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Is movement variability altered in people with chronic non-specific low back pain: a protocol for a systematic review

Amal M Alsubaie,[1,2] Masood Mazaheri,[1] Eduardo Martinez-Valdes ,[1] Deborah Falla [1]

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[1]Centre of Precision Rehabilitation for Spinal Pain (CPR Spine), School of Sport, Exercise and Rehabilitation Sciences, University of Birmingham, Birmingham, UK
[2]Department of Physical Therapy, Faculty of Medical Rehabilitation Sciences, King Abdulaziz University, Jeddah, Saudi Arabia

Correspondence to
Professor Deborah Falla; d.falla@bham.ac.uk

ABSTRACT

Introduction Motor variability is an important feature when performing repetitive movement, and in asymptomatic people functional tasks are typically performed with variable motor patterns. However, in the presence of chronic non-specific low back pain (LBP), people often present with different motor control strategies than those without pain. Movement variability has been assessed using a wide range of variables, including kinetic and kinematic components of motion. This has resulted in a wide range of findings reported in the literature and some contradicting results. Therefore, the aim of this systematic review is to investigate whether the amount and structure of motor variability are altered in people with chronic non-specific LBP, during both repetitive non-functional and functional tasks.

Methods and analysis This protocol for a systematic review is informed by Cochrane guidelines and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols. MEDLINE, EMBASE, CINAHL, ZETOC, Web of Science, PubMed and Scopus will be searched from their inception to December 2020 along with a comprehensive search of grey literature and key journals. Two independent reviewers will conduct the search, extract the data, assess risk of bias (using the Downs and Black Scale) for the included studies and assess overall quality of evidence based on Grading of Recommendations, Assessment, Development and Evaluation guidelines. Meta-analysis will be conducted if deemed appropriate. Alternatively, a narrative synthesis will be conducted and evidence summarised as an increase, decrease or no change in the motor variability of people with LBP compared with healthy controls.

Ethics and dissemination This study raises no ethical issues. Results will be submitted for publication in a peer review journal and presented at conferences.

PROSPERO registration number CRD42020211580.

Strengths and limitations of this study

- This systematic review will be the first to rigorously summarise and evaluate the current body of evidence assessing motor variability in people with chronic non-specific low back pain.
- The protocol is written in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols guidelines.
- The methodology of this protocol allows for a wide range of tasks to be considered, including functional and non-functional tasks.
- Based on the methodological diversity among possible eligible studies, a meta-analysis may not be possible.
- The qualitative method used to synthesise the evidence provides the direction of the effect for individual studies without considering the overall magnitude or precision of the effect size.

INTRODUCTION

The socioeconomic burden of low back pain (LBP) is increasing rapidly despite advances in diagnosis and management. In approximately 85%–90% of cases, the pathoanatomical cause of LBP cannot be identified, hence the term non-specific LBP .[1 2] One of the main reasons for individuals with LBP to seek care is limitation of their functional ability[3] which may include reduced physical performance (e.g., strength, mobility, balance, endurance, and coordination).[4]

Repetitive movements during work or activities of daily living can result in injury, especially of the low back.[5] Variation in movements, posture or muscle activity has been suggested as an effective strategy to minimise the load associated with repetitive movements and hence may prevent or delay any potential musculoskeletal injury.[6] Motor variability is an important feature to consider when performing repetitive movement, and in asymptomatic people functional tasks are typically performed with variable motor patterns.[7] The biological systems illustrate an inherited normal variation (lying between too much variability and complete repeatability) in both space and time to maintain or achieve functional skills.[8] However, in the presence of LBP, people often present with

different motor control strategies than those without pain,[9] and changes in motor variability are often reported in both kinematic parameters (e.g., reduced trunk–pelvis coordination and the degrees of freedom during walking or other activities of daily living)[10 11] and neuromuscular variables (e.g., reduced variability of muscle activity during repetitive lifting or other fatiguing tasks).[6 12]

Using different methods to measure human movement, variability has been assessed at various levels, including kinetic and kinematic components of motion, coordinative aspects of movement, and muscle activity and patterns of muscle recruitment.[13] Recently, with the emergence of a range of different mathematical approaches, researchers have used linear and non-linear tools to analyse the amount and structure of motor variability, respectively.[8 14 15] Linear tools to measure variability in terms of the statistical variance (e.g., range, standard deviation and coefficient variation) provide information only about the quantity of the movement but give no insight regarding the temporal variations of movement.[8] Therefore, non-linear tools are used to reveal the structure of variability or the time-evolving nature of the variations and hence provide additional information about the level of complexity of the motor system.[15 16] Non-linear measures employ a wide range of mathematical tools to capture the structure of variability, such as largest Lyapunov exponent,[16] uncontrolled manifold method or the noise-tolerance-covariance decomposition,[14] entropy measures, recurrence quantification analysis, discrete data analysis, normalised root mean square, Cauchy criterion and cluster analysis.[15]

The various methods used to measure variability in people with LBP have resulted in a wide range of results with some contradicting findings. For example, some studies report increased movement variability during gait in people with LBP.[17 18] Other studies report reduced variability during functional or non-functional tasks, which supports the argument that people with LBP increase trunk stiffness as a protective response to pain.[19 20] Other studies have shown no significant difference or change in motor variability in people with LBP.[21 22] The inconsistency in the literature regarding the influence of LBP on motor variability highlights the need to systematically review and synthesise the current literature. To date, there is no comprehensive systematic review that assesses motor variability in people with chronic non-specific LBP. There are reviews that examined motor control changes in general, however, in this case, only specific functional tasks such as gait or standing were considered,[23 24] or the focus was on an older population only.[25]

Therefore, the aim of this systematic review is to investigate whether the amount and structure of motor variability measured in the thoracolumbar and lumbopelvic regions are altered in people with chronic non-specific LBP. Multiple outcome measures are considered, including kinetic, kinematic, coordination and spatiotemporal parameters, during both repetitive non-functional and functional tasks.

Table 1 Summary of inclusion and exclusion criteria

Inclusion criteria	
Population	Adults (≥18 years old), men and women with chronic non-specific LBP and healthy controls
Indicator/exposure	Motion analysis systems (eg, optoelectronic systems, inertial measurement unit sensors)
Comparison	Difference between people with chronic non-specific LBP and healthy controls
Outcomes	Amount and/or structure of movement variability based on linear or non-linear measures
Study type	Quantitative cross-sectional observational studies
Exclusion criteria	
Population	Individuals under the age of 18, people with LBP attributable to a specific pathology, concurrent systemic disorders, surgery, cardiovascular conditions or pregnancy
Indicator/exposure	None
Comparison	None
Outcomes	Studies used spatiotemporal parameters based on neuromuscular variables
Study type	Cadaveric or animal studies, single-subject case reports and longitudinal cohort studies. Studies not written in English will be excluded

LBP, low back pain.

METHODS

The protocol for this review was developed in accordance with the updated guidelines of the Cochrane Back and Neck Group, Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P)[26–28] (online supplemental file 1). This protocol was registered on PROSPERO on 10 December 2020.

Eligibility criteria

The inclusion and exclusion criteria of the studies to be included in the review are detailed using the PICOS (P: Population; I: Indicator/Intervention; C: Comparator; O: Outcome(s); S: Study design) framework[28 29] (table 1).

Population

Studies that investigated adults aged 18 years or older with chronic non-specific LBP that persisted for at least 3 months with no diagnosable underlying pathology will be considered for inclusion.[30] For the purpose of this review, adults without a history of LBP will represent the control group. Studies will be excluded if they recruited people with LBP due to trauma, fractures, spinal stenosis or radicular pain. Studies will be eligible that included people

Table 2 Summary of outcome measures

Outcome measures domains			
Concept measured	Broad domains	Narrow domains	
Movement variability, captured using movement outcomes specifically related to thoracolumbar and lumbopelvic segments during both functional and non-functional tasks	Amount or magnitude of variability—for example, using traditional linear measures (statistical variance)	SD	
		Range	
		Coefficient of variation	
	Structure and nature of variability—for example, using non-linear dynamics	Intra-trial	Entropy measure
			Recurrence quantification analysis
			Largest Lyapunov exponent
		Inter-trial Inter-subject	Normalised root mean square
			Cauchy criterion
			Cluster analysis
			Uncontrolled manifold

with LBP and healthy participants with no concurrent systemic disorders, including rheumatic and neuromuscular disorders, spinal deformity or surgery, cardiovascular conditions and pregnancy.

Indicator

Studies will be included if they used any method to quantify spinal movement at the thoracolumbar and lumbopelvic level in the form of kinetic, kinematic, coordination or spatiotemporal parameters using motion analysis systems (eg, optoelectronic systems, inertial measurement unit sensors).[19 31]

Comparison

Included studies should have compared motor variability between individuals with chronic non-specific LBP and healthy controls while preforming functional (eg, gait) or non-functional tasks (eg, repetitive trunk movements).

Outcomes

Studies that used any outcome to quantify motor variability will be considered. The outcomes include the amount of motor variability captured by linear tools or the structure of motor variability recorded by non-linear tools.[8] The wide range of movement variables may use kinetic or kinematic components of motion, coordinative aspects of movement or spatiotemporal parameters (table 2).

Study design

Observational cross-sectional studies will be reviewed, excluding cadaveric or animal studies and single-subject case reports as well as studies not written in English.

Information sources

The following databases will be searched from their inception to December 2020: MEDLINE (OVID Interface), EMBASE (OVID Interface), CINAHL (EBSCO Interface), ZETOC (EBSCO Interface), Web of Science, PubMed and Scopus. In addition to the database searching, hand-searching of key journals will be conducted. This will include the following key journals: *Journal of Electromyography and Kinesiology*, *Clinical Biomechanics*, *Journal of Biomechanics*, *Human Movement Science*, *The Clinical Journal of Pain*, *Spine*, *Journal of Orthopaedic & Sports Physical Therapy*, *Musculoskeletal Science and Practice* and *Journal of Back & Musculoskeletal Rehabilitation*.

Distinguished authors in the field will be contacted to identify any relevant work which is currently in preparation or unpublished to carry as extensive search as possible to reduce the risk of publication bias and to identify as much relevant evidence as possible. Grey literature will be included in the search using the British National Bibliography for Report Literature, OpenGrey database, ProQuest Dissertations & Theses Global, and EThOs. Key congresses and meetings in the field will be assessed from 2017 to 2020, including the World Congress of Biomechanics and the International Society of Electrophysiology and Kinesiology congresses. In accordance with the Methodological Expectations of Cochrane Intervention Reviews standards, hand-searching will be conducted to check reference lists in included studies and any relevant systematic reviews identified.[32]

Search strategy

A comprehensive, systematic and reproducible search strategy will be completed by the lead author (AMA). The search strategy has been developed using medical subject heading (MeSH) (including exploded terms) combined with keywords to ensure maximal retrieval. The search strategy will be developed in accordance with the defined PICOS components and will be linked with the Boolean terms AND/OR where relevant. There will be no restrictions implemented during the search in terms of the study design, region or date. The search strategy will remain consistent between databases. However, appropriate modifications with relevant syntax and MeSH terms will be performed to the main search strategy to adapt for other databases. A draft-developed search strategy for MEDLINE (OVID interface) database is available in online supplemental file 2.

Data management

Search data will be imported into EndNote V.X9 (Clarivate Analytics), including citations, abstracts and full text of relevant studies. One reviewer (AMA) will upload studies, identify any duplicate results and remove these prior to the screening process. A complete list of all potentially eligible studies with full text will be stored in EndNote V.X9 and is ready for screening process by two independent reviewers (AMA and MM).

Selection process

An electronic screening form will be created and piloted based on the eligibility criteria to subcategorise the studies into include/exclude/unclear. In the initial step of the screening process, AMA and MM will assess and subcategorise studies based on the title and abstract using the developed screening form. In the case that the eligibility is unclear from the title and abstract, the reviewers will read the full text of the article to assess inclusion. If it is still unclear, reviewers will discuss article eligibility. In the event of disagreement, a third reviewer (DF) will be asked to mediate the process. The study selection process will be summarised and depicted using the PRISMA flow diagram.[27] During all assessment stages, agreement between reviewers will be estimated with percentage of agreement and the κ statistic using SPSS for Windows statistical software package (IBM SPSS Statistics V.25).

Data collection process

Using a standardised form developed to extract data, both reviewers (AMA and MM) will independently extract information from eligible studies. Any disagreement between reviewers will be mediated through discussion with a third reviewer (DF) if needed. Prior to data collection, the data extraction form will be piloted to ensure all relevant information is collected, and any necessary changes will be implemented prior to data extraction from all eligible studies.

Data items

The characteristics of the included studies are summarised and presented in table 3. In the case of missing data or if the results are presented in an ambiguous way, the corresponding author will be contacted for clarification. If the author does not respond within a set time frame (up to 6 weeks) or the provided clarification affects the eligibility, the study will not be considered for review. If two or more papers appeared to use the same sample, the authors will be contacted for further information to ensure data are not duplicated in the review.

Risk of bias

Unlike the abundance of instruments developed to judge the methodological quality of randomised clinical trials, there is lack of a gold-standard instrument designed for quantifying the quality of observational cross-sectional studies. Hence, a modified version of Downs and Black Scale,[33] designed for assessing the quality of both randomised and non-randomised studies, will be used for quality rating in this study. The modified version consists of four domains (12 items), including quality of reporting (7 items), the generalisability of results or external validity (1 item), the relationship between LBP and outcomes, known as internal validity (4 items) and the adequacy of sample size or study power (1 item) (table 4). Two authors (AMA and MM) will separately assess the quality of the eligible studies.

Table 3 Characteristics of included studies

Information area	Data extracted
General study information	Authors Year of publication Title Study design
Patient characteristics	Age, sex, anthropomorphic data, sample size (healthy and LBP) LBP details (pain duration, current and past pain intensity, pain location)
Methodology	Setting Details of task preformed (functional or non-functional, length of recording, repetition, position, etc) Instrument used (3D capture system, Inertial measurement unit sensor etc) Regions of the spine assessed (eg, thoracolumbar or lumbopelvic)
Outcome	Amount or structure of motor variability using any movement outcome related to kinetic, kinematic and coordinative aspects of movement or spatiotemporal parameters of movement

3D, three-dimensional; LBP, low back pain.

Data synthesis

Based on the methodological diversity revealed among the possible eligible studies during the scoping search, pooling of data may not be possible; however, this will not be ruled out and meta-analysis will be conducted if possible. If a meta-analysis is deemed not possible, a narrative synthesis will be performed. An initial step of our synthesis is to systematically and comprehensively assess the results of each study—highlight any important characteristics of the studies, especially the important similarities or differences. Ideally, the processes of narrative synthesis should avoid bias by following a clear specified method in advance. We will make further decisions at review stage about how best to organise and present the data based on the actual review findings.[34]

Results of the included studies will be organised in subgroups in the same order as the comparisons and outcomes. To improve consistency, the following items will be contained[26]: overall quality of evidence, the number of participants, the outcome measures, results

Table 4 Quality rating instrument adjusted specifically for the current review (informed by Downs and Black Scale)

Item	Scoring guideline
Reporting	
1. Is the hypothesis/aim/ objective of the study clearly described?	
2. Are the main outcomes to be measured clearly described in the Introduction or Methods section?	
3. Are the inclusion/exclusion of the participants included in the study clearly described?	
4. Are the demographic characteristics of the participants included in the study clearly described?	The question is answered 'yes' if information about *age and gender* is provided
5. Are the clinical characteristics of the participants included in the study clearly described?	The question is answered 'yes' if information about *LBP type, duration, severity* or *disability level* is provided
6. Is the treatment history of the LBP participants clearly described?	
7. Does the study provide estimates of the random variability in the data for the main outcomes?	The question is answered 'yes' if studies have provided quantitative values of the SE, SD or CI (for normally distributed data) and IQR (for non-normally distributed data)
External validity	
8. Were the participants who were asked to participate in the study representative of the entire population from which they were recruited?	The question is answered 'yes' if the studies have used several recruitment methods (eg, self-report, hospital, insurance companies)
Internal validity/bias and confounding	
9. If any of the results of the study were based on 'data dredging', was this made clear?	The question is answered 'yes' if no retrospective unplanned subgroup analyses were reported
10. Was an attempt made to blind those measuring the main outcomes?	
11. Were the main outcome measures representing movement variability reliable?	The question is answered 'yes' if there is a reference to a reliability study or information on these features in the paper and this paper should cover the field of interest (LBP)
12. Were controls matched with LBP participants in important characteristics?	The question is answered 'yes' if appropriate matching on confounders, that is, age and gender, was performed or if adjustment for these variables is made in the statistical analysis
Power	
13. Was there an appropriate sample size of LBP participants and controls?	The question is answered 'yes' if a sample size justification or power description is provided

LBP, low back pain.

of quantitative analyses (effect size/ Confidence interval CI) and results of qualitative analyses (direction of the effect; an increase, decrease or no change in the motor variability of people with LBP compared with healthy controls).

Examining the effects of heterogeneity will also be assessed, especially how the results of the included studies might be affected by factors such as methodological differences between studies.[34] The robustness of the results will be assessed with a sensitivity analysis to test the effect of quality/risk of bias on the results by excluding studies that were characterised as high risk of bias.[35]

Confidence in cumulative estimate

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) method will be used to rate the overall cumulative quality of the evidence across individual studies.[36] The pooled data will be assessed based on five determinants of the GRADE: risk of bias[37]; inconsistency, heterogeneity in studies in the review (eg, age group and severity of spinal pain)[38]; indirectness; imprecision (larger sample sizes indicate greater precision)[39]; and, finally, publication bias arising from non-publication of relevant results.[40]

As it is anticipated that the included studies will be mostly observational studies with cross-sectional designs, these studies will be given a 'LOW' rating initially in the GRADE framework. However, from this point, the quality of evidence of the study can then be downgraded or upgraded depending on the above determinants. It can also be upgraded based on the large effect sizes or a large number of studies indicating the same direction of effect. Following this process subsequently, quality of evidence will be graded as 'VERY LOW', 'LOW', 'MODERATE' or 'HIGH' according to the GRADE guidelines.[41]

Patient and public involvement

The research question in this study forms part of a larger discussion within our patient and public involvement meetings. Patients will not be involved in the analysis and data collection of the systematic review.

Clinical implications of this study

Motor variability is considered as an important feature of motor control and is therefore relevant to measure and consider in assessment and management of people with LBP.[8] However, it is not well established to what extent motor variability can be affected in the presence of chronic LBP. Thus, the results of this systematic review may identify various features of motor variability which are altered in people with chronic LBP, and subsequently influence the direction of clinical practice.

ETHICS AND DISSEMINATION

No ethical approval is required for this review as the data that will be used in this systematic review will be collected from previously published studies. The results of this

systematic review will be submitted for publication in a peer review journal and presented at conferences.

Amendment protocol

Where amendments are required from the protocol during the review process, these amendments will be documented on PROSPERO. All amendments will be clearly marked with the date of the amendment and a description of the changes, alongside a justification for the change.

Twitter Amal M Alsubaie @AmalAlsubaie15, Eduardo Martinez-Valdes @mredumartinez and Deborah Falla @Deb_Falla

Contributors All authors contributed to the focus of the systematic review topic. AMA is a PhD student with DF as lead supervisor and EM-V as co-supervisor. AMA is the first reviewer for this systematic review, and MM is the second reviewer. AMA drafted the initial protocol with guidance and feedback at all stages from DF, EM-V and MM. All authors have revised and reviewed each draft of the protocol and have approved the final manuscript. DF is the guarantor.

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Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

ORCID iDs

Eduardo Martinez-Valdes http://orcid.org/0000-0002-5790-7514
Deborah Falla http://orcid.org/0000-0003-1689-6190

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PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol*

Section and topic	Item No	Checklist item	(Page No.#)
ADMINISTRATIVE INFORMATION			
Title:			
Identification	1a	Identify the report as a protocol of a systematic review	1
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	N/A
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	2&6
Authors:			
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	1
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	19
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	19
Support:			
Sources	5a	Indicate sources of financial or other support for the review	19
Sponsor	5b	Provide name for the review funder and/or sponsor	19
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	19
INTRODUCTION			
Rationale	6	Describe the rationale for the review in the context of what is already known	5
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	5-6
METHODS			
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	6-7-8/Table 1
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	9
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	10/Supplementary material 2

Study records:			
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	10
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	10-11
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	11
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	11&12/Table 3
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	12/Table 3
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	12-13/Table 4
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised	8&14/Table 2
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, Kendall's τ)	8&14/Table 2
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	14
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	14
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	14
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	14-15

*** It is strongly recommended that this checklist be read in conjunction with the PRISMA-P Explanation and Elaboration (cite when available) for important clarification on the items. Amendments to a review protocol should be tracked and dated. The copyright for PRISMA-P (including checklist) is held by the PRISMA-P Group and is distributed under a Creative Commons Attribution Licence 4.0.**

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015 Jan 2;349(jan02 1):g7647.

Search Strategy:

MEDLINE

1. ((lumba* or low* back) adj3 (pain* or ach* or injur*)).mp.
2. exp Low Back Pain/
3. (lumbago or lumbalgia).mp.

4. 1 or 2 or 3

5. (trunk or torso or back or spine).mp.
6. exp Lumbosacral Region/
7. Thoracolumbar.mp.
8. exp Spine/

9. 5 or 6 or 7 or 8

10. ((movement or motion) adj2 (Varia* or Quality or Complexit* or Irregularit* or Consistenc* or Inconsistenc* or Stabil* or kinematic* or Coordination)).mp.
11. Mechanical coupling.mp.
12. exp motor control/

13. 10 or 11 or 12

14. 4 and 9 and 13

15. limit 14 to (english language and humans)