3D-Fiber type distribution in back muscles in small mammals

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INTRODUCTION

The evolution of the locomotor apparatus in vertebrates is marked by major reorganizations of the trunk's musculature. The plesiomorphic segmental organization was dissolved in the hypaxial but also in the epaxial muscles. In mammals, three epaxial tracts allow for high mobility in all three rotational degrees of freedom as for lateral bending and tilting at symmetrical gaits and for sagittal bending at asymmetrical gaits.

Different roles in stabilizing and mobilizing of the vertebral column were hypothesized for the diverse paravertebral muscles. Large, superficial back muscles are supposed to produce the range of movement, whereas small, deep muscles control the range of movement and especially control segmental motions.

Since metabolic profiles of muscles relate to their function (as shown for limb muscles) it can serve as an indicator of function. Therefore, the aim of the study was to investigate and compare the muscle fiber type distribution in back muscles of different species of small mammals. In order to test current hypothesis on back muscle function the overall, 3D-distribution pattern of fiber types was investigated.

METHODS

Adults of 4 small mammalian species (*Galea musteloides* - the cui, *Ochotona rufescens* - the pika, *Rattus norvegicus* - the rat, *Tupaia belangeri* - the tree-shrew) were used for this study. Serial sections were made from the complete backs including the vertebral column to preserve the topographical relationships between muscles and their intramuscular architecture. Only the posterior thoracic and the lumbar regions were used in this study. Samples were quick frozen in liquid nitrogen cooled isopentan.

Sections were made using a kryostat microtome (SLEE, D-knife, 12 µm) and processed for muscle fiber type characterization using alkaline combination reaction based on Ziegan's protocol [1]. As a result, fiber type I (SO) is stained blue, type IIa (FOG) dark brown, and type IIb (FG) light brown. Drawings were made at different cranio-caudal levels from the serial sections.

RESULTS AND DISCUSSION

Surprisingly, the overall fiber type distribution pattern was highly similar between the species investigated. Most of the muscles showed a heterogeneous distribution of the different fiber types over the muscle's cross section but also along the cranio-caudal axis. Only few of the muscles showed the same fiber type composition from deep to superficial regions or from cranial to caudal direction.

The highest percentage of glycolytic fibers was present in the m. sacrospinalis (longissimus lumborum et iliocostalis) and in the m. psoas major. Only a few oxidative fibers were observed in the posterior thoracic part of the m. sacrospinalis. The m. psoas major was more or less free of oxidative fibers. The fiber type composition of both muscles make them suitable to generate forces and speed for a wide range of movement.

The highest percentage of oxidative fibers were found in the mm. intertransversarii et interspinales as well as in the mm. rotatores et multifidi. In caudal direction, the proportion of oxidative fibers is decreased in the superficial regions of the mm. multifidi. As inferred from their anatomical position and their high percentage of fatigue resistant, oxidative fibers, these muscles are best suited to maintain segmental stability.

A regionalisation of oxidative fibers was found in the m. quadratus lumborum. Around the huge intramuscular tendon oxidative fibers were distinctly arranged. Especially, in the caudal thoracic but also in the cranial lumbar part this oxidative region was extensive. Towards the caudal region the proportion of the oxidative fibers was decreased. Such regionalisation of oxidative fibers in deep parts of a muscle are well known from limb muscles in so called anti-gravity muscles. These muscles enduringly counteract passive limb flexions due to gravitational force. As a muscles involved in ventilation, the oxidative region of the m. quadratus lumborum is supposed to be involved in inspiration movements.

CONCLUSIONS

Diverse back muscles were related to different functions in stabilization and mobilization of the vertebral column. An overall distribution pattern of different muscle fiber types was found in all species under investigation. The major reorganization in the trunk's musculature during the evolution of mammals is suggested to include not only macroscopic changes but also the fiber type distribution pattern.

REFERENCES

1. Ziegan J. *Acta histochem* **65**, 34-40, 1979.

ACKNOWLEDGEMENTS

Technical support by Ingrid Weiß and Leila AlKuweiti is gratefully acknowledged.