早稲田大学審査学位論文
博士（スポーツ科学）
概要書

Morphological and mechanical properties of the human triceps surae aponeuroses and their functional roles in motor performance

人間の下腿三頭筋腱膜の形態的・力学的特性と身体運動パフォーマンスとの関連性

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Chapter abstracts

Chapter 1

In this chapter, both morphological and mechanical properties of triceps surae muscles and aponeuroses were reviewed. Then, the muscle-aponeurosis interaction during contraction and different roles between muscles and aponeuroses in movement performance were reviewed.

Chapter 2

In chapter 2, I aimed to identify the original morphological and mechanical characteristics of the human triceps surae aponeuroses. Specimens of aponeuroses were excised from the eight regions (posterior and anterior regions of the gastrocnemius medialis and lateralis, medial and lateral parts of soleus, proximal, middle, and distal sites each). Aponeurosis thickness and mechanical properties of specimens loaded longitudinally (along the muscle's line of action) and transversely were measured. Young's modulus showed direction-dependent (longitudinal vs. transverse) differences within sites. The distinct anisotropic elastic feature of the aponeuroses suggests that inherent material design of the aponeurosis matches three-dimensional contractile behavior of muscle fibers.

Chapter 3

In chapter 3, I aimed to identify the site- and direction-dependent differences of triceps surae muscles and aponeuroses stiffness *in vivo* during graded isometric submaximal plantarflexion efforts. Shear wave velocities (SWVs) of triceps surae muscles and aponeuroses were obtained longitudinally and transversely during at rest and isometric submaximal plantar flexion contractions (20%, 40%, 60% of MVC). The results further

indicate that the triceps surae muscles and aponeuroses showed inhomogeneous and anisotropic mechanical properties during submaximal muscle contractions, and the stiffening effect of muscle belly possibly make influence on the mechanical properties of aponeuroses during muscle contractions.

Chapter 4

In this chapter, in order to know how the tendinous tissues of the triceps surae with long and various shapes function as springs, I sought to determine the relationships between the aponeurosis stiffness and muscle strength and walking performance in older individuals. Shear wave velocities (SWVs) of the triceps surae aponeuroses at different sites and in two orthogonal directions were obtained in a prone position at rest. The results show clear spatial variations and anisotropy of the triceps surae aponeuroses stiffness *in vivo*, and suggest that stiffer aponeuroses would be favorable for faster walking in the elderly.

Chapter 5

In chapter 5, I generalized the main findings of this thesis and figured out my understanding of implications for muscle-aponeurosis interaction during contraction, then discussed how the sheet-like aponeurosis's property contributes to human motor performance. Additionally, limitations on the cadaveric study and shear wave elastography measurement were discussed. Finally, the conclusions and future direction were addressed to improve the understanding of aponeurosis tissue function within the muscle-tendon unit.