# Population analysis of $B_0$ magnetic field conditions in the human heart


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## Introduction

Cardiovascular magnetic resonance (CMR) suffers from susceptibility-induced artifacts[1-4] (Figure 1) in the myocardium due to $B_0$ variations across the heart. The best remedy to mitigate these issues is cardiac $B_0$ shimming[5], which requires *in vivo* $B_0$ maps in the heart typically acquired with breath-hold[6]. However, the lack of population data in cardiac $B_0$ conditions, especially for the patients with impaired lung capability[7], in pediatrics[8], and in elderly[9] impedes the development of optimal cardiac $B_0$ shim strategy. Here, we propose to investigate $B_0$ conditions in the population via $B_0$ simulation from a large sample of structural CT images.

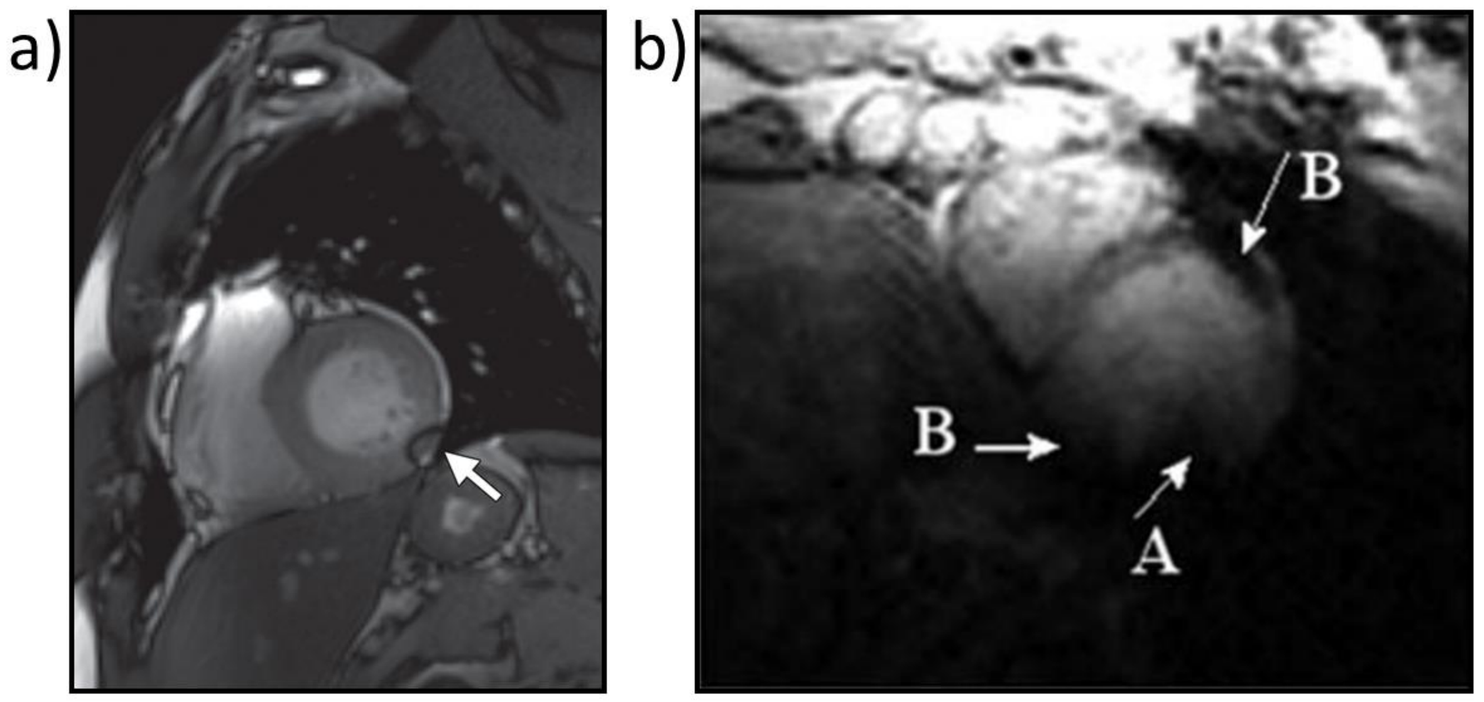


***Figure 1. Susceptibility-induced artifacts in the myocardium caused by $B_0$ variations in the heart. a) Dark band artifact (white arrow) occurred in the inferolateral wall on the myocardium at 3 T (adopted from Rajiah P et al.[2]. b) Signal loss in the myocardium (white arrows) at 7 T (adopted from Meloni A et al.[3].***

## Methods

$B_0$ simulation was performed in B0DETOX[10] based on the CT images of 254 adult subjects under the magnetic field strength of 3 T (Figure 2a). The simulated cardiac $B_0$ distributions were analyzed by standard deviation and unconstrained spherical harmonic (SH) decomposition up to 2[nd] and 3[rd], which were then compared to vendors' $B_0$ shim specifications. These $B_0$ conditions between female and male groups were compared using the student's t-test. Their correlations to the subjects' demographic parameters (Figure 2b) were then calculated.

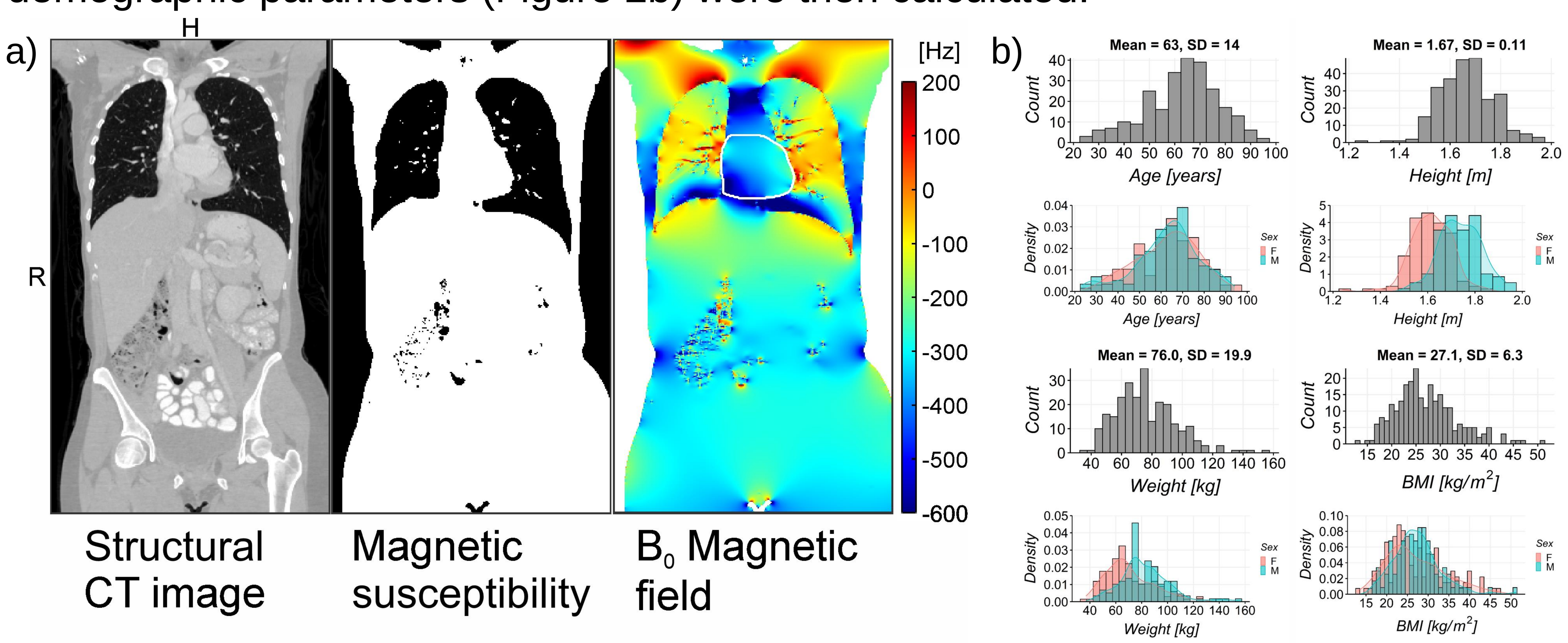


***Figure 2. a) $B_0$ simulation in the heart (white profile) was based on the magnetic susceptibility distribution derived from structural CT images. This approach was applied to 254 subjects with b) a widespread distribution of demographic parameters.***

## Results

$B_0$ inhomogeneity after unconstrained 2[nd] and 3[rd] shim at 3 T was 36 ± 6 Hz and 27 ± 5 Hz, respectively. The shim capability of GE Premier showed limitation at 2[nd] order, leading to increased $B_0$ inhomogeneity for some subjects after shim (Figure 3). Female subjects showed significantly lower $B_0$ inhomogeneity and the Z3 SH coefficient than male subjects. The Z3 term and height have a maximum correlation of 0.343 (Figure 4).

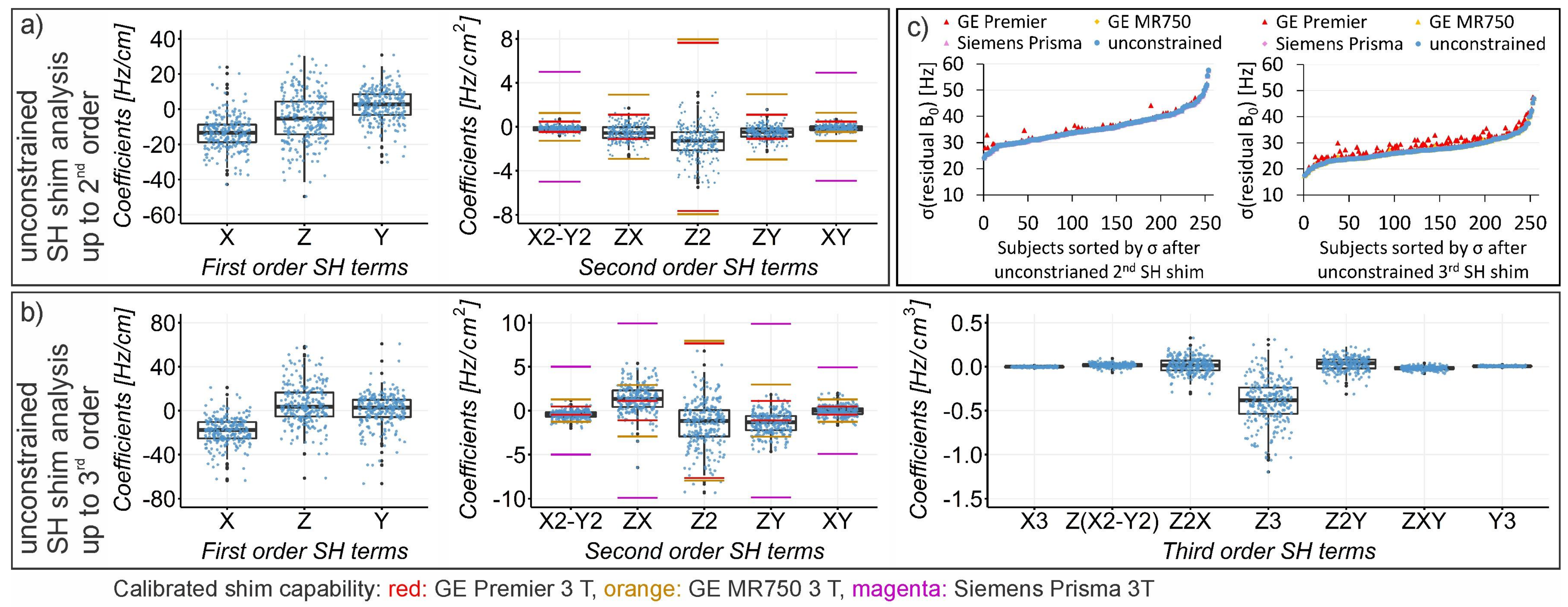


***Figure 3. Theoretical $B_0$ shim analysis of cardiac $B_0$ conditions at 3 T. SH coefficients decomposed from unconstrained shim analysis a) up to 2[nd] and b) up to 3[rd] SH order. C) The same limits of GE Premier have a larger impact on 3[rd] order SH shim than 2[nd] order, leading to more subjects having increased $B_0$ inhomogeneity after shim.***

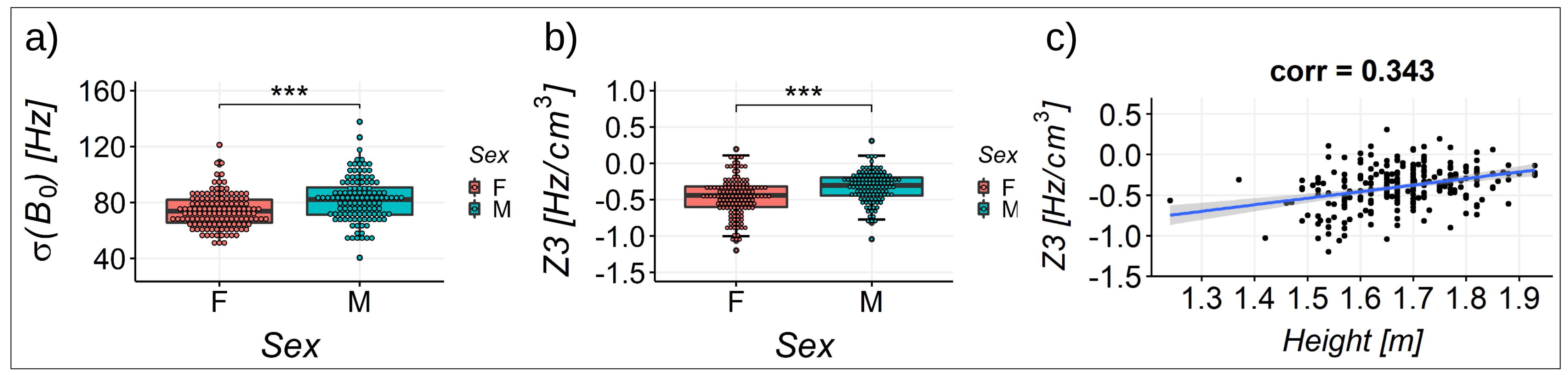


***Figure 4. Correlation analysis between $B_0$ conditions and demographic parameters. Female subjects showed significantly lower a) $B_0$ inhomogeneity and b) Z3 SH term than male subjects. c) The correlation between the Z3 term and height is 0.343.***

## Discussion

The detailed analysis of cardiac $B_0$ conditions suggest the 2[nd] and 3[rd] order SH shim requirements in CMR at 3 T. The association between $B_0$ conditions and demographic parameters is expected to characterize $B_0$ distributions in the heart and develop optimal subject- and population-specific cardiac $B_0$ shim strategies.

## References


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