Health-conscious programme for appropriate use of smart devices: abridged secondary publication

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KEY MESSAGES

1. There is a high prevalence of self-reported musculoskeletal, visual, and psychosocial symptoms among adolescents with excessive use of electronic devices.
2. A moderate association was found between electronic device use and these symptoms.
3. The degree of slumped spinal posture during electronic device use was correlated with the severity and frequency of self-reported musculoskeletal symptoms.
4. Vergence facility and accommodative facility were correlated with the severity and frequency of self-reported eye symptoms and the Ocular Surface Disease Index, respectively.
5. Frequent breaks, physical activity, and focused-group programmes help reduce the negative impacts associated with excessive or problematic use of electronic devices.

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Introduction

Electronic devices have become indispensable among adolescents. In Hong Kong, 56% of adolescents own a smartphone, whereas >50% of primary school students and 90% of secondary school students own a smartphone or tablet. Adverse effects related to prolonged use or addiction to electronic devices include disruptions in mood, sleep quality, and academic performance, as well as various musculoskeletal pains. Associations have been reported between increased use of electronic devices and the presence of neck pain and low back pain in adolescents.[1]

The American Academy of Pediatrics recommends restricting children's media time to a maximum of 2 hours per day. Prolonged use of hand-held smart devices and computers can lead to computer vision syndrome, which encompasses a range of visual strain disorders, including burning, irritation, ocular dryness and tearing, eye fatigue, asthenopia, blurred vision, and slow focusing. These symptoms are related to fatigue of the visual system (eg, binocularity, accommodation, vergence, and oculomotility).[2] In Hong Kong, >50% of primary school students report symptoms of unclear vision and eye strain related to the use of portable electronic devices.[3]

Various types of parental controls to restrict or monitor children's internet access on smart devices have failed to solve this problem, given that 20% of adolescents aged 12 to 15 years know how to disable filters set up by their parents.[3] More proactive approaches that emphasise mutual and peer support for offline social lives and connections among teenagers and encourage physical and outdoor activity are recommended by governments and youth health organisations. Motivational factors involved in problematic internet use and excessive gaming are related to achievement, social engagement, and immersion. Internet use and gaming provide relief from dissatisfaction with life issues; therefore, a combination of child- and parent-focused interventions is required to address both personal and environmental factors associated with problematic use. Motivational interviewing is a person-centred counselling approach that helps enhance motivation for substantive behavioural change in alcohol and substance use, as well as motivation for self-management of diet and diabetes.[4] By incorporating a collaborative conversational style, motivational interviewing assists individuals in resolving ambivalence and increasing motivation and commitment to positive behavioural change related to the excessive use of electronic devices.

This study aimed to enhance adolescents' knowledge and awareness of the health risks associated with prolonged use of smart devices, and to promote healthy smart device use among primary and secondary school students.

Methods

Primary 5 to Secondary 4 adolescents from three schools in Hong Kong were invited to participate in a health survey, vision and spine assessments, and educational seminars. The physiotherapy team evaluated spinal posture during natural sitting and device use (using a two-dimensional spinal mapping method), proprioceptive sense of the spine (using a repositioning test), and spinal muscle strength and endurance. The optometry team conducted vision screening for accommodative amplitude and facility and vergence facility and assessed dry eye status using the Ocular Surface Disease Index (OSDI) and the phenol red test.

Students with higher scores were invited to participate in a group motivational interviewing programme conducted by a social worker. The programme enabled students to explore and formulate strategies and plans to promote healthier habits of electronic device use. The effectiveness of this programme was assessed using the Contemplation Ladder, the Readiness to Change Questionnaire, and the Internet Gaming Disorder Scale–Short Form.

Teachers and parents were invited to participate in health seminars to learn skills and strategies to facilitate behavioural modification related to adolescents' device use. Educational materials were designed to support the sustainability of in-house health education and the promotion of appropriate electronic device use.

Results

Of 1058 students participated, 61% and 78% spent >2 hours per day using electronic devices on school days and weekends/holidays, respectively; in particular, 18% and 36% spent ≥4 hours per day, respectively. Extended electronic device use was associated with increased prevalence and severity of musculoskeletal symptoms (ρ=0.28-0.33, P<0.001), visual symptoms (ρ=0.33-0.35, P<0.001), and poorer device use–related psychosocial health (ρ=0.38-0.47, P<0.001) [Fig]. Secondary school students reported greater device use and more severe symptoms than primary school students.

Among 560 students who completed vision and spine assessments, their craniovertebral angle, thoracic kyphosis angle, lumbar lordosis angle in natural sitting posture and smartphone use posture, proprioceptive accuracy, and cervical extensor strength and endurance were compared with their self-reported Musculoskeletal Discomfort Index, average time spent on electronic devices on weekdays, and school year (Table 1). Students who reported symptoms in the neck, back, or upper limb (ie, Musculoskeletal Discomfort Index >0) had a significantly greater forward head position in both natural sitting and smartphone use postures (P<0.001) and a more slumped sitting posture during smartphone use (P=0.001). Students in secondary school demonstrated more inadequate sitting postures (greater forward head position and

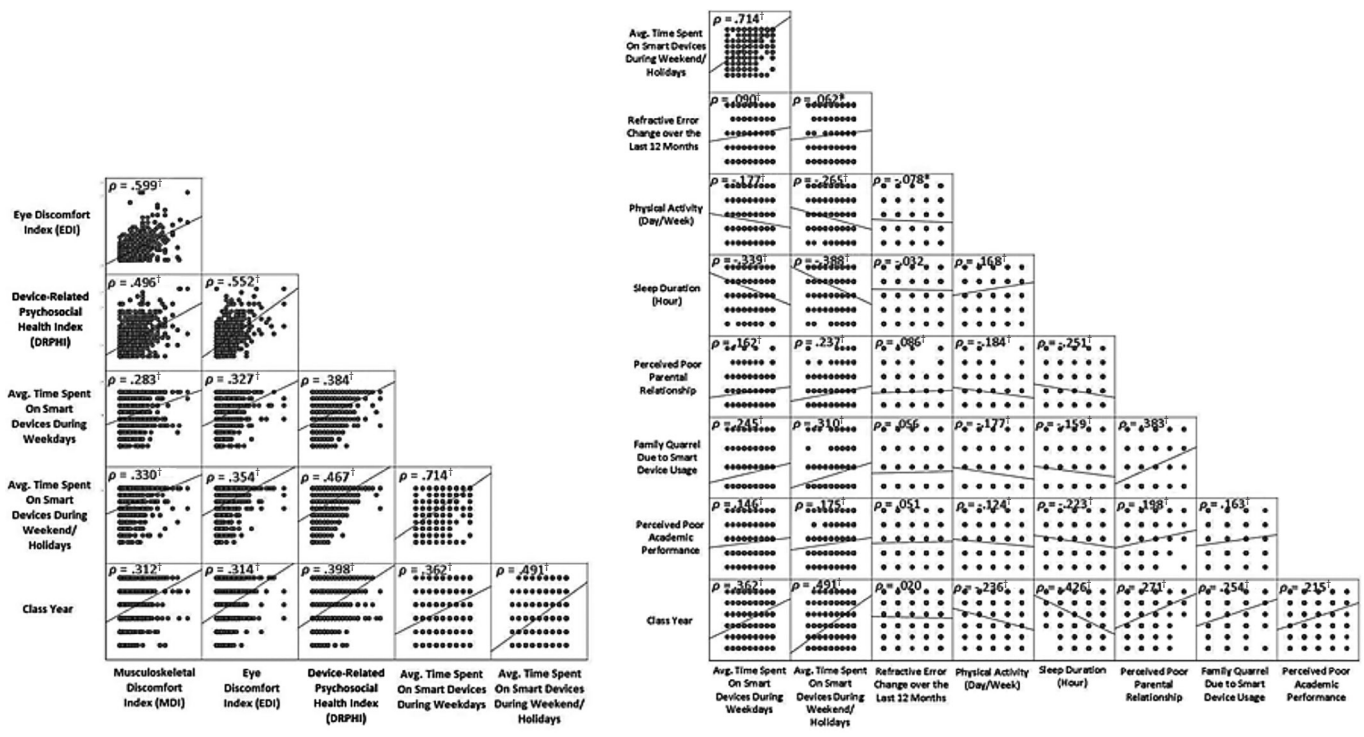

FIG. Spearman's rank correlations between device use and the Eye Discomfort Index, Musculoskeletal Discomfort Index, or Device-Related Psychosocial Health Index, and between device use and quality-of-life domains.

* P<0.05

† P<0.01

more slumped posture) than those in primary school (P<0.05).

Similarly, OSDI and vision results were compared with self-reported eye discomfort, average time spent on electronic devices on weekdays, and school year (Table 2). Vergence facility performance was significantly poorer among primary school students who used electronic devices for ≥2 hours per day, compared with those who used such devices for <2 hours. However, the opposite was observed among secondary school students. Among primary school students, both accommodative facility and vergence facility were poorer in the symptomatic group (Eye Discomfort Index >0 or OSDI >13), compared with the asymptomatic group.

Among 55 students with higher scores, the number of students in the Action stage of the Stage of Readiness to Change significantly increased after the group motivational interviewing programme and at the 3-month follow-up (Table 3). Tables 4 and 5 show the results of goal setting and the barriers to change identified by participants.

TABLE 1. Craniovertebral angle, thoracic kyphosis angle, and lumbar lordosis angle in natural sitting posture and smartphone use posture among students.

Posture	Musculoskeletal Discomfort Index		P value
	Asymptomatic (n=108)	Symptomatic (n=452)	
Natural sitting posture			
Craniovertebral angle, degrees	71.6±10.4	67.5±12.0	<0.001
Thoracic kyphosis angle, degrees	29.8±10.7	28.6±11.4	0.302
Lumbar lordosis angle, degrees	-8.4±12.9	-8.6±12.6	0.870
Smartphone use posture			
Craniovertebral angle, degrees	57.9±20.2	48.5±22.8	<0.001
Thoracic kyphosis angle, degrees	36.4±12.5	35.2±12.2	0.367
Lumbar lordosis angle, degrees	-5.3±15.2	0.1±15.6	0.001
	Average time spent on electronic devices on weekdays		
	<2 hours/day (n=158)	≥2 hours/day (n=402)	
Natural sitting posture			
Craniovertebral angle, degrees	69.1±11.8	68.0±11.8	0.295
Thoracic kyphosis angle, degrees	29.5±11.4	28.6±11.2	0.355
Lumbar lordosis angle, degrees	-9.3±13.3	-8.3±12.4	0.365
Smartphone use posture			
Craniovertebral angle, degrees	53.2±21.8	49.2±22.9	0.053
Thoracic kyphosis angle, degrees	35.9±11.4	35.3±12.6	0.636
Lumbar lordosis angle, degrees	-3.3±16.7	-0.1±15.2	0.029
	School year		
	Primary school (n=174)	Secondary school (n=386)	
Natural sitting posture			
Craniovertebral angle, degrees	77.7±4.9	64.1±11.6	<0.001
Thoracic kyphosis angle, degrees	27.1±9.8	29.6±11.8	0.012
Lumbar lordosis angle, degrees	-7.8±13.7	-9.0±12.1	0.300
Smartphone use posture			
Craniovertebral angle, degrees	70.6±8.3	41.2±21.1	<0.001
Thoracic kyphosis angle, degrees	33.2±11.7	36.5±12.4	0.003
Lumbar lordosis angle, degrees	-1.2±16.4	-0.9±15.3	0.844

Discussion

It is alarming that 18% and 36% of participants spent ≥4 hours per day using electronic devices on school days and weekends/holidays, respectively, which is more than twice the time limit suggested by the American Academy of Pediatrics. Secondary school students reported greater use of electronic devices than primary school students, highlighting the importance of early intervention to minimise development of unhealthy electronic device habits in youth.

The highest prevalence of musculoskeletal symptoms was reported in the neck region. There is a 4% to 7% increase in the odds ratio for musculoskeletal symptom development per additional hour of daily smartphone use.[5,6] Sustained cervical muscle contraction, flexed neck posture due to lower display placement, lack of postural breaks, and poor ergonomic workstation setup are potential mechanisms. Frequent breaks between classes or after-school activities to vary posture, or spending more time to physical education, should be proactively incorporated to help alleviate these physical impacts. Such additional interval breaks or physical education classes can reduce the risk of physical symptoms without sacrificing academic performance.[7]

Greater electronic device use was significantly associated with visual symptoms. One possible cause of the development and persistence of these symptoms is a decreased blink rate and an increased number of incomplete blinks during device use. Low blink rates increase corneal exposure to air, causing tear evaporation, dry eyes, and ocular irritation. Visual symptom severity was associated with school year, highlighting the need to develop and implement more effective strategies within school routines (eg, the 20-20-20 eye-resting rule and addition of 2 hours per day of outdoor activities), particularly given the potential long-term negative consequences of eye problems that develop during childhood.[8]

Prolonged device use was negatively associated with relationships with parents, highlighting the need for parental education and training to help parents effectively support their children in limiting device use while maintaining positive interactions. Parents may also help by providing more guidance on their children's device use and serving as positive role models.

Exposure to video games before sleep and viewing bright screens while engaging in tasks linked to emotional responses may increase an adolescent's

TABLE 2. Accommodative amplitude and facility and vergence facility among students.

School	Eye Discomfort Index		P value
	Asymptomatic (n=122)	Symptomatic (n=438)	
Primary school			
Accommodative amplitude, D	15.3±2.2	14.8±2.5	0.205
Accommodative facility, cpm	6.7±4.5	5.8±3.3	0.192
Vergence facility, cpm	9.8±5.2	8.0±4.7	0.026
Secondary school			
Accommodative amplitude, D	14.3±2.6	13.9±2.7	0.231
Accommodative facility, cpm	8.6±4.5	9.4±4.6	0.165
Vergence facility, cpm	14.0±5.5	14.4±6.1	0.640
	Average time spent on electronic devices on weekdays		
	<2 hours/day (n=158)	≥2 hours/day (n=402)	
Primary school			
Accommodative amplitude, D	15.1±2.7	14.8±2.4	0.512
Accommodative facility, cpm	6.5±3.4	5.9±3.8	0.336
Vergence facility, cpm	9.8±4.8	8.0±4.8	0.039
Secondary school			
Accommodative amplitude, D	13.9±2.7	14.0±2.7	0.796
Accommodative facility, cpm	8.9±4.7	9.4±4.5	0.362
Vergence facility, cpm	12.8±6.0	15.0±5.9	0.002
	Ocular Surface Disease Index		
	Asymptomatic (n=120)	Symptomatic (n=440)	
Primary school			
Accommodative amplitude, D	15.1±2.4	14.8±2.5	0.482
Accommodative facility, cpm	6.7±3.5	5.5±3.7	0.035
Vergence facility, cpm	8.6±4.9	8.3±4.8	0.793
Secondary school			
Accommodative amplitude, D	14.1±2.9	13.8±2.6	0.258
Accommodative facility, cpm	9.2±4.5	9.4±4.6	0.703
Vergence facility, cpm	14.3±5.9	14.4±6.1	0.891

Abbreviations: cpm = cycles per minute, D = diopters

TABLE 3. Motivational interviewing programme for intensive users.

Tool	Pre-treatment (n=55)*	Post-treatment (n=46)*	3 months (n=45)*
Internet Gaming Disorder Scale–Short Form	20.95±5.65	20.93±6.67	20.58±5.73
Stage of Readiness to Change			
Pre-contemplation	8	5	6
Contemplation	31	17	19
Action	16	24†	20†
Contemplation Ladder (0-10)	5.29±1.93	6.68±1.71	6.43±1.91

* Data are presented as mean±standard deviation or No. of participants.
† P<0.05

psychophysiological arousal, interfering with sleep. Insufficient sleep—detrimental to growth—is associated with fatigue and poor academic performance. These findings highlight the need to educate parents about effective strategies to limit the negative effects of device use on their children's sleep quality.

Students with musculoskeletal symptoms often exhibited a more forward head posture. A more kyphotic thoracic spine posture was consistently adopted by secondary school students while sitting and using smartphones. Compared with primary school students, secondary school students demonstrated at least a two-fold increase in the extent of forward head posture and greater thoracic kyphosis during smartphone use. Students with musculoskeletal symptoms or those in higher school years exhibited a more flexed posture, particularly in the cervical region, even when sitting naturally. This may be attributed to undesirable postural habits developed over time, especially prolonged slouched sitting. Early intervention to reinforce the importance of appropriate device use for preventive care is necessary. Regular breaks and exercises should be incorporated into daily routines to minimise the impact of electronic device use.

In the change plans, the most frequently mentioned goal was self-management (n=34, 44.7%), followed by academic study (n=20, 26.3%) and participation in other activities (n=13, 17.1%). Participants demonstrated awareness of their gaming or internet addiction or excessive screen time. Frustration with study and academic results may be linked to the development of gaming addiction.

The most frequently mentioned barriers to change included the use of gadgets and gaming devices (n=15, 29.4%), motivation for change (n=10, 19.6%), lack of self-management (n=7, 13.7%), and academic study (n=7, 13.7%). These findings are largely consistent with the reported change goals. Academic study functioned as both a goal and a barrier. Participants also reported the influence of physical condition (eg, tiredness and sleepiness), emotions, and social pressure from others (eg, playing with friends or siblings); however, these factors were reported less frequently and were therefore unlikely to be key barriers to change.

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Disclosure

The results of this research have been previously published in:

TABLE 4. Goals set by participants during the motivational interviewing programme.

Goals	Examples	No. (%) of goals set
Self-management	Improve self-control, reduce time spent on smartphones, sleep more, reduce gaming, reduce harm to eyes, stop procrastination	34 (44.7)
Academic	Academic study	20 (26.3)
Participation in other activities	More physical activity, more reading, engaging in more productive and fulfilling activities, more extracurricular activities, developing different hobbies	13 (17.1)
Broad goals related to future and development	Wealth, broadening horizons, character development, lifestyle, understanding the world	5 (6.6)
Specific personal goals	Relationships with parents or friends, weight reduction, diet	4 (5.3)

TABLE 5. Barriers to change identified by participants during the motivational interviewing programme.

Barriers	Examples	No. (%) of barriers to change
Use of gadgets and gaming devices	Attraction of new games or videos, gaming, smartphones, electronic devices	15 (29.4)
Motivation	Laziness, lack of motivation, easy to give up	10 (19.6)
Self-management	Poor time management, lack of self-control, number of choices, urgency of other matters	7 (13.7)
Study	Academic burden, study or work	7 (13.7)
Body condition	Sleepiness, tiredness, sickness	4 (7.8)
Pressure from others	Chatting with friends, peer pressure, disagreement with parents	3 (5.9)
Emotions	Boredom, feeling discouraged	2 (3.9)

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