Sexual dimorphism and maturation effects in skeletal muscle metabolites: a proton MRS study

Lievens Eline, Bex Tine, Baguet Audrey, Heyse Jolan, Derave Wim
Ghent University

Introduction

Carnosine is an abundant dipeptide in human skeletal muscle, which most important role is intracellular pH buffering. The concentration of this muscle metabolite is respectively 36% and 28% higher in soleus and gastrocnemius of men compared to women (Everaert et al., 2011). The origin of this sexual dimorphism is not yet known, but can provide useful information as the concentration of carnosine is linked to functional characteristics like muscle fiber type composition and anaerobic metabolism. As there is an incomplete development of the anaerobic metabolism and - enzymes in children when compared to adults, puberty seem to increase the enzymatic pathways and metabolites related to the anaerobic metabolism. In this study we hypothesize that sex differences in carnosine concentration might develop during puberty.

Methods

Proton magnetic resonance spectroscopy was used for absolute quantification of carnosine via phantom replacement technique in 57 children before puberty (2011). In 2017, 48 of these children were rescanned (24 women and 24 men). Next to carnosine, other muscle specific metabolites, like creatine, taurine and carnitine were quantified. All the ^{1}H MRS measurements were performed on a 3-T whole body MRI scanner (Siemens Trio, Erlangen, Germany). To measure the soleus and gastrocnemius medialis muscles, the lower leg was fixed in a spherical knee coil. Single voxel point-resolved spectroscopy sequence with the following parameters was used: repetition time of 2.000 ms, echo time of 30 ms, number of excitations is 128, 1.024 data points, spectral bandwidth of 1.200 Hz, and a total acquisition time of 4.24 min.

Results

Here, only carnosine data are discussed, though also creatine, taurine and carnitine will be reported at the congress. After puberty, significant sex differences in carnosine concentration were found in both muscles. Men had respectively 15.8% and 23.2% higher carnosine concentrations in soleus and gastrocnemius when compared to the women (5.21 mM vs. 4.5mM in the soleus and 8.86 mM vs. 7.19 mM in the gastrocnemius). Though, no significant sex differences were found on the pre-puberty measurements in both muscles (Soleus; men: 3.86 mM vs. women: 3.98 mM and gastrocnemius; men: 7.69 mM vs women: 7.93 mM). Puberty induced a sexual dimorphism as the increase in muscle carnosine was significantly higher in men (+34.62%) when compared to women (+13.06%) in the soleus ($p=0.002$). In the gastrocnemius a significant increase of 15.2% was found in the male subjects ($p=0.001$), while a significant decrease of 9.33% was found in the female participants ($p=0.032$).

Discussion

A muscle-specific sexual dimorphism in human skeletal muscle carnosine concentration develops during puberty. These findings confirm the cross sectional results from Baguet et al., (2011), who found higher carnosine concentrations in male subjects after puberty but not before puberty, and agree with Everaert et al. (2011) who showed that testosterone has an influence on the carnosine concentration in mice.

Conclusion

To our knowledge, the current study was the first to apply proton MR spectroscopy to longitudinally monitor muscle metabolites changes in humans. The current example aimed to better understand the sex-specific development of anaerobic capacity during puberty.

References

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