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ORIGINAL RESEARCH

Effect of Myopic Undercorrection on Habitual Reading Distance in Schoolchildren: The Hong Kong Children Eye Study

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ABSTRACT

Introduction: This study aimed to evaluate the habitual reading distance among non-myopic children and also myopic children with undercorrection and with full correction.
Methods: This was a population-based cross-sectional study with a total of 2363 children aged 6–8 years who were recruited from the Hong Kong Children Eye Study. Cycloplegic autorefraction, subjective refraction, habitual visual acuity, and best corrected visual acuity were measured. The entire reading process (9 min) was recorded using a hidden video camera placed 5 m away from the reading desk. Reading distances were taken at 6, 7, 8, and 9 min after the child began reading and were measured using a customized computer program developed in MATLAB. The main outcome was the association of habitual reading distances with refraction status. Habitual reading distances of children were documented via

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video camera footage.
Results: The habitual reading distances of undercorrected myopic children (23.37 ± 4.31 cm) were the shortest when compared to non-myopic children (24.20 ± 4.73 cm, $P = 0.002$) and fully corrected myopic children (24.81 ± 5.21 cm, $P < 0.001$), while there was no significant difference between the last two children groups ($P = 0.17$). A shorter reading distance was associated with myopia (OR 1.67; 95% CI 1.11–2.51; $P = 0.013$) after adjusting for age, sex, height, near work time, outdoor time, and parental myopia. The association of reading distance with myopia did not hold after undercorrected myopic children were excluded (OR 0.97, 95% CI 0.55–1.73; $P = 0.92$). A shorter reading distance correlated with poorer vision under habitual correction ($\beta = -0.003$, $P < 0.001$).
Conclusion: A shorter reading distance was present among undercorrected myopic children. Myopia undercorrection is not recommended as a strategy for slowing myopic progression.

Keywords: Myopia; Reading distance; Undercorrection of myopia

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Key Summary Points

Why carry out this study?

Undercorrection of myopia has been long prescribed to reduce myopia progression. However, evidence of this proposition has not been substantiated.

We hypothesize that reading distance may be affected by the prescription of myopic spectacles with undercorrection.

What was learned from the study?

We found that the habitual reading distances of undercorrected myopic children were the shortest when compared to non-myopic children and fully corrected myopic children, which may increase the risk of myopia.

Myopia undercorrection is not recommended as a strategy for slowing myopic progression.

INTRODUCTION

Myopia is the most common ocular disorder worldwide, having become increasingly prevalent over the past decades, especially in Asia [1, 2]. As less time outdoors and increased reading time have been associated with greater risk of myopia, these factors may be connected with increasing prevalence [3, 4]. Different underlying reasons for the connection between reading and myopia have been suggested such as increased accommodative demand [5] and more recently peripheral hyperopic defocus [6]. However, active accommodation may not cause myopia in animal studies [7, 8]. In the COMET study, preventing accommodation with progressive addition lenses in children did not help with reducing progression [9, 10].

Reading is a highly complex behavior involving accommodation, visual sensory input, convergence, eye movements, and higher cognitives of comprehension [11–13]. Undercorrection of myopia (− 0.50 D to − 1.00 D) has been long prescribed to reduce myopia progression [14–16]. It was believed to reduce the accommodative stimulus and demand in near work, and thus reducing the blur drive for accommodation, subsequently slowing the myopia progression [15]. However, evidence of this proposition has not been substantiated. Randomized clinical trials have shown that undercorrection or bifocal lens for myopic children to reduce the accommodation demand could not be effective in reducing myopia progression [17–19]. In animal studies, accommodation does not consistently affect myopia progression [8]. Hyperopic defocus in close work has also been proposed to be associated with myopic progression [20]. However, none of the proposed theories have consistently been demonstrated to explain the cause of myopia.

There is some evidence that short reading distance may be an important contributor to myopia development [21]. Based on parents-administrated questionnaires, shorter reading distance (< 30 cm or < 25 cm) was associated with greater myopic refractions [9, 21, 22]. A 2.5-fold increase in risk of myopia in children with a reading distance shorter than 30 cm had been reported [21]. In a separate study, the head posture during reading was associated with myopia [23]. A previous study identified that downward pitch angles were greater in progressing myopes than non-progressing myopes during a reading task [24]. Recently, a study about reading behavior among emmetropic schoolchildren suggested that better ergonomics and text design may decrease asthenopia and binocular anomalies, thus reducing myopia [25]. To obtain standardized and comparable outcomes, quantitative reading distance measurements should be performed.

We hypothesize that reading distance may also be affected by the prescription of myopic spectacles with undercorrection, given that the clarity of near vision is important for reading and writing. Consequently, in contrast to myopia prevention, myopia undercorrection has potential implications for reading distance and, by extension, myopia development. An objective method to document habitual reading distance, such as recording measurements from video camera footage as in the current study, will accurately enable us to study the relationship between reading distance and myopia. The current study aimed to determine the relationship between reading distance and the status of myopic correction in a population-based study, the Hong Kong Children Eye Study (HKCES).

METHODS

Study Population

The current study recruited a subgroup population derived from the HKCES, a population-based study of eye conditions among schoolchildren aged 6–8 years old from primary schools across Hong Kong. The HKCES was designed to determine the occurrence and development of eye disorders in children, including refractive errors, strabismus, amblyopia, and allergic eye diseases, as well as to identify their environmental and genetic determinants [26–28]. Sample selection was based on a stratified and clustered randomized sampling frame. All 571 primary schools in Hong Kong registered across the seven clusters organized by the Education Bureau were randomly assigned an invitation, priority-generated by computer, to contribute participants to the study cohort. Study subjects were recruited continuously from the HKCES between January 2016 and July 2017. Except for children with refractive errors, the study excluded children with systemic or ocular diseases such as amblyopia, glaucoma, and retinal diseases. All participating children were ethnic Chinese.

The project conformed to the tenets of the Declaration of Helsinki and was granted ethical approval (Approval no. 2015.033) from the Institutional Review Board of the Chinese University of Hong Kong. Informed consent was given by all participants and was signed by their parents or guardians.

Ocular Examinations

Distance habitual visual acuity (VA) was measured with (uncorrected visual acuity, UCVA) or without spectacles (corrected distance visual acuity, CDVA) using a logarithm of the minimum angle of resolution (logMAR) chart (Nidek, Gamagori, Japan). Corrected distance visual acuity (CDVA) was obtained by a trained optometrist using subjective refraction for all children with a logMAR score greater than 0.1 in either eye. Ocular alignment was assessed using the cover/uncover test. Refractive status was measured both before and after cycloplegia using an autorefractor (Nidek ARK-510A, Gamagori, Japan). Two cycles of 1% cyclopentolate (Cyclogyl, Alcon-Convreur, Rijksweg, Belgium) and 1% tropicamide (Santen, Osaka, Japan) were given 10 min apart. A third cycle of cyclopentolate and tropicamide drops was administered 30 min later if a pupillary light reflex was still present or the pupil size was less than 6.0 mm. An ophthalmologist then inspected the anterior segment of the eye using a slit-lamp (Haag-Streit, Koeniz, Switzerland) and the retina through a 20 D lens (Volk, Houston, TX).

Reading Distance Measurements

Habitual reading distance was measured from video camera footage. The setting simulated a reading environment at school. The illumination of the room was around 500 lx, and the reading material was the *Old Master*, which is a very popular comic among children. Participating children were seated in chairs with arms and desks were positioned as they would be in a typical classroom setting. The heights of the desks and chairs were standardized according to those used in schools in Hong Kong for the appropriate grade level of the child. The desks were 59 cm tall and chairs 33 cm tall for children aged 6–7 years (Primary 1 and Primary 2); the desks were 66 cm tall and chairs 38 cm for children aged 8–9 years (Primary 3 and Primary 4) (Fig. 1). The height of participants was measured using a professional integrated set (Seca, Hamburg, Germany).

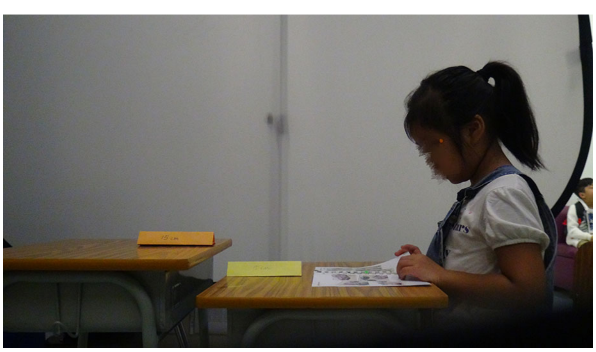

Fig. 1 A picture of one of the participants, taken while she was reading

All children were assigned the same storybook to read and were asked periodically to answer questions about the story to encourage them to pay attention and stay focused. A video camera, hidden 5 m away from the desks at which the children were seated, recorded the entire reading process, which lasted at least 10 min for every child. The children were not aware that they were being recorded until they finished reading. The camera lens was set at 60 cm above ground, a similar height to the children's eyes. A 15-cm-long scale ruler was placed on the table for calibration (the yellow scale, Fig. 1). In addition, each page that the child read was marked with a 15-cm scale for calibration. Before the child began reading, a green sticker was put over the lateral canthus of the left eye and another on the center of each page; a computer program would detect and recognize stickers for subsequent measurements. Before the video records started, each child was asked whether they wore spectacles in daily reading tasks. Then the video was documented according to the spectacle wearing habits. Each child took about 5 min to sit stably, at which point the reading distance also became stable. Subsequently, reading distance was measured from the canthus of the left eye to the center of the book at four time points: 6, 7, 8, and 9 min after reading began. Reading distance was calculated using a customized computer program developed in MATLAB (version R2010a; MathWorks, Inc., Natick, MA), which automatically detected the stickers and scales to enable accurate measurement of the distances between the child's eyes and the page being read.

Near Work and Outdoor Activity Questionnaires

The parents of participating children completed validated questionnaires that were mainly derived from the Chinese version of the questionnaire used in the Sydney Myopia Study [2, 29]. Near work activities included homework, leisure reading, and using electronic devices. Outdoor activities were divided into two categories, namely leisure (including walking, biking, playing in open fields, and picnicking) and sport activities. The average number of outdoor activity hours per day was calculated using the formula [(hours spent on weekdays) × 5 + (hours spent on weekends) × 2]/7.

Definitions

Spherical equivalent refraction (SER) was defined as spherical diopters (D) plus half the value for cylindrical diopters. Based on cycloplegic autorefraction, myopia was defined as SER ≤ − 0.50 D, emmetropia as − 0.5 D < SER < + 0.50 D, and hyperopia as SER ≥ + 0.50 D. Myopia undercorrection was identified if the presenting VA of the better eye was greater than 0.1 on the logMAR chart (equivalent to VA < 0.8 on the Snellen chart) and could be improved by at least two lines using subjective refraction by increasing the minus correction [19, 30, 31]. Parental myopia was defined as one or both of the child's parents having myopia. Data for the right eye were primarily used for analysis given the high correlation between both eyes in terms of refraction and biometry values among all subjects [29, 32, 33]. Only children with complete cycloplegic refraction were included in the analysis.

Data Analysis

Demographic and ocular variables are presented using means and standard deviations (SD). The chi-square test and Fisher's exact test were used to test for group differences in categorical data, while analysis of variance [34] was used to test for group differences in continuous data. Multiple logistic regressions were used to calculate the odds ratios (OR) and 95% confidence intervals (95% CI) for myopia risk factors. Two multiple logistic regression models were constructed. Model 1 was the basic model that investigated the association between myopia and reading distance with adjustments for age, sex, and body height; model 2 also accounted for near work time, outdoor time, and parental myopia. Sensitivity analyses were performed on the subsets of data after exclusion of children with undercorrected myopia. Values for Cohen's kappa (κ) were calculated to evaluate the agreement between the two approaches to ascertaining reading distance, namely questionnaires (subjective) and video recordings (objective). Statistical analyses were performed using SPSS Statistics (version 24; IBM Corp., Armonk, NY).

RESULTS

A total of 2363 children (52.6% boys, 47.4% girls), mean age 7.64 ± 1.06 years, were recruited from the HKCES (Table 1). Comparative analyses of the baseline demographic characteristics for the participants discussed in this report and for participants in the HKCES as a whole did not show a difference (Supplemental Table 1). The mean habitual reading distance of the children was 24.12 ± 4.73 cm. Supplemental Table 2 shows demographics and ocular parameters of the children organized by

Table 1 Demographics and ocular parameters of children

	Mean	(SD)
Age (years)	7.64	(1.06)
Male gender (*N*, %)	1244	(52.6%)
Spherical equivalent, D	0.13	(1.53)
Visual acuity, logMAR unit (poor eye)	0.11	(0.21)
Visual acuity, logMAR unit (better eye)	0.05	(0.17)
Height (cm)	124.72	(8.18)

D diopters, SD standard deviation

Table 2 Habitual reading distance of different refraction and correction status

	Average of reading distance (mm)	Reading distance at 6 min (mm)	Reading distance at 7 min (mm)	Reading distance at 8 min (mm)	Reading distance at 9 min (mm)
All included eyes					
Overall (*n* = 2363)	24.12 (4.73)	24.46 (5.96)	24.28 (6.01)	23.98 (5.90)	24.04 (5.93)
(1) Emmetropia or hypermetropia (*n* = 1704)	24.20 (4.73)	24.49 (5.97)	24.33 (5.96)	24.06 (5.94)	24.15 (5.87)
(2) Myopia with full correction (*n* = 245)	24.81 (5.21)	25.52 (6.30)	25.27 (6.83)	24.77 (6.30)	24.75 (6.46)
(3) Myopia with undercorrection (*n* = 414)	23.37 (4.31)	23.71 (5.63)	23.49 (5.58)	23.19 (5.35)	23.16 (5.75)
p values overall	< 0.001*	0.001*	0.001*	0.002*	0.001*
1 vs 2	0.17	0.03*	0.07	0.23	0.41
2 vs 3	< 0.001*	0.001*	0.001*	0.003*	0.003*
1 vs 3	0.004*	0.05	0.003*	0.02*	0.008*
Combined myopia with full correction and non-myopia					
(1) With full correction or non-myopia (*n* = 1949)	24.27 (4.79)	24.62 (6.02)	24.45 (6.08)	24.15 (6.00)	24.22 (5.95)
(2) With undercorrection (*n* = 414)	23.37 (4.31)	23.71 (5.63)	23.49 (5.58)	23.19 (5.35)	23.16 (5.75)
p values overall	< 0.001*	0.005*	0.003*	0.001*	0.001*

* represent $P<0.05$

different refractive groups. The mean habitual reading distance among myopic children with full correction (24.81 cm) was similar to that for non-myopic children (24.20 cm, $P = 0.17$), but shorter for myopic children with undercorrection (23.37 cm, $P < 0.0001$, Table 2). The mean reading distance for the group of undercorrected myopic children remains shorter when compared to a combined group of fully corrected and non-myopic children (24.27 cm; $P < 0.001$, Table 2).

Association of Habitual Reading Distance with Myopia

After adjustments for age, sex, height, outdoor time, near work time, and parental myopia, multivariate logistic regression found that a shorter habitual reading distance (< 20 cm) confers a higher risk of myopia compared to a longer reading distance (> 30 cm) (OR 1.67; 95% CI 1.11–2.51; $P = 0.013$, Table 3). In the sensitivity analysis, after the undercorrected myopic children were excluded, shorter reading distance (< 20 cm) was no longer associated with myopia ($P = 0.92$, Table 4). Whereas, the association remained for the undercorrected

Table 3 Association of myopia and habitual reading distance

	Myopia (n = 659)	Model 1		Model 2	
		OR (95% CI)	*P* value	OR (95% CI)	*P* value
Reading distance					
> 30 cm (*N*, %)	70 (10.6%)	1		1	
20–30 cm (*N*, %)	448 (68.0%)	1.11 (0.81, 1.51)	0.53	1.19 (0.84, 1.70)	0.33
< 20 cm (*N*, %)	141 (21.4%)	1.53 (1.07, 2.19)	0.021*	1.67 (1.11, 2.51)	0.013*
Age (SD), years	8.02 (1.02)	1.40 (1.24, 1.58)	< 0.001*	1.41 (1.23, 1.62)	< 0.001*
Gender (male, %)	54.80%	1.08 (0.90, 1.30)	0.42	1.04 (0.42, 1.28)	0.74
Height (SD), cm	127.40 (8.44)	1.03 (1.01, 1.05)	0.001*	1.03 (1.01, 1.05)	0.002*
Outdoor time (SD), h	1.47 (0.63)			0.89 (0.76, 1.05)	0.17
Near work time (SD), h	0.84 (0.40)			1.71 (1.28, 2.29)	< 0.001*
Parental myopia (*N*, %)	88.00%			2.87 (1.28, 6.43)	0.01*

Model 1: adjusted by age, gender, and height; model 2: adjusted by age, gender, height, outdoor time, near work time, and parental myopia

SD standard deviation, *CI* confidence interval, * represent $P<0.05$

myopic group after excluding the full-corrected myopic children (OR 2.05; 95% CI 1.30, 3.22; P = 0.002, Table 5). Near work time was associated with myopia in the overall participants (OR 1.71; 95% CI 1.28–2.29; P < 0.001, Table 3).

Correlation of VA in Better Eye with Reading Distance

A shorter reading distance was correlated to a poorer logMAR VA in the better eye for all participants (β = – 0.003, P < 0.001). A similar pattern was observed for undercorrected myopic children (β = – 0.001, P = 0.004), but not for fully corrected myopic or emmetropic children.

Agreement Between Reading Distance as Documented by Videos and Questionnaires

The parents of 2212 children completed the questionnaire on habitual reading distance. Reading distance reported by questionnaire was generally shorter than that measured by video recordings. Of the reading distance values reported by questionnaires, 11.9% were less than 10 cm, yet no such values were measured from the videos. Moreover, 1175 children (53.1%) had reading distances reported in the range of 10–20 cm, yet only 396 children (16.8%) showed such reading distances in their videos. However, overall fair agreement was found between the videos and questionnaires for measuring habitual reading distance (κ = 0.006, Table 6).

We subsequently performed a multivariate logistic regression model based on the questionnaire results. Compared with longer reading distances (> 30 cm), shorter reading distances remained associated with myopia, both in the range below 10 cm (OR 2.46; 95% CI 1.28–4.73; P = 0.007) and in the range of 10–20 cm (OR 2.19; 95% CI 1.22–3.94; P = 0.009) (Supplemental Table 3).

DISCUSSION

To our knowledge, this is the first reported population-based study to document habitual reading distance objectively, as well as to evaluate its relationships with both myopia and

Table 4 Association of myopia and habitual reading distance with the exclusion of myopic children with undercorrection

	Model 1		Model 2	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Reading distance				
> 30 cm (*N*, %)	1		1	
20–30 cm (*N*, %)	0.81 (0.53, 1.22)	0.31	0.87 (0.54, 1.39)	0.56
< 20 cm (*N*, %)	0.97 (0.58, 1.59)	0.89	0.97 (0.55, 1.73)	0.92
Age (SD), years	1.53 (1.28, 1.82)	< 0.001*	1.55 (1.28, 1.88)	< 0.001*
Gender (male, %)	1.13 (0.86, 1.50)	0.39	1.17 (0.86, 1.60)	0.32
Height (SD), cm	1.03 (1.01, 1.06)	0.008*	1.03 (1.00, 1.06)	0.027*
Outdoor time (SD), h			0.87 (0.68, 1.11)	0.26
Near work time (SD), h			1.40 (0.90, 2.17)	0.14
Parental myopia (*N*, %)			2.95 (1.26, 5.92)	0.01*

Model 1: adjusted by age, gender, and height; model 2: adjusted by age, gender, height, outdoor time, near work time, and parental myopia

SD standard deviation, *CI* confidence interval, * represent $P<0.05$

myopic correction, with several notable findings. First, reading distance was shorter among myopic children with undercorrection compared to both myopic children with full correction and non-myopic children. Second, a reading distance of less than 20 cm was associated with a 1.67-fold increase in a risk of myopia. Third, shorter reading distance was no longer associated with myopia when children with undercorrection were excluded from data analysis. Fourth, a shorter reading distance is correlated with poorer VA, suggesting that undercorrection with poorer VA induces a shorter reading distance. Fifth, self-reported reading distances by questionnaire were generally shorter than those measured from video recordings, but both sets of results showed similar trends and associations with myopia. Our data supports the hypotheses that myopic undercorrection induces a shorter reading distance. While shorter reading distance would have a causative relationship with myopia, it is also possible that the observations of shorter reading distance in myopes is in response to these myopes being undercorrected.

Wearing spectacles is effective in correcting myopia, restoring VA, and preventing visual loss in children, yet inadequate corrections remain very common [31]. Undercorrection itself has become one of the causes for visual impairment among schoolchildren in developing countries [30, 35–38]. In this study in the city of Hong Kong, we found an undercorrection rate of 25.75%. By comparison, the undercorrection rate for myopic schoolchildren in mainland China wearing spectacles was reported to be 21.1% in urban areas [39] and 48.8% in rural areas [38]. Undercorrection of children with myopia has been common clinical practice, in an attempt to reduce accommodation and thereby slow myopic progression, yet evidence for the efficacy of this method for limiting myopia progression is limited and contradictory [16–18, 40]. In fact, undercorrection produced more rapid myopic progression and axial elongation in studies in Israel [41], Malaysia [18], America [15], and China [19]. Notably, the current study clearly demonstrated a shorter reading distance among myopic children with undercorrection, suggesting that reading distance could contribute

Table 5 Association of myopia and habitual reading distance with the exclusion of myopic children with full correction

	Model 1		Model 2	
	OR (95% CI)	***P* value**	**OR (95% CI)**	***P* value**
Reading distance				
> 30 cm	1		1	
20–30 cm	1.44 (1.11, 1.88)	0.005*	1.47 (1.12, 1.94)	0.006*
< 20 cm	1.89 (1.24, 2.94)	0.003*	2.05 (1.30, 3.22)	0.002*
Age (SD), years	1.36 (1.19, 1.55)	< 0.001*	1.38 (1.21, 1.60)	< 0.001*
Gender (male, %)	1.13 (0.86, 1.30)	0.546	1.11(0.88, 1.36)	0.423
Height (SD), cm	1.03 (1.01, 1.05)	0.001*	1.02 (1.01, 1.05)	0.002*
Outdoor time (SD), h			0.84 (0.70, 1.00)	0.052
Near work time (SD), h			1.94 (1.43, 2.64)	< 0.001*
Parental myopia (*N*, %)			3.50 (0.84, 14.62)	0.086

Model 1: adjusted by age, gender, and height; model 2: adjusted by age, gender, height, outdoor time, near work time, and parental myopia

SD standard deviation, *CI* confidence interval, * represent $P<0.05$

to the increased progression rate reported in children whose myopia is undercorrected. In addition, undercorrected myopic children with a shorter reading distance more frequently had poorer VA than habitually fully corrected myopic children. Because of their suboptimal vision, undercorrected children tend to read nearer for better vision. Another notable finding of this study is that the association of shorter reading distance with myopia mainly occurred among undercorrected children, but not fully corrected myopic or emmetropic children. This suggests the observed shorter reading distances among myopic children are mainly induced by undercorrection. It is a vicious circle that the undercorrection of myopia would lead to a closer reading distance, and the closer reading distance would accelerate the myopia progression.

Table 6 Comparison of two methods for the measurement of reading distance

	Actual measurements			
	< 20 cm	**20–30 cm**	**> 30 cm**	**Total**
Questionnaire				
< 20 cm	265	1002	120	1387
20–30 cm	117	503	96	716
> 30 cm	14	80	15	109
Total	396	1585	231	2212

$\kappa = 0.006$, $p = 0.61$

The current study employed a cross-sectional design. Further longitudinal studies are thus needed to investigate whether shorter reading distance is a causative factor for myopic progression. Second, near work reading includes both spatial (reading distance) and temporal (reading time) dimensions. As our study has shown, large amounts of near work time remain significantly associated with myopia. Excessive periods of near work should be discouraged in the interest of child ocular health. Our study uniquely obtained reading distance measurements through both video recordings and questionnaires administered to parents, observing an agreement between both methods. However, the latter method was more imprecise, subjective, and prone to recall bias compared to the former. It is noted that the values it generated were generally shorter. In the actual measurements of our study, the reading distance was seldom less than 10 cm in the whole reading period. According to the questionnaire, 11.9% of parents selected the choice of the reading distance less than 10 cm, especially for those having myopic children, which is subjective. Our study confirms that more objective methods for quantifying reading distance are required. Nonetheless, the reading distance values obtained from questionnaires followed a similar trend to those measured by video recordings. Questionnaires can therefore still be used as a convenient estimation of reading distances. However, from the results of the two measurements, the estimates of questionnaires were shorter than the true measures of reading distance.

Our results affirmed the association of shorter reading distance with greater myopic refraction [9, 21, 22], even though this relationship may be due to undercorrection among myopic children. Compared to non-myopic and fully corrected myopic children, undercorrected myopic children exhibited the shortest reading distance. Furthermore, our results showed that a greater amount of near work time is consistently associated with myopia. We therefore advocate that reading or other forms of near work should be at an appropriate distance with full correction for VA. It is also as a simple, direct, and economical way for slowing myopic progression. Our results indicate that the therapeutic strategy of myopia undercorrection among children may not only be unwarranted but may also be potentially harmful.

Consistent with the findings of the current study, a previous study reported a positive correlation between mean spherical equivalent and working distance for book reading ($r = 0.41$; $P = 0.025$) in a cohort of 14 myopic and 16 non-myopic young adults [24]. Another study concluded that higher prevalence of myopia was associated with shorter near work distance [42]. The objective and continuous method of measuring reading distance used in this study has high reproducibility and therefore reduced recall bias. We have simulated an actual reading environment according to local chair and desk settings in primary schools. Our results thus reflect real-life study conditions. Meanwhile, this is a population-based study with reduced selection bias and high participation rate [2, 27, 43].

There are some limitations in this study. First, the causal relationships of reading distance with myopia and undercorrected refraction cannot be inferred because we collected cross-sectional data and not longitudinal data, which will have to be collected in a follow-up study to examine the effects of undercorrection and near reading distance on myopic progression. Second, the measurements in our study could only simulate one type of near work situation, namely reading conditions in schools. A different simulating setting is required, for example, when a child plays video games or use smartphones. Third, the child's reading habits recorded during the short duration of the videos may not be exactly the same as their usual reading habits over a longer period, since reading posture generally changes after prolonged periods. The measurement time last for only 10 min, which was relative shorter compared with the actual day-to-day reading time. Also, although the camera was hidden in a box during the measurements, some children might still understand it was a test, and they might sit straighter than usual. It may induce bias in the measurements. The font size of the books and the types of books would also affect the reading distance. Therefore, a more objective and precise method was warranted on these aspects in the future study. Fourth, we did not measure the near VA and therefore we cannot tell whether the correction of distance VA would influence the near VA, thus further affecting the reading distance. Fifth, the difference in reading distance among groups is minimal (less than 1.5 cm). Although the difference seems trifle, the effect may be accumulative in the long term. Finally, non-ophthalmic medical conditions, which may also impact reading habit and distance, were not investigated in this study.

CONCLUSIONS

We found a shorter reading distance among undercorrected myopic children compared to both fully corrected myopic and non-myopic children. Shorter reading distance was associated with myopia and lower VA, both mainly occurring in children with undercorrection. It is possible that undercorrection of myopia and consequentially reduced vision may lead to observations of shorter reading distance in myopic children and further longitudinal studies should address whether there is evidence of a causative relationship between reading distance and myopic progression. These findings also imply that routine clinical undercorrection should not be employed as a strategy to slow myopic progression because of its potential to increase progression through shortened reading distance.

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Data Availability. The data sets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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