## Image Registration Required for Magnetic Resonance Imaging Experiments of Accommodation

Using 7 Tesla magnetic resonance imaging (MRI), Richdale et al.[1] measured the change in lens and ciliary muscle ring dimensions of the occluded right eyes of 26 emmetropic subjects (30–50 years of age) while their left eyes changed fixation on a Maltese cross placed at different distances to stimulate from 0 to 6 diopters of accommodation. The MRI scans were repeated at least eight times for each accommodative demand over a time period of 10 minutes. A masked examiner identified the central slice of each scan and measured the equatorial lens diameter, central lens thickness, and ciliary muscle ring diameters. The authors do not specify how the masked examiner determined the central slice of each scan, and the reproducibility of the measurements (mean, SD, and range) are not given for the eight MRI scans of each subject at each accommodative demand. In addition, the authors make statements of correlations, but do not supply the coefficients of determination, $r^2$, so the reader can assess the strength of the authors' conclusions.[2,3]

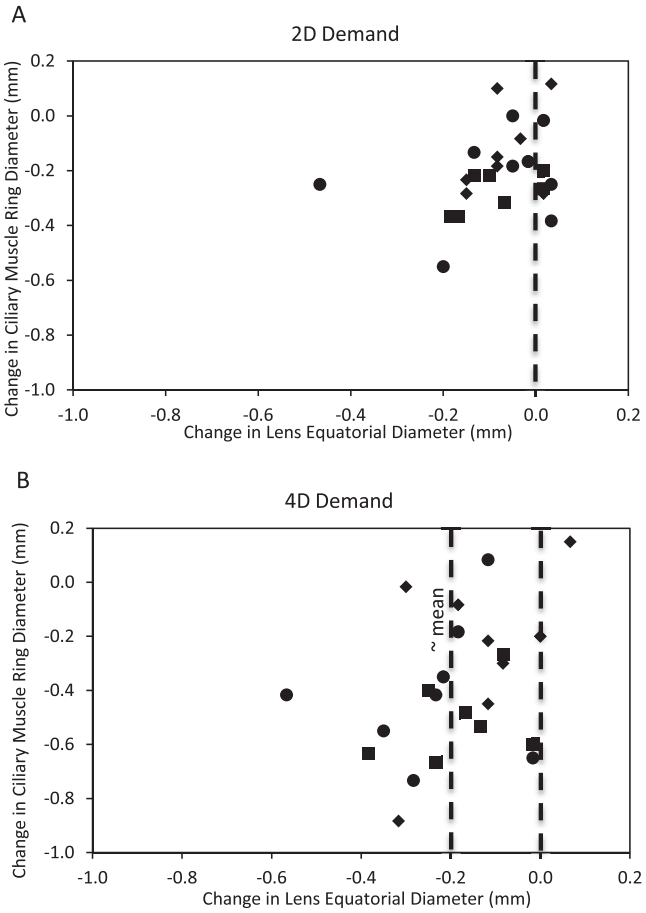


**Figure.** A reproduction of the authors' Figure 7 (top and middle), which shows the change in lens equatorial diameter for accommodative demands of (**A**) 2 diopters and (**B**) 4 diopters. The *dashed vertical lines* have been added to make those subjects that had an *increase* in equatorial diameter more apparent and to show the approximate mean change to the 4 diopter demand. The *circles* are 30 to 35, *squares* 35 to 40, and the *diamonds* 45 to <50-year-old subjects.

Examination of the authors' Figure 7 demonstrates that there was an *increase* in lens equatorial diameter in response to the 2 diopter (D) and 4 D accommodative demands in eight subjects, Figure A, B. According to the generally accepted Helmholtz's theory of accommodation, the lens equatorial diameter (LED) *must* always decrease during accommodation greater than zero D. The finding that 8 of 26 subjects, 31% (5 were <40 years of age), had an *increase* in LED brings into question the reliability of the authors' measurements and/or the Helmholtz theory of accommodation.

One possibility to account for the authors' findings is that they compared images taken from different planes due to convergence and cyclotorsion of the nonfixating eye.[4] For example, since the mean accommodative convergence[5,6] and cyclotorsion[7] for the subjects' age is expected to be approximately 12° and 1.6°, respectively, for 4 D of accommodation and the mean baseline LED of the subjects was 9.42 mm, the observed approximate mean 0.2 mm decrease in LED for the 4 D demand, Figure B, may have resulted from an off-axis measurement[8]: 9.42 mm − 9.42 mm cos(12°) cos(1.6°) = 0.2 mm.

Unfortunately, the reader is unable to independently assess whether the compared images were obtained from identical planes, since the authors do not supply MRI images of the unaccommodative and maximally accommodated eye of a subject. In addition, it is not clear why the authors omitted the four subjects in the 40- to 45-year-old age group from the scattergrams of their Figure 7.

In summary, nonrandom accommodative eye movements may have caused a systematic error[9] in the authors' study. Similar to the other studies referenced by the authors,[10–12] the authors' study is flawed because multiple unchanging positional references were not included in their analysis to permit proper image registration. This methodological omission and the lack of proper controls make the authors' measurements of the dimensional and directional changes of the lens and ciliary muscle during accommodation unreliable.

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