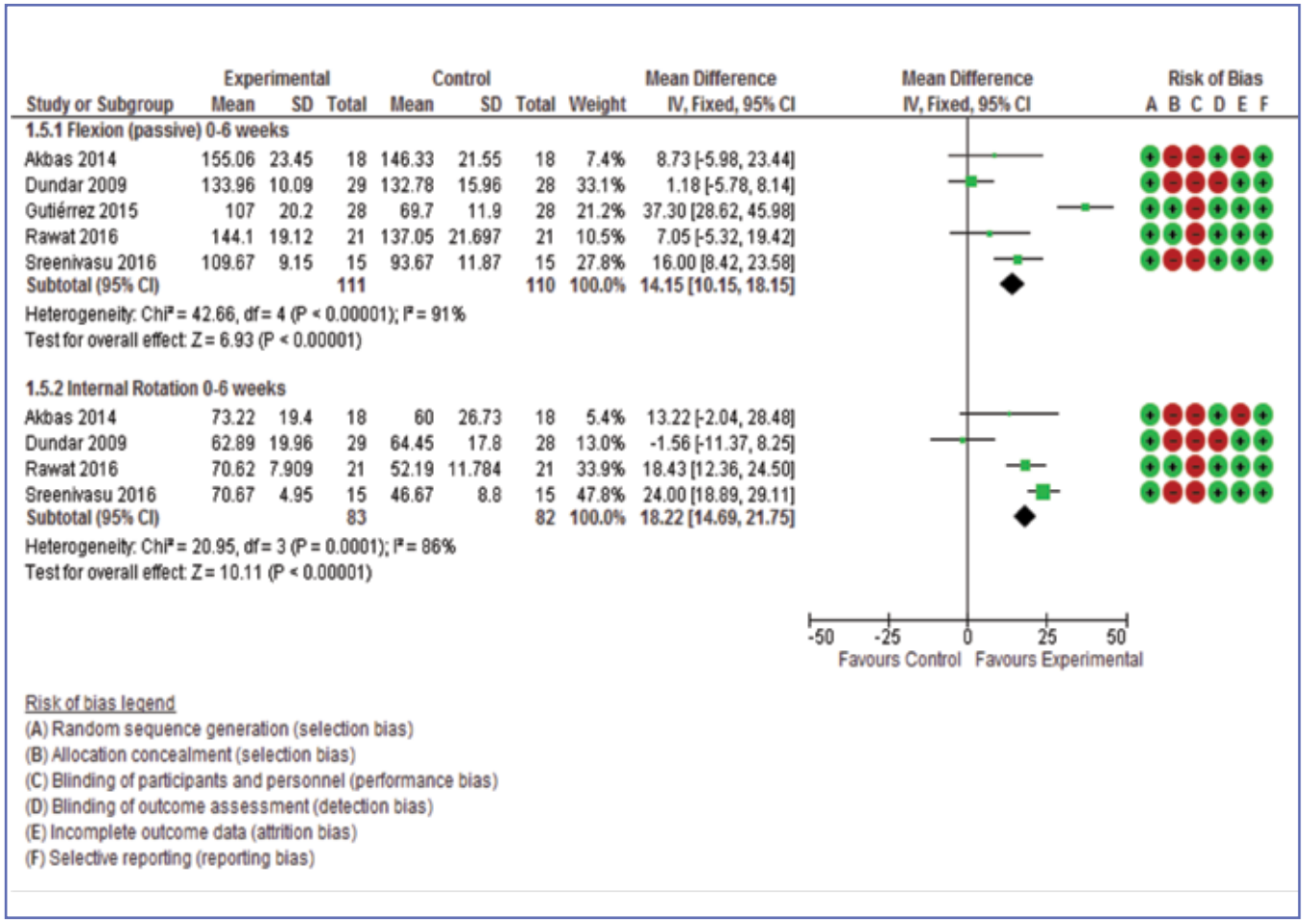

Figure 7. Forest plot. Outcome: ROM in external rotation.

A lot of articles focused on manual therapy techniques: an end-range mobilization technique at high grade (III or IV) seems to be effective in improving ROM particularly external rotation (8,22,24,27,28). This is in accordance with other studies (15,40-42). It may be the reason that a end-range mobilization at high grade is oriented not only to restore the right joint function but also to stretch all soft contracted periarticular structures (24,41).

According to Gutiérrez et al. (24), Johnson (15) evaluated some techniques with different glides, finding significant differences favour to mobilizations with posterior glide in restoring external rotation and function. Also Srikanth et al. (43) compared the same mobilization technique in different glide: significant differences were found in posterior glide group in improving external rotation. Posterior glide of movement seems to be effective in stretching the anterior structures of glenohumeral articulation (21,43), which normally are tightened and responsible for movement restriction specially in external rotation (21,44).

Considering pain as outcome, Dundar *et al.* (23) showed that continuous passive motion (CPM) seems to bring benefits in short period compared to a classic conservative treatment; these results are in accordance with Chung *et. al.* (20) who found similar results in a 24 weeks follow-up. Ekim *et. al.* (45) also investigated CPM effectiveness in secondary frozen shoulder and found statistically significant improvements. It may be that continuous stretching of the shoulder in all directions provided by a CPM machine may lead to decrease sensitivity of second-order neurons in the dorsal horn. Eventually these changes may result in decreased sensitivity to painful stimuli or hypoalgesia (23). Further studies with long term follow-up are needed. Moreover a part of the literature focus its attention in scapulohumeral rhythm: it seems to be that shoulder dyskinesia is cause/consequence of an altered

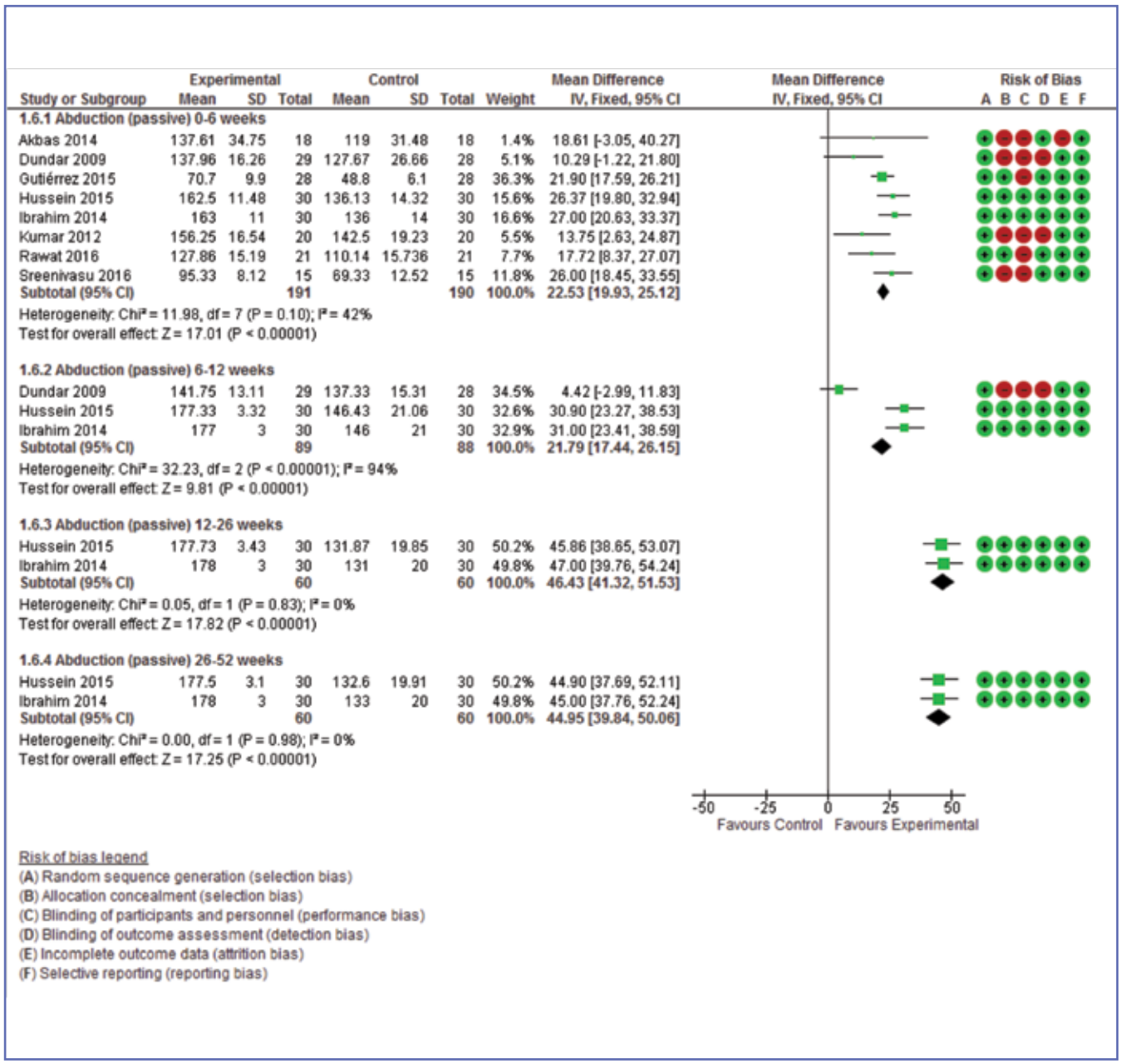

Figure 8. Forest plot. Outcome: ROM in passive abduction.

scapular mobility and rhythm, particularly some movements as posterior tipping and protraction (8,28,46), which could lead to wrong compensative patterns (47).

Two studies in this review (8,28) with sample size limits found positive effects in short period in function and disability adding specific scapular mobilizations to gleno-humeral mobilizations.

It is to be considered that two articles (25,26) included in this meta-analysis were prosecution with each other, so they had the same patients and the same data; although their inclusion is methodologically correct, we can't expect these results fully believable.

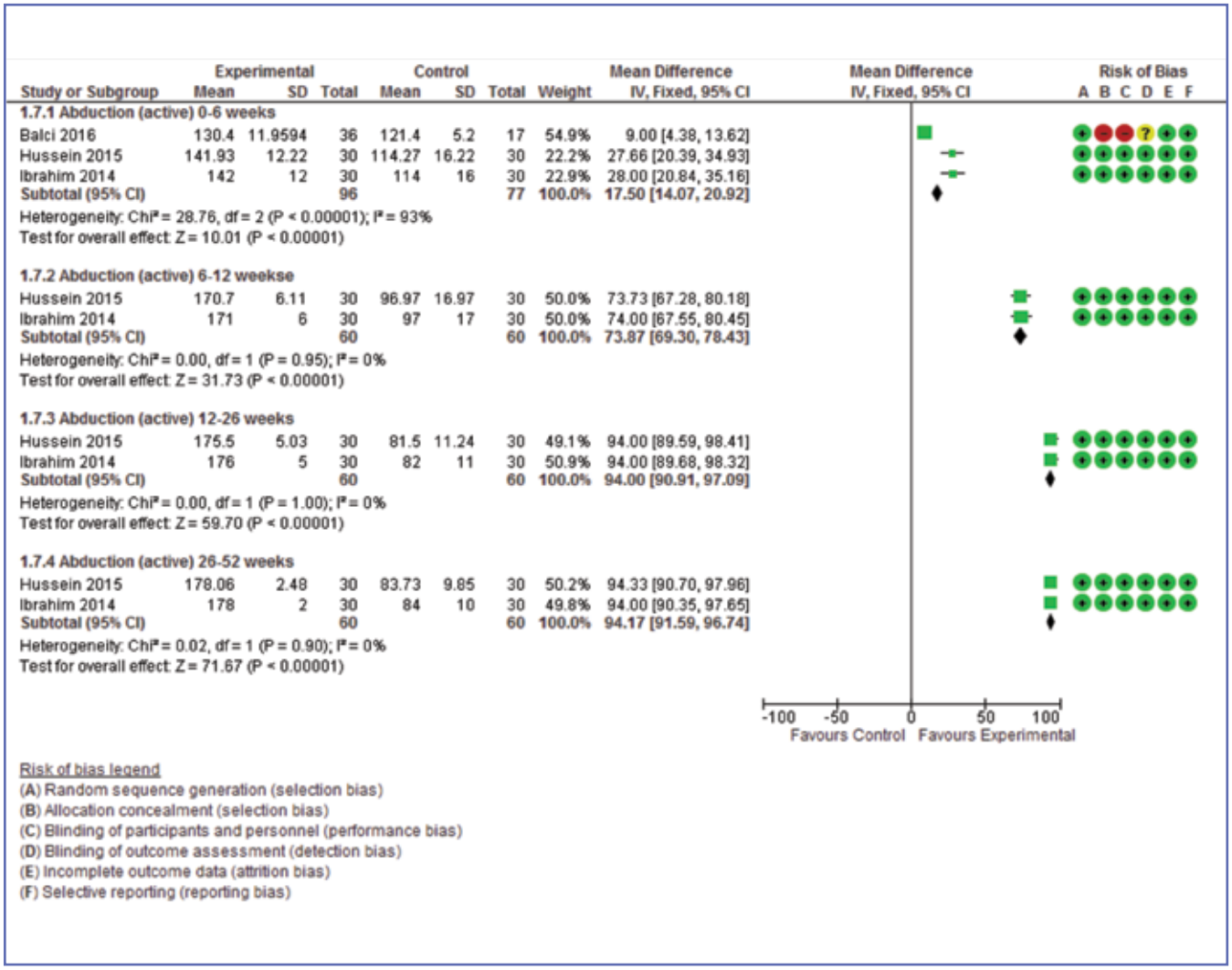

Figura 9. Forest plot. Outcome: ROM in active abduction.

STUDY LIMITS

This study has several limitations. First, the number of samples was limited for the generalization of the results and the number of studies found was not enough to give a proper picture of the treatments. A limit of some studies of this review was the inclusion of patients in different stages of the disease; sometimes the stage disease was not reported (8,22,24,25,27).

However, many studies reported a mean duration of symptoms associated to frozen shoulder or some specific restriction criteria. After all frozen shoulder is a condition characterized by some different stages with specific characteristics that may influence the right treatment approach.

Another limit of some articles (8,24,27-31) was the absence of follow-up, so it was not possible to assess long period effectiveness.

Due to the physiotherapy intervention in many studies, double-blinding was not possible; only two studies (25,26) had maximum score according to Jadad scale. Anyway, all studies were conducted by physiotherapists, sometimes specific competences in specific techniques were required (8,22,24,27,28).

CONCLUSIONS

This study was conducted in collaboration with Tor Vergata University of Rome, UniCamillus University of Rome and

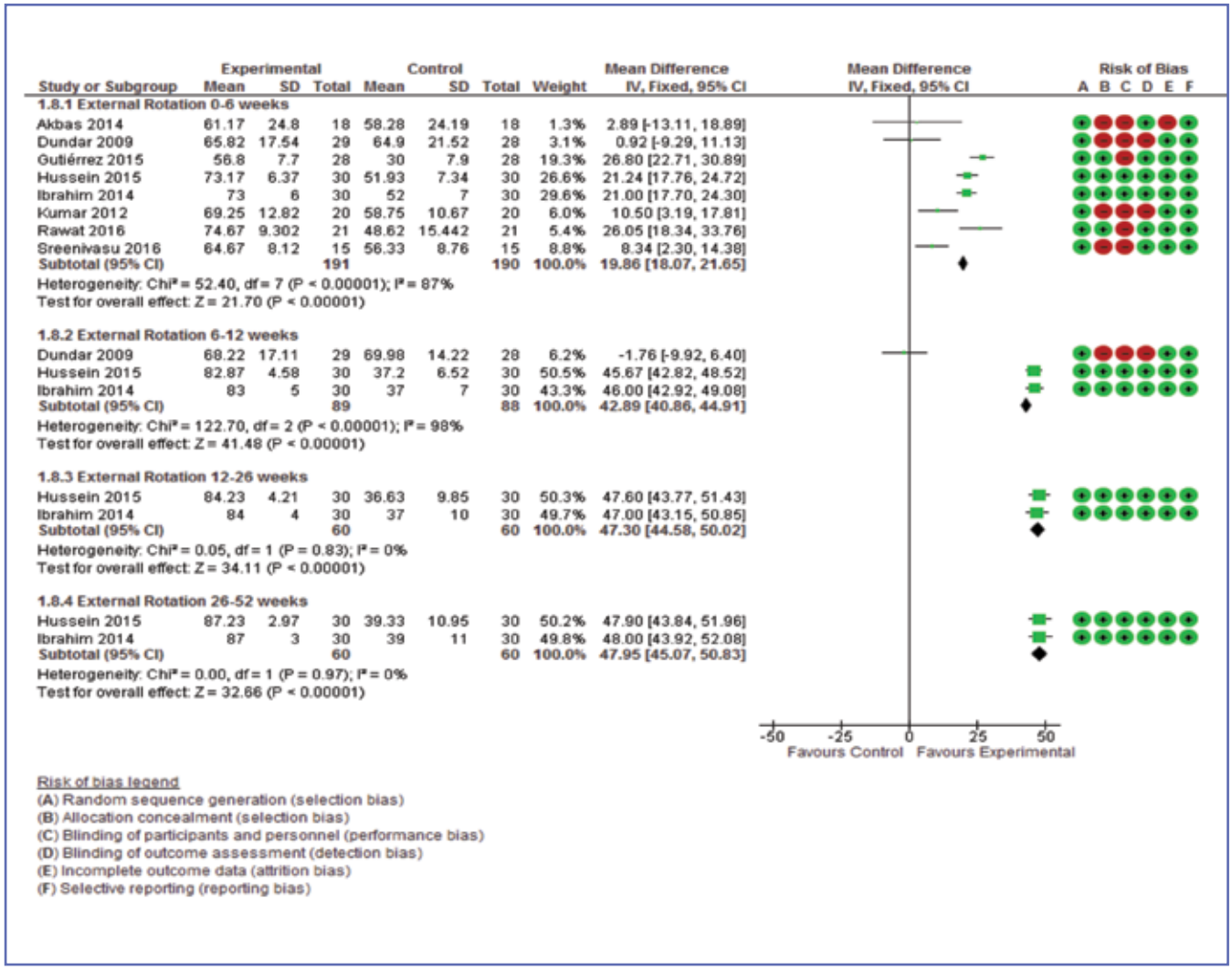

Figure 10. Forest plot. Outcome: ROM in external rotation.

Rehabilitation & Outcome Measures Assessment (ROMA) association. The institutes composed the Institutional Review Board and have guaranteed ethical standard and procedures. In the last years, the research group has dealt different validation studies in Italy (48-54).

Rehabilitative treatment has to be considered in individuals affected by frozen shoulder. Physiotherapy demonstrates effectiveness in sub-acute phases of the disease where the primary targets are to avoid and reduce mobility and movement restrictions (stages II-III); according to great part of literature, early phase of the disease is characterized by pain, so other therapeutic options are preferable (eg: NSAID, corticosteroid injections).

Mobilization techniques at the end-range of motion in addition to therapeutic exercise seems to be recommended for function, pain and ROM, particularly external rotation by posterior glenohumeral mobilization. Further studies are needed to investigate effectiveness of continuous passive motion, that may be considered an auxillary tool in decreasing pain in short term, and specific scapular mobilization (55).

CONFLICT OF INTERESTS

The authors declare they have no conflict of interests.

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