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Segmental stabilizing exercises and low back pain. What is the evidence? A systematic review of randomized controlled trials

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Study design: A systematic review of randomized controlled trials.
Objectives: To evaluate the effectiveness of segmental stabilizing exercises for acute, subacute and chronic low back pain with regard to pain, recurrence of pain, disability and return to work.
Methods: MEDLINE, EMBASE, CINAHL, Cochrane Controlled Trials Register, PEDro and article reference lists were searched from 1988 onward. Randomized controlled trials with segmental stabilizing exercises for adult low back pain patients were included. Four comparisons were foreseen: (1) effectiveness of segmental stabilizing exercises versus treatment by general practitioner (GP); (2) effectiveness of segmental stabilizing exercises versus other physiotherapy treatment; (3) effectiveness of segmental stabilizing exercises combined with other physiotherapy treatment versus treatment by GP and (4) effectiveness of segmental stabilizing exercises combined with other physiotherapy treatment versus other physiotherapy treatment.
Results: Seven trials were included. For acute low back pain, segmental stabilizing exercises are equally effective in reducing short-term disability and pain and more effective in reducing long-term recurrence of low back pain than treatment by GP. For chronic low back pain, segmental stabilizing exercises are, in the short and long term, more effective than GP treatment and may be as effective as other physiotherapy treatments in reducing disability and pain. There is limited evidence that segmental stabilizing exercises additional to other physiotherapy treatment are equally effective for pain and more effective concerning disability than other physiotherapy treatments alone. There is no evidence concerning subacute low back pain.
Conclusion: For low back pain, segmental stabilizing exercises are more effective than treatment by GP but they are not more effective than other physiotherapy interventions.

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Introduction

Low back pain is reported by approximately 80% of the population at some point in their life and is, therefore, a major public health problem in today's industrialized societies.[1,2] In addition to human suffering, it causes substantial economic burden.[3]

For acute low back pain (< six weeks duration) the advice is to stay active, apply analgesic and muscle relaxant medications and use spinal manipulation.[4,5] In addition, multidisciplinary treatment programmes in occupational settings may be an option for workers with subacute low back pain (6–12 weeks duration).[4,5] For chronic low back pain (> 12 weeks duration)[4] cognitive behavioural therapy, exercise therapy, brief education interventions, multidisciplinary treatment, antidepressants, analgesics, muscle relaxants and capsicum plasters are recommended.[6]

Recently, exercise programmes focusing on segmental stabilizing exercises have been introduced, as first described by Richardson *et al*.[7] This approach aims at relearning a precise co-contraction pattern of the deep trunk muscles: the Mm. transversii abdomini and lumbar multifidus muscles. It is based on knowledge about how the muscles provide stability for the spine in normal situations. These exercises are used in practice to relieve pain and prevent further episodes of low back pain.[8]

Based on anatomic characteristics, Bergmark identified stabilizing muscles as either 'global' or 'local'.[9] Global muscles are large superficial muscles, crossing multiple segments of the spine that control spinal motion, orientation and balance. Local muscles cross one or a few segments and have a limited moment arm to move the joint, controlling intervertebral motion. The transverse muscles of the abdomen and the lumbar multifidus muscles are local muscles of the lumbar spine. Studies indicate that the transverse muscle of the abdomen changes its functional performance in people with low back pain.[10,11] In addition, it has been suggested that abdominal muscle recruitment is altered in patients with low back pain following segmental stabilizing exercises.[12] The loss of muscle size of the lumbar multifidus muscle is not automatically restored after resolution of acute low back pain. Recovery of this muscle was reported to be more rapid and more complete in people who received segmental stabilizing exercises.[13]

However, there is lack of evidence concerning the effectiveness of segmental stabilizing exercises. Therefore, the objective of this systematic review is to evaluate the effectiveness of segmental stabilizing exercises in the prevention and treatment of acute, subacute and chronic low back pain, focusing on pain, recurrence of pain, disability and return to work. Four comparisons are intended: (1) effectiveness of segmental stabilizing exercises versus treatment by general practitioner (GP); (2) effectiveness of segmental stabilizing exercises versus other physiotherapy treatments; (3) effectiveness of segmental stabilizing exercises combined with other physiotherapy treatments versus treatment by GP and (4) effectiveness of segmental stabilizing exercises combined with other physiotherapy treatments versus other physiotherapy treatments.

Materials and method

Inclusion criteria

The review only includes randomized controlled trials. The intervention group has to have received segmental stabilizing exercises at least as part of the treatment. Participants had to be at least 18 years old and take part in a programme treating acute, subacute or chronic low back pain with or without sciatica. Articles published in English, German, French, Dutch, Norwegian, Danish and Spanish were included. The most important outcome variables are pain, recurrence of back pain, disability and return to work.[14] We included these in the analysis. Further outcome measures are presented in the table of included studies (Table 1).

Exclusion criteria

Pilot studies and abstracts were excluded. Studies in which participants were pregnant, had undergone back surgery six months prior to the intervention or had suffered from infection, inflammation, osteoporosis, rheumatoid arthritis, fractures, malignancies or any kind of systematic diseases were excluded.

Table 1 Table of included studies

Study/year	Participants	Interventions	Outcomes and results (statistical significance) + statistical significant in favour of the segmental stabilizing exercises − statistical significant in favour of the control group 0 not statistical significant	Notes/comments
Danneels 2001[18+19] (B)	a. Inclusion: history of LBP > 3 months; exclusion: previous lumbar surgery, spondylolysis or spondylolisthesis, lumbar scoliosis exceeding 10°, involvement in sport or fitness training to the low back muscles during the previous three months b. *N* = 59 (group 1 = 19; group 2: 20; group 3 = 20) c. Age (mean) group 1:43 ; group 2: 44 ; group 3: 43 d. M/F group 1:10/9; group 2: 9/11; group 3: 8/12 e. Chronic LBP; exact duration: nm; radiation: nm f. Working/not working: nm	Duration: 10 weeks; intensity: nm; frequency: 3 times a week Feedback methods: nm 1. SSEG 1: SSE + Warmth, massage 2. SSEG 2: See 1. + dynamic strengthening training: three standard strengthening exercises (concentric and eccentric movements were repeatedly alternated) 3. SSE 3: See 1./2. + dynamic static strengthening training: the cycling movement of the strengthening exercises was each time interrupted by a 5 s static contraction between the concentric and eccentric phase.	Mann–Whitney *U*-test (95% CI) 1. Post measurement at 10 weeks (*N* = ?): CSA (cross sectional area) A: paravertebral muscles: Group 1/2: + (favours group 2) Group 1/3: + (favour group 3) Group 2/3: 0 B: multifidus muscle: group differences nm 2. Long-time follow-up: nm	Small sample size. Unclear is the number of people measured at the post measurement. Duration of back pain before treatment not mentioned. Only muscle CSA as outcome
Hides 1996[13] & 2001[20] (AU)	a. Inclusion: first episode of unilateral, mechanical LBP for less that 3 weeks; exclusion: previous history of LBP or injury, previous lumbar surgery, spinal abnormalities indicated on radiogrphs, neuromuscular or joint disease, reflex and/or motor signs of nerve root compression or cauda equine compression, any fitness training involving the low back muscles done in the past 3 months. b. *N* = 41 (SSEG: 21; CG: 20) c. Age (mean) SSEG: 31; CG:31 d. M/F SSE: 8/13; CG: 10/10 e. Acute LBP; exact duration: SSE: 8.10 days; CG: 9.16 days; with or without radiation f. Working/not working: nm	Duration: 4 weeks; intensity: nm; frequency: SSEG: twice a week; CG: nm Feedback methods: SSEG: realtime ultrasound; CG: not mentioned 1. SSEG: SSE + treatment by GP (medical treatment) 2. CG: treatment by GP (advice to bed rest (1–3 days) and absence from work, medical treatment)	One-way ANOVA over time (week 0,1,2,3,4,[10]) 1. Post measurement at 4 weeks (*N* = SSEG/CG: 20/19): Pain: 0 Disability: 0 Lumbar range of motion: 0 CSA (muscle thickness) lumbar multifidus: + 2. 10 weeks follow up (*N* = 19/15) CSA (muscle thickness) lumbar multifidus: + Habitual activity level: 0 Relative risk ratio, χ^2 – test 3. 12 months follow-up (*N* = 20/19): Recurrence of back pain: +	Small sample size. Problem of change in the outcome parameters between 4/10 weeks and 1/3 year follow-up.

Table 1 (*Continued*)

Study/year	Participants	Interventions	Outcomes and results (statistical significance) + statistical significant in favour of the segmental stabilizing exercises − statistical significant in favour of the control group 0 not statistical significant	Notes/comments
			4. 36 months follow-up ($N = 20/16$): Recurrence of back pain: +	
Moseley 2002[29] (AU)	a. Inclusion: history of LBP for more than 2 months; exclusion: worsening neural signs, awaiting surgery b. $N = 57$ (SSE: 29; CG: 28) c. Age (mean) SSE: 43 ; CG: 38 d. M/F SSEG: 10/18 ; CG: 13/15 e. Subacute/chronic LBP; exact duration: SSEG: 39 (18) months; CG: 37 (12) months; radiation: nm f. Working fulltime: SSEG: 19%; CG: 24% Working parttime: SSEG: 32%; CG: 32% Receiving compensation: SSEG: 44%; CG: 50%	Duration: 4 weeks; Intensity and frequency: SSEG: a) 1 hour education once a week, b) treatment twice a week, intensity nm; CG: nm Feedback methods: nm 1. SSEG: SSE + manual therapy (spinal mobilization/ manipulation/ soft tissue massage/ muscle and neuromeningeal mobilization echniques) + education (focus on neurophysiology of pain, completion of a workbook) 2. CG: treatment by GP (medication)	Two factor ANOVA (group, time); Bonferroni correction ($\alpha = 0{,}025$) 1. post measurement at 4 weeks (N = SSEG/CG: 24/25): Pain: + Disability: + 2. 12 months follow-up ($N = 19/19$) Pain: + Disability: + Health visits: +	High drop-out rate ($> 30\%$). The SSEG group was not asked about analgesics or other treatment while the CG was
Niemistö 2003[22] (FIN)	a. Inclusion: LBP for at least 3 months duration and a selfrated disability index (Oswestry LBP Disability Questionnaire) score at least 16%; exclusion: ankylosing spondylitis, severe osteoporosis, severe osteoarthritis, paralysis, progressive neurologic disease, haemophilia, spinal infection, previous spinal operation, vertebral fracture during the previous 6 months, severe psychiatric disease, or severe sciatica with a straight leg raising test less that 35° b. $N = 204$ (SSEG: 102 ; CG: 102) c. Age (mean) SSEG: 37.3; CG: 36.7 d. M/F SSEG: 46/56; CG: 48/54 e. Chronic LBP; exact duration: median years (range) SSEG: 6 (1-31); CG: 6 (1-29) ; with or without radiation f. Working: SSEG: 99%; CG: 91%	Duration: 4 weeks; intensity/frequency both groups: Information: 60 min/once during the 4 weeks and once at the 5 months follow up; SSEG only: Therapy: 60 min/at least once mean 4 times; Feedback methods: SSEG: Pressure Biofeedback meter; CG: nm 1. SSEG: SSE + Manipulation (muscle energy technique). + treatment by GP (see CG) 2. CG: treatment by GP (25 page education booklet (anatomy, physiology, principles of ergonomics for LBP patients and instructions on how to exercise and to cope with the acute phase of LBP))	Repeated measures ANOVA (group, time), logarithmic transformation/ square-root transformation 1. no post measurement 2. 5 months follow-up ($N =$ SSEG/CG: 100/100) and 12 months follow-up ($N = 96/100$) pain: + disability: + health related quality of life: 0 depression: 0 health care service: 0	Noticeably the SD in the article are nearly always the same (authors state that that is correct). VAS for pain: unclear which time frame

O'Sullivan 1997[23] & 1998[12] (AU)	a. Inclusion: recurrent LBP for more than 3 months, radiologic diagnosis of isthmica spondylolysis or spondylolisthesis; exclusion: undergone spinal surgery, scored less than 2/10 on the visual analogue pain scale for their average pain intensity levels over the previous 2 weeks patients were withdrawn from the study if they had less than 50% compliance with the intervention or if they withdrew their consent or had persistent exacerbation of their symptoms b. $N = 44$ (SSEG: 22; CG: 22) c. Age (mean) SSE: 33; CG: 29 d. M/F SSEG: 15/6; CG: 12/9 e. Chronic LBP; exact duration in months: SSEG: 28; CG: 29; with or without radiation f. Working: nm; compensation claimants SSEG:3; CG: 3	Duration: 10 weeks; intensity: SSEG: once a week; CG: nm; frequency: nm Feedback methods: SSEG: pressure biofeedback unit; CG: nm 1. SSEG: SSE 2. CG: treatment by GP (e.g. advice for swimming, walking, gym work)	Repeated measures analysis of variance 1. Post measurement at 10 weeks (N = SSEG/CG: 21/21): pain: + disability: + spinal flexion/extension: 0/0 hip flexion/extension: +/0 abdominal muscle recruitment patterns: altered Two-way repeated measures analysis of variance. 2. 3 months follow-up (N = 21/20) and 6 months follow-up (N = 21/19) and 30 months follow-up (N = 19/15): pain: + (maintained) disability: + (maintained)	Small sample size
Rasmussen-Barr 2003[24] (S)	a. Inclusion: LBP > 6 weeks; exclusion: prior segmental stabilizing training, manual treatment in the previous 3 months, overt neurological signs, known lumbar disc hernia, diagnosed inflammatory joint disease, known severe osteoporosis b. $N = 47$ (SSEG: 24 ; CG:23) c. Age (mean) SSEG: 39; CG: 37 d. M/F SSEG: 7/17 ; CG: 5/18 e. Chronic (> 12 weeks: SSEG: 88%; CG: 91%) and subacute (6-12 weeks: SSEG: 12%; CG: 9%) LBP ; exact duration: nm; with or without radiation f. Working/not working: SSEG: 22/2; CG: 20/3	Duration: 6 weeks; intensity: once a week; frequency: 45 min Feedback methods: SSEG: pressure biofeedback meter; CG: nm 1. SSEG: SSE + basic ergonomics 2. CG: manual techniques, based on findings from the physical examination (e.g. muscle stretching, segmental traction, soft tissue mobilization) + basic ergonomics	Mann–Whitney U-test (95% CI) 1. Post measurement at 6 weeks (N = SSEG/CG: 24/23): pain: 0 disability (pain related): 0 disability (activity related): + general health: 0 2. 3 months follow-up (N = 22/19): pain: 0 disability (pain related): 0 disability (activity related): +	Small sample size High drop-out rate (> 25%)

Table 1 (*Continued*)

Study/year	Participants	Interventions	Outcomes and results (statistical significance) + statistical significant in favour of the segmental stabilizing exercises − statistical significant in favour of the control group 0 not statistical significant	Notes/comments
			general health: 0 treatment sought: + 3. 12 months follow-up ($N = 17/14$): pain: 0 disability (pain related): 0 disability (activity related): + general health: 0 treatment sought: +	
Kladny 2003[21] (D)	a. Inclusion: LBP with or without disc hernia or protrusion; exclusion: operation of the spine, arthritis of the big joints, injuries, trauma b. $N = 99$ (SSEG: 50 ; CG: 49) c. Age (mean) SSEG: 41 ; CG: 37 d. M/F SSEG: 34/16 ; CG: 31/18 e. SSEG/CG: 66/69% chronic; 32/29% subacute; 2/2% acute LBP; exact duration: nm, with or without radiation f. Working SSEG: 20.8%; CG: 38,8%	Duration: unclear; intensity: nm; frequency: nm Feedback methods: for some participants in the SSEG: ultrasound imaging 1. SSEG: SSE + Exercise therapy, move-spa, heat/warmth, electrotherapy, massages 2. CG: individualized personal instruction of physiotherapy (e.g. strengthening of back and belly muscles, stretching, McKenzie, Manual therapy)	Mann–Whitney *U*-test (95% CI) 1. Post measurement at end of treatment (exact time unclear) ($N =$ SSEG/CG: 50/49) pain: 0 disability: + function: + 2. 3 months follow-up: ($N = 39/38$) pain: 0 disability: 0 function: 0	Methodological score = 0! Description of drop-outs unclear Duration and intensity of intervention unclear Exact time of post measurement unclear

nm, not mentioned; LBP, low back pain; CSA, cross-sectional area; SSE, segmental stabilizing exercises; SSEG, segmental stabilizing exercise group; CG, control group; AU, Australia; B, Belgium; D, Germany; FIN, Finland; S, Sweden; SD, standard deviation; VAS, visual analogue scale.

Searching

A systematic search in MEDLINE (1988 to December 2004) and EMBASE (1989 to December 2004) was performed following 'Cochrane Back Group' guidelines using the methodological filter to identify randomized controlled trials.[15] In addition, the following keywords were used (MESH and text words): 'back pain', 'backache', 'lumbago', 'stabil*', 'specif*', 'exercis*' and 'treat*'. CINAHL (up to November 2004) was systematically searched using the keywords (MESH and text words) 'trial*', 'back pain' and 'exercis*'. Cochrane library 2004 Issue 3 was searched using the words 'exercis*' and 'stabil*'. The PEDro database was screened inserting the words 'exercis*' in abstract and title. Reference tracking was performed on all included studies.

Abstract selection

Two reviewers (one blinded to author, journal and publication year) independently applied the inclusion criteria. In the case of disagreement a third researcher was used to reach a consensus.

Methodologic quality assessment

Two reviewers (one blinded to author, journal and publication year) independently assessed each selected study for self-reported methodological quality, based on the Guidelines for Systematic Reviews in the Cochrane Collaboration Back Review Group.[15]

Quality summary scores were not used as weighting tools for the meta-analysis, but to distinguish between high- and low-quality studies for the quantitative analysis in consensus with the Cochrane Guidelines for Systematic Reviews.[15,16] We did not contact authors concerning the methodological quality of the studies. No studies were excluded from data analysis or presentation of results because of a low methodological quality score.[17]

Data extraction

Two authors (one blinded to author, journal and publication year) independently extracted descriptive and outcome data from the included studies using a standardized form developed by the authors. A third reviewer was consulted if disagreement persisted.

Clinical heterogeneity of the studies was assessed by examining the subjects, type of back pain and intervention, outcome variables used and follow-up periods.

Data analysis

A quantitative and qualitative analysis was planned if studies provided sufficient and homogeneous data for the outcomes pain, recurrence of back pain, disability and return to work.[14]

The following comparisons were foreseen:

1) Effectiveness of segmental stabilizing exercises versus treatment by GP
2) Effectiveness of segmental stabilizing exercises versus other physiotherapy treatments
3) Effectiveness of segmental stabilizing exercises combined with other physiotherapy treatments versus treatment by GP
4) Effectiveness of segmental stabilizing exercises combined with other physiotherapy treatments versus other physiotherapy treatments.

For the qualitative analysis the level of evidence rating system of the Cochrane Collaboration Back Review Group was used.[15]

Results

Study selection

The systematic search in EMBASE and MEDLINE led to 156 abstracts (28% duplicates) and in CINAHL to 117 abstracts. Thirteen papers were located through the abstract selection process. After reading the studies in detail, nine papers fulfilled the inclusion criteria.[12,13,18–24] However, three of the trials were described by two papers (refs 18 and 19, 13 and 20, 12 and 23). Four papers were excluded from the review: two because the stabilizing exercises described failed to be segmental stabilizing exercises,[25,26] one because the exercise intervention was not described in the paper and therefore it could not be identified whether segmental stabilizing exercises were applied,[27] and one because it was published in Turkish language.[28] In Cochrane and PEDro no additional studies were found. One study could be detected through reference tracking.[29] Ultimately, seven studies with a total of 551 patients were included in this review.

Study description

Acute low back pain

One study applied segmental stabilizing exercises in patients suffering from unilateral, mechanical, acute, first episode, non-specific low back pain, with or without radiation.[13+20]

Subacute low back pain

No study was found.

Chronic low back pain

Three studies included subjects with subacute and chronic low back pain.[21,24,29] In all three studies predominantly chronic patients took part. Therefore, they were included in the subgroup 'chronic low back pain'. Three studies included chronic low back pain patients only.[12+23,18+19,22] Four studies included participants with non-specific low back pain.[18+19,22,24,29] One study included only people with radiological diagnosis of isthmica spondylolysis or spondylolisthesis.[12+23] One study included participants with or without disc protrusion or disc hernia.[21] Four studies included participants with low back pain with or without radiation[12+23,21,22,24] and two studies did not mention this factor.[18+19,29]

General information

Three studies were conducted in Austra lia,[13+20,12+23,29] the rest in Belgium,[18+19] Finland,[22] Sweden[24] and Germany[21]. All studies were published since 1996 and included participants of both sexes. Three studies did not mention whether the participants were working or not,[18+19,12+23,13+20] and four reported inclusion of both groups.[21,22,24,29] The numbers of subjects included in the studies ranged from 41 to 204. The duration and frequency of the intervention varied from 4 to 10 weeks, and once a week to three times a week respectively. For pain, six studies used a visual analogue scale (VAS)[12+23,13+20,21,22,24,29] and two studies additionally used the McGill Questionnaire.[12+23,13+20] For comparability reasons, only the results of the VAS were used in the data analysis. For the outcome disability two studies used the Roland Morris Disability Questionnaire[13+20,29] and four studies the Oswestry Disability Questionnaire.[12+23,21,22,24] For comparability reasons, results of the Disability Rating Index, additionally used by one study,[24] were not included in the data analysis. Only one study reported recurrence of back pain.[13+20] No study reported return to work. One study did not measure pain, recurrence of pain, disability or return to work and therefore could not be included in the data analysis.[18+19] No side effects were reported. Further information about the studies can be found in Table 1.

Methodological quality assessment

The methodological quality scores (Table 2) of all included studies ranged from 0 to 8 points out of a maximum of 11 points, with a median score of 5.3 points. Using a cut-off point of 6 points,[30] four of the seven studies were considered as being of high quality.

One study had a particular low methodological quality score.[21] However, the effect sizes of this study (Figure 1) are rather comparable with the other studies, so the authors assume no significant bias due to low quality. Only three studies described their treatment allocation as being concealed (B).[12+23,22,29] In the rest of the studies this feature remained unclear, which might just have been because it was not described. Only one study assessed compliance (H)[12+23] and only three studies used an 'intention to treat' analysis (K).[22,24,29]

Qualitative analysis. Effectiveness of segmental stabilizing exercises

The results of the studies in the qualitative analysis are presented at post measurement and at long-term follow-up ($\geq$ one year).

Acute low back pain

Comparison 1. Effectiveness of segmental stabilizing exercises versus treatment by GP. One *high-quality* study ($N = 41$) showed *moderate evidence* that there are no differences between segmental stabilizing exercises and the treatment by GP concerning pain and disability at post measurement (four weeks) for patients with acute low back pain.[13+20] There is *moderate evidence* that segmental stabilizing exercises are more effective in reducing long-term recurrence of low back pain (one- and three-year follow-up) than treatment by GP for patients with acute low back pain. There is a *lack of evidence* concerning the outcome of return to work.

Table 2 Methodologic quality assessment

Study	A Randomization adequate?	B Treatment allocation concealed?	C Groups similar at baseline?	D Blinding of patient?	E Blinding of care provider?	F Outcome assessor blinded?	G Cointervention avoided/ similar?	H Compliance acceptable?	I Drop-out rate acceptable?	J Timing outcome assessment similar?	K Intention to treat?	Total
Danneels[18+19]	+	?	?	−	−	+	+	?	?	+	?	4
Hides[13+20]	+	?	+	−	−	+	+	?	+	+	−	6
Kladny[21]	?	?	?	−	−	?	?	?	?	?	?	0
Moseley[29]	+	+	+	−	−	+	+	?	+	+	+	8
Niemistö[22]	+	+	+	−	−	+	+	?	+	+	+	8
O'Sullivan[12,23]	+	+	+	−	−	+	?	+	+	+	−	7
Rasmussen-Barr[24]	?	?	+	−	−	+	−	?	−	+	+	4

Yes = +; No = −; Don't know = ?

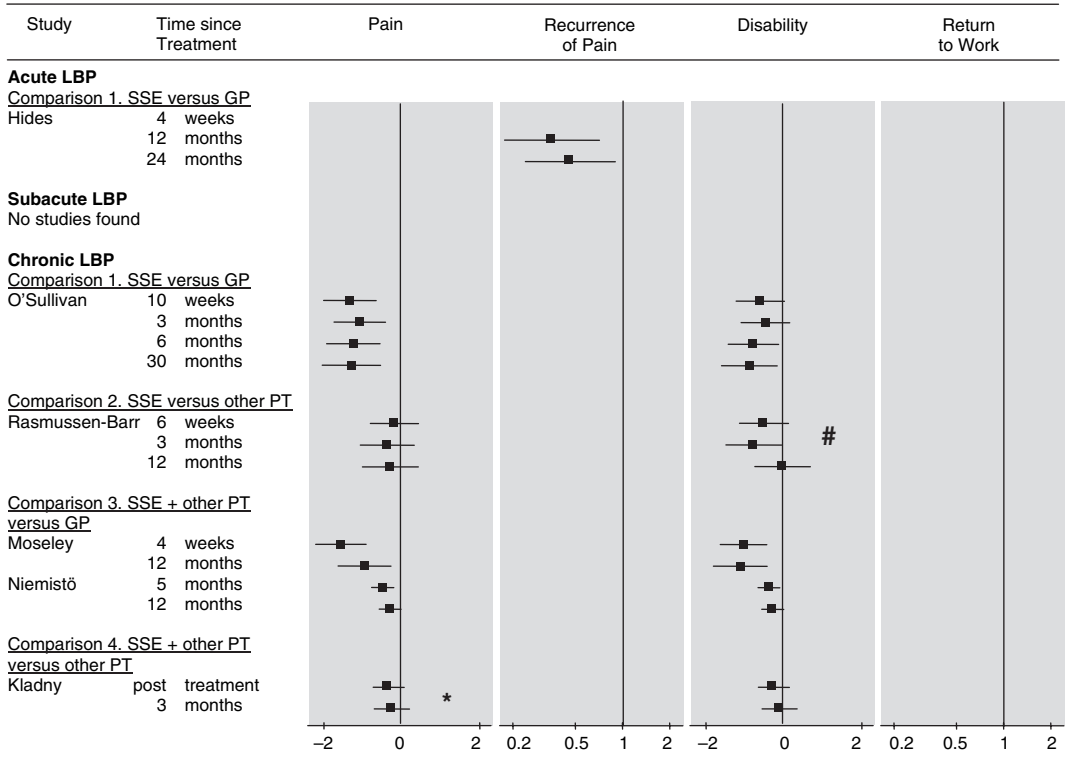

Figure 1 Treatment effect sizes for six comparisons of segmental stabilizing exercises versus a control group. Bars represent standardized mean differences (Hedges' adjusted *g*) and 95% confidence intervals or relative risks for comparison of segmental stabilizing exercise group (SSEG) and control group. Treatment effect sizes to the left of the vertical line indicate treatment effects in favour of SSEG. Different measures for the same construct (pain, disability) were used in two trials. We presented the following: * results of NRS 2, # results of Oswestry Disability Index. LBP, low back pain; SSE, segmental stabilizing exercises; GP, general practitioner; PT, physiotherapy treatment.

Comparisons 2–4. No randomized controlled trials were identified. No evidence concerning segmental stabilizing exercises in acute low back pain can be established.

Subacute low back pain

Comparisons 1–4. No randomized controlled trials were identified. No evidence concerning segmental stabilizing exercises in subacute low back pain can be established.

Chronic low back pain

Comparison 1. Effectiveness of segmental stabilizing exercises versus treatment by GP. One *high-quality* study ($N = 44$) showed *moderate evidence* that segmental stabilizing exercises are more effective in reducing pain and disability at post measurement (10 weeks) and at 30-month follow-up than treatment by GP for patients with chronic low back pain and radiologic diagnosis of isthmica spondylolysis or spondylolisthesis.[12+23] There is a *lack of evidence* concerning the outcome of recurrence of back pain and return to work.

Comparison 2. Effectiveness of segmental stabilizing exercises versus other physiotherapy treatment. One *low-quality* study ($N = 47$) comparing segmental stabilizing exercises with other physiotherapy treatment showed *limited evidence* that there are no differences between segmental stabilizing exercises and manual therapy techniques at post measurement (six weeks) and 12 months follow-up concerning pain and disability for chronic low

back pain.[24] There is *lack of evidence* concerning the outcome of recurrence of back pain and return to work.

Comparison 3. Effectiveness of segmental stabilizing exercises combined with other physiotherapy treatment versus treatment by GP. Two *high-quality* studies ($N = 57 + 204$) were found comparing segmental stabilizing exercises combined with manual therapy and treatment by GP (education) with treatment by GP (education).[22,29] Only one study measured effects at post measurement (four weeks) and showed *moderate evidence* that segmental stabilizing exercises combined with manual therapy and treatment by GP is more effective in reducing pain and disability than treatment by GP alone.[29] Both trials showed *strong evidence* that segmental stabilizing exercises combined with manual therapy and treatment by GP are more effective in reducing pain and disability at 12-month follow-up than treatment by GP alone. It should be taken into consideration that in one study, having used an ANOVA over time, it is not clear whether the statistically significant results refer to the five- or the 12-month follow-up.[22] There is *lack of evidence* concerning the outcome of recurrence of back pain and return to work.

Comparison 4. Effectiveness of segmental stabilizing exercises combined with other physiotherapy treatment versus other physiotherapy treatment. One *low-quality* study ($N = 99$) comparing segmental stabilizing exercises combined with other physiotherapy treatment (e.g. exercises using devices, massage, electrotherapy, heat) versus other physiotherapy treatment (e.g. strengthening, stretching, McKenzie, Maitland, Manual Medicine)[21] showed *limited evidence* that segmental stabilizing exercises combined with other physiotherapy treatment are more effective concerning disability and equally effective regarding pain at post measurement (exact time unclear) compared with other physiotherapy treatment for chronic low back pain. No long-term follow-up was conducted. There is *lack of evidence* concerning the outcome of recurrence of back pain and return to work.

Quantitative analysis

Looking at the small number and heterogeneity of studies, the authors decided not to pool the effect sizes, but chose to show the treatment effect sizes over time in a descriptive manner (Figure 1).

For continuous data (pain, disability), standardized mean differences (95% confidence interval (CI)) were calculated with the Hedges adjusted g formula.[31] For the dichotomous outcomes (recurrence of pain), the relative risk (95% CI) was calculated. The analysis was conducted using RevMan software (version 4.2) of the Cochrane Collaboration (www.cochrane.org).

Studies awaiting assessment

One study awaits assessment for the post-treatment measurement because available data were insufficient for effect size calculations.[13+20] Efforts to contact the authors have, to date, been unsuccessful.

Discussion

Acute low back pain

The results for acute low back pain only rely on one study and show first that segmental stabilizing exercises are as effective in reducing pain and disability as the treatment by GP after four weeks of intervention.[13+20] These results are in line with the findings of other reviews and guidelines about general exercises, which do not recommend exercises for acute low back pain.[5,32] Moreover, the literature shows that in 80–90% of the cases back pain is self-limiting, benign and improves spontaneously within approximately six weeks.[2] The problem regarding the course of an acute episode is that approximately 75% of the patients consulting about low back pain still report recurrences of back pain 12 months later.[33–36] Therefore, one should especially look at long-term results. The findings of this review are that segmental stabilizing exercises effectively reduce recurrence of back pain at long-term follow-up. One explanation for the long-term effectiveness could be the findings concerning the lumbar multifidus muscle size at baseline and post measurement. Multifidus muscle recovery did not occur spontaneously on remission of painful symptoms. In the group that received segmental stabilizing exercises the muscle size recovery was significantly more complete than in

the control group. Further studies will be needed to confirm these findings.

Chronic low back pain

Three studies comparing segmental stabilizing exercises (with or without other physiotherapy treatment) with treatment by GP (comparison groups 1 and 3) achieved better results concerning pain and disability in favour of the treatment group.[12+23,22,29] Two studies comparing segmental stabilizing exercises, with or without other physiotherapy treatment, with other physiotherapy treatment (comparison groups 2 and 4)[21,24] and found both interventions to be equally effective regarding pain and no[24] or little[21] difference in effectiveness in favour of segmental stabilizing exercises combined with other physiotherapy treatment for disability. Unfortunately, the latter studies are of low quality (0 and 4 out of 11 points). Therefore, the strength of evidence is very limited.[21,24] Additionally, it should be noted that in three of five studies segmental stabilizing exercises are only part of the treatment. Therefore the results cannot be attributed to segmental stabilizing exercises.[21,29,22] This probably would be possible as add on, but unfortunately, the study of the comparison group 4 (segmental stabilizing exercises combined with other physiotherapy treatment versus other physiotherapy treatment) used different kinds of physiotherapy treatment for the two groups.[21] Thus interpretation of the results of this study is impossible. Due to different statistical methods, small deviations between reported statistical significances in two studies and statistical significances indicated by the confidence interval of the standardized mean differences (see Figure 1) are plausible.[12+23,21] The results for chronic low back pain are in line with the findings of other reviews and guidelines that found exercise therapy being more effective than care by GP and exercise therapy equally effective to other forms of physiotherapy treatment.[6,32]

Summarizing, for chronic low back pain segmental stabilizing exercises are more effective in both the short and long term than treatment by GP and may be as effective as other physiotherapy treatments in reducing disability and pain. Segmental stabilizing exercises combined with other physiotherapy treatments are more effective in reducing short- and long-term disability and pain than treatment by GP but there is no evidence for an additional effect of segmental stabilizing exercises to other physiotherapy treatment.

Limitations of the review

Although a systematic and comprehensive search was performed, the possibility of publication and study identification bias remains.[37] No effort was made to identify unpublished studies, since they are hard to find and some studies are not published for a number of reasons linked to bias. There may also be a bias because of language restrictions in this review. One study published in Turkish could not be analysed, because none of the authors was able to read the language.[28] In an update, efforts should be made to include this study.

The heterogeneity of the included studies has led to some concern. The studies involved both specific[12+23,21] and nonspecific[13+20,21,22,24,29] low back pain and back pain with or without sciatica. The studies also used different scales and time periods measuring pain (e.g. VAS 0–10, VAS 0–100, pain in last 24 h, pain in last months) and disability (e.g. Oswestry Disability Index, Roland Morris Disability Index). Heterogeneity is also caused by the different length of intervention (4–10 weeks) and different time points of follow-up (3, 5, 6, 12, 30 and 36 months). For practicability reasons, the post measurement (regardless of exact time point) and a long-term follow-up ($\geq$ one year) were analysed in the quantitative analysis. In addition, the methodological quality of the studies (0–8) varies considerably. Thus, it is difficult to compare the results. The comparison groups are also heterogeneous. Especially problematic in this sense is the often ill-defined treatment provided by the GP. In general, there are not sufficient homogeneous trials to pool results.

It is disappointing to note the relatively low quality of the studies, especially concerning the allocation concealment, the assessment and description of compliance and the use of intention-to-treat-analysis.

In addition to the limitations mentioned above, there are general reasons to interpret the results with caution. Clinicians and patients who want to know whether an intervention for low back pain is effective are seeking answers concerning the clinical significance. Unfortunately, there is still lack of

Clinical messages

- In acute low back pain segmental stabilizing exercises and treatment by general practitioner are equally effective in reducing short-term disability and pain but segmental stabilizing exercises are more effective in reducing recurrence of pain.
- For chronic low back pain, segmental stabilizing exercises are more effective than treatment by general practitioner and may be as effective as other physiotherapeutic treatments in reducing disability and pain.

knowledge concerning, for example, the minimal clinical important differences, which one day might help to answer this question.[38–41] Another problem is that most studies do not include participants regarding clinical findings. In the included studies some participants might have benefited from segmental stabilizing exercises, and others have not. These differences in effects might have been masked. There is a need to identify subgroups of patients that benefit from segmental stabilizing exercises or other specific exercise treatments.

Implications for research

Generally speaking, there is a need for high-quality studies in acute, subacute and chronic low back pain conditions in order to evaluate the effectiveness of segmental stabilizing exercises. Especially interesting and yet unclear is the comparison of segmental stabilizing exercises with other physiotherapy treatments and the comparison of single versus group intervention. Knowing that the outcome return to work is an important measure for the effectiveness of an exercise treatment there is need for further research.[42]

Research is also needed to enhance the knowledge about functional mechanisms of segmental stabilizing exercises. This knowledge combined with clinical findings might improve the ability to identify subgroups of patients with low back pain and which subgroups benefit from segmental stabilizing exercises and which do not. To overcome the problem of heterogeneity concerning outcome measurement, future application of the World Health Organization's International Classification of Functioning, Disability and Health (ICF) may serve as a common framework.[43]

Implications for practice

Evidence for segmental stabilizing exercises is still limited. First results imply that they can be recommended for acute low back pain to reduce long-term recurrence of back pain. For chronic low back pain segmental stabilizing exercises are recommended to reduce short- and long-term disability and pain. It remains unclear whether segmental stabilizing exercises are more effective than other physiotherapy treatments.

Considering the feasibility of segmental stabilizing exercises in practice, therapists must keep in mind that special training in order to teach these exercises is necessary and that patients with poor body awareness have problems in learning them. Feedback methods such as real-time ultrasound and pressure biofeedback units enhance learning and are recommended for these patients.[44] An advantage with segmental stabilizing exercises is the active therapy approach which enables patients to help themselves. Segmental stabilizing exercises are easily applicable in daily life, which enhances compliance.

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Competing interests

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BR: Conception and design, analysis of the data, writing and editing of the manuscript (guarantor).

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