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Deep Learning-Based Muscle Segmentation Using Digitally Reconstructed Radiographs and Prediction of Muscle Volume from Plain Radiographs

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Abstract:
***Purpose:** To develop a deep learning model to segment muscles from plain radiographs of the lower extremities using Digitally Reconstructed Radiographs (DRRs) generated from CT scans, and to validate this model for predicting three-dimensional muscle volume from plain radiographs.
***Methods and Materials:** Two hundred patients who underwent lower extremity CT for the preoperative evaluation of knee surgery were included in the study, of whom 180 were assigned to the training set and 20 were assigned to the test set. The CT scan range included both hip joints to the ankle joints, and muscles were manually segmented on the CT images using a threshold-based semi-automated method. From CT coronal images, we reconstructed average intensity projection images to generate DRRs, and reconstructed maximum intensity projection images from the muscle segmentation mask to create a corresponding 2D mask of muscles for the DRR images. We then trained an ensemble model of UNet++ and MANet to segment muscles from 2D DRR images, and created a prediction model from multivariate linear regression analysis to predict the three-dimensional volume of lower extremity muscles using the patient's age, sex, and the square of the two-dimensional muscle area measured from the DRR.
***Results:** The result of muscle segmentation on DRR using deep learning was a Dice similarity coefficient of 0.98 and an intersection over union of 0.96. The results of the multivariate linear regression analysis showed that sex and the square of area were significant predictors of muscle volume ($p < 0.001$), while age was not a significant predictor ($p = 0.23$). When using the muscle area measured by the deep learning model on DRRs in the test set, the muscle volume predicted by the prediction model showed a high level of agreement with the ground truth measured by manual segmentation on CT, with an intraclass coefficient of 0.90.
***Conclusions:** This study demonstrates the potential of utilizing a deep learning segmentation model trained on DRRs to predict three-dimensional muscle volume from plain radiographs, providing an efficient method for evaluating the status of lower extremity muscles.
***Clinical Relevance/Application:** The deep learning model, which can accurately predict muscle volume from plain radiographs, can be used for opportunistic diagnosis of sarcopenia, providing a simple and efficient screening tool for early management of this muscle wasting condition.

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IRB / IACUC Response: Human subject, and received IRB approval
Has this work been previously presented or published?: No
2nd Format Opportunity: Yes, I would be interested if accepted to showcase my work in an additional format (2 meter Hardcopy Backboard).

Attached Files: DRR MUSCLE SEGMENTATION (PDF, 263473 bytes)

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