Effect of diabetes on amplitude of accommodation

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Purpose: To determine the effect of Type 1 diabetes (DM1) on amplitude of accommodation. Method: There were 43 participants (33 ± 8 years) with DM1 and 32 (34 ± 8 years) age-balanced controls. Amplitude was measured objectively with a COAS wavefront aberrometer and subjectively with a Badal hand optometer. Results: Across both groups, objective amplitude was less than subjective amplitude by 1.4 ± 1.2 D. People with diabetes had lower objective (2.7±1.6 D) and subjective (4.0±1.7 D) amplitudes than people without diabetes (objective 4.1±2.1 D, subjective 5.6±2.1 D). For the DM1 group, the objective and subjective multivariate linear regressions were 7.1 – 0.097Age – 0.076DiabDur (R² 0.51) and 9.1 –0.103Age – 0.106DiabDur (R² 0.63), respectively. Conclusion: Objective and subjective techniques showed lowered amplitude of accommodation in DM1 participants compared with age-matched controls. Loss was affected strongly by duration of diabetes. People with diabetes will experience presbyopia earlier in life than people without diabetes.

Keywords: amplitude of accommodation; ageing; diabetes; presbyopia

1. Introduction

Diabetes mellitus is a group of metabolic diseases characterized by chronic hyperglycaemia. The primary subtypes are Type 1 diabetes mellitus (DM1), characterized by auto-immune destruction of pancreatic beta-cells that leads to loss of insulin secretion, and Type 2 diabetes mellitus which is the most prevalent form. Diabetes affects all parts of the human eye with its most debilitating complication being diabetic retinopathy. Little is understood about how diabetes also affects the optics and biometry of the eye.

In many respects, eyes of individuals with diabetes appear to be more aged versions of normal eyes. There are several age-related biometric changes [1] which are exacerbated in diabetes: anterior chamber depth decreases, lens thickness increases, lens surface curvatures increases, and lens equivalent refractive index decreases [2-5]. Amplitude of accommodation is reduced in people with diabetes compared to age-matched controls [6].

Previous studies of accommodation amplitude related to diabetes involved subjective techniques affected by depth-of-focus, resulting in overestimation of amplitude. We obtained objective as well as subjective estimates in order to better understand loss of accommodation accompanying diabetes.
2. Methods

Participants were under 47 years and consisted of 43 participants (33 ± 8 years) with DM1 and 32 (34 ± 8 years) age-matched controls. There was no significant difference in the mean equivalent refractive error and visual acuity between the two groups.

Comprehensive visual functions testing and ocular health assessment included case history, glycaemic control with HbA1c, capillary blood glucose level in people with diabetes, slit lamp biomicroscopy, intraocular pressure (I-Care) and colour vision assessment (L’Anthony desat. D15).

Participants with corrected visual acuities ≥0.1 log minutes of arc resolution (logMAR), Pelli-Robson contrast sensitivity scores ≥1.65, equivalent spherical refraction ≤±3.5 D, and normal colour vision were included. Participants with more than mild diabetic retinopathy were excluded. One eye of each participant was tested. Slit lamp photographs and C-Quant values (straylight >1.60 log(s) was excluded) were used to classify participants with and without cataract. Participants using systemic medications with known accommodation or central nervous system effects were excluded.

Subjective amplitude of accommodation was measured with a Rodenstock hand held Badal optometer. The participant was instructed to move the target from the far end towards the eye and stop where the bottom line first became clear; this was noted as the far point. The participant was instructed to bring the target towards eye until the bottom line become first unreadable; this point was noted as near point of accommodation. The amplitude of accommodation was the average of three differences between values for near and far points.

Objective amplitude of accommodation was measured using a COAS wavefront aberrometer (Wavefront Sciences). Usually the internal target of the aberrometer is fogged automatically by about 1.5 D, but the position of the internal target can be controlled manually to provide a variable accommodative stimulus. Accommodative response was determined as the difference in mean spherical equivalent refractions between the two situations, where the refraction was determined from the average of three aberration measurements using 2nd and 4th order Zernike aberration terms for a 4 mm pupil. Aberrations were referenced to the anterior corneal plane. The target was adjusted in 1D stimulus steps until it was clear that a maximum accommodation response had been achieved. Figure 1 presents an example.

3. Results

Figure 2 is a Bland-Altman plot of agreement between the objective and subjective methods for the combined data of the people with and without diabetes. Objective amplitudes were smaller than the subjective amplitudes by 1.4 ± 1.2 D. People with diabetes had significantly lower objective (2.7 ± 1.6 D) and subjective (4.0 ± 1.7 D) amplitudes of accommodation than people without diabetes (objective 4.1 ± 2.1 D, subjective 5.6 ± 2.1 D).

Figure 3 shows relationships between age and amplitude. The rates of change of amplitude losses with age were lower in people with diabetes than in people without diabetes. Multivariate regression was performed with age and diabetes duration as predictors using the combined groups (duration of diabetes = 0 for people without diabetes) and only the diabetes group. The independent effects of both of these factors were significant and both factors contributed significantly to fits. For objective amplitude of accommodation and combined groups we obtained
\[ y = -0.083\text{DiaDur} - 0.145\text{Age} + 9.00, \quad R^2 = 0.59 \quad (1) \]

For objective amplitude and diabetes group we obtained
\[ y = -0.076\text{DiaDur} - 0.097\text{Age} + 7.13, \quad R^2 = 0.51 \quad (2) \]

For subjective amplitude of accommodation and combined groups we obtained
\[ y = -0.104\text{DiaDur} - 0.153\text{Age} + 10.79, \quad R^2 = 0.67 \quad (3) \]

For subjective amplitude and diabetes group we obtained
\[ y = -0.106\text{DiaDur} - 0.103\text{Age} + 9.09, \quad R^2 = 0.63 \quad (4) \]

Estimates of the importance of diabetes duration relative to that of age from these four fits are, in order, 0.57, 0.78, 0.70 and 1.03.

Figure 1. Accommodative response/stimulus curves of a participant without diabetes. Error bars are standard deviations of three measurements.

Figure 2. Bland-Altman plot comparing objective and subjective amplitudes. The mean difference and the prediction limits are given by straight lines.

Figure 3. Amplitudes of accommodation as a function of age in people with and without diabetes. **Left panel Objective**: Linear fits are \( Y = -0.117\text{Age} + 6.6, \quad R^2 0.38, \quad p < 0.01 \) with diabetes and \( Y = -0.226\text{Age} + 11.9, \quad R^2 0.70, \quad p < 0.01 \) without diabetes. **Right panel Subjective**: Linear fits are \( Y = -0.131\text{Age} + 8.7, \quad R^2 0.41, \quad p < 0.01 \) with diabetes and \( Y = -0.232\text{Age} + 13.6, \quad R^2 0.73, \quad p < 0.01 \) without diabetes.

Figure 4 shows predictions of objective amplitude in people with diabetes based on the age fit in Figure 3 left and on the multivariate eq. (2) at different diabetic durations. The age-only equation matches the 10-year duration plot at 15 years and matches the 20-year duration plot at 50 years.
4. Conclusion

Supporting Moss et al. [6], we found lower amplitudes of accommodation in participants with diabetes than in age-matched controls. From eq.s (1)-(4) estimates of importance of diabetes duration relative to that of age were 0.6 to 1.0, which overall indicate greater importance of age than of diabetes duration, but are higher than previous subjective amplitude estimates of 0.4 to 0.6 [6-7].

![Figure 4](image-url)  
**Figure 4.** Objective amplitude of accommodation fits for people with diabetes. Plots are the age fit from Figure 3 left and multivariate equation (2) corresponding to diabetes durations of 5, 10 and 20 years.

This study provides objective amplitude of accommodation measures unaffected by depth-of-focus. Objective amplitudes were a mean 1.4 D lower than subjective amplitudes, and the difference was similar for diabetic and non-diabetic groups. Proportional effects of age and duration on amplitude appeared similar for the two groups (Figures 3 and 4).

Although our results show clearly that amplitude of accommodation is reduced in people with than without diabetes and that this difference is exacerbated as the duration of diabetes increases (Figure 4), rate of loss with age is lower in the diabetes group than in the non-diabetes group. If presbyopia occurs at 45 years in people without diabetes, Figure 3 suggests that people with diabetes become presbyopic only 3-5 years earlier than people without diabetes. The DM1 group in our study may not have been representative of a wider DM1 population in that diabetes was under particularly good control and the duration in the older people was not much longer than in the young members of the group, and thus effects of age on amplitude may have been underestimated.

References


