Effect of Aging on Presynaptic Control of Ia Afferent to α-Motoneuron Transmission Across Different Muscle Lengths and Contraction Types.

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Résumé

INTRODUCTION

Muscle spindles detect changes in muscle length and transmit this information via Ia afferents to alpha motoneurons, a pathway tightly regulated by presynaptic inhibition, particularly through post-activation depression (PAD) (Matthews & Stein, 1969; Pierrot-Deseilligny & Burke, 2012). In young adults, presynaptic inhibition via PAD increases during eccentric contractions and at longer muscle lengths, supporting flexible motor control (Colard et al., 2023). However, aging reduces muscle spindle sensitivity (Kim et al., 2007; Swash & Fox, 1972), which alter PAD regulation and may impair the ability to modulate presynaptic inhibition via PAD according to muscle length and contraction type, an aspect that has not yet been studied. The aim of this study was to determine whether aging affects the regulation of presynaptic inhibition via PAD based on contraction type and muscle length. We hypothesized that, unlike young adults, older adults exhibit reduced or absent regulation of presynaptic inhibition via PAD, impairing the modulation of Ia-alpha motoneuron transmission according to muscle length and contraction type.

METHODS

We included 19 older adults and 16 young individuals, each participating in three experimental sessions. We used percutaneous electrical stimulation of the tibial nerve to record the maximal Hoffmann (H) reflex (Hmax) and the maximal compound muscle action potential (Mmax) in the soleus muscle. The Hmax/Mmax ratio was calculated to estimate the efficacy of Ia-alpha motoneuron transmission. We also employed the D1 method, consisting of a conditioning electrical stimulation applied to the fibular nerve 21 ms before tibial nerve stimulation, eliciting a submaximal H reflex. The HD1/Htest ratio was used to assess presynaptic inhibition via PAD. Additionally, we investigated heteronymous Ia facilitation, consisting of a conditioning electrical stimulation applied to the femoral nerve approximately 7 ms after tibial nerve stimulation, eliciting a submaximal H reflex. The Hfac/Htest ratio was used to measure ongoing Ia presynaptic inhibition. These assessments were conducted for two contraction types (i.e., isometric and eccentric) and two muscle lengths (i.e., i.e.,

*Intervenant

intermediate and long, corresponding to 0∘ and -15∘ dorsiflexion) in the soleus. For each contraction, participants were required to maintain a torque level corresponding to 50% of maximal soleus myoelectrical activity.

RESULTS

In young adults, the HD1/Htest ratio was lower at long muscle lengths than at intermediate lengths and during eccentric contractions compared to isometric contractions (-29.3% of HD1/Htest, $p < 0.001$). The Hfac/Htest ratio also varied with these factors, being lower during eccentric contractions and at longer muscle lengths compared to isometric contractions at intermediate muscle length (-14.6% of Hfac/Htest, $p < 0.001$). In contrast, older adults did not exhibit modulation of HD1/Htest or Hfac/Htest based on these factors ($p > 0.05$). Hmax/Mmax was distinctly regulated, typically decreasing during eccentric contractions at intermediate muscle length in young subjects (-18.6%, $p < 0.001$), but not in older adults ($p > 0.05$).

CONCLUSION

This study demonstrates that aging impairs the presynaptic regulation of Ia-alpha motoneuron transmission according to contraction type and muscle length. Specifically, young adults modulate presynaptic inhibition based on these factors, whereas older adults exhibit no such modulation. However, this inhibition does not fully explain the discrepancy in the efficacy of Ia-alpha motoneuron transmission across experimental conditions with aging, suggesting that other mechanisms, including postsynaptic ones, may account for this difference.

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