Comparison of Free-Breathing and Breath-Held Cine DENSE Strain in Boys with Duchenne Muscular Dystrophy

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INTRODUCTION

Duchenne Muscular Dystrophy is a fatal, genetic muscle wasting disorder impacting 1:3800 boys [1]. The most common cause of mortality is cardiac failure and/or respiratory failure [2]. In order to assess the progression of cardiac disease and response to current and novel therapeutics, peak mid-wall circumferential strain (E_{cc}) has been proposed as a biomarker [3].

CINE Displacement Encoding with Stimulated Echoes (CINE DENSE)
- permits rapid, navigator-gated assessment of E_{cc} in the heart
- validated against MRI tagging
- has not been reported in a DMD cohort.

Breath holding can impact measures of cardiac function [2], but no comparison of free-breathing and breath-held E_{cc} measurements has been conducted in boys with DMD using cine DENSE encoding.

OBJECTIVES

Our **objectives** were:
1) To characterize E_{cc} in a DMD cohort using CINE DENSE
2) To compare the E_{cc} measurements derived from free-breathing and breath-held CINE DENSE.

METHODS

Study Population: Boys with DMD (N = 15) were prospectively enrolled in this IRB approved, HIPAA compliant study after obtaining informed consent. DMD boys had an age of (13 ± 2.1 years) and a Left Ventricular Ejection Fraction (LVEF) of (50.35 ± 10.78)

Acquisition: Single slice, short-axis, mid-ventricular data was acquired on a 3T Siemens Skyra using two protocols:
1. Navigator-gated, free-breathing CINE DENSE examination (2.5x2.5x8mm, TE/T_{Res}=1.2/15 ms, Denc = .08 cycles/mm, spirals = 10, Navg = 3, scan time = 2.5 minutes)
2. Breath-held CINE DENSE (3.0x3.0x8mm, TE/T_{Res}=1.2/15 ms, Denc = .08 cycles/mm, spirals = 6, Navg = 1, scan time = 25 seconds)

Post processing:
- A custom post-processing tool (Matlab) was used to segment the data and transform the x and y displacement encoded phase information into Lagrangian displacements and E_{cc}.
- The mid-wall wall was identified and global E_{cc} values were computed for both acquisitions.

Statistics:
- E_{cc} values were summarized as mean ± standard deviation for each subject.

METHODS (Continued)

- Bland-Altman analysis summarized mean difference and bias between the breath-held and free-breathing acquisition.
- A paired two-tailed t-test was used to compare differences in E_{cc} values for the free-breathing and breath-held acquisitions. A p-val≤0.05 indicated statistical significance.

RESULTS

Strain Values: Mid-wall E_{cc} in DMD patients was -14.9 ± 4.4% and -15.2 ± 5.0% for the breath held and free breathing technique respectively (P=0.53).

Further Analysis: **Figure 1** shows Bland-Altman analysis between the breath-held and free-breathing acquisitions (E_{cc} Bias = - 0.05%, Limits of agreement [-5.50% , 4.50%]) and **Figure 2** demonstrates a paired box-plot comparing the free breathing and breath held technique with individual pairs of data mapped to one another.
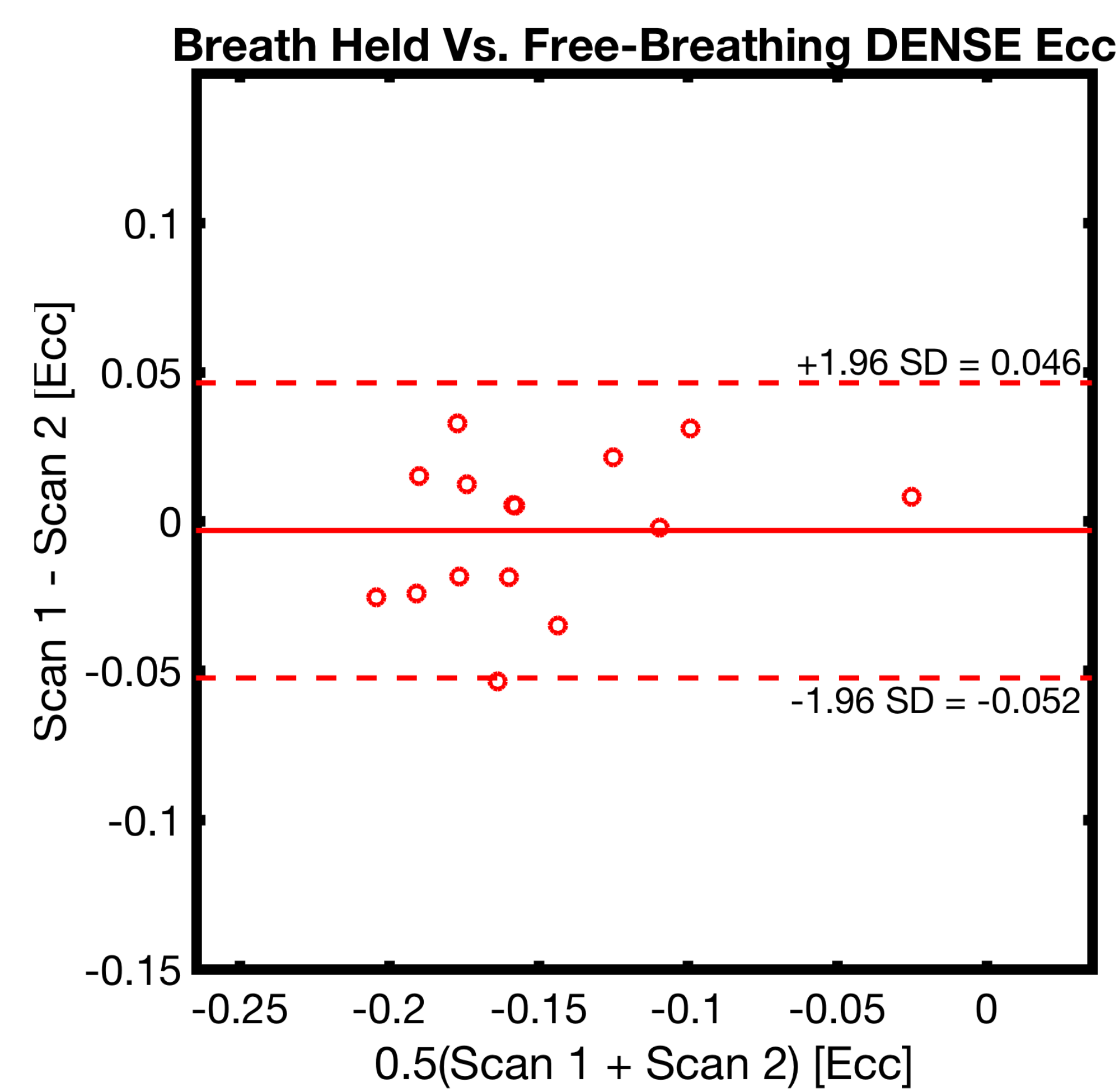

Figure 1. Bland-Altman analysis of peak mid-wall E_{cc} measured using breath held and free breathing CINE DENSE.
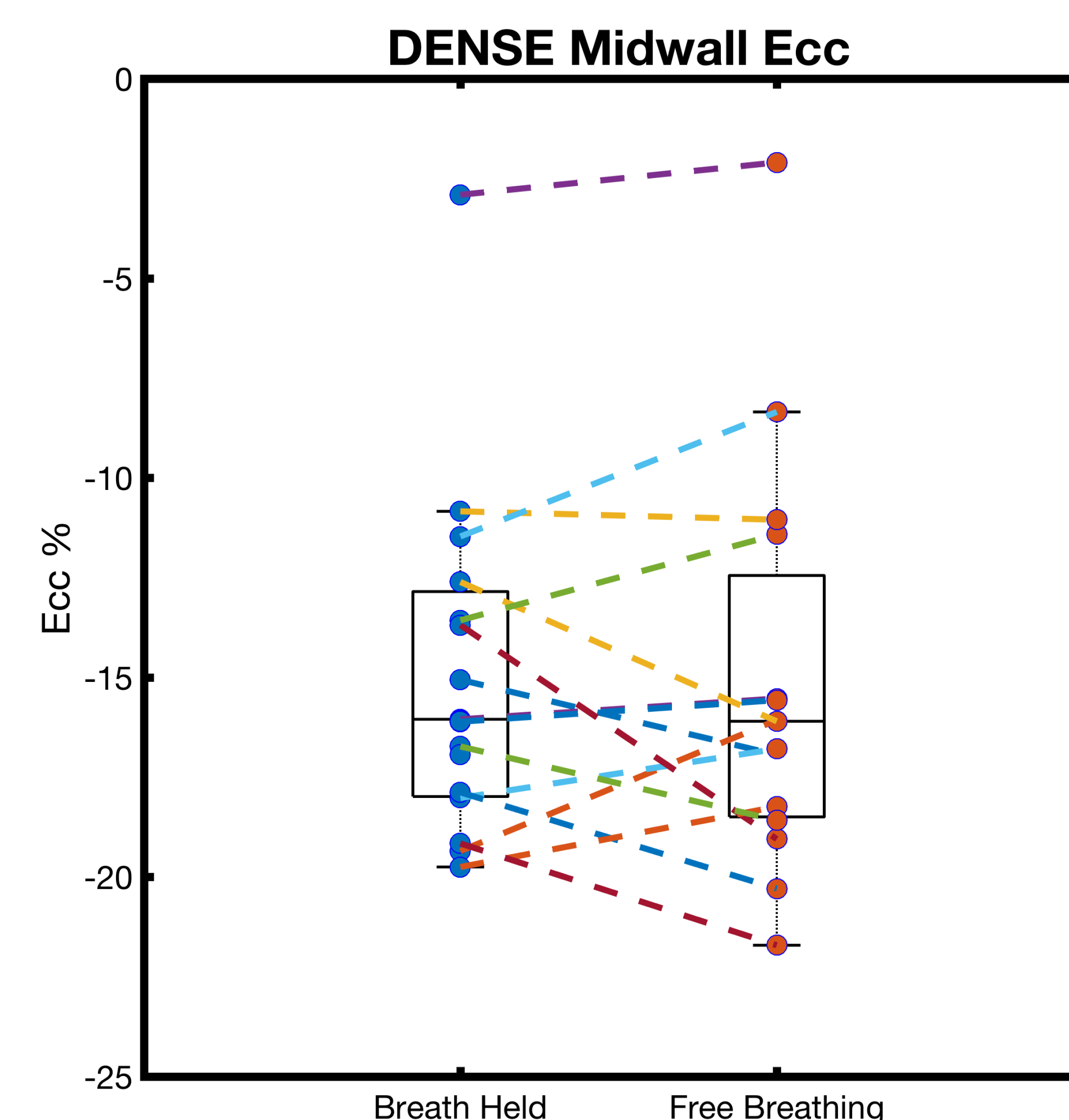

Figure 2. Paired box-plot comparing E_{cc} results for breath held and free breathing CINE DENSE. There is no significant difference between the two groups. Each individual's scans are connected with dashed lines for reference.

RESULTS (Continued)

Figure 3 shows a side by-side comparison of breath-held and free-breathing cine DENSE at peak systole in a representative subject.
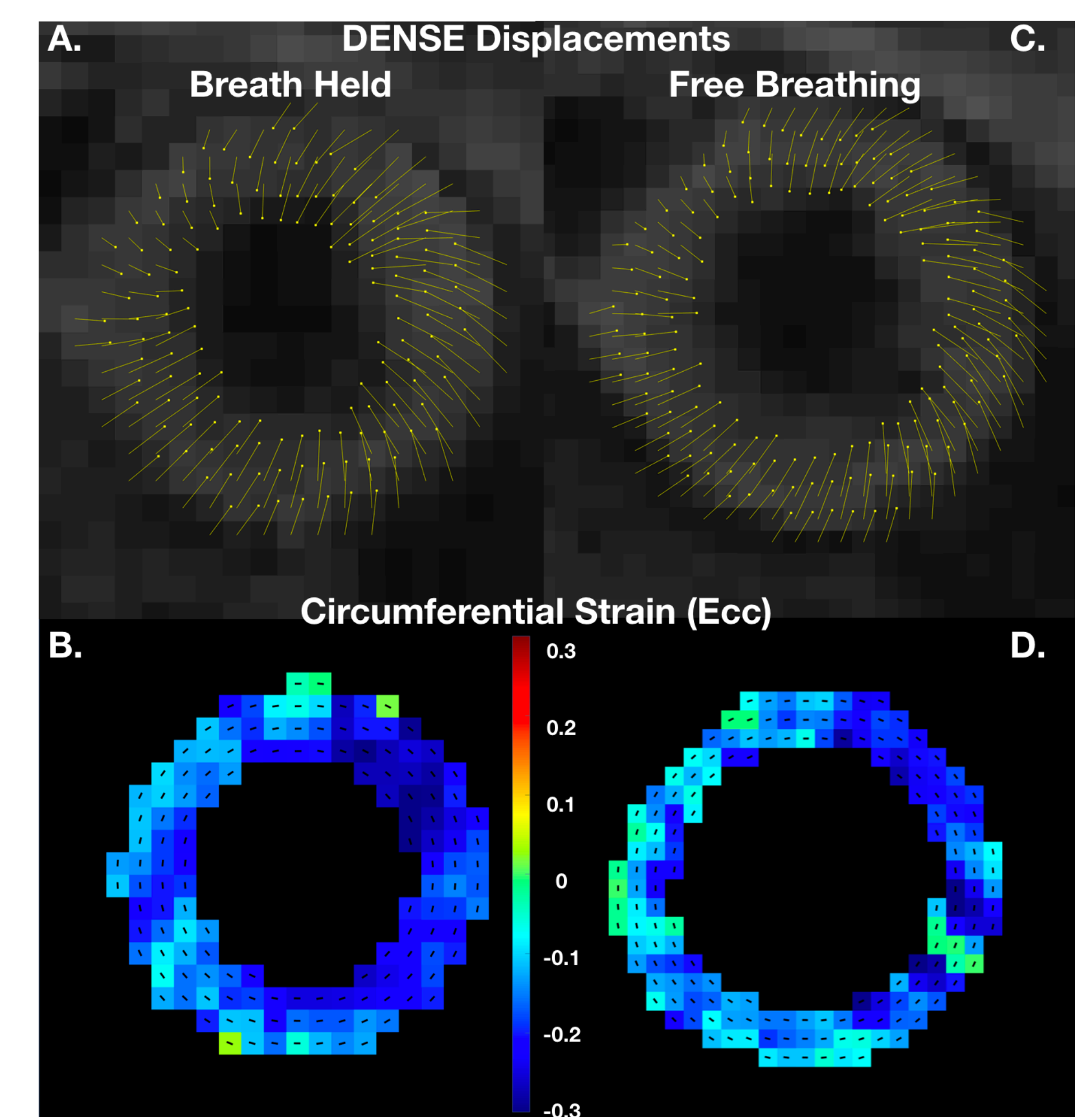

Figure 3. Representative image of DENSE displacements and E_{cc} in one DMD patient for the breath held acquisition (A and B) and the free breathing acquisition (C and D).

DISCUSSION

- This report is the first time that normative values for peak mid-ventricular mid-wall E_{cc} have been reported using CINE DENSE in a DMD cohort.
- The results show good agreement with previous E_{cc} reports in boys with DMD using MRI tagging (-12.4% and -15% E_{cc}, [3,4]).
- The use of a breath-held or free breathing technique did not significantly alter the resultant strain values.
- However, because of the difficulty DMD patients frequently have with breath-holding, capitalizing on DENSE's ability to acquire strain information without breath holding is a compelling way to improve clinical workflow and patient compliance, especially for more severely effected boys.
- Anecdotally, image quality is better with free breathing data and is more easily processed.

CONCLUSION

Free breathing CINE DENSE strain estimates are an excellent technique for characterizing myocardial function in boys with DMD.

ACKNOWLEDGEMENTS

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