Figure 4. Calculated angle of convergence in prism dioptres

B= Ø of measured working distance and distance to the end of the table.

AC/A: CI is a low AC/A diseases (>2).

Figure 5 and formula 1.

$$\text{Formula 1: Correction } \triangle = \frac{PD\,(cm)}{B\,(meter)} - \left(AC/A_{max} \times \frac{1}{B\,(meter)}\right)$$

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Working Distance of Children between 7 to 14 Years of Age and Calculation of the Convergence Angle and the Prismatic Correction for Treatment of Convergence Insufficiency
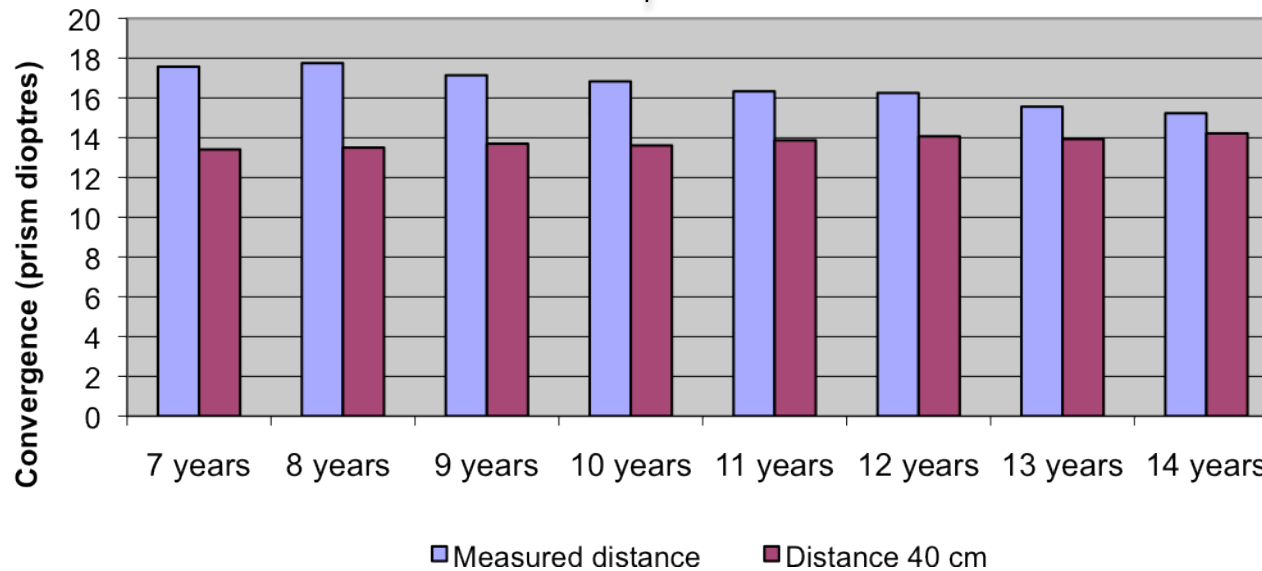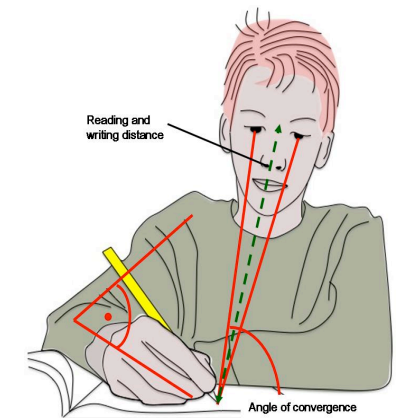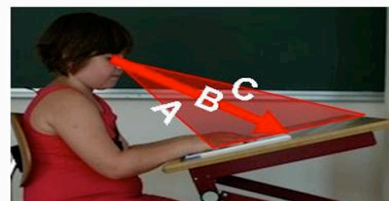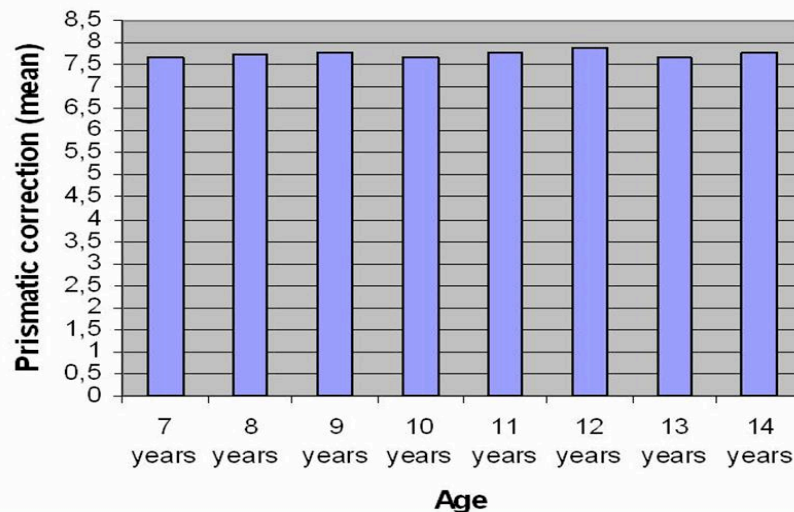
Introduction

Accommodation and convergence are related to the distance from the eyes to the object. Both systems are activated by the autonomic nervous system and mediated by muscle groups. The ciliary muscle is involved in changing the focus of the eye, and both the medial and lateral recti muscles are involved in convergence and divergence of the eyes to see single images at all distances. The closer the object, the more power must be generated by the ciliary muscle to increase the dioptric power of the eyes and keep the picture of the object clear on the retina. To see single images is it necessary that the medial recti muscles of both eyes generate an inward movement of the eyes. The angle of convergence depends on the interpupillary distance and the distance from the eyes to the object. The closer the object, the greater the angle of convergence and the more action both medial recti muscles is necessary (Figure 1).

Figure1. Correlation between working distance and convergence.

Method

Retrospective clinical data from 376 subjects - 203 (54%) subjects without reading difficulties (Control group) and 173 (46%) subjects with reading difficulties (Referred Group) - measured with two methods. Ergonometric data as shown in Figure 2 were measured in all subjects. Each subject held the upper arm along the upper part of the body with the forearm making a right angle to the upper arm. The subject was instructed to look at his/her palm while the researcher measured the distance between eye and palm. For the second measurement the subject sat in front of a height adjustable table and was instructed to write three words on a paper while the distance from the eye to the paper was measured. This procedure was repeated three times and the average was noted.

Results

One way ANOVA demonstrated no statistical significance between control group and referred group (eye to palm ANOVA $p=0.832$, eye to paper ANOVA $p=0.896$). One way ANOVA demonstrated no statistically significant difference between the measurement of eye to palm and eye to paper (ANOVA $p=0.754$) in both control and referred groups.
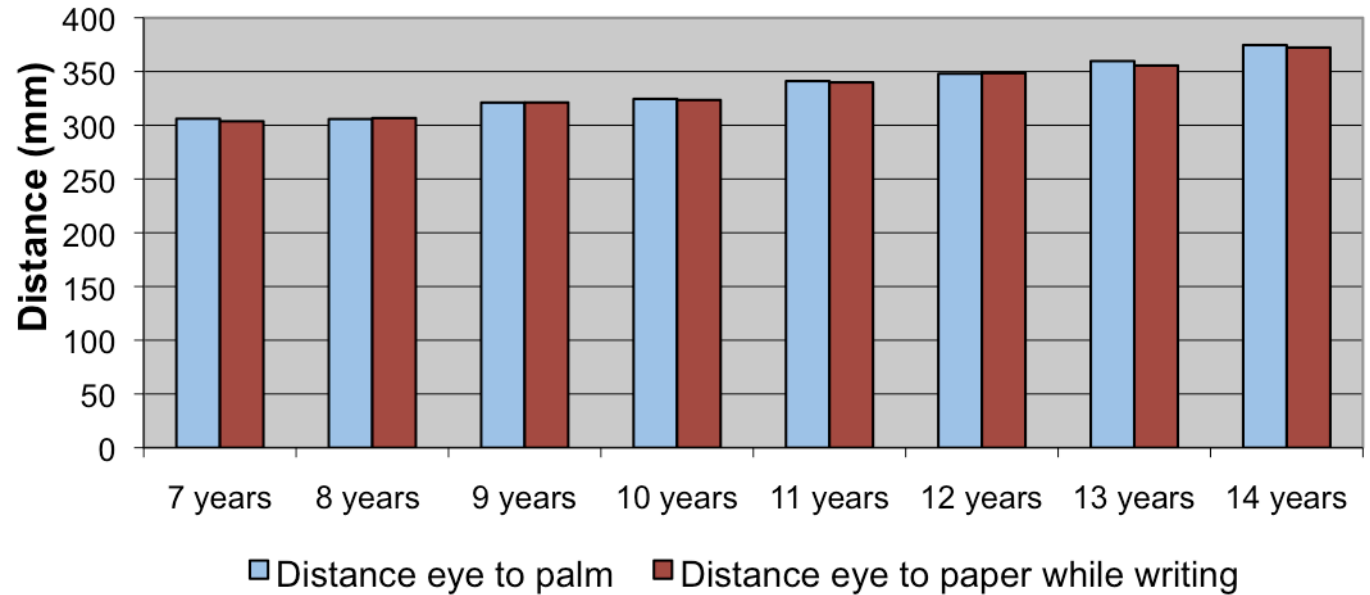

Figure 3. Measured distance eye to palm (blue) and eye to paper while writing (red) in each age group.
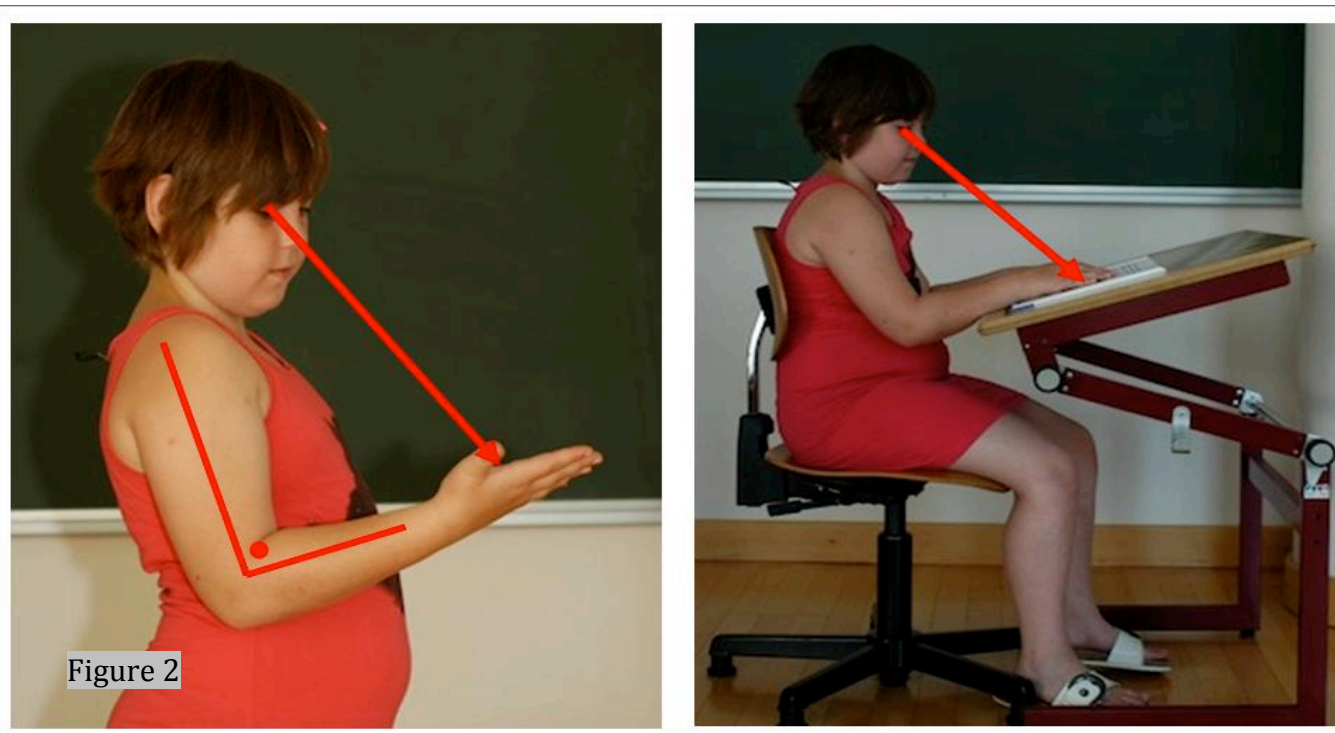

Figure 2

Discussion

The working distance used by children aged between 7 to 14 years is considerably closer than 40 centimetres and the resulting convergence angle for reading and writing is therefore much greater than the convergence angles that have been generally accepted in the literature. (Figure 4). The evidence for reduced working distance could have consequences for calculating prismatic reading glasses for children with reading difficulties and CI. In spite of the gradually increasing working distance with age (Figure 3), the appropriate prismatic correction calculated using formula (1) is around 8 prism dioptres for the entire age range studied (Figure 5).

Conclusions

A standard prism with 8 prism dioptres base in will treat convergence insufficiency without the risk of an overcorrection. Further studies are necessary to find out the effect of using 8 prism base on the reading performance by children with reading difficulties and convergence insufficiency.