

Accuracy and Precision Error of Muscle Cross-sectional Area Measured Using Peripheral Quantitative Computed Tomography in Adults

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Abstract

Purpose: Using muscle area from standard spiral Computed Tomography (CT) as the gold standard this study assessed the accuracy of muscle cross-sectional area derived from peripheral Quantitative Computed Tomography (pQCT) images acquired at 0.4 mm and 0.8 mm voxels. The precision error for muscle area derived at these two voxels was also determined.

Method: Twenty subjects participated in this study. Two pQCT images of the leg were obtained at 66% of the distance from the medial malleolus to the medial condyle of the tibia using a STRATEC XCT2000. Image #1 was acquired with standard scan parameters (voxel=0.8 mm, scan speed=30 mm/sec). For image #2 the voxel and speed were lowered to 0.4 mm and 20 mm/sec. The spiral CT images were acquired on a General Electric scanner with 0.4 mm voxels and 2 mm thick slices. pQCT muscle cross-sectional area was derived using standard analysis parameters. To reduce noise, median filtering was applied to the 0.4 mm voxel image before analysis. Custom software was used to extract muscle area from the spiral CT images. To assess precision, 10 subjects had the 0.8 mm and 0.4 mm voxel pQCT images acquired on three different days within three weeks. Subjects were not repositioned between the scans. Least squares analysis was used to compare pQCT and spiral CT muscle area. Precision error was assessed as percent coefficient of variation.

Results: There was good agreement between pQCT and spiral CT muscle cross-sectional area ($R > 0.9$, $p < 0.001$). As well, good agreement was found between muscle area derived from the 0.8 mm voxel pQCT image and the filtered 0.4 mm voxel image. The precision error for muscle cross-sectional area derived at either voxel setting was small (1-2%).

Conclusion: Muscle cross-sectional area derived from pQCT images is accurate when compared to muscle area from spiral CT. Second, filtering 0.4 mm voxel pQCT images to remove noise does not reduce the accuracy or precision of muscle measurements.

Introduction

pQCT is valuable for assessing the relationship between bone and muscle because it can simultaneously assess the cross-sectional area of bone and muscle in the limbs of adults and children. While assessment of muscle cross-sectional area has been widely used on clinical CT scanners the correlation between muscle area measured on a clinical CT scanner and a dedicated pQCT scanner has not been determined. **This work compares calf muscle cross-sectional area derived from a group of subjects scanned with pQCT and clinical CT.**

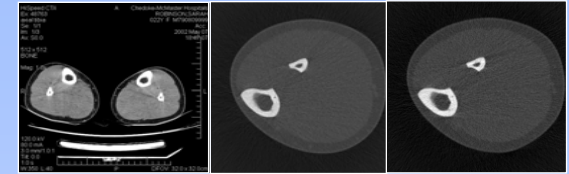
Subjects & methodology

Subjects: Comparison of muscle cross-sectional area from pQCT and spiral CT was done in 18 normal adult volunteers: 9 males, 9 females. Reproducibility of pQCT muscle area was assessed in 10 subjects scanned twice with a 2-week time interval between the first and second set of scans. Subjects were scanned at 0.4 mm and 0.8 mm voxel settings without repositioning.

Muscle assessment: images of the left tibia were obtained at 66% of the distance from the medial malleolus to the medial condyle. Skin was marked with ink to ensure alignment of pQCT and spiral CT scan locations (pQCT and spiral CT done on the same day). Figure 1 details the scan parameters used in the study.

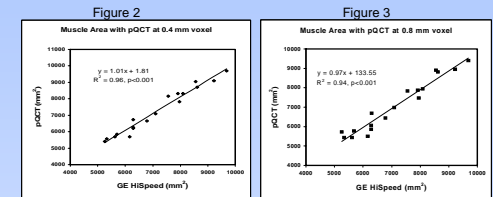
Image analysis: pQCT image data was analyzed using the manufacturer software and settings (Stratec XCT version 5.5). A median filter was applied to the 0.4 mm voxel pQCT images before muscle area segmentation. Spiral CT images were analyzed for muscle cross-sectional area using commercial software (BonAlyse Genie 1.3).

Figure 1:
pQCT and spiral CT scan parameters



Results

Figures 2 and 3 show the relationship between muscle cross-sectional area derived from the spiral CT scanner and the pQCT scanner operating at 0.4 mm and 0.8 mm voxel settings. The results of a least squares fit to the data is shown on each plot.



The table below gives the precision of muscle cross-sectional area derived for the pQCT scans acquired at two different voxel settings. The precision error terms (Root Mean Square Standard Deviation, RMSSD; and Coefficient of Variation, CV(%) were calculated according to the method of Gluer et al. (Osteo. Int. 5:262-270, 1995).

	0.4 mm Voxel	0.8 mm Voxel
Overall mean (mm ²) ± SD	7156.8 ± 1112.5	6998.4 ± 1138.5
RMSSD (mm ²)	181.1	208.4
CV(%)	2.5	2.9

Conclusions

Muscle cross-sectional area derived from a pQCT exam of the calf is accurate when compared to muscle area derived from spiral CT. Second, filtering 0.4 mm voxel pQCT images to reduce noise does not reduce the accuracy of muscle area determination. Third, muscle area is determined with precision errors less than 3%. We conclude that muscle cross-sectional area can be determined just as reliably on a pQCT unit as on a clinical CT scanner.

C. Gordon is a consultant for Orthometrix and holds shares in the company