

ARTICLE



The association between smartwatch usage and myopia progression in primary school students: a 1-year prospective observation

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OBJECTIVE: To explore the association between smartwatch usage and annual changes in refraction and axial length in primary school students.

METHODS: A 1-year prospective, school-based, observational study. 661 students (Grade 5 at baseline, ages 11–13) were invited. The cycloplegic spherical equivalent refraction (SER), axial length (AL) and questionnaires were measured at baseline and 1-year visit.

RESULTS: Five hundred twenty-six participants (mean age, 11.31 ± 0.47 years; 52.3% male) completed the 1-year study, and were divided into three groups based on smartwatch time (<0.5, 0.5–1, >1 h/day). Participants with more daily smartwatch usage (>1 h/day) showed more significantly myopic shift in refraction (–0.95 D) and axial elongation (0.47 mm) compared to those with moderate (0.5–1 h/day: –0.29 D and 0.25 mm) or low (<0.5 h/day: –0.33 D and 0.28 mm) usage (both $p < 0.001$). The weekday time of the smartwatch was strongly associated with changes in SER ($r = -0.173$, $p < 0.001$) and AL ($r = 0.163$, $p < 0.001$). The generalised linear mixed model (GLMM) revealed that total screen time ($\beta = -0.07$ for SER change, $\beta = 0.03$ for AL change, both $p < 0.001$) and weekday smartwatch usage ($\beta = -0.58$ for SER change, $\beta = 0.16$ for AL change, both $p < 0.001$) were significantly associated with myopic shifts in refraction and axial elongation.

CONCLUSIONS: Observational data indicate an association between total screen time (including smartwatch) and myopic shifts in refraction or axial elongation. These findings suggest that reasonable management of screen time may be warranted.

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INTRODUCTION

Myopia has emerged as a significant public health concern, particularly in East Asia, due to its dramatically increased prevalence in the past few decades. The increasing incidence of myopia is accompanied by its progressively younger age of onset, consequently elevating the risks of high myopia [1, 2]. High myopia, in particular, is associated with severe, long-term complications and visual impairment [3]. Evidence indicates that high myopia carries a much greater risk of myopic macular degeneration, retinal detachment, cataract, and open-angle glaucoma [4]. Therefore, it is essential to investigate the risk factors of myopia, such as screen exposure. Smartwatches are emerging multifunctional wearable devices that combine entertainment and digital interaction, and have become increasingly popular among children in recent years. However, as a new form of screen-based exposure, the association between smartwatch exposure and myopia remains unexplored.

The aetiology of myopia involves multifactorial and interactive risk factors. In recent years, electronic devices have become integral to children's daily lives. According to a report, the market penetration rate of children's smartwatches in China is about

30%, and the wearing rate of children's smartwatches is approximately 50% in cities [5]. Smartwatches are becoming increasingly common among Chinese children, yet the impact on visual development remains unclear. Traditional screen time mainly refers to the duration spent using devices like computers, smartphones, and tablets [6]. In contrast, smartwatches are used at more closer distances when viewing the screens, creating a research gap in understanding their role on visual health compared to traditional screens. For the near-distance screens, more control may be warranted. The widespread use of screens may increase near-work activities, with children spending more time on screens and less time outdoors [7–9]. Studies suggest that myopia progression may accelerate due to behavioural changes, including increased screen time from online learning [10, 11]. Excessive screens are not only a potential risk factor for myopia but may also be associated with mental health [12], dry eye [13], and even cognitive function [14]. While the causal relationship between screen time and myopia remains uncertain [7, 15], growing evidence supports that managing screen time and encouraging outdoor activities can help promote systemic health [16–18]. Increasing outdoor activities may be a more

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effective intervention until more causal evidence between screens and myopia is established.

Moreover, as children's use of electronic devices evolves, smartwatches represent a unique category of screen exposure due to their portability, frequent usage, and potential for prolonged near-work activities. Unlike traditional screens such as tablets or televisions, smartwatches are often worn throughout the day, enabling uninterrupted access to digital content and potentially reinforcing behavioural patterns associated with myopic shifts in refraction and axial elongation. Despite the increasing prevalence of smartwatch usage, there remains a gap in understanding how this specific screen exposure affects ocular health. Addressing this gap is critical, as smartwatches may contribute to near-work activity and alter the form or habits of screen exposure.

Therefore, the present study aims to conduct a longitudinal observation among primary school students to examine the relationship between myopic shifts in refraction and axial elongation and screen time, specifically focusing on smartwatches.

METHODS

Study design

A prospective, observational study. The participants are from a school-based cohort (Guangzhou, China). The research was approved by the Institutional Review Board of the School of Public Health, Sun Yat-sen University, and conducted in accordance with the Declaration of Helsinki. Data were collected after the informed consents and processed with privacy protection principles, and all personal identifiers are anonymised. The procedure or baseline information has been described in previous studies [19–21]. Currently, the cohort has completed 5 years of annual ophthalmic follow-up visits. As a complementary sub-study of the primary cohort, the analysis defined a 1-year observational period from March 2023 to March 2024, with the 2023 visit serving as the baseline and the 2024 follow-up as the endpoint. No intervention was administered during the study period. The primary objective was to identify the association between smartwatch exposure and the development of myopia among primary school students during the 1-year period.

Participants

The research invited 661 primary students (Grade 5 at baseline) to complete a structured questionnaire in 2023. A total of 526 participants (mean age: 11.31 ± 0.47 years; range: 11–13 years) who completed both baseline (2023) and follow-up (2024) ophthalmic examinations were eventually included in the analysis. Following a detailed explanation of the study's aims and procedures during school seminars, written informed consent was acquired from parents or guardians, including the current sub-study. No rewards or encouragements were provided for taking part in the study. In the primary cohort, participants were excluded with the following conditions: poor compliance with tests; unsuccessful cycloplegia; tropia; amblyopia; ocular or systemic conditions; underwent other myopia control or treatment (e.g. Ortho-K, microstructure spectacle lenses, low-concentration atropine) except single-vision lenses.

Follow-up visits and data collection

At baseline, ophthalmic examinations and questionnaire administration were conducted in March 2023. The follow-up visit with the second ophthalmic examination was conducted 12 months \pm 30 days later as the endpoint. The visits included an ophthalmic examination (cycloplegic SER, ocular biometry) and a watch-related questionnaire.

The primary outcome was the annual change in cycloplegic spherical equivalent refraction from baseline. The SER was measured at least 30 min following the three-times administration of drops of 1% cyclopentolate, with an interval of 5 min between each drop, using a KP8800 Topcon autorefractor (Topcon Corporation, Japan). Objective refraction was conducted only after adequate cycloplegia. Complementary drop was administered, if pupillary light reflex persisted, until cycloplegia was successful. The annual change in Axial Length (AL) was defined as the secondary outcome. AL was measured by the IOL Master 500 (Carl Zeiss,

Germany) and recorded an average of five measurements. The questionnaire was sent to participants and parents 1 week before the scheduled school follow-up visits. Students were asked to record the patterns of screens for the seven days. On the follow-up day, all students independently completed the questionnaires in schools without parental interference. Examiners provided clarification if participants did not understand specific items. (Table S1).

Statistical analysis

Statistical analyses were performed using R version 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria) and SPSS version 27 (IBM Corp., Armonk, NY, USA). Categorical variables are presented as percentages, and continuous variables as the mean \pm standard error. For quantitative data, both the homogeneity of variance and normal distribution were tested. The average screen time (hours/day) was calculated using device-specific time logs by the following Formula (1). Weekday and weekend screen times were summed separately. The screen time of the smartwatch for participants without a smartwatch was recorded as 0 h/day. According to the calculated average watch time, all participants were divided into three groups for comparison of myopia development (0–0.5 h/day, 0.5–1 h/day, >1 h/day). Post hoc power analysis of ANOVA was conducted using GPower 3.1.9.7 (Franz Faul, Germany). The statistical power achieved 99.3% with an alpha level of 5% and a total sample size of 526. Group comparisons employed independent t-tests or one-way ANOVA. The pairwise comparisons following ANOVA were conducted using the Least Significant Difference Test. Chi-square tests were utilised to analyse categorical variables. Pearson's correlation assessed the relationship between two continuous variables. The significant interactions between baseline SER and smartwatch time were identified for both AL change and SER change as dependent variables (both $p < 0.001$). In the stratified analysis, participants were divided into four groups according to baseline SER ($SER \leq -0.50$ D; -0.50 D $< SER \leq +0.25$ D; $+0.25$ D $< SER \leq +0.75$ D; and $SER > +0.75$ D). The linear regression assessed the associations between smartwatch time and AL change or SER change within each SER group. To investigate factors influencing myopic shifts in refraction and axial elongation, generalised linear mixed models (GLMMs) were employed, with schools of participants specified as random effects and the remaining variables (baseline information and screen time) as fixed effects. Due to the high correlation between the two eyes ($r = 0.922$ and 0.807 for baseline axial length and spherical equivalent refraction, respectively; both $p < 0.001$), only data from the right eye were used for analyses. All statistical analyses were two-sided, with a significance level set at $p < 0.05$.

$$\text{Screen time (hours/day)} = \frac{\text{Weekday time} \times 5 + \text{Weekend time} \times 2}{7} \quad (1)$$

RESULTS

Study population

Six hundred sixty-one participants who completed the baseline examination in 2023 were randomly invited for the questionnaire. Eleven participants were excluded for incomplete questionnaires, and 85 participants withdrew after baseline examination. A total of 526 participants were included in the analysis. They completed the questionnaire at baseline and two ophthalmic examinations (baseline and visit after 1 year). The mean age of 526 participants was 11.31 ± 0.47 years, of whom 275 (52.3%) were male. Based on self-report, the holding rate of smartwatches is 50.2% in the population of primary students. Reasons for participant drop-out were unrelated to the questionnaire or ophthalmic examination. There were no significant differences in baseline parameters except the time of outdoor activities and average watch time, screen time on weekdays or weekends (Table 1).

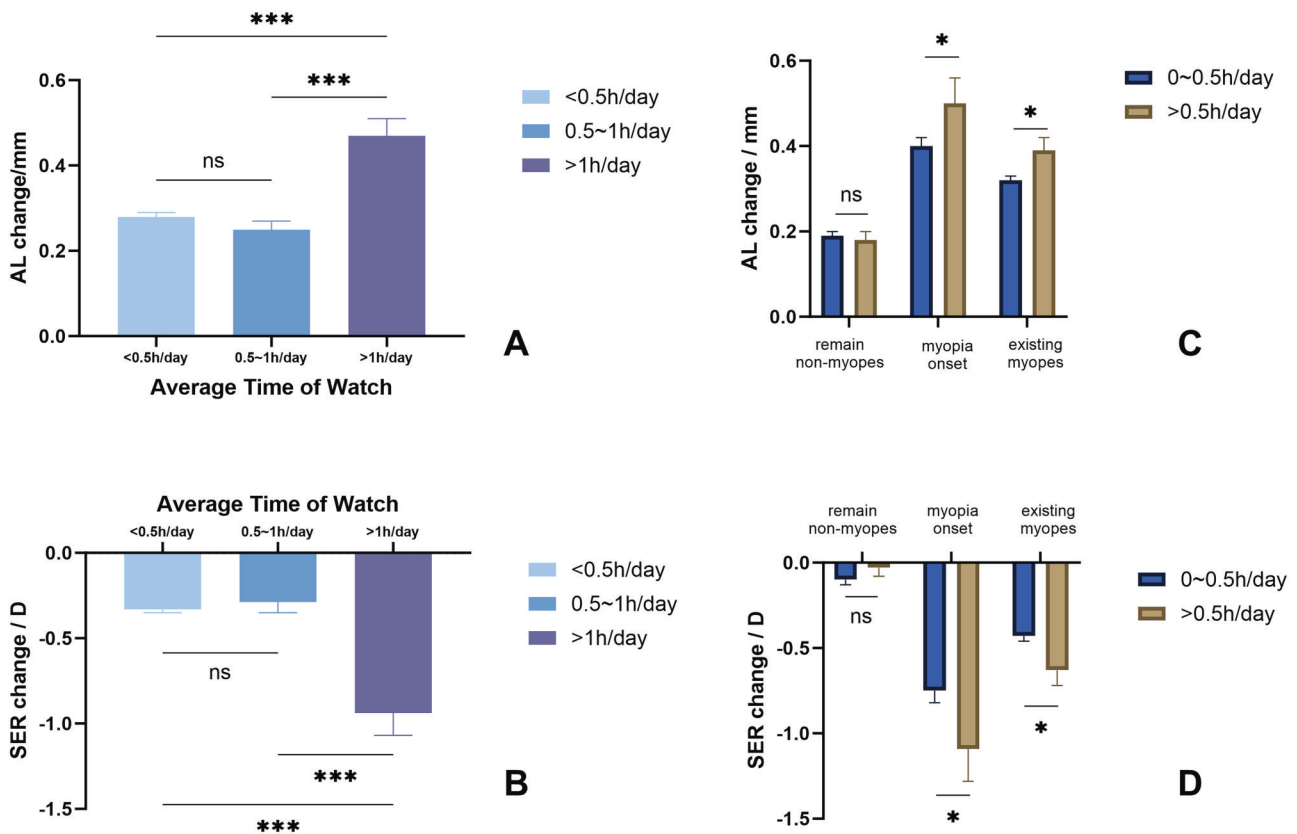
The annual changes in SER and AL

After 1-year observation, longer watch time was associated with more pronounced myopic progression. The annual change in SER was -0.33 ± 0.02 D, -0.29 ± 0.06 D, and -0.95 ± 0.13 D for the

Table 1. Baseline information (mean \pm SE, or ratio) of individuals who completed two visits.

variables	Average smartwatch time (hours/day)			P value
	0–0.5 h (n = 432)	0.5–1 h (n = 67)	>1 h (n = 27)	
Baseline age/years ^a	11.94 \pm 0.02	11.98 \pm 0.06	11.98 \pm 0.11	0.865
Baseline SER/D ^a	–0.72 \pm 0.09	–0.73 \pm 0.19	–0.90 \pm 0.30	0.865
Baseline AL/mm ^a	23.86 \pm 0.05	23.70 \pm 0.10	23.93 \pm 0.16	0.406
Gender (male or female) ^b	54.9%/46.1%	44.8%/55.2%	44.4%/55.6%	0.266
Number of myopic parents ^b (0/1/2)	51.4%/31.9%/16.7%	46.3%/40.3%/13.4%	25.9%/55.6%/18.5%	0.063
Outdoor time/hours per day ^a	1.04 \pm 0.03	1.23 \pm 0.13	0.86 \pm 0.09	<0.001
Average watch time/hours per day ^a	0.11 \pm 0.01	0.60 \pm 0.01	1.27 \pm 0.03	<0.001
Total screen time ^a	2.39 \pm 0.07	2.71 \pm 0.17	2.86 \pm 0.18	0.093
Total screen time ^a (weekday)	1.84 \pm 0.07	2.02 \pm 0.18	2.87 \pm 0.21	0.001
Total screen time ^a (weekend)	3.77 \pm 0.11	4.44 \pm 0.27	2.83 \pm 0.20	0.006

SER spherical equivalent refraction, D dioptre, AL axial length.

^aANOVA.^bChi-square test.**Fig. 1** The comparison of SER development and axial elongation. **A** Changes of AL under different smartwatch times; **B** changes of SER under different smartwatch times; **C** changes of AL in different outcomes; **D** changes of SER in different outcomes.

three groups of watch time, respectively. The differences in SER change between the three groups were significant ($p < 0.001$) (Fig. 1 and Table 2). Similarly, the change of axial elongation from baseline was 0.28 ± 0.01 mm, 0.25 ± 0.02 mm, and 0.47 ± 0.04 mm for the three groups of watch time, respectively. The difference in AL change between the three groups was significant ($p < 0.001$) (Fig. 1 and Table 2). Subgroup analyses further revealed differential progression by outcomes. The pronounced effects

were observed in established myopes ($n = 256$), where both myopia progression (-0.63 D vs. -0.43 D, $p = 0.015$) and AL (0.39 mm vs. 0.32 mm, $p = 0.013$) elongation were significantly greater in the >0.5 h/day group, compared to the <0.5 h/day group (Table S2; Fig. 1C, D). A similar trend was found in the myopia onset group but not in the group of non-myopes (Table S2). Smartwatch usage time remained significantly associated with both axial elongation and myopic shift in

refraction after adjusting for gender, age, outdoor time, and baseline AL ($\beta = 0.07$, $p = 0.003$) or SER ($\beta = -0.21$, $p = 0.004$). This association was insignificant in the subgroup with baseline SER $> +0.75$ D. (Table S3).

Correlation analyses indicated that SER ($r = -0.185$, $p < 0.001$) and AL ($r = 0.208$, $p < 0.001$) changes are strongly associated with total screen time for all participants. The screen time on weekdays ($r = 0.235$, $p < 0.001$) is more significantly correlated with Axial elongation, when compared with the screen time of weekends ($r = 0.110$, $p = 0.012$) (Table S4). Specifically, weekday TV, PC, phone use, along with weekday watch use, were significantly associated with annual myopic shift in refraction ($r = -0.173$ to -0.123 , all $p < 0.05$) or axial elongation ($r = 0.097$ – 0.195 , all $p < 0.05$) to varying levels (Table S4).

The shifts in screen time allocation

The screen time allocation habits of participants with varying smartwatch usage duration indicate a device-related shift (Table S5). Smartwatch users with >1 h/day usage (high) spent significantly less time on TV (0.87 h/day) and PC (0.57 h/day) during weekends compared to those with moderate usage (0.5–1 h/day: 1.64 and 0.94 h/day, respectively) or low usage (<0.5 h/day: 1.43 and 1.00 h/day, respectively) (TV: $p = 0.017$; PC: $p = 0.038$). Total screen time (2.39 vs. 2.71 vs. 2.86 h/day for low, moderate, and high usage, respectively) did not differ significantly ($p = 0.093$). This suggests reallocation of screen time toward watch users, while total screen time needs to remain stable. Although the total screen time is similar, the results further indicated a decreasing gap of screen time between weekdays and weekends with increasing watch time (Table 1).

Subgroup analyses validated associations between smartwatch use and change in screen time habits (Table S6). Comparing screen time (TV, PC, phone) across watch usage durations (<1 year, 1–2 years, >2 years), TV time on weekdays decreased with watch usage time (0.74 vs. 0.51 vs. 0.45 h/day, $p = 0.007$), as did PC time (0.67 vs. 0.49 vs. 0.39 h/day, $p = 0.021$) and phone time (0.61 vs. 0.49 vs. 0.39 h, $p = 0.006$) on weekdays.

Table 2. The comparison of SER myopia development (mean \pm SE).

Watch time	1-year myopia development	
	Change in SER	Change in AL
0–0.5 h	-0.33 ± 0.02	0.28 ± 0.01
0.5–1 h	-0.29 ± 0.06	0.25 ± 0.02
>1 h	-0.95 ± 0.13^{bc}	0.47 ± 0.04^{bc}
<i>P</i> value ^a	<0.001	<0.001

^aANOVA.

^bCompared with the 0–0.05 h/day, $p < 0.05$.

^cCompared with the 0.5–1 h/day, $p < 0.05$.

Table 3. Associations with 1-year SER change.

Model 1		Model 2		Model 3	
Significant predictor ^a	β	Significant Predictor ^a	β	Significant Predictor ^a	β
Total screen time	-0.07	time of watch (weekday)	-0.58	Total screen time (weekday)	-0.09
Baseline SER	0.06	time of PC (weekday)	-0.09	Baseline SER	0.06
		Baseline SER	0.04		

Model 1: adjusted for baseline information + baseline SER + total screen time (Table S7).

Model 2: adjusted for baseline information + baseline SER + time of specific screens (TV, PC, phone and watch) (Table S8).

Model 3: adjusted for baseline information + baseline SER + total screen time (weekday) + total screen time (weekend) (Table S9).

^aOnly variables with a significant *p* value (<0.05) were shown.

In summary, watch users allocated more time on their watches while maintaining total screen use, likely driven by longer smartwatch usage.

Variables associated with myopic shifts in refraction and axial elongation

For the annual change in SER (Table 3), Model 1 of GLMM indicated that total screen time was significantly associated with SER change ($\beta = -0.07$, $p < 0.001$) after adjusting for baseline parameters (gender, age, baseline SER, parental myopia, watch usage time, and outdoor time). Specifically, Model 2 suggested that weekday PC time ($\beta = -0.09$, $p = 0.037$) and smartwatch time ($\beta = -0.58$, $p < 0.001$) were significantly associated with annual change in SER when adjusting for baseline parameters and specific time of all screens (TV, PC, phone and Watch). Similarly, Model 3 suggested that total screen time on weekdays ($\beta = -0.09$, $p < 0.001$) was significantly associated with annual change in SER, but not total screen time at weekends.

For the annual change in AL (Table 4), Model 1 of GLMM indicated that the total screen time was significantly associated with axial elongation ($\beta = 0.03$, $p < 0.001$), after adjusting for baseline parameters (gender, age, baseline AL, parental myopia, watch usage time, and outdoor time). Specifically, the results of Model 2 suggested that weekday PC time ($\beta = 0.03$, $p = 0.019$), phone time ($\beta = 0.02$, $p = 0.047$) and smartwatch time ($\beta = 0.16$, $p < 0.001$) were significantly associated with axial elongation after adjusting for baseline parameters and specific time of all screens (TV, PC, phone and Watch). Similarly, Model 3 suggested that total screen time on weekdays ($\beta = 0.03$, $p < 0.001$) was significantly associated with AL change, but not total screen time on weekends.

Notably, watch ownership status was not associated with myopic shifts in refraction or axial elongation in any adjusted models, for both SER change and AL change.

DISCUSSION

In recent years, mounting evidence has demonstrated a positive correlation between screen exposure and myopia progression, supported by both cohort and cross-sectional studies [9, 22–25]. However, the specific association between smartwatches and myopia remain underexplored. Our findings underscore that total screen time is significantly associated with myopic shifts in refraction and axial elongation in primary school students, and notably, excessive smartwatch use may represent a novel risk factor for myopia development.

After 1 year of observation, significant differences in myopic shifts in refraction and axial elongation among the three groups were observed. Overall, total screen time was strongly correlated with annual changes in SER and AL, reinforcing the importance of managing overall screen exposure in myopia control strategies. Given that myopic shift is different in various stages and is more pronounced approximately 1 year prior to myopia onset, we

Table 4. Associations with 1-year axial elongation.

Model 1		Model 2		Model 3	
Significant predictor ^a	β	Significant predictor ^a	β	Significant predictor ^a	β
Total screen time	0.03	Time of watch (weekday)	0.16	Total screen time (weekday)	0.03
Baseline AL	0.03	time of PC (weekday)	0.03	Outdoor time	-0.03
Outdoor time	-0.03	time of phone (weekday)	0.02	Gender (male/female)	0.03
				Baseline AL	0.05

Model 1: adjusted for baseline information + baseline AL + total screen time (Table S10).

Model 2: adjusted for baseline information + baseline AL + time of specific screens (TV, PC, phone and watch) (Table S11).

Model 3: adjusted for baseline information + baseline AL + total screen time (weekday) + total screen time (weekend) (Table S12).

^aOnly variables with a significant *p* value (<0.05) were shown.

performed subgroup analyses. The results suggest that, at least in terms of trends, longer use of smartwatches may be associated with more axial elongation or myopic shift, especially in the onset process and established myopia. Among individual devices, phone, PC, and smartwatch usage were most strongly associated with myopic shifts in refraction and axial elongation, highlighting the need for targeted interventions. Current findings were further supported by GLMM analyses, which identified weekday smartwatch usage as a significant predictor of myopic shifts in refraction and axial elongation, after adjusting for baseline characteristics such as age, gender, parental myopia, and outdoor activity. Weekday smartwatch usage demonstrated the strongest association with both myopic shifts in refraction ($\beta = -0.58$) and axial elongation ($\beta = 0.16$), compared with phone usage (AL: $\beta = 0.02$) and PC viewing (SER: $\beta = -0.09$; AL: $\beta = 0.03$). These results suggested the correlation between smartwatches and myopic shifts in refraction or axial elongation, likely driven by differences in viewing distance and usage behaviour. Myopic children spend more time per day on activities at a distance of <20 cm than non-myopic children [26]. The analysis suggested that the smartwatch may amplify myopia risk via shorter viewing distance required for screens interaction, compared with paper [27]. Compared with phones or televisions, smaller screens typically require sustained near-distance activities, potentially increasing accommodation and convergence in smartwatch users [28]. In contrast, phones, which are often used at slightly greater distances, and televisions, which are typically viewed from several metres away, pose progressively lower near-work demands, as reflected in their smaller impact values. A further analysis revealed significant intergroup differences in daily screen time. The myopia onset group exhibited higher screen exposure (3.10 h/day) compared to both the remaining non-myopia (2.33 h/day) and established myopia (2.43 h/day) groups ($p < 0.001$), suggesting increased near work during myopia onset. However, outdoor time showed no significant difference (1.1 vs. 1.2 vs. 1.0 h/day, respectively; $p = 0.132$). Collectively, these findings may reflect an imbalance between outdoor activity and near work, especially in the onset population. The sudden change in excessive near work may have increased the risk of onset. For established myopia, diminished protective effects of outdoor time may contribute to accelerated progression under comparable screen exposure. Our results cannot fully explain the underlying mechanisms. Therefore, further longitudinal studies are warranted to elucidate the complex phenomena.

The total daily screen time across our three groups (2.39–2.86 h/day) was consistent with previous reports of 2.77 h per day in children aged 6–14 years [29]. Notably, while total screen time appears relatively stable across groups, smartwatch users exhibit a redistribution of screen habits, allocating more time to smartwatches than non-users. Device availability (e.g. personal exclusive devices) is the biggest potential predictor of screen time change [30]. Smartwatches, being wearable and easily accessible

throughout the day, may encourage intermittent but frequent usage patterns. This 'always available' nature might exacerbate near-work exposure compared with phones, which are less frequently used in short bursts, or televisions, which are generally used during designated leisure periods. In addition, parental mediation of screen use may strongly influence children's habits [31]. The students are more likely to spend time on screens for random durations on weekdays because of insufficient parental supervision in schools [32]. And it is often helpless for schools or teachers to control screen time and fully monitor without well-defined management and policy [33]. In contrast, inappropriate habits at home may be reminded by parents. Given rising parental awareness of myopia control in China, a study found that 41.68% Chinese parents frequently supervised children to practice good eye habits and 33.98% sometimes took children to outdoor activities for >2 h per day [34]. These insights partly explain why weekday time of watch may be more hazardous than weekend use. However, further research is required to investigate whether screen time on weekdays is more strongly associated with myopia. On the one hand, more weekday learning tasks and near-distance work may introduce potential bias. Over time, this redistribution could influence time spent on other devices, such as phones or computers, a hypothesis that warrants further longitudinal investigation to evaluate its potential long-term implications. Although most smartwatch owners are not heavy users, and the possible risks of myopia are not yet fully understood, it is meaningful to consider the necessity of a smartwatch in children, given that the effects on physical and mental development are also unclear.

Despite these findings, this study has limitations. Screen time was self-reported via questionnaires, introducing potential recall bias. The 1-year study period, while sufficient for short-term observations, limits the ability to assess long-term effects. Importantly, our observational results could just indicate potential correlation; establishing a causal relationship requires a future randomised controlled trial. Smartwatches are available in a diversity of brands, screen sizes, and functions, making it challenging to quantify and analyse these differences. Additionally, the sample was restricted to primary school students in urban areas, limiting generalisability to other populations. Future research should include longer follow-up, diverse populations, and objective measures of screen time to validate and extend these findings.

In conclusion, observational findings suggest that total screen time is potentially correlated with greater myopic shifts in refraction and axial elongation. These findings underscore the value of comprehensive screen management strategies, including smartwatches, to mitigate myopia risk.

SUMMARY

What was known before

- Existing evidence links increased screen time to myopia progression. Smartwatches are popular among primary students. However, the specific association between smartwatch usage and myopia remains underexplored.

What this study adds

- This study firstly identifies that smartwatch usage may be associated with annual myopic shifts in refraction and axial elongation. The results reveal device-specific risks tied to usage habits. Findings emphasise holistic screen time management, prioritising smartwatch use limitation in myopia prevention strategies.

DATA AVAILABILITY

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

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AUTHOR CONTRIBUTIONS

ZL and RM contributed to the study design, data interpretation, and manuscript drafting. LG and FZ supervised the data collection and quality control. CL contributed to the critical review and manuscript revision. YH participated in the study design and statistical analysis. XY supervised the research process, contributed to manuscript revision and critical review, and approved the final version for publication. All authors reviewed and approved the final manuscript.

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COMPETING INTERESTS

The authors declare no competing interests.

ETHICS APPROVAL

The research was approved by the Institutional Review Board of the School of Public Health, Sun Yat-sen University and carried out in line with the Declaration of Helsinki. All participants provided informed consent.

ADDITIONAL INFORMATION

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