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Research Paper Review

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Acute repetitive lumbar syndrome: A multi-component insight into the disorder

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ABSTRACT

Purpose

Repetitive Lumbar Injury (RLI) is common in individuals engaged in long term performance of repetitive occupational/sports activities with the spine. The triggering source of the disorder, tissues involved in the failure and biomechanical, neuromuscular, and biological processes active in the initiation and development of the disorder, are not known. The purpose is, therefore, to test, using in-vivo feline model and healthy human subjects, the hypothesis that RLI due to prolonged exposure to repetitive lumbar flexion–extension is triggered by an acute inflammation in the viscoelastic tissues and is characterized by lingering residual creep, pronounced changes in neuromuscular control and transient changes in lumbar stability. This report, therefore, is a summary of a lengthy research program consisting of multiple projects.

Methods

A series of experimental data was obtained from in-vivo feline groups and normal humans subjected to prolonged cyclic lumbar flexion–extension at high and low loads, high and low velocities, few and many repetitions, as well as short and long in-between rest periods, while recording lumbar displacement and multifidi EMG. Neutrophil and cytokines expression analysis were performed on the dissected feline supraspinous ligaments before loading (control) and 7 h post-loading. A comprehensive, time based model was designed to represent the creep, motor control, tissue biology and stability derived from the experimental data.

Results

Prolonged cyclic loading induced creep in the spine, reduced muscular activity, triggered spasms and reduced stability followed, several hours later, by acute inflammation/tissue degradation, muscular hyperexcitability and hyperstability. Fast movement, high loads, many repetitions and short rest periods, triggered the full disorder, whereas low velocities, low loads, long rest and few repetitions, triggered only minor but statistically significant pro-inflammatory tissue degradation and significantly reduced stability.

Conclusion
Viscoelastic tissue failure via inflammation is the source of RLI and is also the process which governs the mechanical and neuromuscular characteristic symptoms of the disorder. The experimental data validates the hypothesis and provides insights into the development of potential treatments and prevention.

ANALYSIS

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Background Information
Repetitive lumbar injury (RLI), also known as repetitive stress or cumulative trauma, can present with weakness, range of motion deficiencies, myofascial pain and joint dysfunction. Whether you are working at a desk in front of a computer, on the construction site or in the sporting arena, repetitive lumbar injury is prevalent and relevant to the treating clinician.

The key to this type of injury is cumulative stress from repetitive activities performed over prolonged periods of time. What influences the repetitive injury and why do some people develop these injuries, while others do not? Unfortunately, this is not a black and white answer. The answer likely lies on a continuum that is multi-factorial. The interaction between load magnitude, repetition quantity and the amount of range of motion will influence injury development. Unfortunately, a comprehensive understanding of the multi-factorial sources of RLI is a work in progress, and much of our knowledge in the physiological and biomechanical realms has been pieced together through various independent research studies conducted thus far.

Through testing of both an in-vivo feline model and healthy human subjects, Solomonow's research group hypothesized that RLI, from repetitive lumbar flexion and extension, triggers an acute inflammation in the viscoelastic tissues. In turn, creep develops in these tissues which create changes in neuromuscular control and changes the lumbar stability. The purpose of this paper was to piece together multiple research initiatives that obtained hard physiological and biomechanical data, in an attempt to clarify the complex story of RLI.

PERTINENT RESULTS

Feline Experiment
During the animal experiments the authors found that the typical mechanical response of the lumbar spine to prolonged cyclic flexion-extension is the development of creep (laxity) during the loading periods. During the rest periods there was partial recovery but never complete recovery, leaving residual creep ranging from 5 to 35%. As expected, the trials with minimal loads, low repetitions and short frequency with lots of rest only had 5% residual creep. At the other end of the spectrum the trials that

had high loads, increased repetitions and large frequency demonstrated 25-35% residual creep.

The neuromuscular function measurements from the animal experiments demonstrated:

- A gradual decrease of EMG amplitude during the loading period.
- Partial recovery of the EMG amplitude during the in-between rest periods.
- Continuous decrease in EMG amplitude during each consecutive loading period.
- Random spasms during the loading periods themselves.
- More intense spasms with high loads or high velocity flexion.
- Low loads, repetitions, frequency and long rest displayed gradual recovery.
- High loads, frequency, repetitions and short in-between rest exhibited a sharp increase of muscle hyperexcitability.

Stability of the lumbar spine was examined using the neuromuscular neutral zones. In this section, the authors observed:

- An increase in the neuromuscular neutral zones in the post-loading times, pointing towards a decrease in muscular stabilizing function.
- Decreased stability periods were short during high loads and frequencies.
- Decreased stability periods were long during mild loads and low frequencies.

From these observations, the authors surmise that a combination of deficient muscular reflex and tissue laxity develops a deficit in spine stability and even temporary instability.

Under the tissue biology analysis, generally under higher loads and frequency, it was demonstrated that there was a significant increase in neutrophil density indicating acute inflammation. Lower loads and frequencies resulted in only a small increase in neutrophils, which did not qualify as acute inflammation.

Human Experiment

The experiments on healthy human subjects (21-35 yoa) examined EMG and kinematics of flexion-extension and lateral rotation demonstrated:

- Creep developed over time when under static or cyclic loading.
- There was a shift in the time when EMG ceased during flexion and the time when EMG was initiated during extension – this was consistent with the feline model.
- Spasms were observed as the static/cyclic activity was continued.
- Re-orientation of the gravity vector altered the motor control scheme and caused the muscles to activate in a different mode.
- Twisting movements also induced creep and altered muscle activity.

CLINICAL APPLICATION & CONCLUSIONS

Biomechanical, neuromuscular, tissue biology and stability components all contribute to the multi-factorial RLI syndrome – it is a relatively general term, but an important concept. Increased loads, durations, velocities, repetitions and short rest are risk factors for RLI through the inflammatory process. Therefore, preventive actions, which can include rest in-between sessions and lower cyclic loading frequency, can minimize creep, avoid inflammation and allows the body time for recovery when there is damage. For example, rotations to perform different activities in the work place could minimize joint exposures to repetitive stressors and can help employees avoid RLI.

The most prominent risk factor noted is high cyclic loading frequency (high rates or high velocity motion). This information can be applied to both the workplace and sporting tasks. Many RLIs result from the nature of the work or sporting activity due to their inherently high cyclical loading activities. Therefore, we have to be reactive to these scenarios, providing adequate rest periods and variation in the activity. Cross training in sport is a great way to improve an athlete's physical fitness without overloading certain areas of the body. Similarly, randomization of tasks at work is a way to off-load the workers joints and avoid RLI syndrome.

As we all know, it is not always possible to avoid injury. Injuries do occur. Once spine stability is compromised through ligamentous creep and decreased muscle activity, there is inflammation which initiates muscular hyperexcitability to protect the tissues from further damage and allowing for repair. However, it takes 2-3 hours for the inflammation to develop fully before the hyperexcitability is initiated. It is not clear if this excitability is due to the inflammation or the associated pain. Either way, the worker/athlete might not be aware of the damage to their lumbar spine after the completion of the working day/sporting activity. The authors suggested a back brace to be worn 2-3 hours after work to stabilize the spine, protect the viscoelastic tissue and allow the body to heal (note: this recommendation certainly requires further study, as many experts in the field may disagree with this statement). A brace might not be practical in many scenarios, however, applying the concept of off-loading repetitively stressed joints can go a long way to repair and avoidance of injury. (EDITOR'S NOTE: *this may be best achieved by formal, structured breaks from repetitive strain, versus unloading affected tissues and structures after the fact.*)

Clinically speaking, reducing neuromuscular hyperexcitability after injury may not be appropriate until healing and tissue repair is completed. Hyperexcitability of the lumbar spine muscles compensates for the significantly decreased stability of the spine, and without this compensation the spine may be exposed to additional injury. Clinicians should avoid prescribing exercise therapy that may engage the lumbar spine at this stage until both inflammation and pain has decreased. Additionally, the inflammatory process is a part of the healing process. Therefore, it may be prudent to avoid anti-inflammatory medication as it can slow down or prevent the healing process. Pain medication or muscle relaxants may be necessary for the patient to be able to perform their activities of daily living and avoid muscle atrophy. Even though rehabilitation exercises might be contra-indicated in the acute inflammatory phase of an injury, it is important to understand that rest, in this context, means avoiding whatever activity caused the injury, not common activities of daily living. We all know that bed rest is a detrimental approach to treating low back pain!

One final note on inflammation and spinal pain: Interestingly, recent evidence has demonstrated that spinal manipulations reduce blood cytokine expression levels in the blood of human subjects (1-2). However, before we can directly apply this information, additional research in this area is required to better understand where in the rehabilitation process of RLI it is best suited. Interesting things on the horizon.

STUDY METHODS

This study summarized a variety of feline and human studies.

During the animal experiments, *in-vivo* feline (cats) were anaesthetized and put through various different protocols of lumbar spine flexion-extension loading. Wire EMG recordings were taken from the L-3/4 to L-5/6 multifidi. Following prolonged load/rest sessions, changes in creep recovery, muscle function and inflammatory condition were measured. The supraspinous ligaments were dissected and tested for inflammation.

During the human experiments the subjects were required to perform repetitive or static anterior flexion-extension or trunk rotation over a period of time while recording the flexion or rotation angles and surface EMG from various muscles.

STUDY STRENGTHS / WEAKNESSES

The most glaring weakness of this research is evidently the missing verification through human subjects. The majority of the findings were attained from the feline model, with only some confirmation obtained through healthy human subjects. Surgical removal of lumbar ligaments from healthy human subjects is not an option and consequently many of the results from this research were ascertained, understandably, through indirect evidence of the feline model. However, this research was able to experimentally pull together the several multifactorial components of RLI through hard scientific data and justify its application into everyday practice.

Additional References

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