

# **Muscle Spindle Distribution, Morphology, and Density in Longus Colli and Multifidus Muscles of the Cervical Spine**

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## FROM ABSTRACT

### Study Design.

Tissue blocks comprising muscle and bone from C5 to C7 segments were harvested at autopsy from 16 individuals ranging in age from 4 to 77 years.

The prevertebral longus colli and postvertebral multifidus muscle pairs from one side in each individual were randomly selected for this study of muscle spindles.

### Objectives.

To determine muscle spindle distribution, morphology, and density for the longus colli and multifidus in caudal segments of the human cervical spine, and to assess whether changes are evident from infancy to old age.

### Summary of Background Data.

Age-related changes to the osteoligamentous framework of the cervical spine have been well documented.

Postural modification accompanies these structural alterations, but there have been limited attempts to document whether muscle sustains a comparable level of morphologic alteration.

### Methods.

The longus colli and multifidus were resected between C5 and C7, and between left and right pairs selected randomly for spindle analysis.

These vertebral segments were selected deliberately because they form the apex of the cervical lordosis and the site at which the greatest age-related modification occurs.

Spindle characteristics were examined using light microscopy and analyzed by unbiased stereologic methods.

A one-sample paired *t* test was used to ascertain whether the differences in spindle density between the two muscles were statistically significant.

### Results.

The longus colli has a high density of muscle spindles, which appear clustered and concentrated anterolaterally, away from the vertebral body.

The multifidus has a low density of muscle spindles, which are found predominantly as single units concentrated closely to the vertebral lamina.

No change in spindle distribution, morphology, and density were observed with age. **[IMPORTANT]**

Conclusions.

The current study examined spindle characteristics for an intrinsic neck muscle pair whose coactivation contributes to segmental stability of the cervical spine.

The distribution and morphology of muscle spindles differ between the longus colli and the multifidus.

In addition, these muscles have significant differences in terms of mean spindle density.

Spindle characteristics represent one of many factors that govern proprioceptive regulation in skeletal muscle, and in neck muscles, the central connectivity of these receptors remains undefined.

Therefore, although there are anatomic differences between the neck flexor and extensor muscles, the functional implications of these differences are not clear.

It is also of interest that spindle characteristics remain unchanged in these intrinsic muscles whose underlying segments are subject to age-related osteoligamentous changes. **[IMPORTANT]**

THESE AUTHORS ALSO NOTE:

“Progressive dehydration of intervertebral discs is an age-related phenomenon that contributes to decreased discal height and loss of cervical lordosis.”

“Osteoligamentous changes represent postural adaptations to these structural alterations and are most prominent in lower cervical segments.”

“Muscle spindles constitute one type of muscle transducer that respond to stretch, providing fundamental cues to the central nervous system for control of muscle tone and position sense.”

“Afferent spindle discharge in antigravity muscles results in reflex contraction, the extent of which precisely complements the initial strength of the stimulus, thereby restoring equilibrium.”

Reduced proprioception is reported in patients with low back pain as compared with control groups.

Electromyographic studies have established that proprioceptive paraspinal receptor imbalance contributes to the development and progression of idiopathic scoliosis.

“By relaying signals to the central nervous system, the muscle spindles, together with the Golgi tendon organs, joint receptors and mechanoreceptors, regulate the passive (spinal column) and active (spinal musculature) subsystems.”

“It is suggested that functional aberrations in either of these interdependent systems may yield movements that exceed the physiologic range, predisposing spinal elements to acute or subsequent chronic injury or degeneration.”

“The positional integrity of cervical articulations relies partly on the synergistic function of pre- and postvertebral muscles under physiologic loading.”  
**[“Positional Integrity” sounds like subluxation complex].**

Lumbar Spine lordotic antagonistic muscle pair that provides segmental stability and neutral posture:

### **Psoas and Multifidus**

Cervical Spine lordotic antagonistic muscle pair that provides segmental stability and neutral posture:

### **Longus Colli and Multifidus**

The longus colli maintains cervical lordosis by resisting gravitational force and contraction of dorsal neck muscles.

The multifidus contributes to the retention of cervical posture.

Spinal degenerative change results in reduced discal height and loss of cervical lordosis.

Degeneration is most pronounced at C5–C7 which is the pivot through which movements of the head and neck are mediated.

In this study, three spindle receptor characteristics were examined in the longus colli and multifidus: spindle distribution, morphology, and density.

In this study of 16 individuals age from 4 to 77 years tissues were harvested within 24 hours.

## **RESULTS**

There were no discernible changes in spindle distribution, morphology, or density for either muscle [longus colli or multifidus] with increasing age.

The spindle density was determined as the spindle number per gram of wet muscle tissue.

#### Density of Muscle Spindles Per Gram Of Muscle Tissue

Longus Colli	48.6
Multifidus	24.3

The mean spindle number in the multifidus was less than that of the longus colli (111 vs 143).

“Therefore relative to one another, the multifidus had a large tissue volume with few spindles, and the longus colli had a small tissue volume with many spindles.”

The mean spindle density in the longus colli was determined to be 48.6/g and that of multifidus to be 24.3/g.

#### DISCUSSION

Muscle spindles in the multifidus are generally isolated, whereas those in the longus colli appear in aggregates of 2 to 10 spindles.

“From a proprioceptive perspective, it appears that small muscles required for fine motor control have large spindle densities, whereas those recruited for gross movement are comparatively devoid of spindle density.”

Studies have shown significant differences in connectivity between spindle afferents in lumbosacral and upper cervical regions:

[Rose PK, Keirstead SA. Segmental projection from muscle spindles: A perspective from the upper cervical spinal cord. Can J Physiol Pharmacol 1986; 64: 505–8.]

- (1) Muscle afferents from both lumbar and cervical regions terminate in the intermediate zone of the cord. **[IMPORTANT, because this is where the intermediate lateral column of the sympathetic nervous system lives]**
- (2) Lumbosacral afferent endings routinely form monosynaptic connections with motoneurons.
- (3) Upper cervical endings also project to the inferior olive and cerebellum. **[WOW!, VERY IMPORTANT]**

The results of the current study indicate that “spindle populations are strategically arranged to subserve a particular function.” **[WOW!]**

“The organization of spindles in the multifidus may be important for resisting gravitational forces that would otherwise encourage multifidus lengthening.”

The spindles noted in these two muscles provide sensitive sensory information to control neck posture, lordosis, and movement.

“It is acknowledged that spindle characteristics represent one aspect of many factors contributing to proprioceptive regulation in skeletal muscle.”

“The current findings show that the longus colli contains a significantly greater mean spindle density than the multifidus.”

“The longus colli also has a mean spindle density that is significantly greater than that of the multifidus.”

“None of the spindle characteristics examined showed any consistent pattern of change with aging.”

“In light of this finding, morphologically, aged muscle retains its functional capacity despite osteoligamentous degeneration.”

“This is the first study that has rigorously quantified spindle characteristics for muscles acting segmentally in the lower cervical spine.”

#### KEY POINTS FROM DAN MURPHY

- (1) Muscle spindles respond to stretch, and provide important cues to the central nervous system for control of muscle tone and position sense.
- (2) Afferent spindle discharge in antigravity muscles results in reflex contraction to restore postural equilibrium.
- (3) Reduced proprioception is reported in patients with low back pain as compared to control groups.
- (4) Other related afferent inputs to the central nervous system include the Golgi tendon organs, joint receptors and mechanoreceptors.
- (5) Functional aberrations in any of these afferent input systems results in loss of the “positional integrity of cervical articulations” **[Subluxation Complex]**, abnormal movement, and predisposition to chronic spinal injury or degeneration.

(6) There are no changes in spindle distribution, morphology, or density for the longus colli or multifidus with increasing age. Consequently, the aged muscle retains its functional afferent spindle capacity despite spinal degenerative changes.

(7) Small muscles **[like the suboccipital muscles]** have large spindle densities, whereas muscle used for gross movement have small spindle density.

(8) Muscle spindle afferents from both lumbar and cervical regions terminate in the intermediate zone of the cord **[which is where the intermediate lateral column of the sympathetic nervous system lives]**.

(9) Upper cervical afferent endings project to the inferior olive and cerebellum. **[WOW!, VERY IMPORTANT]**

(10) Muscle spindle populations are strategically arranged to subserve a particular function. **[Recall, upper cervical afferents project to the inferior olive and to the cerebellum]**

(11) Although the longus colli and multifidus muscles have high muscle spindle density as compared to other muscles, their density remains small compared to the suboccipital spine.

[V. Kulkarni, M.J. Chandy, K.S. Babu; Quantitative Study of Muscle Spindles in Suboccipital Muscles of Human Foetuses, Neurology India, 49, December 2001: 355-359]

#### Density of Muscle Spindles Per Gram Of Muscle Tissue

Inferior Oblique	242
Superior Oblique	190
Rectus Capitis Posterior Major	98
Rectus Capitis Posterior Minor	98
<b>Longus Colli</b>	<b>48.6</b>
<b>Multifidus</b>	<b>24.3</b>
Lateral Pterygoid	20.3
Opponance Pollicis	17.3
First Lumbrical	16.5
Trapezius	2.2
Latissimus Dorsi	1.4

#### COMMENT BY DAN MURPHY

These muscle spindles and other mechanical afferent input mechanisms are certainly a component of the subluxation complex and influenced by chiropractic adjustments. This article continues to add to the evidence for chiropractic spinal adjustments affecting the brain (cerebellum) and viscera (intermediate zone).