Childhood muscle growth is mediated primarily by transverse rather than longitudinal growth of muscle fibres

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Summary

Postnatal muscle growth is primarily due to addition of new sarcomeres to existing muscle fibres rather than addition of new fibres. Serial addition of sarcomeres increases muscle fibre length (longitudinal growth) and the operating range of the muscle, whereas parallel addition (transverse growth) increases the muscle's maximum force-generating capacity. Here, we use multi-modal magnetic resonance imaging data of the lower legs of 197 children aged 0 to 15 years to show that lower leg muscles grow primarily, and over some age ranges in some muscles almost exclusively, through transverse fibre growth, rather than longitudinal growth.

Introduction

Skeletal muscles undergo changes in size, shape and architecture throughout the lifespan, but the most dramatic changes occur during childhood. Previous studies have described the architecture of selected muscles in small samples of children over narrow age ranges. However, a comprehensive analysis of the distribution of muscle architectural parameters during childhood development is lacking.

Methods

Anatomical mDixon and diffusion-weighted magnetic resonance images were obtained from the lower legs of five infants (2 girls) aged under four months and 192 typically developing children (81 girls) aged 5 to 15 years. Seven lower leg muscles (medial gastrocnemius, lateral gastrocnemius, soleus, tibialis anterior, tibialis posterior, flexor digitorum longus, flexor hallucis longus) were segmented from the images [1]. Anatomically constrained tractography methods [2] were used to reconstruct the 3D architecture of the muscles and to measure mean fascicle length and physiological cross-sectional area (PCSA; muscle volume divided by mean fascicle length). Quantile regression with b-spline basis functions was used to estimate age- and sex-conditional distributions of fascicle lengths and PCSA.

Results and Discussion

The PCSAs of the median 15-year-old boy and girl were, on average across muscles, 3.5 and 3.7 times larger than in the median 5-year-old boy and girl, respectively (range across muscles: 3.0 to 4.7). The fascicle lengths of the median 15-year-old were, on average across muscles, 1.3 times greater than in the median 5-year-old (range across muscles: 1.1 to 1.7). Tibia lengths of the median 15-year-old were 1.7 times greater than in the median 5-year-old.

A plot of PCSA against fascicle length shows that, for all muscles at all ages, age-related increases in muscle volume are mediated more by increases in PCSA than by increases in fascicle length (Fig. 1). For all muscles, the largest increase in fascicle length occurs under 5 years of age. After 5 years of age, soleus muscle growth is almost exclusively transverse growth.

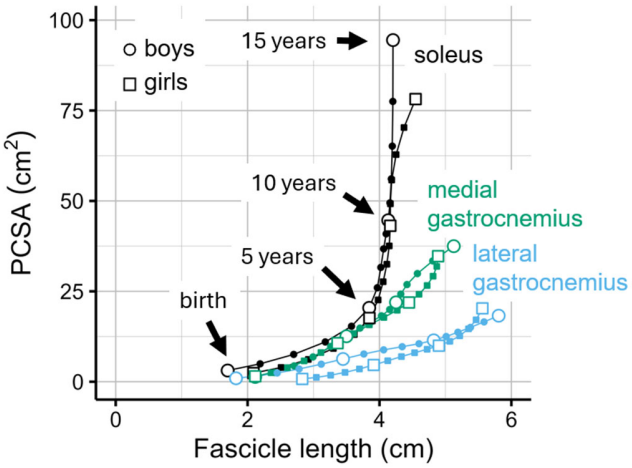

Figure 1: The relationship between physiological cross-sectional area (PCSA) and fascicle lengths for the triceps surae muscles from birth to 15 years of age. Data are medians at each year of age with multiples of 5 years indicated by open circles (boys) or squares (girls).

Conclusions

Childhood muscle growth is mediated more by transverse rather than longitudinal growth of muscle fibres, especially above 5 years of age. Future studies should investigate the functional consequences of muscle architecture adaptations during childhood growth.

Acknowledgments

The authors acknowledge assistance of NeuRA Imaging (National Imaging Facility, a NCRIS capability) and funding from the NHMRC (APP1156394, APP1117192).

References

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