### Appendix A. Search strategy

| Keywords                  | Search terms                                      |
|---------------------------|---------------------------------------------------|
| “Perturbation”            | Perturbation                                      |
|                           | Unexpected perturbation                            |
|                           | Postural perturbation                              |
|                           | Sudden release                                    |
|                           | Sudden loading                                    |
|                           | Quick release                                     |
|                           | External load                                     |
| AND                       | Trunk                                             |
| “Trunk”                   | Back                                              |
|                           | Spine                                             |
|                           | Spinal                                            |
|                           | Lumbar                                            |
| AND one of the following keywords |                                    |
| “Pain”                    | Pain                                              |
|                           | Impairment                                        |
|                           | Disorder                                          |
| OR                        | Creep                                             |
| “Creep”                   | Stretch                                           |
|                           | Viscoelastic deformation                           |
|                           | Passive tissue                                    |
|                           | Paraspinal tissue                                 |
|                           | Prolonged flexion                                 |
|                           | Tension–relaxation                                |
|                           | Stiffness                                         |
|                           | Static flexion                                    |
|                           | Cyclic movement                                   |
|                           | Flexion                                           |
|                           | Passive movement                                  |
| OR                        | Muscle fatigue                                    |
| “Fatigue”                 | Fatigue                                           |
|                           | Muscle endurance                                  |

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Appendix B

**Item 1.** Is the hypothesis/aim/objective of the study clearly described?
Yes = 1 / No = 0

When hypothesis was mentioned, a score of 1 was only attributed if the authors have stated a bi or unidirectional hypothesis.

**Item 2.** Are the main EMG reflex response outcomes to be measured clearly described in the methods section?
Yes = 1 / No = 0

If the main outcomes are first mentioned in the Results section, the question should be answered no. Only the outcomes of interest were considered to answer this question.

**Item 3.** Are the characteristics of the participants included in the study clearly described?
Yes = 1 / No = 0

If there were two or more groups, inclusion/exclusion criteria should be given for all groups. A minimum of 3 relevant criteria should be given for each group to attribute a score of 1. Criteria should answer the question [1] if participants experienced or not back pain, [2] for how long they had back pain or for how long they did not have back pain, and [3] if they had any medical condition?

**Item 4.1.** Are the perturbation protocol clearly described?
Yes = 1 / No = 0

**Item 4.2.** Are the protocol of either muscle fatigue, or spinal creep or experimental pain clearly described?
Yes = 1 / No = 0

**Item 6.** Are the main EMG reflex response findings of the study clearly described?
Yes = 1 / No = 0

**Item 7.** Does the study provide estimates of the random variability in the data for the main outcomes?
Yes = 1 / No = 0

In non-normally distributed data the inter-quartile range of results should be reported. In normally distributed data the standard error, standard deviation or confidence intervals should be reported. If the distribution of the data is not described, it must be assumed that the estimates used were appropriate and the question should be answered yes.

**Item 10.** Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?
Yes = 1 / No = 0

**Item 12.** Were those subjects who participated representative of the entire population from which they were recruited?
Yes = 1 / No = 0 / Unable to determine = 0
The study must identify the source population for patients. Where a study does not report the proportion of the source population from which the patients are derived, the question should be answered as unable to determine.

**Item 16.** If any of the results of the study were based on “data dredging”, was this made clear?
Yes = 1 / No = 0 / Unable to determine = 0
Any analyses that had not been planned at the outset of the study should be clearly indicated. If no retrospective unplanned subgroup analyses were reported, then answer yes.

**Item 18.** Were the statistical tests used to assess the main outcomes appropriate?
Yes = 1 / No = 0
The statistical techniques used must be appropriate to the data. If the distribution of the data (normal or not) is not described it must be assumed that the estimates used were appropriate and the question should be answered yes. Statistical analysis plans should correspond to the proposed experiment. When multiple comparison are done, post hoc or planned comparison must be present. The use of covariable must be justified.
| Authors years | Subjects & conditions | Perturbation description | E M G | Outcomes | Main findings |
|---------------|----------------------|--------------------------|------|----------|---------------|
| Akbari et al. 2015 | - 20 cLBP (7M/13F) - 20 healthy (10M/10F) | Standing position: 1% of body mass released from eye level | ES IO EO | - Reflex latency (ms) | - Reflex latency (mean±SD): no difference between groups for ES healthy (56±41) vs ES LBP (59±32), ratio transversus/IO healthy (86±46) vs ratio transversus/IO LBP (88±52) and EO healthy (111±75) vs EO LBP (69±39) |
| Bazrgari et al. 2011 | - 12 healthy (6M/6F) with creep | Standing position: 5mm anterior–posterior external push (T8) | ES RA EO | - Reflex latency (ms) | Baseline (total across all muscles, mean±SD): no difference between pre- (0.043±0.009) and post-creep (0.044±0.011) |
| Dupeyron et al. 2010 | - 10 healthy (M) with fatigue | Semi-sitting position: External push at the upper back (pendulum 50% of the total body mass) | ES EO | - Reflex latency (ms) - Reflex amplitude (%MVC) | Baseline: no difference pre-post fatigue |
| Gao et al. 2014 | - 21 cLBP (M) - 21 healthy (M) | Standing position: Sudden imbalance simulating a sudden fall | ES MF EO | - Reflex latency (ms) - Reflex amplitude | Reflex latency (mean±SD): ES decreased in healthy (182.50±51.02) vs LBP (210.28±48.10), no difference between groups for MF and EO |
| Granata et al. 2001 | - 25 healthy (11M/14F) with fatigue | Standing position: Load of 2.5% of maximal lifting capacity released from 0.5m | ES RA IO EO | - Reflex latency (ms) - Reflex amplitude | Baseline (mean±SD): higher with fatigue for right EO (1.4±0.7 vs 2.1±1.3), right IO (3.8±2.1 vs 5.2±3.7), left IO (5.8±3.2 vs 7.1±5.2), right ES (12.2±5.7 vs 14.3±10.4), left RA (1.3±1.6 vs 1.8±2.7); no difference pre-post fatigue for left EO (3.7±7.1 vs 4.4±7.8), right RA (1.3±1.4 vs 1.7±2.8), left ES (3.7±6.5 vs 15.2±10.1) |
| Study                          | Participants | Fatigue/Creat | Standing position | ES | RA | IO | EO | Reflex activity | Reflex latency | Reflex amplitude | Kinematics | Notes |
|-------------------------------|--------------|--------------|-------------------|----|----|----|----|-----------------|----------------|------------------|------------|-------|
| Granata et al. 2005           | 18 healthy   | with creep   | External push of 75N (T10) | ES | RA | Baseline activity (%MVC) | Reflex latency (ms) | Reflex amplitude (%/N) | Kinematics (mm/N) | Baseline (mean±SD): no difference for RA between pre- (0.05±0.13) and post-creep (0.059±0.14) | Reflex latency: no difference for ES between pre- (67.43±12.84) and post-creep (67.08±13.87) | Reflex amplitude (mean±SD): higher with creep for ES but not significant (1.20±0.57 vs 1.37±0.76) | Kinematics(mean±SD): lower with creep (570±95.1 vs 545±80.8) |
| Granata et al. 2004           | 21 healthy   | with fatigue | Standing position: 2.27kg load released from 0.5 and 1m | ES | RA | Baseline activity (%MVC) | Reflex latency (ms) | Baseline: higher with fatigue for ES (4.74±2.84 vs 6.17±4.36), RA (13.33±4.06 vs 14.23±4.19) and EO (6.5±4.19 vs 7.33±4.24); no difference for IO between pre- (2.8±2.38) and post-fatigue (3.71±3.55) | Reflex latency: No difference pre-post fatigue for ES (126.6±54.5 vs 125.1±66.3), RA (114.8±57.9 vs 130.8±82.8), IO (87.1±41.8 vs 78.6±58.1) and EO (98.70±39.8 vs 90.8±55.7) | Reflex amplitude: No difference pre-post fatigue for ES (18.75±9.30 vs 19.85±7.79), RA (13.09±6.98 vs 10.81±5.66), IO (17.08±8.77 vs 20.15±9.72) and EO (18.77±6.83 vs 14.71±8.44) | Kinematic: No difference between pre- (10.21±8.05) and post-fatigue (10.57±6.63) |
| Grondin et al. 2009           | 15 healthy   | with fatigue | Standing position: 5kg released load from 2.5cm | ES | RA | Baseline activity (%MVC) | Reflex latency (ms) | Baseline: higher with fatigue for all muscles | Reflex amplitude: no difference between pre- and post-fatigue |
| Hendershot et al. 2011        | 12 healthy   | with creep   | Standing position: 5-mm anterior–posterior external push (T8) | ES | RA | Baseline activity (V) | Reflex latency (ms) | Baseline (total across all muscles, mean±SD): no difference between pre- (0.44±0.096) and post-creep (0.45±0.095) | Reflex latency (mean±SD)*: no difference for ES between pre- (63.3±4.9) and post-creep (63.4±4.3) |
| Hermann et al. 2006           | 10 healthy   | with fatigue | Standing position: External push of 170N (inferior | ES | RA | Baseline activity | Reflex latency (ms) | Baseline: no difference between conditions | Reflex latency: no difference between pre- (60±18) and post-fatigue | Reflex amplitude: higher with fatigue (0.65±0.28 vs 0.94±0.37) |
| Study                        | Participants | Standing position | ES | RA | IO | EO | - Baseline activity | - Reflex amplitude | Reflex latency (ms) | Reflex amplitude | Kinematics (°) |
|------------------------------|--------------|-------------------|----|----|----|----|---------------------|--------------------|-------------------|------------------|----------------|
| Jacobs et al. 2011           | - 24 cLBP (13M/11F) | Linear surface translations (moveable platform) | ES | RA | IO | EO | - Baseline activity | - Reflex amplitude | Baseline: higher for ES and RA muscles in LBP group versus healthy group |
|                              | - 21 healthy (8M/13F) |                   |    |    |    |    |                      |                    | Reflex amplitude: no difference between groups |
| Jones, Henry et al. 2012     | - 20 recurrent LBP (9M/11F) | Linear surface translations (moveable platform) | ES | RA | IO | EO | - Baseline activity | - Reflex amplitude | Baseline: higher in LBP group versus healthy group |
|                              | - 21 healthy (8M/13F) |                   |    |    |    |    |                      |                    | Reflex amplitude: higher in LBP group for all trunk muscles (except the right IO) vs healthy participants |
| Jones, Hitt et al. 2012      | - 16 acute LBP (8M/8F) | Linear surface translations (moveable platform) | ES | RA | IO | EO | - Baseline activity | - Reflex amplitude | Baseline: lower in LBP group for the right EO |
|                              | - 16 healthy (8M/8F) |                   |    |    |    |    |                      |                    | Reflex amplitude: higher in LBP group for the left ES and left EO muscles vs healthy participants |
| Larivière et al. 2010        | - 30 cLBP (14M/13F) | Semi-sitting position: 50% of the L5/SI extension moment (upper back) | ES | RA | OE |    | - Baseline activity (%EMGmax) | - Reflex latency (ms) | Baseline (median (interquartile range 25th and 75th percentiles)): higher in LBP group for ES (for M: 15 (12, 21), for F: 24 (15, 27)) vs healthy participants (for M: 11 (9, 14), for F: 15 (6, 21)). No difference for RA (LBP group for M: 20 (10, 28), for F: 24 (11, 35)); healthy group for M: 18 (10, 38), for F: 31 (15, 35)) and OE (LBP group for M: 15 (8, 28), for F: 28 (18, 48); healthy group for M: 19 (10, 34), for F: 24 (16, 36)) |
|                              | - 30 healthy (15M/14F) |                   |    |    |    |    |                      |                    | Reflex amplitude: no difference between LBP and healthy participants for ES (at L3 level for F: 92.07±24 vs 97.8±26.4; for M: 89.6±31.1 vs 85.03±15.5) |
|                              |                   |                   |    |    |    |    |                      |                    | Reflex amplitude: higher in LBP group for ES vs healthy participants |
|                              |                   |                   |    |    |    |    |                      |                    | Kinematics: no difference between groups |
| Author et al.  | Participants | Standing position | Motor Variables | Reflex Activity | Summary |
|---------------|--------------|-------------------|----------------|----------------|---------|
| Liebe-trau et al. 2013 | - 17 cLBP (F) - 17 healthy (F) | Standing position: Sudden loading of 150N at the hand level (hand-held grip) | ES, MF, RA, IO, EO | Baseline activity (μV), Reflex latency (ms), Reflex amplitude (μV) | Baseline (mean±SD): no difference between LBP and healthy groups for ES (2±2 vs 3±2), MF (3±3 vs 2±2), RA (4±3 vs 2±1), IO (14±13 vs 14±11) and EO (9±8 vs 6±3) - Reflex latency (mean±SD): longer in LBP group vs healthy group for RA (54±11 vs 39±11) and IO (76±26 vs 55±11). No difference between LBP and healthy participants for ES (74±39 vs 57±31), MF (85±37 vs 79±43) and EO (39±11 vs 33±6) - Reflex amplitude (mean±SD): no difference between LBP and healthy participants for ES (26±24 vs 30±29), MF (27±25 vs 29±34), RA (42±36 vs 65±53), IO (79±71 vs 85±43) and EO (88±53 vs 104±41) |
| MacDo-nald et al. 2010 | - 13 recurrent unilateral LBP (6M/7F) - 14 healthy (8M/6F) | Standing position: 1kg mass released from the eye level | MF | Baseline activity (μV), Reflex amplitude (μV) | Baseline: no difference between groups - Reflex amplitude: lower in LBP group for deep and superficial MF vs healthy group |
| Mawston et al. 2007 | - Group1: 18 healthy (M) with fatigue - Group2: 13 healthy (M) without fatigue | Standing position: Downward vertical force of 100N at a box hold by participants | ES, RA, IO, EO | Baseline activity (mV), Reflex latency (ms), Kinematics | Baseline and kinematics: no difference between groups - Reflex latency: shorter in both the control and fatigue groups following exercise for ES and EO |
| Muslim et al. 2013 | - 12 healthy (6M/6F) with creep | Standing position: 5mm anterior–posterior external push (T8) | ES, RA, EO | Baseline activity (mV), Reflex latency (ms) | Baseline (total across all muscles, mean±SD): no difference between pre- (0.054±0.009) and post-creep (0.053±0.01) - Reflex latency (mean±SD): shorter after creep for ES (62.9±4.6 vs 61.3±4) |
| Newco-mer et al. 2002 | - 20 cLBP (9M/11F) - 20 healthy (9M/11F) | Standing position: Footplate perturbation (forward, backward) | ES, RA | Baseline activity (μV), Reflex latency (ms) | Reflex latency (mean±SD)*: no difference between healthy (131±28.1) and LBP participants (138.1±23.6) |
| Study                  | Participants                                      | Position                  | Mass released | Reflux latency (ms) | Reflex amplitude | Reflex latency (ms) | Reflex latency (mean±SD) |
|------------------------|---------------------------------------------------|---------------------------|---------------|--------------------|-------------------|--------------------|--------------------------|
| Olson 2014             | 18 healthy (9M/9F) with creep (active and passive conditions) | Standing position: 9.07kg mass released from 1m | ES RA EO | Baseline activity Reflex latency Reflex amplitude Kinematics (°) | Baseline: no difference between pre- (ES: 0.042±0.048, RA: 0.060±0.055 and EO: 0.033±0.063) and post-creep Onset latency: no difference between conditions Reflex amplitude (mean±SD): no difference pre- (ES: 0.35±0.3, RA: 0.25±0.3, EO: 0.16±0.1) and post-active creep (ES: 0.28±0.3, RA: 0.32±0.4, EO: 0.21±0.3). No difference between pre- (ES: 0.37±0.2, RA: 0.19±0.3, EO: 0.17±0.2) and post-passive creep (ES: 0.38±0.4, RA: 0.25±0.4, EO: 0.15±0.1) Kinematics (mean±SD): no difference between pre- and post-creep (10.5±5.2 vs 9.1±5.3 for the active condition, and 10.2±5.0 vs 8.6±5.5 for the passive condition) |
| Radebold et al. 2000   | 17 cLBP (12M/5F) - 17 healthy (12M/5F)            | Semi-sitting position: Sudden released corresponding to 20%-30% MVC (T9) | ES RA EO | Reflex latency Reflex amplitude | Reflex latency (mean±SD): longer in LBP group for ES (85±25) vs healthy participants (69±8) |
| Radebold et al. 2001   | 16 cLBP (15M/1F) - 14 healthy (13M/1F)            | Same as Radebold et al. 2000 | ES RA EO | Reflex latency Reflex amplitude | Reflex latency (mean±SD): longer in LBP group for ES (80±20) vs healthy participants (63±9) |
| Ramprasad et al. 2010  | 25 cLBP (18M/7F) - 25 healthy (15M/10F)           | Standing position: 3kg mass released from 8cm | ES RA EO | Reflex latency Reflex amplitude | Reflex latency (mean±SD): longer in LBP group for RA (52±27) and ES (59±22) muscles vs healthy group for RA (53±19) and ES (53±12) Reflex amplitude: lower in LBP group for RA and ES muscles vs healthy participants |
| Reeves et al. 2005     | 35 cLBP (10F/27M) - 32 healthy                    | Semi-sitting position: Sudden released | ES RA EO | Reflex latency Reflex amplitude | Reflex latency (mean±SD): longer in LBP group for ES (82±15) vs healthy participants (62±10) |
| Study                                      | Participants | Conditions                                                                 | Measures                                                                 | Results                                                                 |
|-------------------------------------------|--------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------|
| Rogers et al. 2006                        | 25 healthy   | Semi-sitting position: External push 75N (T10)                             | ES RA IO EO - Baseline activity - Reflex gain (%MVC/N) - Kinematics (mm/N) | - Baseline: lower after creep for EO - Reflex gain (mean±SD): lower after creep for ES (5.06±3.64 vs 3.98±2.46) - Kinematics (mean±SD): no difference between pre- and post-creep (0.589±0.097 and 0.539±0.093) |
| Shanchez-Zuriaga et al. 2010              | 15 healthy   | Standing position: Moving the trunk from 20° to 40° of trunk flexion at 100°/sec | ES - Reflex latency (ms) - Reflex amplitude (μV)                          | - Reflex latency (mean±SD): longer after creep for ES (left ES: 60±14, right ES: 65±13) vs pre-creep (left ES: 100±28, right ES: 106±31); no difference between pre- (left ES: 62±15, right ES: 70±20) and post-fatigue (left ES: 71±31, right ES: 76±28) - Reflex amplitude (mean±SD): No difference between pre- (left ES: 176±139, right ES: 218±137) and post-creep (left ES: 176±125, right ES: 155±74); no difference between pre- (left ES: 154±82, right ES: 164±75) and post-fatigue (left ES: 145±73, right ES: 158±84) |
| Shenoy et al. 2013                        | 24 cLBP (16M/8F) | Standing position: 3kg mass released from 8cm                             | ES RA - Reflex latency - Reflex amplitude                               | - Reflex latency: longer in LBP group for RA and ES vs healthy participants - Reflex amplitude (mean): lower in LBP group for RA (24.12 ± 7.18) vs healthy (59.96±17.43) and for ES in LBP (56.89±16.58) vs healthy (83.12±14.28) |
| Stokes et al. 2006                        | 21 acute episodic LBP (10F/11M) | Standing position: External push of 5% or 10% of MVC in 80ms (upper back) | ES RA IO EO - Baseline activity                                         | - Baseline: higher in LBP group for all muscles vs healthy participants |
| Toosizadaeh et al. 2013                   | 12 healthy (6M/6F) with creep | Standing position: 5 mm anterior–posterior external push (T8) | ES - Reflex latency                                                    | - Reflex latency (mean±SD)*: longer for ES after creep (61.5±5.08 vs 62.5±5.87) |
EMG: Electromyography; F: Female; M: Male; LBP: Low back pain; cLBP: Chronic low back pain; MVC: Maximal voluntary contraction; SD: Standard deviation; SE: Standard error; ES: Erector spinae; MF: Multifidus; RA: Rectus abdominis; IO: Internal obliquus; EO: External obliquus.

*Reflex latency values from these articles have been obtained by directly asking the authors.*