Influence of Near Tasks on Posture in Myopic Chinese Schoolchildren

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ABSTRACT

Purpose. To investigate near-vision posture in Chinese myopic schoolchildren and compare near-vision posture during different near-vision tasks (i.e., playing video games, reading, and writing).

Methods. The study investigated 120 myopic children (grades 1 through 6 and aged 6 to 13 years). An electromagnetic motion-tracking system was used for continuous measurements of the working distance and head declination of the subjects while they were playing video games or reading or writing at a desk. The reading and writing documents were adjusted by grade level (i.e., grades 1 to 2, 3 to 4, and 5 to 6). For analysis, the subjects were grouped in two refractive groups according to their median spherical equivalent refractive error (−1.50D).

Results. The myopic schoolchildren used close working distances for all tasks: 21.3 ± 5.2 cm (video games), 27.2 ± 6.4 cm (reading), and 24.9 ± 5.8 cm (writing). The mean head declinations were 63.5 ± 12.2 deg (video games), 37.1 ± 12.8 deg (reading), and 44.5 ± 14.1 deg (writing). Working distance decreased significantly across time for the reading and writing tasks (p < 0.001). Head declination increased significantly across time only for the reading task (p < 0.001). Grade level significantly influenced working distance, but the difference was not significant when working distance was adjusted by the subject's size. No differences were observed within the refractive or the accommodative lag groups in terms of the posture data (p > 0.05). Working distance was negatively correlated with head declination (r = −0.53, p < 0.001).

Conclusions. Close working distances were observed for Chinese myopic schoolchildren. The attention dedicated to each task, the task difficulty, and the page/screen size may affect near working distance and head declination. Handheld video games were associated with the closest working distance, which may be a risk factor for myopia progression, according to previous studies.

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Key Words: myopia, working distance, head declination, video game, Chinese schoolchildren

In the past, a higher prevalence of myopia and greater progression have often been associated with tasks involving intensive schoolwork and near work. Although some studies did not find any relationship between near work and myopia,1–3 many others have shown that near work activity is related to myopia onset or progression. A longitudinal 3-year observation study suggested that near work, such as reading or writing, might cause myopic shifts in emmetropic students.4 In Australia, children who performed near work at a distance of less than 30 cm were 2.5 times more likely to become myopic than children who worked at a farther distance. Similarly, children who spent a longer time reading for pleasure and children who read at a distance closer than 30 cm were more likely to have higher myopic refractions.5 Pärsinen et al.6 showed that faster myopic progression in children was closely related to short working distances. Charman7 suggested that the conflicting accommodation demands caused by pronounced head turns during near-vision work might cause myopic shifts. It is plausible that continuous hyperopic defocus during near work, induced by the lag of accommodation, drives the emmetropization mechanism to correct this apparent refractive error by making the eye myopic.8–10

In recent years, numerous epidemiological studies have used questionnaires to gather information concerning the number of near work hours per day in children, but near working posture has rarely been mentioned, particularly for schoolchildren. Few studies have described the reading posture of schoolchildren in detail.6,11–16 In
particular, a study using photography analysis found that Chinese
drometropic schoolchildren usually work at a desk at close
distances (25.4 cm for a reading task and 20.6 cm for a reading/
writing task). Therefore, Wang et al. suggested that near
testing during ophthalmic examinations should be performed
at 25 cm for schoolchildren and perhaps even at 20 cm for the
youngest schoolchildren because these were the near distances
actually used by the children when they were reading or writing.
However, it is unclear to what extent this suggestion also applies
to Chinese myopic schoolchildren, although white myopic chil-
dren have been shown to perform near tasks at closer distances
compared with emmetropic children. Few ophthalmic studies
have investigated the near work posture of Chinese myopic
schoolchildren in detail. The aim of the present study was
to compare working distance and head declination between
different near-vision tasks (i.e., playing video games, reading,
and writing) for myopic schoolchildren from the same primary
school using continuous recording of these parameters during
the entire task.

METHODS

Subjects

After regular vision screening of 642 schoolchildren from
grades 1 through 6 at an elementary school in Wenzhou, Zhejiang
province, China, all myopic subjects (N = 142) were recruited
during a period of 3 months for posture measurements. Twenty-
two children were excluded because of incomplete posture data
records. The remaining 120 children consisted of 54 boys and
66 girls with an age range of 6 to 13 years and a mean age of 9.20 ±
3.62 years. Each child was myopic, with a spherical equivalent
refractive error (SE) between −0.50D and −6.50D in both eyes
(Fig. 1), astigmatism 1.50D or less, and anisometropia 1.25D or
less, as measured by noncycloplegic subjective refraction. The
monocular best-corrected distance visual acuity was 20/20 or
better. All subjects were free of strabismus and had no history of
ocular pathology, trauma, or surgery.

Informed consent was obtained from all subjects and their
accompanying parents or guardians after the nature of the study
and possible consequences had been explained. The study was
approved by the ethics committee of the School of Ophthal-
mology and Optometry, Wenzhou Medical University, and
followed the tenets of the Declaration of Helsinki.

Tasks

The three near tasks were playing a handheld video game and
reading and writing at a desk. For the video game task, the subjects
were instructed to play the handheld video game (Donkey Kong
Country 2; Game Boy Advance SP, Nintendo) for 7 min (2 min

FIGURE 1.
Distribution of noncycloplegic spherical equivalent refractive error in the right eyes of 120 myopic children.
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Reading and writing tasks had three grade-appropriate modes. For the reading task, the text for grades 1 and 2 used Chinese Hanyu Pinyin (a phonetic language that uses Western alphabet), according to their Chinese textbooks (Fig. 2, left), whereas the text for higher grade levels contained only Chinese characters (Fig. 2, middle). For the writing task, there were one to four character strokes in grades 1 and 2, four to six character strokes in grades 3 and 4, and five to nine character strokes in grades 5 and 6. All participants were divided into three grade groups that used level-appropriate reading and writing materials: grades 1 to 2, grades 3 to 4, and grades 5 to 6.

Procedures

For all subjects, two experienced optometrists performed the eye examinations, which included a case history, visual acuity, cover test, objective and subjective refraction, and slit-lamp examination, as well as accommodative response of the right eye at 33 cm, which was measured under binocular viewing conditions with a free-space autorefractor (WAM-5500; Grand Seiko Co., Ltd., Japan) fixated on a Maltese cross target. Because working distance may depend on the size of a child, we measured the height and forearm length (distance from the elbow to the wrist) of each subject.

All subjects were provided with full-correction glasses after their eye examinations. During a minimum 2-week adaptation period (for the glasses), posture measurements were performed. Posture was measured in the following order: writing, reading, and playing video games, with a 5-min break between each task. After the reading session, the subjects were asked three questions about the text passage that they had just read to confirm that they had truly read and understood the content.

Our experiment was performed in a reading laboratory where lighting conditions were carefully controlled. The average lighting intensity for the reading materials was 254 lx (248 to 260 lx). The desk and chair heights (73.2 cm and 43.7 cm, respectively) remained constant for all grade levels and were similar to those used for all subjects in grades 1 through 6 at their elementary school.

Working distance and head declination were continuously recorded at 10 Hz with a Fastrack (Polhemus, USA) electromagnetic motion-tracking system, which is commonly used for near posture measurements. This electromagnetic device was composed of an emitter and several receivers. One receiver was attached to the head of the child by means of a headband, and the others were fixed to the task materials (reading and writing materials, handheld video game). This device provided complete freedom of movement during the near tasks. Before each task, calibration measurements were performed to determine the reference (vertical) head posture, location of the base of the nose and sagittal plane of the head relative to the head receiver, as well as the location of text/screen corners relative to the task material receiver.

Data from the first 3 min of each task were used for the analysis. Working distance was defined as the distance from the base of a child’s nose to the center of each line (for reading or writing) or to the center of the screen (for the video game). Head declination was defined as the angle in the sagittal plane between the head and the vertical upright position measured during calibration.

One-way analysis of variance was used to compare the means of the basic biometric characteristics, such as height, forearm length, refractive error, and lag of accommodation for each grade group. A repeated-measures analysis of variance was used to analyze the mean differences for postural data, and covariates included the height and forearm length of the subjects. Post hoc analysis was then performed using Fisher’s least significant difference test between each grade group and between each task. Pearson’s correlation analysis was used to determine the strength of the relationship between the different
posture measures. Statistical analysis was performed using SPSS 20.0 statistics software, and p < 0.05 was considered to be statistically significant.

RESULTS

Basic biometric characteristics of the subjects are described in Table 1. There were no significant sex-based differences in age, height, forearm length, refractive error, or accommodative lag (p > 0.05). Therefore, the sex data were combined. For the analysis, the subjects were divided into two refractive groups (SE ≥ 1.50D group containing 62 subjects and SE < 1.50D group containing 58 subjects) based on the median of the refractive error (SE = 1.50D).

Working Distance

The mean working distances of the 120 subjects were 21.3 ± 5.2 cm (video game), 27.2 ± 6.4 cm (reading), and 24.9 ± 5.8 cm (writing). The task had a significant influence on working distance (F2,357 = 31.45, p < 0.001), and pairwise comparisons showed that the working distances differed significantly between each task (p < 0.005).

Grade level influenced working distance (F 2,357 = 7.61, p = 0.001), and working distance was shorter for grades 1 to 2 compared with grades 5 to 6 for each task (video games, p = 0.007; reading, p = 0.018; writing, p = 0.029). However, no difference was

| Grade | N  | Age, yr | Height, cm | Forearm length, cm | SE (OD), D | SE (OS), D | Accommodative lag at 33 cm, D |
|-------|----|---------|------------|-------------------|------------|------------|-------------------------------|
| 1-2   | 28 | 7.0 ± 0.5 | 126.6 ± 6.5 | 19.6 ± 1.8 | −1.76 ± 0.80 | −1.58 ± 0.81 | 1.49 ± 0.56 |
| Girls | 14 | 7.1 ± 0.5 | 126.2 ± 6.7 | 19.2 ± 1.5 | −1.74 ± 0.92 | −1.62 ± 0.98 | 1.49 ± 0.45 |
| Boys  | 14 | 7.0 ± 0.6 | 127.1 ± 6.5 | 20.0 ± 2.1 | −1.78 ± 0.69 | −1.55 ± 0.62 | 1.49 ± 0.67 |
| 3-4   | 44 | 8.5 ± 0.8 | 133.9 ± 7.5 | 20.6 ± 1.9 | −1.89 ± 1.12 | −1.87 ± 1.20 | 1.77 ± 0.43 |
| Girls | 23 | 8.5 ± 1.0 | 132.0 ± 7.0 | 20.1 ± 1.8 | −2.15 ± 1.29 | −2.07 ± 1.44 | 1.61 ± 0.56 |
| Boys  | 21 | 8.6 ± 0.6 | 136.0 ± 7.7 | 21.1 ± 1.9 | −1.61 ± 0.85 | −1.64 ± 0.84 | 1.93 ± 0.61 |
| 5-6   | 48 | 11.1 ± 0.9 | 149.6 ± 8.7 | 22.7 ± 2.0 | −1.69 ± 0.91 | −1.72 ± 0.91 | 1.49 ± 0.49 |
| Girls | 29 | 11.0 ± 0.8 | 149.9 ± 7.9 | 22.7 ± 1.9 | −1.64 ± 0.86 | −1.67 ± 0.87 | 1.33 ± 0.47 |
| Boys  | 19 | 11.2 ± 1.0 | 149.1 ± 10.1 | 22.5 ± 2.3 | −1.77 ± 0.99 | −1.80 ± 0.99 | 1.74 ± 0.60 |
| Total | 120| 9.2 ± 1.8 | 138.5 ± 12.3 | 21.2 ± 2.3 | −1.78 ± 0.97 | −1.74 ± 1.00 | 1.59 ± 0.56 |

Mean ± SD data for all 120 myopic schoolchildren. There were no significant sex-based differences in age, height, forearm length, refractive error, or accommodative lag (p > 0.05).

SE, spherical equivalent refractive error; OD and OS, right eye and left eye, respectively.
found for the other pairwise comparisons (p > 0.05) (Fig. 3). These differences were no longer significant when the working distance was adjusted by the subject’s height (F_{2,357} = 2.23, p = 0.11) or forearm length (F_{2,357} = 1.34, p = 0.26). There was no task by grade group interaction for the changes in working distance (p = 0.96). Moreover, no difference in working distance was found between the refractive groups (SE \geq -1.50D group vs. SE < -1.50D group) (p = 0.48).

To analyze the change in working distance across time, we measured the average working distance in 30-s increments for 3 min. Working distance did not change across time for the video game task (Fig. 4; F_{5,714} = 0.15, p = 0.98). In contrast, the average working distances decreased significantly by 6.08 cm (0.80D) and 3.83 cm (0.62D) after 3 min for the reading and writing tasks, respectively (reading task, F_{5,714} = 12.78, p < 0.001; writing task, F_{5,714} = 7.29, p < 0.001).

**Head Declination**

The mean head declinations of 120 subjects were 63.5 \pm 12.2 deg (video game), 37.1 \pm 12.8 deg (reading), and 44.5 \pm 14.1 deg (writing). The tasks had a significant influence on head declination (F_{2,357} = 129.44, p < 0.001), and pairwise comparisons showed that the head declinations differed highly between each task (p < 0.001). Grade level did not influence head declination (F_{2,357} = 0.12, p = 0.88) (Fig. 5). There was no task by grade group interaction for the changes in head declination (p = 0.10). Moreover, there was no difference in head declination between the refractive groups (p = 0.46).

We also analyzed the average head declination in steps of 30 s for 3 min. Head declination did not change across time for the video game (F_{5,714} = 0.22, p = 0.95) and writing task (F_{5,714} = 2.03, p = 0.07) during the first 3 min (Fig. 6). However, head declination increased significantly with time for the reading task (i.e., toward a more horizontal head posture) (F_{5,714} = 6.45, p < 0.001).

**Correlations Between Posture Measurements**

Because near tasks may induce different combinations of working distance and head declination, we performed a correlation analysis between these two measurements for each task.

Overall, working distance was negatively correlated to head declination ($r = -0.53$, p < 0.001). The children demonstrated a shorter working distance, with greater head declination, during the reading task, with greater head declination, during the reading and writing tasks (reading, $r = -0.52$, p < 0.001; writing, $r = -0.52$, p < 0.001), but no correlation was found between these two posture measurements for the video game task ($r = -0.10$, p = 0.29).

**Accommodative Lag**

The average accommodative lag for the myopic children was 1.59 \pm 0.56D at 33 cm (Table 1). For the analysis, the subjects were divided into two lag groups of 60 subjects each based on the median accommodative lag (1.60D). There was no difference in the working distance or the head declination between the two lag groups (p > 0.05).

**DISCUSSION**

A recent investigation of more than 2000 American children and teenagers aged between 8 and 18 years reported that, in an average day, more than an hour was dedicated to playing video games.\textsuperscript{19} Similarly, all types of near distance video game devices, such as handheld video games, cell phones, and tablet PCs, have become increasingly popular among adults and even schoolchildren in China. Therefore, it may be important to understand the influence of these video games on posture in myopic schoolchildren and to
investigate whether the impact of video games was any different when compared with more traditional tasks (reading/writing). We also hope that this work will help extend the prior recommendation for emmetropic Chinese schoolchildren\(^1\)\(^6\) to use an appropriate near-vision testing distance for myopic Chinese schoolchildren.

In our study, the order of testing was kept constant (writing, reading, and then playing video games) instead of randomized. In a pilot study\(^1\)\(^5\) on posture of Singaporean Chinese children, we did not find that the order of tasks affected the outcome within a short period. We designed the order of the tasks from hard to easy. Moreover, we designed the study to reduce interference between tasks; therefore, video games were played last, which a child may consider as a reward. In fact, in a prior pilot study, we noticed that many children did not stop playing when the proctor declared that the time had elapsed.

We performed the vision screening at the elementary school and sent them an invitation for a further eye examination at our hospital, including a free eye examination, free glasses for myopic children, and a reading posture test. Eventually, 120 myopic children were recruited to this study. The reading distances of myopic Chinese and emmetropic\(^1\)\(^6\) Chinese children in our study (27.2 ± 6.4 cm) were comparable to those observed in emmetropic\(^1\)\(^6\) children (26.3 ± 6.0 cm) of similar ages and ethnicities for 14-pt reading (\(t = -0.89, p = 0.38\)). However, compared with the study by Wang et al.\(^1\)\(^6\), the writing distances in our sample (24.9 ± 5.8 cm) were significantly farther away than those of emmetropic children (21.2 ± 6.7 cm) (\(t = -3.88, p < 0.001\)). The main difference in the research methodology between these two studies is that we used an electromagnetic motion capture device with continuous posture recording instead of a digital camera with analysis of only a few photos per task. It has been previously reported that working distances of both children and adult myopes and emmetropes do not differ significantly.\(^1\)\(^5\),\(^1\)\(^8\),\(^2\)\(^0\),\(^2\)\(^1\) However, these results do not align with the findings of Marumoto et al.\(^1\)\(^2\) and Haro et al.\(^1\)\(^3\), who found that myopic children worked significantly closer during near work tasks than nonmyopic children. During their experiments, table and chair heights were adjusted according to the height of each child, and the vision correction was not specified. Moreover, we did not find that the degree of myopia had any influence on the working distances of myopic schoolchildren with full-correction glasses. Nevertheless, close working distances were measured for both myopic (this study) and emmetropic\(^1\)\(^6\) Chinese children.

In our sample of myopic Chinese children, the working distance decreased significantly from the reading task to the writing task to the video game task. As previously mentioned, the working distance decreased while attentional and haptic workload and concentration increased.\(^1\)\(^3\),\(^1\)\(^6\) Furthermore, the working distances also changed across time (Fig. 4); therefore, concentration and task difficulty might also be possible explanations for those differences. The handheld video game showed the closest and most stable working distances compared with reading or writing at a desk. Thus, the visual hazard of handheld video games could be even worse than traditional near-vision tasks (reading and writing on paper) by inducing higher levels of accommodative lag.\(^9\),\(^2\)\(^2\),\(^2\)\(^4\) and visual fatigue.\(^2\)\(^5\) Using the same setting of the desk and chair, the working distance for the video game was nearest (21.3 cm). Although the reading and writing tasks were performed at slightly farther distances (27.2 cm and 24.9 cm, respectively), they were still closer than the traditional near point distance (33 cm) used for ophthalmic examinations in China. These findings were consistent with the results of Wang et al.\(^1\)\(^6\) in emmetropic children, whose working distances were also significantly affected by the tasks (reading and writing) and were closer than 33 cm. Based on the previous results in emmetropic Chinese children\(^1\)\(^6\) and our results in myopic children (average value for different near-vision tasks, 24.5 cm), we suggest that near testing during ophthalmic examination of 6- to 12-year-old children should be performed at 25 cm instead of 33 cm in China, independent of the child’s refractive status.

In our study, myopic children showed a larger amount of accommodative lag (1.59 ± 0.56D at 33 cm) compared with the study\(^2\)\(^6\) in Canadian Chinese myopic children (1.06 ± 0.43D at 33 cm), in which numbers were used as the near fixation target. The difference in accommodative lag between these two studies may be caused by different characteristics of the visual target used in each study, such as differences in visual angles, lighting, and attention factors. Based on the average reading distances for each task, the accommodative demands for the myopic children were 4.69D (video game), 3.68D (reading), and 4.02D (writing). Earlier reports have found that accommodative lag significantly increases with high accommodative demands.\(^9\),\(^2\)\(^2\),\(^2\)\(^4\) The Chinese myopic children could therefore experience large accommodative lags, such as 1D and perhaps even 1.50D, while performing near work. An increased accommodative lag during the course of a sustained near task would induce a higher level of retinal hyperopic defocus.\(^2\)\(^2\),\(^2\)\(^7\),\(^2\)\(^9\) Hyperopic defocus, induced by accommodative lag, has been identified as a potential, but challenged, factor for myopic development.\(^3\)\(0\)–\(^3\)\(3\)

During the first 3 min, myopic children performed the video game task with a more stable working distance and a more stable head declination compared with the other two tasks (Figs. 3 and 5). This stability may be caused by the much smaller screen size (40.8 x 61.2 mm) than those used for the reading (148 x 189 mm) and writing (148 x 192 mm) texts. Working distance decreased and head declination increased across time for reading and writing tasks (Figs. 3 and 5). We found that, during the reading or writing conditions, head tilt and working distance were negatively correlated. One plausible explanation is that the children lowered their heads to read or write the lines at the bottom of the page.

Although, in the present study, we found that grade group significantly influenced working distance, these differences were no longer significant when working distance was adjusted based on the subject’s height and forearm length. These results demonstrated that working distance at the desk is closely linked to the size of a child and highlighted the importance of matching an adapted desk and chair setting with the anthropometrics of schoolchildren. Marumoto et al.\(^1\)\(^2\) suggested that the recommended desk height should be equal to the sitting height/3 + leg length, after setting the chair height at 44 cm according to the standard in the School Health Law in Japan. Molenbroek et al.\(^3\)\(^4\) also suggested that the design of classroom furniture should be based on students’ popliteal heights. In our study, we had a similar chair height (43.7 cm), but we still chose a constant desk height for all grades, in accordance with the usual setting of our subjects’ elementary school. The height of the 120 subjects in our study increased significantly in conjunction with grade level (\(F_{2,117} = 51.75, p < 0.001\)). For example, the average height of the children in grades 1 and 6 was 118.0 ± 7.1 cm and...
153.0 ± 7.8 cm, respectively. The mismatch between school furniture and student size has been noted by many researchers in the field of ergonomics as a cause of neck-shoulder pain, low-back pain, stress to spinal structures and lumbar intervertebral discs, and even headaches.35–37 Although China has a national standard for desk and chair height in high school and primary school (GB/T3976–2002), methods for describing the relationship between the height settings of the desk/chair and the size of children remain ambiguous.

In our study, head declination was affected by the tasks but not by the grade group. Head declination increased significantly from the reading task to the writing task to the video game task. Thus, head declination increased while attentional and haptic workload and concentration increased. We found that, during reading or writing tasks, the working distance became closer as a child’s head tilt increased. This finding is consistent with the results from a study performed by Marumoto et al.12 Although our subjects performed the video game task at a closer working distance and with higher head declination (i.e., more horizontal head declination, 63.5 ± 12.2 deg) than they did during reading or writing, no correlation was found between working distance and head declination for this task. One possible explanation is that most subjects held the game machine above the desk. Thus, the link between working distance and head declination was broken when the working materials were no longer placed on the desk.

The head declinations for reading (37.1 ± 12.8 deg) and writing (44.5 ± 14.1 deg) among myopes in our study were significantly higher than those of emmetropes in the study of Wang et al.16 (reading, 26.9 ± 10.1 deg; writing, 40.3 ± 11.7 deg) (reading, t = 5.76, p < 0.001; writing, t = 2.02, p = 0.045). One possible explanation is that the lower edge of the glass frame limits the visual field of the child, forcing him or her to adopt a less vertical head posture. Another possible explanation is that myopic children bend their heads more during near-vision tasks to reduce off-axis aberrations induced by the lenses in their glasses (i.e., the myopic children preferred to look at the page or screen through the part of the lens that was close to the optical center). Similar to working distance, the degree of myopia had no significant influence on head declination.

CONCLUSIONS

Close working distances were observed for Chinese myopic schoolchildren, particularly for the handheld video game. The average value for three near-vision tasks, which are the most common near tasks at school and in everyday life, was 24.5 cm. Thus, we recommend that near testing during ophthalmic examination of all primary schoolchildren should be performed at 25 cm instead of 33 cm in China. The children experience high levels of hyperopic defocus because of a large accommodative lag during near work every day at a young age, thereby increasing the risk of greater myopia progression. Improving near posture through appropriate desk and chair settings during near work might help to slow the progression of myopia in children.

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