284.9: Evaluation of a Quantitative Magnetic Resonance Imaging System for Whole Body Composition Analysis in Rodents

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Introduction

In studying the neural mechanisms underlying propensity for weight gain, it is often desirable to quickly obtain accurate, repeated measurements of body composition. Standard whole-body carcass composition analysis (CCA) is a time consuming, terminal procedure[1]. Newer methods such as dual-energy X-ray absorptiometry (DXA) allow repeated measures in live subjects, but require the use of anesthesia and can take between 5 to 35 minutes per subject[2].

Body composition scanning using quantitative magnetic resonance (QMR) appears to be superior to both CCA and DXA methods in that QMR offers rapid measurement of body composition in live, unanaesthetized animals. While the EchoMRI system designed specifically for mice has previously been evaluated[3], no similar comparison has been performed for a QMR system designed for use with rats. To address this issue, we evaluated the precision and accuracy of QMR in comparison to traditional whole-body CCA, using the Echo Medical Systems EchoMRI (Model 700), a device designed to analyze both rats and mice, to compare data obtained from QMR and CCA analyses for outbred, lean, and obese strains of rats and mice.

Methods

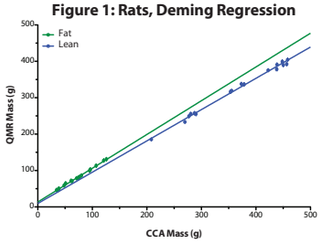
To compare data obtained from QMR with CCA analyses, we examined adult male rats and mice of varying body adiposity and genetic background. For each species, we examined one outbred, one lean, and one obese strain. For rats, Fisher rats (n = 6) were used as an outbred strain, and obesity-prone (OP, n = 6) and obesity-resistant (OR, n = 5) Sprague-Dawley rats were used as obese and lean animals, respectively. For mice, we examined BALB/cJ outbred, (n = 6), B6.V-*Lep*^{ob}/J obese (n = 6), and C57BL/6J lean mice (n = 6).

For all animals, three replicate live measurements were performed using QMR. For rats, QMR scans were performed with accumulation times of 2 minutes. For mice, all animals were scanned using a 4-minute accumulation.

Following QMR, animals were sacrificed, total lipid content was determined by chloroform extraction[4], and an ashing oven was used to determine protein content[5].

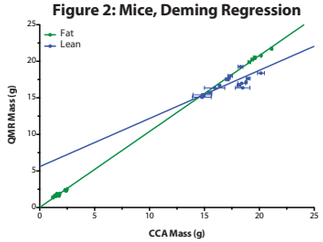
For comparisons, we used QMR measures of total fat and lean mass. For CCA, fat mass was defined as total lipid weight, while lean mass measurements were defined as water weight plus ash and protein weights. Measurements from each method were compared using Deming regressions. The precision of each method was determined by calculating the coefficient of variation (CoV) for QMR and CCA measurements.

Figure 1: Rats, Deming Regression



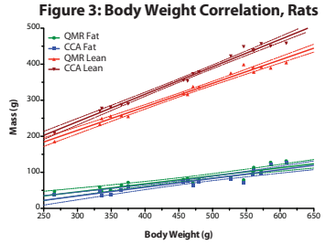
- QMR fat and lean mass values for rats are positively correlated with those obtained through CCA.
- Fat mass slope = 0.927 ± 0.0168
- Lean mass slope = 0.860 ± 0.017

Figure 2: Mice, Deming Regression



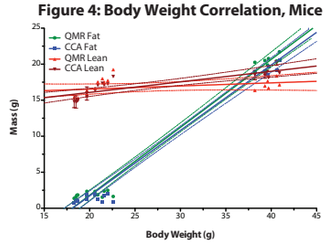
- QMR fat and lean mass values for mice are also positively correlated with those obtained through CCA.
- Fat mass slope = 0.927 ± 0.0168
- Lean mass slope = 0.860 ± 0.017

Figure 3: Body Weight Correlation, Rats



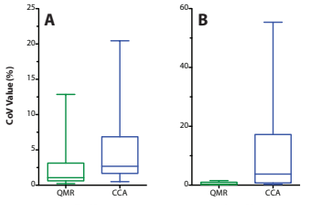
- Correlations between rat body weight and fat mass values for QMR and CCA are not significantly different.
- Rat lean mass values for QMR and CCA differ significantly (p = 0.0024).

Figure 4: Body Weight Correlation, Mice



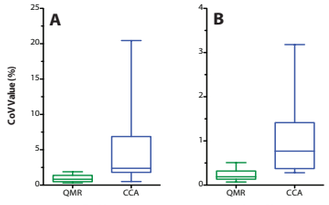
- Correlations between mouse body weight and fat mass values for QMR and CCA do not differ.
- Mouse lean mass values for QMR and CCA differ significantly (p = 0.0094).

Figure 5: Coefficient of Variation, All Animals



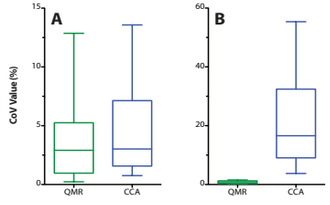
- For all animals combined, QMR CoV values were significantly lower than CCA CoV values.
- Fat mass CoV: p = 0.0072
- Lean mass CoV: p = 0.0001

Figure 6: Coefficient of Variation, Rats



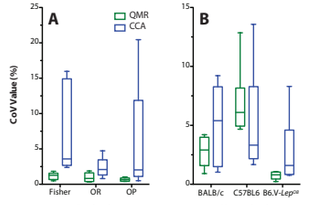
- Rat QMR lean mass CoV values are significantly lower than CCA CoV (p = 0.0095).
- Rat QMR lean mass CoV values are also lower than CCA CoV (p = 0.0010).

Figure 7: Coefficient of Variation, Mice



- QMR and CCA fat mass CoV does not differ in mice.
- However, mouse QMR lean mass CoV is significantly lower than CCA CoV (p < 0.0001).

Figure 8: Fat Coefficient of Variation, by Strain



- Fat CoV is similar in all rat strains.
- Mouse fat mass CoV differs by strain (p = 0.0203).
- Lean mass CoV is not affected by strain for either rats or mice.

Results

Fat mass: Deming regressions showed positive correlations between fat mass as determined by QMR and CCA for both rats (slope = 0.927 ± 0.0168; Fig. 1) and mice (slope = 1.038 ± 0.0044; Fig. 2). Linear regression against body weight shows no difference in slope between QMR and CCA measures for both rats (Fig. 3) and mice (Fig. 4).

Lean mass: Deming regressions showed positive correlations between lean mass as determined by QMR and CCA for both rats (slope = 0.860 ± 0.017; Fig. 1) and mice (slope = 0.659 ± 0.131; Fig. 2). When regressed against body weight, QMR and CCA measurements show significantly different slopes for both rats (F = 11.045, df = 1, p = 0.0024; Fig. 3) and mice (F = 7.646, df = 1, p = 0.0094; Fig. 4).

Precision of measurements: Overall, QMR CoV values were significantly lower than those obtained for CCA analysis for both fat (QMR = 2.24 ± 0.44; CCA = 4.79 ± 0.82; p = 0.0072; Fig. 5A) and lean mass (QMR = 0.55 ± 0.08; CCA = 11.04 ± 2.03; p = 0.0001; Fig. 5B).

For rats, QMR CoV values were significantly lower than CCA for both fat (QMR = 0.94 ± 0.12; CCA = 5.29 ± 1.46; p = 0.0095; Fig. 6A) and lean mass (QMR = 0.22 ± 0.03; CCA = 0.97 ± 0.18; p = 0.0010; Fig. 6B).

For mice, lean mass QMR CoV values were significantly lower than CCA (QMR = 0.85 ± 0.10; CCA = 20.55 ± 3.47; p < 0.0001; Fig. 7A), but no difference was observed for fat mass (QMR = 3.47 ± 0.75; CCA = 4.33 ± 0.85; p = 0.3557; Fig. 7B).

While no significant differences in fat mass CoV were observed between rat strains for either method of analysis (Fig. 8A), one-way ANOVA showed significant effects of mouse strain for fat measurements only (F = 5.11, df = 2, p = 0.0203; Fig. 8B). However, QMR fat estimates are expected to be more variable in very lean animals[3]. No significant differences in lean mass CoV were observed across strains for both rats and mice.

Summary

1. **Body composition analysis using EchoMRI QMR returns fat and lean mass values comparable to those obtained by CCA.**
2. **The consistent linear correlations between measurement methods indicate that studies using either method can be directly compared.**
3. **EchoMRI QMR measurements have higher overall precision for both fat and lean mass than measurements obtained using CCA.**

We conclude that the EchoMRI QMR system offers a fast, non-terminal, and accurate method of body composition analysis for rats and mice, yielding measurements comparable to those obtained by CCA without the need for the time-consuming chemical analyses of the latter method.

References

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Acknowledgements

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