Approche des systèmes complexes dans la lombalgie : une exploration des liens entre douleur et mouvement

Alexis HOMS
Médecine Physique et Réadaptation, CHU Nîmes

Cursus

Master 2 Sciences du Mouvement Humain – 2018
Parcours Apprentissage, Biomécanique et Contrôle moteur

Co-encadrement : Kjerstin TORRE et Arnaud DUPEYRON

Relation entre complexité et douleur
dans une tâche de marche avec distraction
chez le patient lombalgique chronique par analyse fractale

Résultats partiels

Premiers contacts avec la réalité pratique d'une recherche

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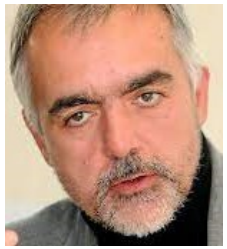
Relationship between gait complexity and pain attention in chronic low back pain

Alexis F. Homs[a,b,*], Arnaud Dupeyron[a,b], Kjerstin Torre[b]

[a] *Physical Medicine and Rehabilitation Department, CHU Nimes, Univ Montpellier, Nimes, France,* [b] *EuroMov Digital Health in Motion, Univ Montpellier, IMT Mines Ales, Montpellier, France*



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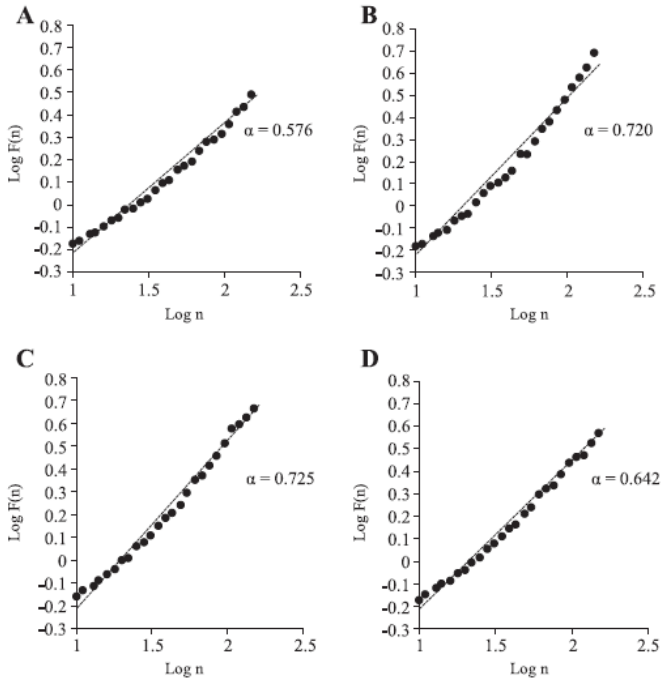

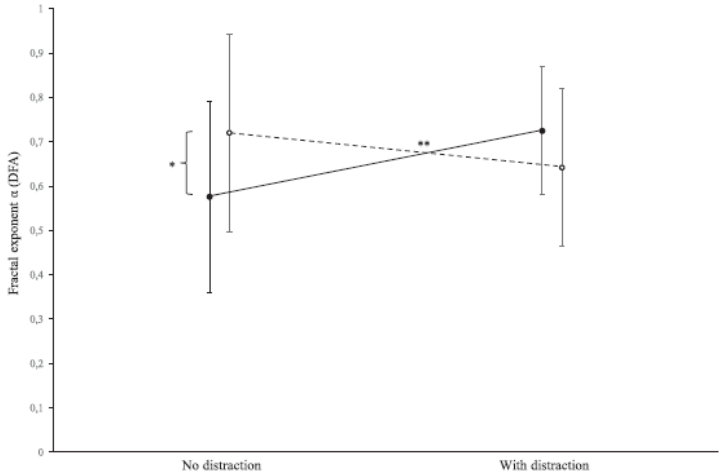

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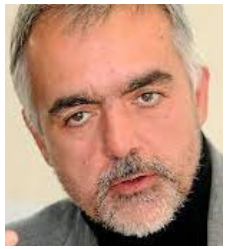

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EDITORIAL

Physical rehabilitation research and pain science

Sterling, Michele[a]; Keefe, Francis J.[b]

Author Information

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1. Introduction

There is growing recognition of the important contributions that physical rehabilitation research can make in our understanding and ability to treat pain. In light of the burgeoning research in this area, *PAIN* has recently added a new Section Editor (coauthor: M.S.) to our Clinical Section; Dr. Sterling's specific focus will be on research articles in the pain rehabilitation area. This new effort in our Clinical Section is in recognition of the increasingly important that role physical rehabilitation science plays in pain research.

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Sujet de thèse

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Approche des systèmes complexes dans la lombalgie : une exploration des liens entre douleur et mouvement

Doctorat à temps partiel

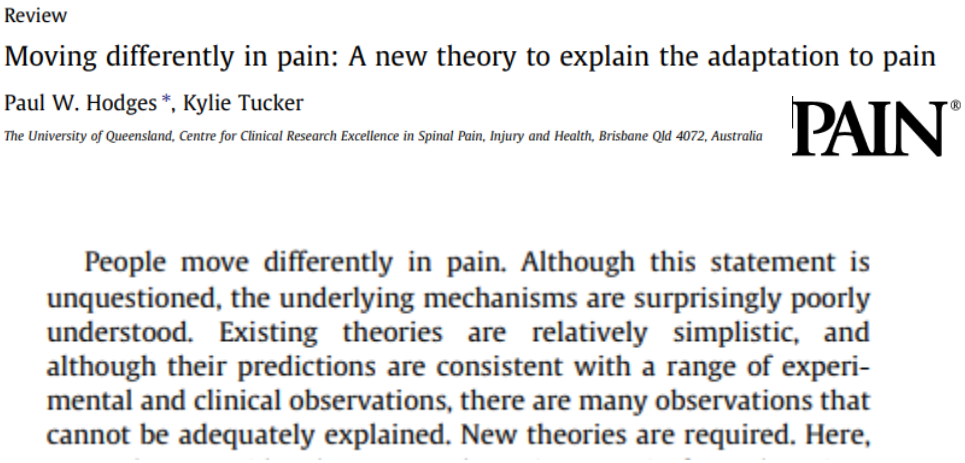
Plutôt 4 ans

Sujet de thèse

Approche des systèmes complexes dans la lombalgie : une exploration des liens entre douleur et mouvement

Répercussions fonctionnelles majeures de la lombalgie chronique

Modifications qualitatives et quantitatives de la façon de bouger



Review

Moving differently in pain: A new theory to explain the adaptation to pain

Paul W. Hodges *, Kylie Tucker

The University of Queensland, Centre for Clinical Research Excellence in Spinal Pain, Injury and Health, Brisbane Qld 4072, Australia

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People move differently in pain. Although this statement is unquestioned, the underlying mechanisms are surprisingly poorly understood. Existing theories are relatively simplistic, and although their predictions are consistent with a range of experimental and clinical observations, there are many observations that cannot be adequately explained. New theories are required. Here,

Time to Reflect on the Role of Motor Control in Low Back Pain

PAUL W. HODGES, *PT, PhD, DSc, MedDr, BPhty (Hons)*
Clinical Centre for Research Excellence in Spinal Pain, Injury and Health, School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, Australia.

JAAP H. VAN DIEËN, *PhD*
Department of Human Movement Sciences, Vrije Universiteit Amsterdam and Amsterdam Movement Sciences, Amsterdam, the Netherlands.

JACEK CHOLEWICKI, *PhD*
Center for Orthopedic Research, Michigan State University, Lansing, MI.
Department of Osteopathic Surgical Specialties, Michigan State University, East Lansing, MI.

J Orthop Sports Phys Ther 2019;49(6):367-369. doi:10.2519/jospt.2019.0104

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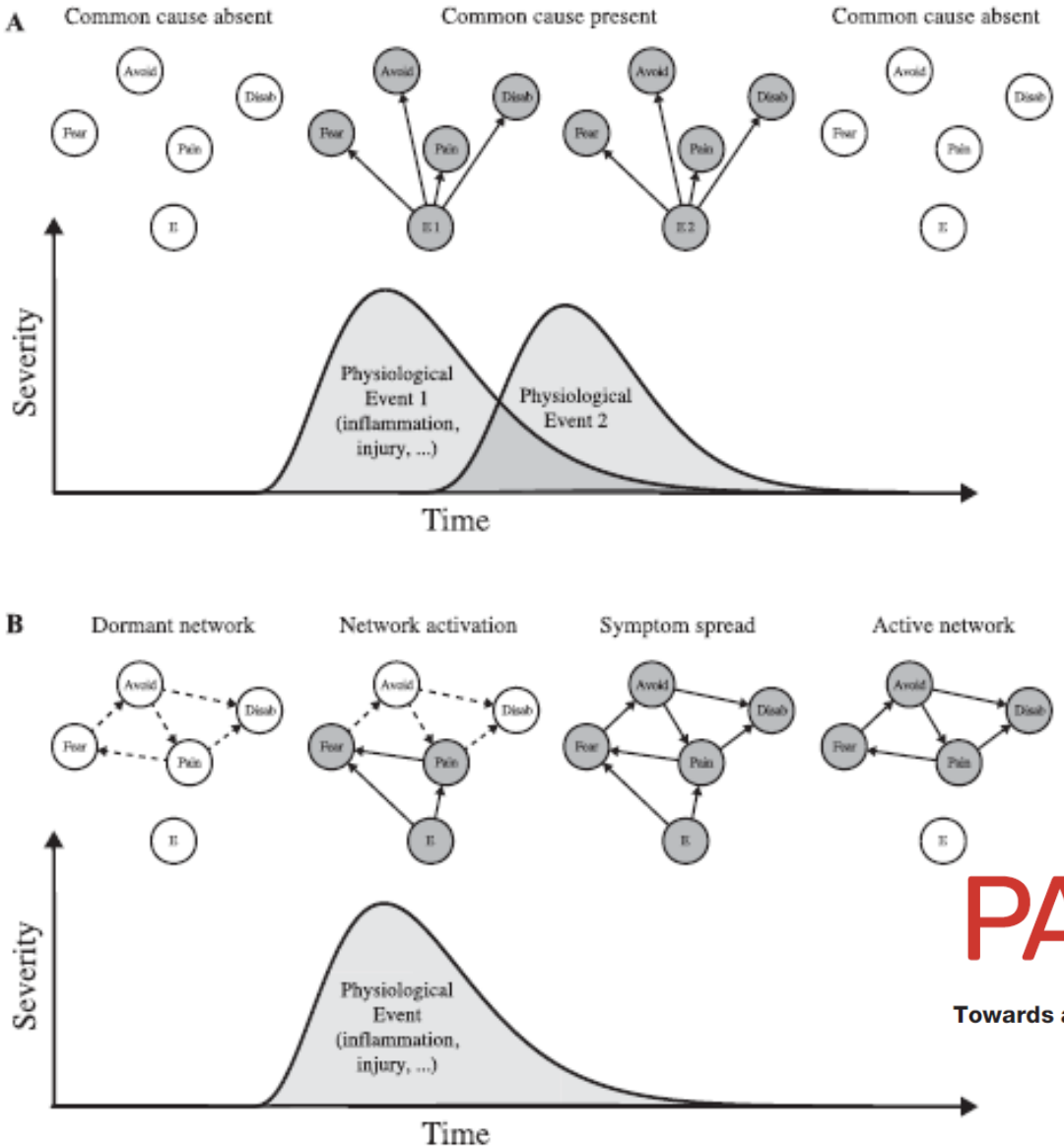

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Towards a dynamic account of chronic pain

Vlaeyen et al., 2022

Figure 1. Development of chronic pain after injury (based on ref. 1). (A) A simplified presentation of the common cause model: symptoms (fear, pain, avoidance, disability…) are assumed to be caused by a common cause (E1 and E2, eg, a physiological event such as injury or inflammation). If the common cause resolves, the symptoms also disappear. (B) A simplified presentation of dynamics of the network model: symptoms influence each other and can be maintained even when the nociceptive or neuropathic contributions are resolved. For example, a physiological event (E) that is external to the network activates a dormant network of observable and connected symptoms such as pain and fear, which may spread to other symptoms, such as avoidance and disability. In a strongly connected network, removal of the physiological event does not lead to recovery as the network is self-sustaining.

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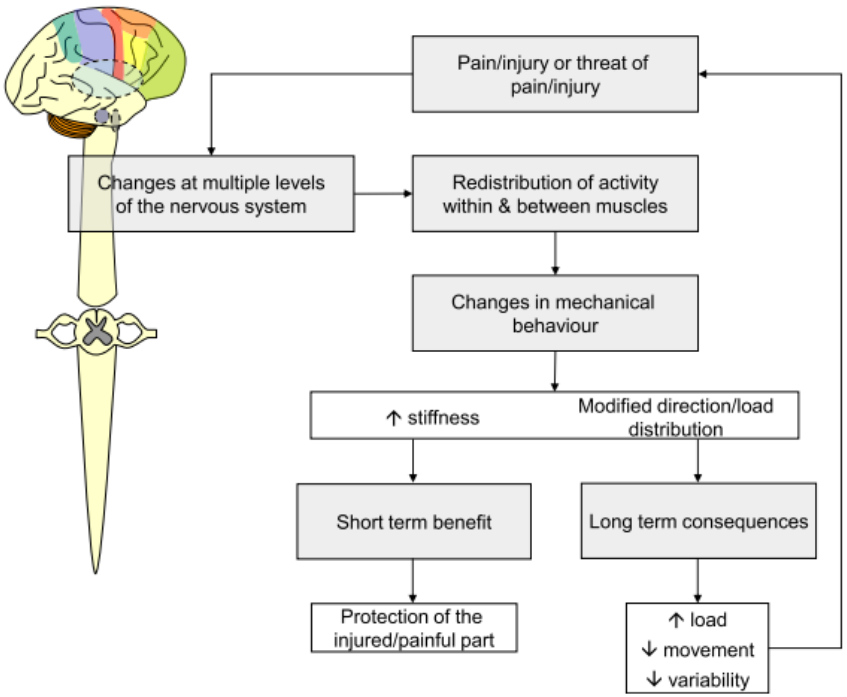
3.2. Changes in motor control during pain are not always stereotypical or predictable

Existing theories predict relatively stereotypical change in whole-muscle behaviour, but this has not been observed, and variable patterns of adaptation are identified in clinical populations and in response to experimental pain (e.g., [35,99]). Although some aspects of the motor adaptation to pain are consistent between individuals (e.g., [36,37,50]), changes in behaviour of other muscles are unique to the individual and possibly to the task [36,99]. This is most common in complex systems such as the trunk, where the muscle system has considerable redundancy (multiple muscles achieve a similar goal) [35,99]), and jaw [63,74], where there is complex muscle anatomy [26]. New theories must account for the variability.



4. New theory for the motor adaptation to pain

A theory to explain the adaptation to pain must account for each issue highlighted above, particularly the variability between individuals and tasks. We propose a new theory based on existing data at the micro (motoneuron discharge) and macro (whole-muscle behaviour) levels. The theory has 5 key elements that expand

4.1. Pain leads to redistribution of activity within and between muscles

4.2. Adaptation to pain changes mechanical behaviour

4.3. Adaptation to pain leads to protection from pain or injury, or threatened pain or injury

4.4. Adaptation to pain involves changes at multiple levels of the motor system

4.5. Adaptation to pain has short-term benefit, but with potential long-term consequences

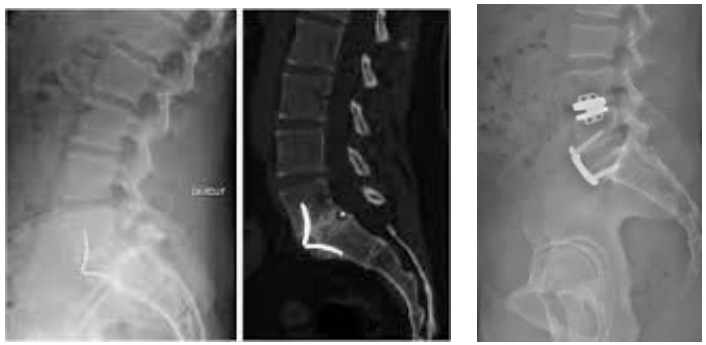
Complexity of movement dynamics is one typical feature of final motor output, representing the integration of these interactions,[12] at a biomechanical and neurological level, from peripheral to central regulations.[49] Loss of complexity can be associated with a reduction of degrees of freedom in the system, thereby resulting in reduced adaptive capacities, and has been found to be related to senescence or pathological conditions.[44,77] On the one hand, such loss can result from a loss of components and/or loss of interactions between components of the system.[14] On the other hand, loss of complexity is also found when a component or system process becomes dominant, eg, when environmental constraints force the attentional prioritization of one source of feedback over the others.[15,75] In the context of pain-related movement and especially cLBP, a reduction of complexity could thus basically be interpreted as a reduction in movement degrees of freedom, either as a result of disk degeneration or neuromuscular modifications (trunk stiffening and reduction of lumbopelvic relative movements[38]) or as a result of the prominence of attentional resources allocated to pain processing and to fear of pain.[42]

This result has clinical implications at several levels. Indeed, motor control changes associated with cLBP and their long-term negative consequences have been extensively described.[38] However, evidence is scarce as to the mechanisms driving these changes,[67] especially in ecological contexts. The finding that visual distraction leads to improved structural variability of gait pattern in cLBP emphasizes the relationship between motor control and cognitive and behavioral processes, known to be distorted in cLBP in clinical settings.[13] Especially, our results

Objectif : utiliser l'approche des systèmes complexes pour explorer la relation entre douleur lombaire et mouvement

Etude n°1

Etude prospective sur l'évolution de la complexité dans les suites d'une chirurgie lombaire



Chirurgie d'arthrodèse => perte de degrés de liberté

Cette perte de DDL ⇔ perte de capacités d'adaptation ?

Hypothèse : L'intervention chirurgicale entraîne une amélioration de la complexité des patients lombalgiques

CPP et financement

Etude n°2

Le fait d'imposer une stratégie de guarding induit-il une perte de complexité chez les sujets sains ?

Guarding = attitude de protection

Rigidification du mouvement

Hypothèse : Le fait d'imposer une stratégie de guarding induit une diminution de la complexité des sujets sains

IRB  Moyens techniques 

Etude n°3

Relation entre kinésiophobie et paramètres non-linéaires de la marche des patients lombalgiques chroniques en situation écologique à l'aide d'une approche d'apprentissage automatique

Kinésiophobie : notion très imagée cliniquement / peu de données en vie réelle

Identifier ces patients clairement => stratégies thérapeutiques différentes

Hypothèse : Il est possible de différencier les patients lombalgiques K+ des K- par l'analyse de leur pattern de marche

CPP ! Moyens techniques ✗ Moyens humains ! Financement !

Contents lists available at ScienceDirect

Computers in Biology and Medicine

journal homepage: www.elsevier.com/locate/compbiomed

Association between central sensitization and gait in chronic low back pain: Insights from a machine learning approach

Xiaoping Zheng [a,*], Michiel F. Reneman [b], Jone Ansuategui Echeita [b], Rita HR. Schiphorst Preuper [b], Herbert Kruitbosch [c], Egbert Otten [a], Claudine JC. Lamoth [a]

[a] University of Groningen, University Medical Center Groningen, Department of Human Movement Sciences, Groningen, Netherlands
[b] University of Groningen, University Medical Center Groningen, Center for Rehabilitation, Groningen, the Netherlands
[c] University of Groningen, Center for Information Technology, Data Science Team, Groningen, the Netherlands

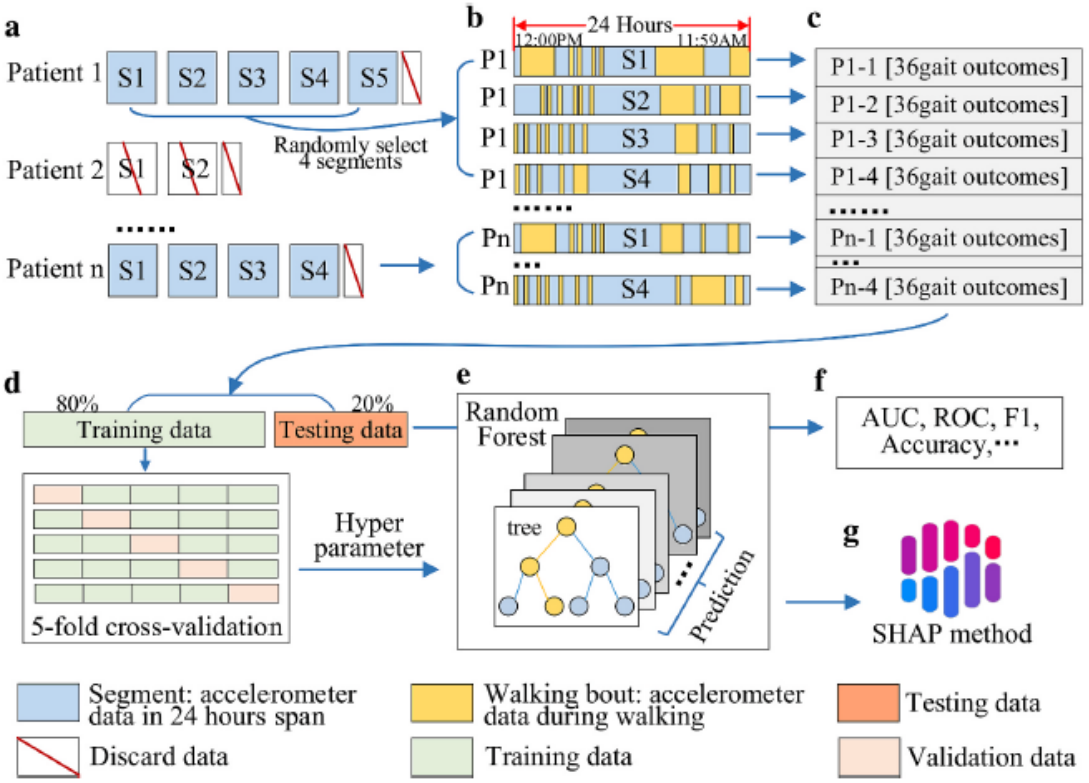


Fig. 1. The data processing and analysis: (a) raw data segmentation, (b) walking bouts extraction, (c) gait outcome vectors, (d) training and testing data preparation, (e) Random Forest classifier, (f) accuracy evaluation, (g) feature importance.

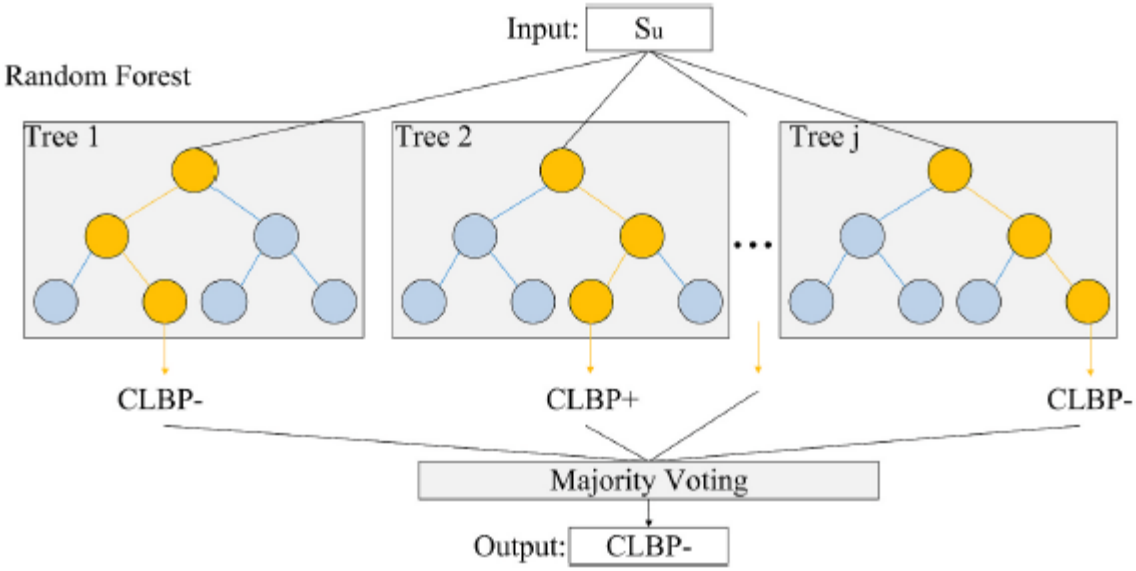


Fig. 2. Architecture of the Random Forest classifier.

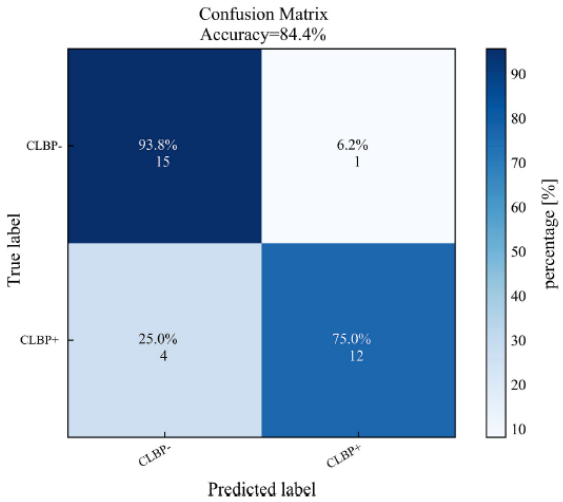


Fig. 3. Classification results for Random Forest, and the mean accuracy was 84.4%. CLBP-, CLBP+: Patients with chronic low back pain with lower (–) and higher (+) central sensitization levels.

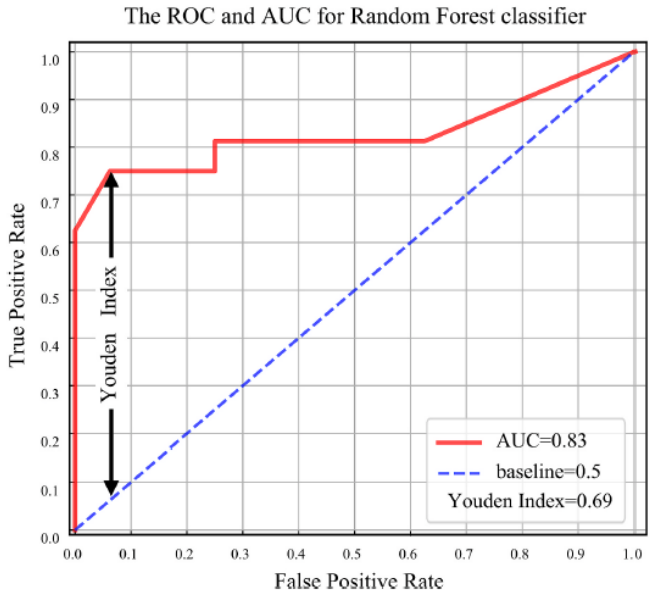


Fig. 4. The receiver operating characteristic (ROC) curve (in red) for Random Forest classifier. AUC: area under the curve.

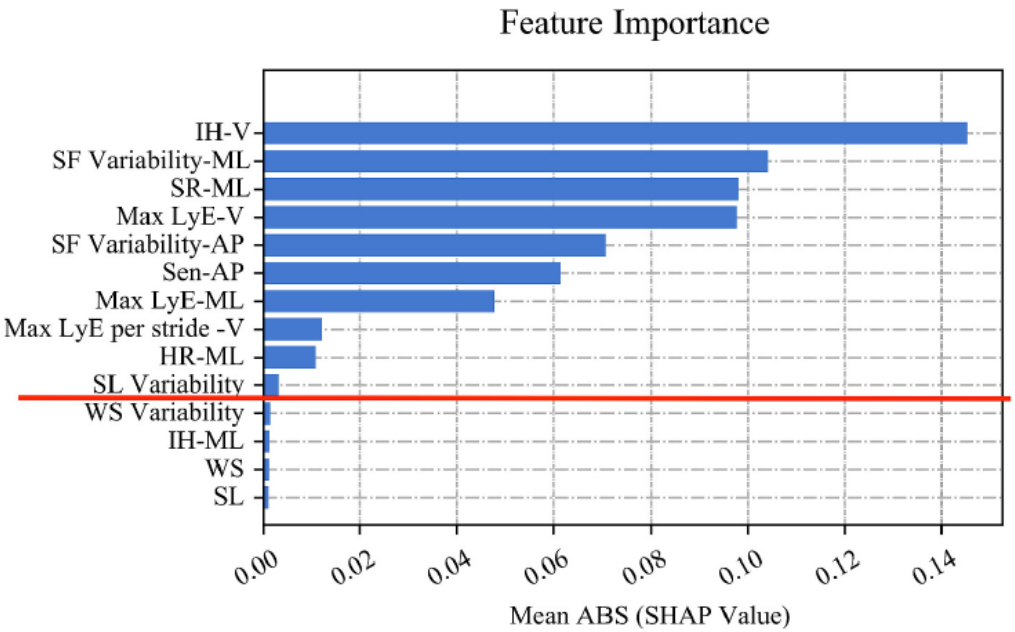
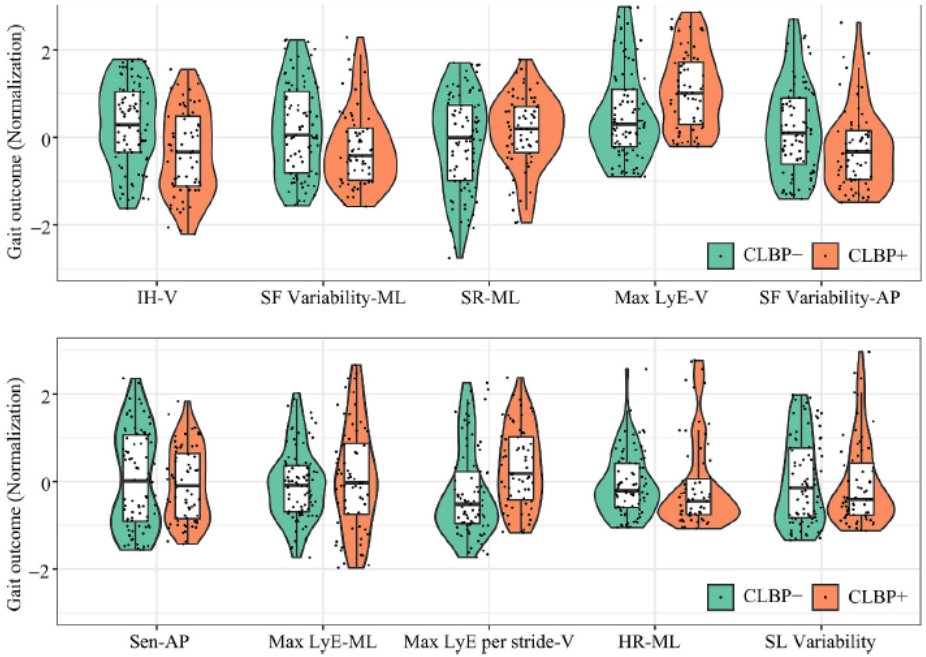


Fig. 5. Features importance of Random Forest classifier. The 10 gait outcomes above the red line are: index of harmonicity in vertical direction (IH–V), variability of stride frequency in mediolateral/anteroposterior direction (SF variability-ML/AP), stride regularity in mediolateral direction (SR-ML), Maximal Lyapunov exponent in vertical/mediolateral direction (Max LyE-V/ML), sample entropy in anteroposterior direction (Sen-AP), Max LyE-V: Maximal Lyapunov exponent per stride in vertical direction, harmonic ratio in mediolateral direction (HR-ML) and variability of stride length (SL variability). The remaining gait outcomes below the red line are: WS variability: variability of walking speed, IH-ML: index of harmonicity in mediolateral direction, WS: mean walking speed and SL: mean stride length. ABS: absolute value. SHAP: SHapley Additive exPlanations.



comes. Dots show the individuals data. CLBP-, CLBP+: Patients with chronic low back pain with low (−) and high (+) CS levels. IH-V: index of harmonicity in vertical direction, SF variability-ML/AP: variability of stride frequency in mediolateral/anteroposterior direction, SR-ML: stride regularity in mediolateral direction, Max LyE-V/ML: Maximal Lyapunov exponent in vertical/mediolateral direction, Sen-AP: sample entropy in anteroposterior direction and HR-ML: harmonic ratio in mediolateral direction.