The Ergonomics of Vascular Surgery

Joseph A Davis, MD, FACS, RPVI

Pacific Northwest Endovascular Conference

Seattle, WA

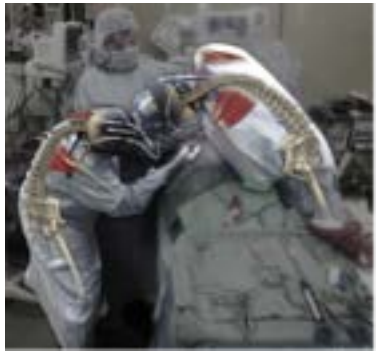
June 15, 2018

DISCLOSURE

Joseph Davis, MD

- **No relevant financial relationship reported**

PACIFIC NORTHWEST
ENDOVASCULAR
CONFERENCE



The Impact of Being a Vascular Surgeon

On You

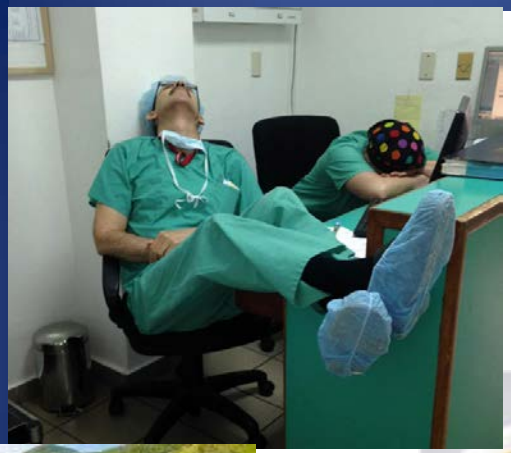
Joseph A Davis, MD, FACS, RPVI

Rocky Mountain Vascular Society

Midway, UT July 2017

What are the issues?

- Ergonomics of surgery
- Chronic effects of sleep deprivation
- Long term radiation exposure
- Diet and exercise



RMVS

A full review of the vascular surgery literature on surgical ergonomics, cervical issues and debility

PACIFIC NORTHWEST
ENDOVASCULAR
CONFERENCE

PACIFIC NORTHWEST ENDOVASCULAR CONFERENCE

An ergonomic assessment of operating table and surgical stool heights for seated otolaryngology procedures

Anam F. Azimuddin, B.S.,[1] Erik K. Weitzel, M.D.,[2] Kevin C. McMains, M.D.,[2] and Philip G. Chen, M.D.[1]

JAMA Surgery | Original Investigation

Prevalence of Work-Related Musculoskeletal Disorders Among Surgeons and Interventionalists

A Systematic Review and Meta-analysis

Surg Endosc (2017) 31:2457–2466
DOI 10.1007/s00464-016-5247-5

N. Tran, MD; Qing Z. Ruan, MD; Jack T. Dennerlein, PhD;

Ergonomics in the operating room

Shiromani Janki[1] · Evalyn E. A. P. Mulder[1] · Jan N. M. IJzermans[1] · T. C. Khe Tran[1]

The Need for Ergonomics Education in Dermatology and Dermatologic Surgery

Sit Up Straight, Stand Up Tall, and Carry a Sharp Scalpel

The Current State of Surgical Ergonomics Education in U.S. Surgical Training

A Survey Study

Work-Related Musculoskeletal Injuries in Plastic Surgeons in the United States, Canada, and Norway

Ergonomics in the Development and Prevention of Musculoskeletal Injury in Interventional Radiologists

Jamaal L. Benjamin, MD, PhD,* and Quinn C. Meisinger

PACIFIC NORTHWEST ENDOVASCULAR CONFERENCE

Ergonomics in Surgery: A Review

MD,*† Jasmine Tan-Kim, MD, MAS,†
MD, MAS,‡ and Shawn Menefee, MD†

Ergonomic risk and preventive measures of musculoskeletal disorders in the dentistry environment: an umbrella

Work-related musculoskeletal symptoms amongst Otolaryngologists and Head and Neck surgeons in Canada

Josiane Bolduc-Bégin[1] · François Prince[2] · Apostolos Christopoulos[3] · Tareck Ayad[3]

Surgeon symptoms, strain, and selections: Systematic r
analysis of surgical ergonomics

Chee-Chee H. Stucky[a,*], Kate D. Cromwell[a], Rachel K. Voss[a,1], Yi-Ju C
Jeffrey E. Lee[a], Janice N. Cormier[a]

A study of the prevalence of musculoskeletal disorders in surgeons performing minimally invasive surgery

Work-related physical, psychosocial and individual factors associated with musculoskeletal symptoms among surgeons: Implications for

Sitting versus standing makes a difference in musculoskeletal discomfort and postural load for surgeons performing vaginal surgery

d [b],

Ruchira Singh[1] · Ladin A. Yurteri-Kaplan[2] · Melissa M. Morrow[3,4] · Amy L. Weaver[3] · Michaela E. McGree[3] · Xinhui Zhu[5] · Victor L. Paquet[6] · John B. Gebhart[7] · Susan Hallbeck[3,4]

Definition

PACIFIC NORTHWEST ENDOVASCULAR CONFERENCE

TABLE 1. Common WMSDs and Their Etiologies (Adapted From Kroemer, 1989[34])

Syndrome	Etiology
Carpal tunnel syndrome	Repetitive activities involving wrist flexion/extension, rapid wrist rotation, radial/ulnar deviation, and pinching
Epicondylitis	Repetitive activities involving wrist pronation with extension
Neck tension syndrome	Prolonged static posture of the head and neck, as with typing and computer work
Pronator teres syndrome	Forceful wrist flexion or pronation
Shoulder tendonitis and rotator cuff injury	Shoulder abduction and continuous elbow elevation
Wrist tendonitis	Forceful wrist extension/flexion or forceful ulnar deviation
Thoracic outlet syndrome	Repetitive shoulder flexion and arm hyperextension
Trigger finger	Repetitive finger flexion and particularly flexion of the distal phalanx alone
Ulnar nerve entrapment	Prolonged flexion/extension of the wrist and pressure on the hypothenar eminence

WMSD indicates work-related musculoskeletal disorder.

Do No Harm, Except to Ourselves? A Survey of Symptoms and Injuries in Oncologic Surgeons and Pilot Study of an Intraoperative Ergonomic Intervention

Disease Control as "musculoskeletal disorders (injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal discs) in which the work environment and performance of work contribute significantly to the condition; and/or the condition is made worse or persists longer due to work conditions."[33]

Prevalence

- Very high (20-90%)
- Equal or higher than industrial workers, nurses, physical therapists
- 12 month prevalence (meta-analysis)
  - Neck pain 60%
  - Shoulder pain 52%
  - Back pain 49%
  - Upper extremity pain 35%
- MIS surgeons tend to have more discomfort than open surgeons
  - Fatigue 83 vs 37%
  - Pain 69 vs 60%
  - Significantly more back, neck, shoulder and arm pain (roughly 50% vs 30%)
- Robotic surgeons tend to have less discomfort than open surgeons

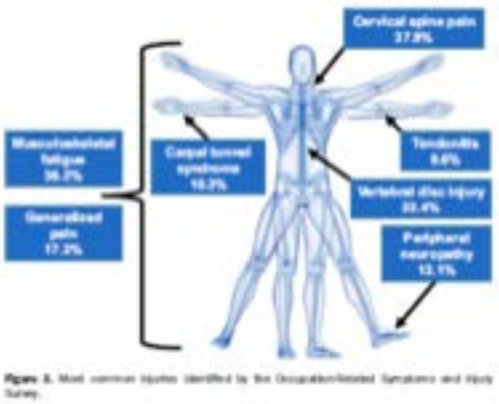


Table 1
Surgeon work-related symptoms reported on various published surveys.

First Author, Year of Publication	No. of Participants	Overall Pain N (%)	Neck Pain N (%)	Back Pain N (%)	Arm Pain N (%)	Hand Pain N (%)	Leg Pain N (%)	Eye Pain N (%)	Numbness N (%)	Stiffness N (%)	Fatigue N (%)	Pain Influences Type of Surgery N (%)	Surgery Exacer-bates Pain N (%)	Sought Treatment for Pain N (%)
Albayrak, 2007	7												2 (29)	
Bagrodia, 2009	106	46 (43)	23 (22)	23 (22)								27 (25)	39 (37)	
Berguer, 1999	149		77 (52)		82 (55)	70 (47)			51 (34)	92 (62)				
Berguer, 2004	726	145 (20)												
Cass, 2014	128	127 (99)	95 (74)	99 (77)	102 (80)	90 (70)	69 (54)	51 (40)	59 (46)	102 (80)	105 (82)			6 (5)
Cavanagh, 2012	100	62 (62)	37 (37)	35 (35)	35 (35)	12 (12)	2 (2)	35 (35)	17 (17)	30 (30)	37 (37)		62 (62)	35 (35)
Davis, 2013	140	62 (44)	14 (10)	27 (19)	10 (7)	35 (25)								24 (17)
Davis, 2014	260	104 (40)	49 (19)	96 (37)	23 (9)	57 (22)	18 (7)					91 (35)	172 (66)	127 (49)
Esposito, 2013	23	16 (70)		12 (52)	12 (52)							3 (13)	13 (57)	9 (37)
Forst, 2006	285					91 (32)						20 (7)	29 (10)	
Hemal, 2001	204		20 (10)	18 (9)	31 (15)	27 (13)	14 (7)	37 (18)	27 (13)	20 (10)				
Indramohan, 2012	50		13 (26)											
Kaya, 2008	40		29 (73)	23 (58)			15 (38)	10 (25)						
Liang, 2013	241		140 (58)	128 (53)	81 (34)	73 (30)	52 (22)							
Miller, 2012	61	61 (100)	56 (92)	53 (87)	35 (57)	22 (36)	23 (38)						61 (100)	
Park, 2010	317	273 (86)										95 (30)	184 (58)	266 (84)
Plerhoples, 2012	1215	838 (69)	510 (42)	486 (40)	231 (19)	170 (14)	85 (7)	158 (13)				365 (30)	838 (69)	207 (17)
Santos-Carreras, 2012	49	42 (86)	19 (39)	18 (37)	13 (27)	12 (25)								
Soueid, 2010	77	62 (81)	30 (39)	36 (47)		24 (31)						33 (43)	64 (83)	22 (29)
Sutton, 2014	314											201 (64)		15 (5)
Szeto, 2009	135	108 (80)	112 (83)	92 (68)	78 (58)							11 (8)	92 (68)	27 (20)
Szeto, 2010	25	21 (84)	5 (20)											
Wauben, 2006	284		222 (78)	219 (77)	219 (77)						250 (88)		219 (77)	
Welcker, 2012	216		177 (82)	180 (83)	165 (76)				157 (73)		167 (77)			
Total (n = 24)	5152	3362	3480	3279	3205	2909	2249	1687	797	581	728	2732	2870	2709
Pooled report		1967 (68.55)	1628 (47.71)	1545 (49.90)	1117 (42.85)	683 (29.71)	278 (221.38)	291 (26.01)	311 (36.70)	244 (45.29)	559 (71.36)	846 (29.22)	1775 (60.92)	738 (29.83)

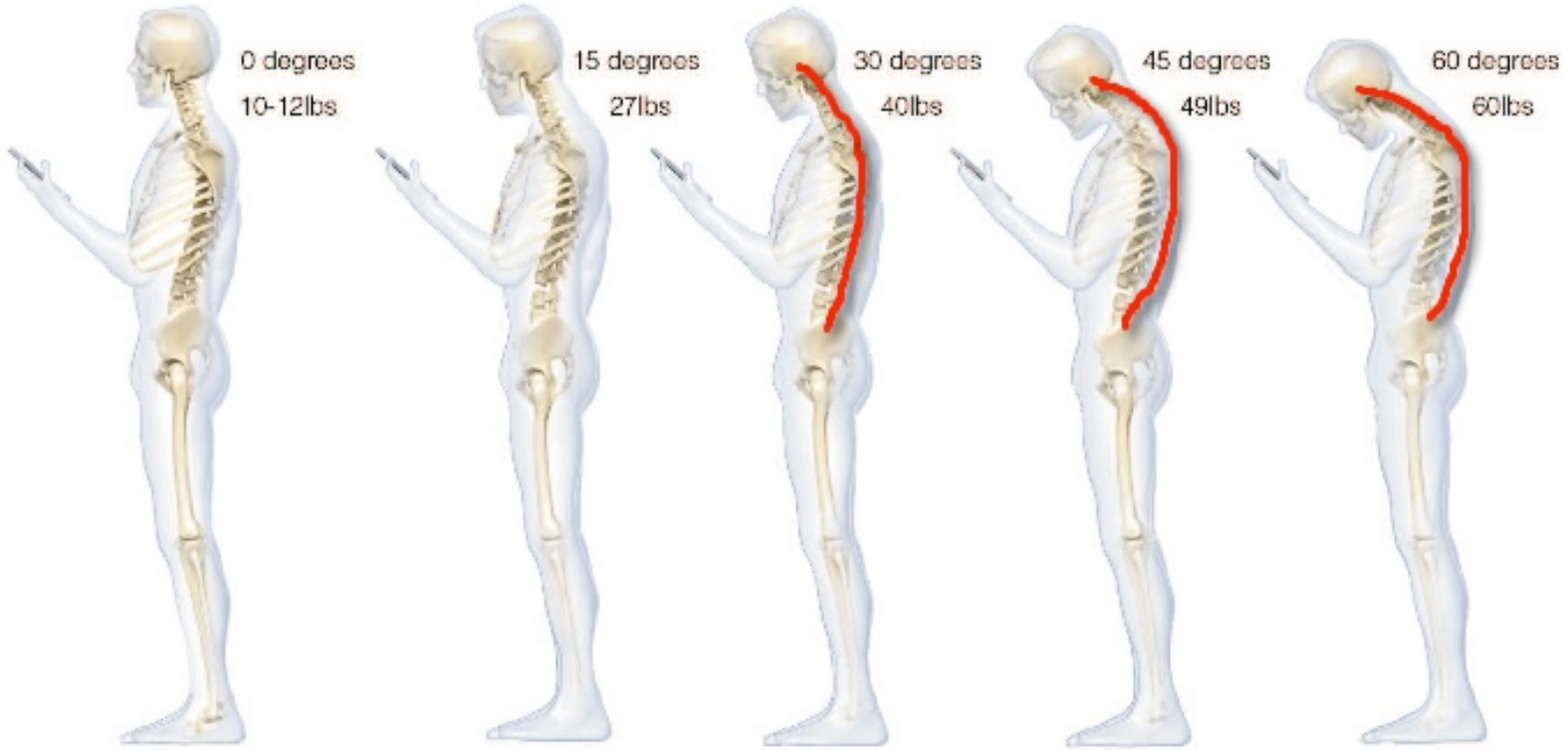
Surgeon symptoms, strain, and selections: Systematic review and meta-analysis of surgical ergonomics

Chee-Chee H. Stucky[a,*], Kate D. Cromwell[a], Rachel K. Voss[a,1], Yi-Ju Chiang[a], Karin Woodman[b],

Etiology

- Maintaining awkward , non-neutral static posture
- Highly repetitive, forceful hand and arm motion
- Forward inclined head and trunk
  - Vision, wide tables, high or low tables
- Fine manipulative tasks
- Foot pedals (atherectomy, thrombectomy, fluoroscopy, vein ablation)
- Head mounted lights, loupes, lead caps
- Fulcrum effect of long laparoscopic instruments-excessive arm abduction, elbow deviation, wrist deviation
- Lead protective garments- “interventional disc disease”
- Prolonged working hours and prolonged operative times
- Increasing workloads?

- And it’s even worse for women-
  - body size, hand size (instruments) , table height, etc-OR’s are set up for men
    - Increased hand injuries in women



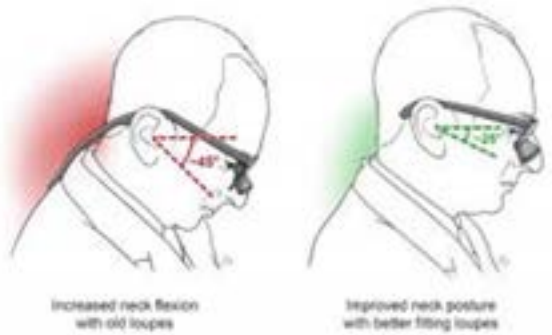
Position	Neutral	15 °	30°	45 °	60 °	90°
Force To Cervical Spine	10-12lbs.	27lbs.	40lbs.	49lbs.	60lbs.	Not Measurable

Figure 1. The weight seen by the spine increases when flexing the neck at varying degrees. An adult head weighs 10-12 pounds in the neutral position. As the head tilts forward the forces seen by the neck surges to 27 pounds at 15 degrees, 40 pounds at 30 degrees, 49 pounds at 45 degrees and 60 pounds at 60 degrees.

Consequences

- 29% of surgeons have sought treatment
- 30% take their own physical symptoms into account when recommending procedure
- 41% have modified surgical practice
- 12% have required a leave of absence, practice restriction, or early retirement due to work related MSD
  - Orthopedics-
    - 27% cervical radiculopathy
    - 11% required surgery
    - 19% required time off work

Treatment



- Shallow declination loupes
- Targeted stretching micro breaks
- Laparoscopic/endovascular handle design
- Monitor height (at or 15 degrees below eyes; 60 cm away, straight ahead)
- Anti-fatigue/compliant mats
- Neutral positions
- Keep extremities as close as possible
- Alternate sitting and standing (not just in the OR-adjustable desks!)
- Avoid truncal rotation
- Avoid headlights
- Table height (suggested 0.7-0.8 ratio to surgeon elbow height for minimally invasive surgery and interventional radiology)
- Two piece lead; avoid front only shielding (radiation and unequal weight)
- Compression stockings
- Pre and post surgery intervention (stretching, yoga , Pilates, massage)
- Lumbar/abdominal support belt
- Core body strength

TABLE 3. Published Surgical Ergonomics Recommendations, Listed by Applicable Body Site or Equipment

Body Part/ Equipment	Recommendation	Studies—First Author, Year(s)
Shoulder/upper arm	Upper arm should remain perpendicular to floor.	Craven 2013
	Shoulders should be dropped and hands relaxed. Intraoperative stretching with arm raises recommended.	Rosenblatt 2013
	Shoulder abduction should be <30 degrees. Arms should be slightly abducted and rotated inward.	Xiao 2012
	Assistants should rotate responsibility for retraction to avoid prolonged strain for any individual. In laparoscopic and vaginal surgery, assistants and surgeons should consider rotating sides to balance upper extremity strain.	Hullfish 2009
Forearm/elbow	Angle between forearm and upper arm should be 90 degrees.	Craven 2013
	To avoid excessive elbow flexion/extension, forearm should be held in horizontal position, parallel to the floor. To avoid excessive torque, forearm should be held in neutral position between supination and pronation.	Matern 2009
	Elbows should be held between 90-and 120-degree flexion.	Xiao 2012
Wrist	Wrist should be held in slight extension with fingers bent slightly.	Matern 2009
	Avoid wrist deviations beyond 20-degree extension, 40-degree flexion, 15-degree radial deviation, and 25-degree ulnar deviation. Extreme wrist excursions should not occupy >30% of operating time.	Van Veelen 2004
Hand/fingers	Instruments should not require more force than 15 N to completely close.	Van Veelen 2004
Neck	Neck flexion should be about 20 degrees. In robotic surgery, forehead should rest only lightly on the headrest.	Craven 2013
	Surgeons should avoid excessive "head forward" posture, as this increases degenerative changes in the cervical spine.	Rosenblatt 2013
	Prolonged static positioning of the neck, particularly if in excessive flexion, should be avoided.	Szeto 2012
	Neck should be flexed at an angle between 10 and 30 degrees. Excessive twisting should be avoided; surgeons should limit axial rotation to less than 15 degrees.	Van Det 2008
Back/trunk	Avoid pelvic girdle asymmetry by keeping feet hip's width apart with weight evenly distributed. Do not lock knees. Engage deep muscles of trunk and pelvis to maintain neutral position. Perform postural "resets" and intraoperative stretching with squats.	Rosenblatt 2013
	Prolonged static positioning should be avoided.	Szeto 2012
Lower extremity	In robotic surgery, excessive knee flexion should be avoided. Feet should rest on ground in front of pedals at angle ≥90 degrees.	Craven 2013
	Dorsal flexion of the foot should be <25 degrees when controlling foot switch.	Van Veelen 2004
	Consider antifatigue mats in the operating room to decrease lower extremity fatigue. Surgeons should also consider supportive hose if prolonged standing is required.	Hullfish 2009
Monitor position	Laparoscopic monitors should be between 10 and 30 degrees below eye level.	Van Det 2009
	Image should be 15 to 45 degrees below eye level.	Van Veelen 2004
	Screen height of 160 cm is recommended.	Zehetner 2006
Table height	Table heights in general should be adjusted to the height of the tallest surgeon with step stools used for other team members.	Hullfish 2009
	In vaginal surgery, surgeons should be seated whenever possible with table and stool heights adjusted so primary surgeon is looking straight ahead.	Hullfish 2009
	To prevent extreme upper extremity excursions during laparoscopic surgery, the operating table should be between a factor 0.7 and 0.8 of surgeons' elbow height so instruments can rotate around elbow level.	Berquer 2002
Standing support	Standing support adjustable between 780 and 1020 mm may help prevent prolonged static standing posture.	Van Veelen 2004
Instrument manipulation	Working angle between instruments when stitching and knotting should be 60 degrees. This will keep arms in comfortable, slightly inwardly rotated, position.	Matern 2009
	Instrument intracorporeal to extracorporeal ratio should be >1.	Xiao 2012
Arm boards	To avoid trunk twisting, surgeons should tuck patient's arms whenever possible.	Rosenblatt 2013
Foot pedal position	Surgeons should be able to reach pedals without balancing on one foot.	Matern 2009
	Foot pedals should be placed next to foot in line with target instruments toward the target quadrant.	Rosenblatt 2013
Postsurgery interventions	Perform neck, hamstring, and back stretches immediately after breaking scrub. Surgeons should incorporate stretching/flexibility modules into their exercise programs (eg, yoga, pilates) and engage in regular massage.	Hullfish 2009

PACIFIC NORTHWEST ENDOVASCULAR CONFERENCE

Ergonomics in Surgery: A Review

Tatiana Catanzarite, MD,† Jasmine Tan-Kim, MD, MAS,† Emily L. Whitcomb, MD, MAS,‡ and Shawn Menefee, MD†*

Barriers

- Culture of surgery and training
  - Don’t complain
  - Take care of patient first
  - Severe under-reporting (19 % reported injury but 35% operated less)
- Very scant ergonomic training
- Patients are unique; making standardization difficult
- Working within time constraints
- Concentrating on procedure, forgoing adjustment
- Regulatory restraints for instrument design
- Difficult to study ergonomics in OR (sterile environment)

Editorial

- We devote our lives to taking care of others
- We do a lousy job of taking care of ourselves
- Surgery is a harsh mistress

Table 2. Nonpharmacologic Treatments Versus Sham, No Treatment, or Usual Care for Chronic Low Back Pain

Intervention	Pain			Function		
	Magnitude of Effect	Evidence	SOE	Magnitude of Effect	Evidence	SOE
Exercise vs. usual care	Small	1 SR (19 RCTs) + 1 SR	Moderate	Small	1 SR (17 RCTs) + 1 SR	Moderate
MCEs vs. minimal intervention	Moderate (short to long term)	1 SR (2 RCTs)	Low	Small (short to long term)	1 SR (3 RCTs)	Low
Tai chi vs. wait list or no tai chi	Moderate	2 RCTs	Low	Small	1 RCT	Low
Yoga vs. usual care	Moderate	1 RCT	Low	Moderate	1 RCT	Low
Yoga vs. education	Small (short term) and no effect (longer term)	5 RCTs (short term) + 4 RCTs (longer term)	Low	Small (short term) and no effect (longer term)	5 RCTs (short term) + 4 RCTs (longer term)	Low
Mindfulness-based stress reduction vs. usual care or education	Small	3 RCTs	Moderate	Small	3 RCTs	Moderate
Progressive relaxation vs. wait-list control	Moderate	1 SR (3 RCTs)	Low	Moderate	1 SR (3 RCTs)	Low
Electromyography biofeedback vs. wait list or placebo	Moderate	1 SR (3 RCTs)	Low	No effect	1 SR (3 RCTs)	Low
Operant therapy vs. wait-list control	Small	1 SR (3 RCTs)	Low	No effect	1 SR (2 RCTs)	Low
Cognitive-behavioral therapy vs. wait-list control	Moderate	1 SR (5 RCTs)	Low	No effect	1 SR (4 RCTs)	Low
Multidisciplinary rehabilitation vs. no multidisciplinary rehabilitation	Moderate	1 SR (3 RCTs)	Low	Small	1 SR (3 RCTs)	Low
Multidisciplinary rehabilitation vs. usual care	Moderate (short term), small (long term), and favors rehabilitation	1 SR (9 RCTs) (short term) + 1 SR (7 RCTs) (long term)	Moderate	Small (short and long term)	1 SR (9 RCTs) (short term) + 1 SR (7 RCTs) (long term)	Moderate
Acupuncture vs. sham acupuncture	Moderate	1 SR (4 RCTs) + 5 RCTs	Low	No effect	1 SR (4 RCTs) + 5 RCTs	Low
Acupuncture vs. no acupuncture	Moderate	1 SR (4 RCTs)	Moderate	Moderate	1 SR (3 RCTs)	Moderate
Spinal manipulation vs. sham manipulation	No effect	1 SR (3 RCTs) + 1 RCT	Low	Unable to estimate	1 RCT	-
Spinal manipulation vs. inert treatment	Small	7 RCTs	Low	-	-	-
Massage vs. usual care	No effect	1 RCT	Low	Unable to estimate	2 RCTs	Insufficient

MCE = motor control exercise; RCT = randomized, controlled trial; SOE = strength of evidence; SR = systematic review.