MORPHOLOGY OF THE TRANSVERSUS ABDOMINIS, OBLIQUUS INTERNUS AND OBLIQUUS EXTERNUS MUSCLES

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SUMMARY

The anterior and posterolateral abdominal walls were serially dissected in embalmed human cadavers to examine the morphology of the abdominal muscles. The fascicle orientation, thickness and length of the upper, mid and lower regions of transversus abdominis (TrA), and the mid-regions of obliques internus abdominis (OI) and obliques externus abdominis (OE) were documented. Morphological differences were evident between regions of TrA, and between the mid-regions of TrA, OI and OE. These findings indicate functional differentiation between regions of TrA and provide further evidence to support the role of TrA in spinal control.

BACKGROUND AND PURPOSE

The mechanisms by which the abdominal muscles provide stability to the lumbar spine are not clearly defined. A comprehensive knowledge of abdominal muscle morphology may assist in further understanding these mechanisms. It is hypothesized that regions of TrA arising from different bony attachments may have different functions and contributions to spinal stability. However, the regional anatomy of TrA has not been examined, and reports on abdominal muscle morphology are either conflicting or lack quantitative investigation (1,2,5,6,9,). Therefore the aims of this study were to document the fascicle orientation, thickness and length of the upper, mid and lower regions of TrA, and the mid-regions of the OI and OE muscles.

MATERIALS AND METHODS

Dissection of 13 embalmed human cadavers (6 female, 7 male, mean age: 82 years, age range: 60-93) was undertaken to expose the inner aspect of the posterolateral abdominal wall. A further 6 specimens (3 female, 3 male, mean age: 87 years, age range: 81-93) were dissected to expose the anterior wall. Bilateral fascicle orientation, thickness and length measures were documented for the upper, mid and lower regions of TrA, and the mid-regions of OI and OE. The width of the mid-region (distance between the superior margin of the iliac crests and the inferior margin of the rib cage) was measured along the mid-axillary line. Fascicle orientation measures were calculated from digital photographic images using an image analysis program, Image J. Thickness measures were obtained using a manual micrometer (accuracy +/- 0.005mm), while fascicle length was measured with a tape measure or anthropometer (accuracy +/- 1.0mm).

RESULTS

Differences in fascicle orientation between regions of TrA were evident; the upper region fascicles were oriented superomedially or transversely, the mid-region inferomedially, and the lower region inferomedially (but with greater angulation than the mid-region). For the anterior dissections, the mean thickness of the upper region of TrA was found to be greater than that of the mid and lower regions. The mean length of the fascicles in the lower region was less than a third of that of the upper and mid-regions.

The mean width of the mid-region was 5 cm (14% of total abdominal region) and was significantly smaller than the upper and lower regions ($F_{2,30} = 111.16, p < 0.0001$). Clear differences between the mean fascicle orientation of all muscles were evident in the mid-region; TrA and OE being oriented inferomedially, and OI directed superomedially. TrA was thinner than OI and OE ($F_{2,36} = 19.6, p < 0.0001$), while the length of the fascicles of OE were greater than those of OI and TrA ($F_{2,10} = 24.95, p < 0.0001$).

DISCUSSION

This study provides a detailed description of regional differentiation in the morphology of TrA, and quantitatively documents the fascicle orientation, thickness and length of TrA, OI and OE. Differences in fascicle orientation, thickness and length between the regions of TrA were clearly evident. In contrast with contemporary assumptions and recent anatomical texts, TrA fascicles were not consistently directed horizontally, but displayed varying fascicle orientations across regions.

The fasciculi of the upper region of TrA, originating from the costal cartilages in a superomedial or transverse direction, were observed to be relatively longer and thicker than those of the mid and lower regions. In contrast, the mid-region fascicles of TrA inserting into the thoracolumbar fascia were relatively thinner than the upper fascicles, and were directed in an inferomedial orientation. The mid-region of TrA also differed morphologically to the mid-region of OI and OE. Similar to the mid-region, the lower portion of TrA was oriented inferomedially at its origin from the ilia and was relatively thinner than the upper region.

The separate attachments and varying fascicle orientations of the different regions of TrA suggest that each part may have different roles in trunk rotation and stability. For instance the rotational function of the upper superomedial or transverse fibres may be opposite to that of the lower inferomedial fibres. Furthermore it is likely that only the middle 14% of the muscle can tension the thoracolumbar fascia due to the limited width of the mid-region. However the other fibres may contribute to lumbopelvic control via a contribution to increasing intra-abdominal pressure (3) and force closure of the sacroiliac joints (7).

These findings support the results of recent electromyographic (EMG) studies, which indicate that the tonic activity and onsets of TrA differ between regions during rapid limb movements (4,8). Further investigation is required however, to clearly determine the functions of these morphologically different regions.

CONCLUSION

Regional variation in morphology was documented for the upper, mid and lower regions of TrA. Differences in fascicle orientation, thickness and length were also evident between the mid-regions of TrA, OI and OE. These differences may reflect variation in function and differing contributions of the abdominal muscles and regions of TrA to spinal control.

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