ARCHITECTURAL DIFFERENCES OF LOWER LIMB MUSCLE-TENDON FOR MONOZYGOTIC TWINS WITH DIFFERENT SPORT EXPERIENCES

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The purpose of this study was to examine architectural differences of lower limb muscle-tendon for monozygotic twins with different sport experiences and for monozygotic twins with same sport experiences. 50 monozygotic twins (MZT) participated in this study, consisting of 16 MZT with different sport experiences, 34 MZT with same sport experiences. Musculoskeletal ultrasonography is applied to measure the muscle fascicle length of gastrocnemius medialis (GM) muscle as well as Achilles and patella tendon cross-sectional area (CSA) and length. Achilles tendon was separately measured from the AT insertion point on the calcaneus to the distal end of soleus muscle (AT_{SOL}) and to the AT junction between medial and lateral gastrocnemii muscles (AT_{GML}), respectively. The measured intraclass correlation coefficient (ICC) clearly showed poor concordances in the AT_{SOL} length of MZT with different sport experiences (ICC of 0.74), and good concordance in the MG fascicle length of MZT with different sport experiences (ICC of 0.83). Other parameters in all intra-pears showed excellent concordances (ICC>0.9). Thus, different concordances of AT length between GM and SOL parts can indicate the different plasticity by the structural and functional mechanics and different concordances between groups indicate that AT_{SOL} and GM fascicle length are affected not only by genetic factors but also by acquired environmental factors.

KEYWORDS: ultrasound, Achilles tendon, sport experience, twins

INTRODUCTION: The growth and development of skeletal muscles are triggered not only by a genetic factor but also by environmental factor or by a combination of both factors. Classically, a genetically controlled study design has provided a powerful tool to study the role of genetic and/or environmental consequences for muscle fiber composition (Komi et al. 1977), for example. However, very few attempts have been made at tendon plasticity by the genetic and environmental factors. Therefore, we hypothesized that the tendon length and cross-sectional area (CSA) of Achilles and patella tendon would differ between the monozygotic twins (MZT) with different sport experiences but not between MZT with same sport experiences. The purpose of this study was to examine the concordance of each other's muscle–tendon architecture of lower limbs for monozygotic twins (MZT) with different sport experiences and with same sport experiences.

METHODS: 50 monozygotic twins (MZT) who have the experiences of competitive sports participated in this study, consisting of 16 MZT with different sport experiences, 34 MZT with same sport experiences (Table 1).

Table 1. Subject's physical characteristics

	n	Age	Height (cm)	Body mass (kg)	Shank length (cm)
Monozygous twins with same sport experiences	34	16.1 ± 16.1	147.1 ± 31.1	40.3 ± 22.2	29.2 ± 8.5
Monozygous twins with different sport experiences	16	20.2 ± 5.9	145.2 ± 16.2	45.8 ± 12.8	33.5 ± 4.0

Shank length was defined as the distance between the proximal head of fibula to the tip of the lateral malleolus and was measured bilaterally in a resting standing position. Musculoskeletal ultrasonography (α10; Hitachi, Japan) is applied to measure the muscle fascicle length of gastrocnemius medialis (GM) muscles as well as Achilles tendon (AT) and patella tendon cross-sectional area (CSA) and length. AT length was separately measured from the AT insertion point on the calcaneus to the distal end of soleus muscle (AT_{SOL}) and to the AT junction between medial and lateral gastrocnemii muscles (AT_{GML}), respectively. These lengths and CSA were analysed from the ultrasound images by using analysis software (Image J, NIH, Bethesda, Maryland, USA) on both legs (e.g., Ying et al. 2003; Kunimasa et al. 2014). The distal end of soleus muscle was identified by the point where the soleus muscles disappeared by scanning the transverse ultrasound images along the AT from the proximal to distal direction. AT CSA was quantified below the distal end of soleus muscle.
Intraclass correlation (ICC) measures the concordance of each other's parameter between twins. ICC values less than 0.5 are indicative of poor concordance, values between 0.5 and 0.75 indicate moderate concordance, values between 0.75 and 0.9 indicate good concordance, and values greater than 0.90 indicate excellent concordance.

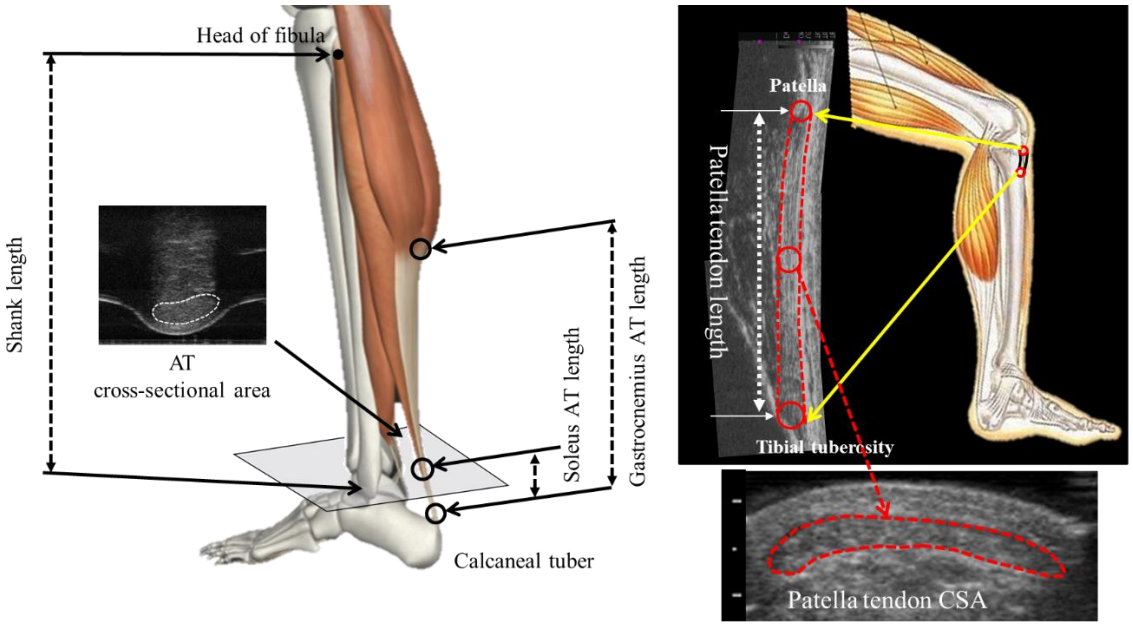

Figure 1. Measurement schema for Achilles tendon and patella tendon length and cross-sectional area as well as length of shank.

Gastrocnemii and soleus AT lengths as well as AT cross-sectional area were measured from the ultrasound images of both legs. The soleus and gastrocnemii AT lengths were measured from the AT insertion point on the calcaneus to the distal end of soleus muscle and to the AT junction between medial and lateral gastrocnemii muscles, respectively. AT cross-sectional area was quantified below the distal end of soleus muscle.

RESULTS: Table 2 shows ICC concordances for the height, body mass and shank length. These parameters showed the excellent concordances between the twins with the same and different sport experience groups.

Table 2. Concordance (ICC) of each other's parameter between the twins.

	Height	Body mass	Shank length
Monozygous twins with same sport experiences	0.99	0.99	0.99
Monozygous twins with different sport experiences	0.99	0.99	0.99

Table 3 shows ICC concordances for the Achilles and patella tendon length and muscle fascicle length of GM. The excellent concordances between the twins was observed in MZT with the same sport experience group. The ICC concordances between the twins in MZT with the different sport experience group showed the poor concordance in AT_{SOL} and good concordance in GM fascicle length.

Table 3. Concordance (ICC) of muscle-tendon length between the twins.

	Achille tendon length		Patella tendon length	GM fascicle length
	GM	SOL		
Monozygous twins with same sport experiences	0.98	0.97	0.97	0.91
Monozygous twins with different sport experiences	0.95	0.74	0.96	0.83

Table 4 shows ICC concordances for the Achilles and patella tendon CSA. These parameters showed the excellent concordances between the twins with the same and different sport experience groups.

Table 4. Concordance (ICC) of tendon CSA between the twins.

	Achilles tendon CSA	Patella tendon CSA
Monozygous twins with same sport experiences	0.99	0.99
Monozygous twins with different sport experiences	0.97	0.93

DISCUSSION: Our results confirmed that physiological parameters such as height, body mass and shank length are affected by genetic factors. In addition, results of this study provided a possibility of environmental factor-induced different plasticity of muscle-tendon architectures in human GM muscle fascicle length and Achilles tendon length which connect to soleus muscle.

The different concordances of AT length between GM and SOL parts may be related to structural and functional differences of mono- and bi-articular muscles (Ishikawa M and Komi PV 2008). Mono-articular soleus muscle can act mainly as a force generator or load bearer during human movements, whereas the bi-articular gastrocnemius muscle is likely to function as a fine tendon strain regulator. Therefore, these different functions may result in the different concordances of synergistic GM and soleus muscles selectively in MZT. On the other hand, the CSA of both Achilles and patella tendons showed excellent concordances between the twins with the same and different sport experience groups. These high concordances for

tendon CSA with the twins may indicate the difficulty of tendon hypertrophy as compared to the length changes.
Methodological limitation: In the present study, we cannot get high reliability of the soleus muscle fascicle length due to the tangled complexly fascicle lines. Therefore, only GM fascicle length was reported.

CONCLUSION: The different concordances of AT length between GM and SOL parts can indicate the different plasticity by the structural and functional mechanics and different concordances between groups indicate that AT_{SOL} and GM fascicle length are affected not only by genetic factors but also by acquired environmental factors.

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