Short-term changes in axial length during simulations of typical far, intermediate and near tasks

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Purpose: To investigate the changes in axial length with the combined effect of accommodation and angle of gaze (convergence and downward gaze) over 5 minutes in groups of myopes and emmetropes.

Methods: A total of 31 subjects (nine emmetropes, 10 low myopes, and 12 moderate to high myopes) aged from 18 to 31 years were recruited. To measure ocular biometrics in infero-nasal gaze with accommodation, an optical biometer (Lenstar LS900) was inclined on a tilt and height adjustable stage, with the subject's chinrest mounted on a rotary stage to induce various levels of convergence by rotation of the subject's head in primary or downward gaze. Initially, the subjects performed a distance viewing task in primary gaze for 10 minutes to provide a 'wash-out' period for prior visual tasks, and then the subject's axial length and ocular biometrics were measured in nine different combinations of gaze/accommodation over 5 minutes. These nine sessions for all gaze measurements (i.e. three levels of accommodation 9 three levels of convergence) were completed across 3 days of testing (one accommodation condition on each day).The nine combinations of gaze/accommodation were based on those required to view the centre, right and left edges of a distant TV at 6 m in primary gaze, an intermediate task (i.e. computer at 50 cm in 10° downward gaze) and a near task (i.e. reading A4 page at 20 cm in 20° downward gaze). Subjects were wearing a custom built three-axes head tracker throughout the experiment that monitored subjects' relative head movements (roll, pitch and yaw) during measurements.

Results: A significant increase in axial length occurred with the combined effect of accommodation, convergence and downward gaze (repeated measures ANOVA, $p < 0.001$), with the greatest axial elongation during the near task in downward gaze with convergence (i.e. downward 20°/inward 33°, with 5 D accommodation) (mean change 33 ± 13 lm, after 5 minutes task) followed by the intermediate task (i.e. downward 10°/inward 25°, with 2 D accommodation) (mean change 14 ± 11 lm, after 5 minutes task).Changes in axial length for the distance task (i.e. primary gaze/9° convergence, with 0.16 D accommodation) were not statistically significant (mean change 4 ± 8 lm, after 5 minutes task, $p > 0.05$). Moderate to high myopes had a greater change in the axial length (mean change 40 ± 11 lm after 5 minutes of near task) than that of emmetropes (mean change 29 ± 15 lm after 5 minutes of near task) and low myopes (mean change 29 ± 16 lm after 5 minutes of near task) associated with time ($p = 0.02$) and accommodation by time ($p = 0.03$).

Conclusions: The combination of accommodation, convergence and downward angle has a significant short term effect on axial length over time. The near task in downward gaze with convergence caused a greater change in axial length than the intermediate and distant visual tasks. The greater axial elongation measured in the infero-nasal direction with accommodation is most likely associated with a combination of biomechanical factors such as, extraocular muscle forces and ciliary muscle contraction.