Heliyon 9 (2023) e15654

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Effect of tablet tilt positioning on ergonomic risks and respiratory function

Pimonpan Taweekarn Vannajak [a,b], Kunavut Vannajak [a,b,*]

[a] Physical Therapy Division, Faculty of Allied Health Sciences, Burapha University, Chonburi 20131, Thailand
[b] Exercise and Nutrition Innovation and Sciences Research Unit, Burapha University, Chonburi 20131, Thailand

ARTICLE INFO

Keywords:
Tablet
Ergonomic risks
Respiratory function
Rapid upper-limb assessment
Craniovertebral angle

ABSTRACT

The static posture associated with continuous tablet use can lead to musculoskeletal disorders of the neck and upper extremities as well as respiratory function disorders. We hypothesized that 0-degree tablet placement (flat on a table) would affect ergonomic risks and respiratory function. Eighteen undergraduate students were divided into two groups (n = 9 per group). In the first group, the tablet was placed at a 0-degree angle, whereas in the second group, it was placed at a 40- to 55-degree angle on a student learning chair. The tablet was used continuously for 2 h for writing and internet use. Rapid upper-limb assessment (RULA), craniovertebral angle, and respiratory function were assessed. There was no significant difference in respiratory function, including forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC), and FEV_1/FVC, between the groups ($p = 0.09$) or within groups. However, there was a statistically significant between-group difference in RULA ($p = 0.001$), with the 0-degree group having a greater ergonomic risk. There were also significant within-group differences between pre- and posttest. The CV angle differed significantly between groups ($p = 0.03$), whereby the 0-degree group had poor posture, as well as within the 0-degree group ($p = 0.039$), though not within the 40- to 55-degree group ($p = 0.067$). Undergraduate students who place their tablets at a 0-degree angle face increased ergonomic risks and higher potential for developing musculoskeletal disorders and poor posture. Thus, elevating the tablet and instituting rest intervals may prevent or decrease the ergonomic risks among tablet users.

1. Introduction

The number of people using tablets is increasing worldwide [1] and the use of tablets has been reported to be associated with musculoskeletal discomfort [2]. The internet can be accessed anywhere and from various types of equipment, especially tablets, with studies reporting an increased number of tablet owners every year [3,4]. More than 360 million tablets were sold in 2016, compared to 60 million in 2011. The average age of users ranges from 14 to 18 years in the USA (87%), with 92% in the USA and 95% in Australia of users aged 18–34 years [3]. The average time spent using a tablet each day is 3–3.35 h for various activities, such as internet use. Previous studies have reported that the use of desktop and laptop computers can cause sleep disturbances that affect the user's mental stress [5], attention-deficit disorder, headache [6], and musculoskeletal disorders - especially neck and shoulder pain [3]. Moreover, smartphones, and telecommunication signals can result in sleep disturbances, depression, headache, and thumb pain from typing on a

* Corresponding author. Physical therapy division, Faculty of allied health sciences, Burapha University, Chonburi 20131, Thailand.
E-mail address: kunavut@go.buu.ac.th (K. Vannajak).

https://doi.org/10.1016/j.heliyon.2023.e15654
Received 6 April 2022; Received in revised form 13 April 2023; Accepted 17 April 2023
Available online 24 April 2023
2405-8440/

screen [7]. Tablet use in children has been reported to result in muscle discomfort and poor posture after only 2 h of use [8–10]. One study reported that neck pain and shoulder pain were present in 33.1% of 3600 secondary school–level students in Shanghai, China, which was hypothesized to be resultant of tablet and smartphone use [10]. Prolonged tablet use causes a reduction in movement, and static posture leads to musculoskeletal disorders at the neck and upper extremities [11,12]. Increased trunk flexion, rounded shoulders, and shoulder elevation have been reported as being associated with tablet-use posture as compared with desktop computer use [13]. A prior study employed lateral view imaging to evaluate posture during tablet use. The researchers drew a line on the images between the acromion process and the seventh cervical spine to measure the angle between the horizontal line. A normal angle is 52°, indicating mean normal neck posture [14]. In individuals with a smartphone addiction, the craniovertebral (CV) angle is reduced, as indicated on the images by marking the tragus of the participant's ear and the seventh cervical vertebrae. A line is then drawn to connect the two points; the angle of this line - with the horizontal line is then assessed. A reduction in this angle indicates a forward head angle [15]. A reduction in shoulder angle, i.e., the angle between the horizontal line and seventh spinous process link to the acromion process of the scapular which means the shoulders have moved forward, resulting in rounded shoulders [16]. In another study, a rounded shoulder posture in seated male workers was measured via the acromial distance from a wall during a standing lean against a wall (intraclass correlation coefficient = 0.94) [17]. A distance from the acromion to the wall of >2.6 cm indicated a rounded shoulder posture.

Because tablets provide paperless use and make it easy to access the free internet service of universities, undergraduate students comprise one of the main groups of tablet users. There has also been an increase in their use for online learning activities, such as work assignments, downloading worksheets, meetings, conferences, and examinations. Each tablet use session can last from 3 to 4 h. Research has reported that more than 50% of university students who use electronic devices have a musculoskeletal disorder [18].

Many researchers have reported that tablet placement positioning has an effect on poor posture [9,10]. Using a tablet lying flat on a table results in a head flexion of 100° and neck flexion of 50° which represents poor posture [4]. Indeed, an appropriate posture in using a tablet is head flexion not more than 100° and neck flexion not more than 50°. With an increase in shoulder elevation and shoulder flexion [10], the neck extensor works harder to hold the neck upright, which increases stress on the joint capsule of the cervical spine and tissue around the neck [19]. The tablet-holding position preference of the user [20], holding a tablet with one hand or two hands can also increase neck and shoulder muscle activity [3]. Thus, tablet placement affects the user's posture and ultimately leads to ergonomic risk and Ergonomic risk can lead to pain and to poor posture. To date, only a few studies have examined the disadvantages caused by the tablet tilt position used and its association with musculoskeletal disorders and decreased respiratory function. A previous study reporting smartphone group use showed decreased forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV1) when compared with a control group [21].

As mentioned above, poor posture caused by tablet use may result in increased ergonomic risks as assessed by RULA (Kelly et al., 0 2009), increased forwarded head posture assessed by decreased craniovertebral angle, and decreased respiratory function reported via FVC, FEV_1 and FEV_1/FVC. This parameter results in airflow limitation with an obstructive pattern. Thus, this study aimed to evaluate the effect of different tablet tilt positions on ergonomic risks and respiratory function.

2. Materials and methods

2.1. Study design

This study was conducted by incorporating a randomized controlled trial. Following recruitment, participants were divided into 2 groups aimed at different tablet placement angles (0° or lying flat on a table group and 40–55° group) to carry out an identical writing task of copying journal papers. The 2 groups were then compared to assess the effects of tablet angle used. CV angle, RULA and respiratory function were assessed pre- and posttest. This study received ethical approval from the Research and Innovation Administration Division, Burapha University (No. HS004/2564; 2021). Restricted research conducted in accordance with ethical approve procedure. All approved changes in procedure were reported to the ethical committee. On research completion, the researcher reported to the Research and Innovation Administration Division, Burapha University. Clinical registry number: ISRCTN16053224.

2.2. Sample size

We estimated the sample size based on a pilot study on the effect of tablet tilt positioning on ergonomic risks. Participants performed the same writing task using an electronic pencil to transcribe words or rewrite a health sciences review article onto a blank paper application which was printed out onto paper and laid by the right side of the tablet continuously for 2 h in the same environment consisting of an identical temperature, light level, and chair attribute. The main parameter was the rapid upper-limb assessment (RULA) tool as applied to upper limb use amid the writing task. A power calculation was conducted based on a critical α value of 0.05 and a $1 - \beta$ of 0.9. To achieve a power level of 80%, in addition to accounting for a 20% dropout rate, we calculated that 18 participants were required, who were divided into two groups of 9.

2.3. Participants

Inclusion criteria were undergraduate students aged 18–25 years who used a tablet for more than 2 h per day 6 month prior to the study. Exclusion criteria were a history of neck or upper-extremity surgery in the previous year; disorder or malalignment of the cervical spine or upper extremity; neck and upper-extremity pain, as measured by a visual analog scale score of greater than 3/10; chronic musculoskeletal disorder such as rheumatoid arthritis, osteoarthritis, or fibromyalgia; nervous or musculoskeletal system disorder affecting sensory input; visual problems unable to be fixed with glasses; dizziness resulting in poor balance; and sedative drug uptake or alcohol consumption 48 h before. Following recruitment, participants passing the inclusion criteria gave their written informed consent as approved by the Research and Innovation Administration Division, Burapha University.

2.4. Procedures

A total of 18 undergraduate student participants were divided into two groups of 9. Group 1 positioned their tablets at a tilt of 0° (lying flat on a table), and group 2 used a tablet tilt position of 40–55°. Participants performed the same writing task using an electronic pencil to transcribe words or rewrite a health sciences review article onto a blank paper application which was printed out onto paper and laid by the right side of the tablet continuously for 2 h in the same environment consisting of an identical temperature, light level, and chair attribute. Data on the RULA were assessed by two professional physical therapists. They observed and agreed to sum up RULA score in a cross-sectional analysis on pretest and posttest (2 h after writing task). During data collection the assessors did not notify participants that they were observed and assessed throughout 2 h of the study. Respiratory function and CV angle were assessed prior to and subsequent to the study. In addition, fatigue symptom was also assessed after the study. We employed a standard student chair that cannot adjustable and tablet with a tilting tool. Respiratory function was measured via spirometer (CareFusion MicroLab), with a CV angle assessment tool for evaluation. Testing was conducted at a physical therapy laboratory room in the afternoon at Burapha university, Thailand.

2.5. Statistical analysis

We analyzed baseline characteristics, including age, weight, height, body mass index, tablet use per day, hand preference, respiratory function, and CV angle, per mean ± SD, using independent-sample *t* for between-group comparisons and paired-sample *t*-test for within-group comparisons. RULA was represented as the median between groups via the Mann-Whitney *U* test and the Wilcoxon signed-rank test were used for between-group and within-group comparisons, respectively. A p value < 0.05 was considered statistical significance.

3. Results

3.1. Baseline characteristics of participants

Table 1 shows the baseline characteristics of the study participants. Study participants consisted of 8 women (88.89%) and 1 man (11.11%) in both groups. The table reports participant weight, height, body mass index. All subjects reported right-handed dominance (100%).

Participants' average age was 20.8 ± 0.7 years, body weight 56.9 ± 11.1 kg, height 161 ± 3.6 cm, and body mass index 21.9 ± 3.7 kg/m^2 in group 1 (0-degree tablet placement) and 20.6 ± 0.88 years, body weight 52.7 ± 5.85 kg, height 161 ± 3.56 cm, and body mass index 20.3 ± 2.37 kg/m^2 in group 2 (45- to 55-degree tablet placement).

3.2. Effects of tablet tilt positioning on ergonomic risks

Table 2 reports the RULA score based on tablet-tilt positioning. The median score of RULA was 7 in group 1 (0-degree tablet placement) and 6 in group 2 (45- to 55-degree tablet placement). The CV angle of group 1 was 50.77 ± 4.52° pretest and 47.77 ± 3.59° posttest. In group 2, CV angle was 47.11 ± 4.72° pretest and 46.11 ± 4.4° posttest. We discovered a statistically significant difference between groups ($p = 0.001$) and within the 0-degree group ($p = 0.039$). Figs. 1 and 2 show the RULA score and CV angle change, respectively.

3.3. Effects of tablet tilt positioning on respiratory function

Table 2 demonstrates the effects of tablet-tilt positioning on respiratory function, including forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC), and FEV_1/FVC. There was no significant difference in the change in FEV_1 between the 0-degree group and the 45- to 55-degree ($p = 0.09$) or within groups ($p = 0.65$ and $p = 0.716$, respectively). The FEV_1 of the 0-degree group was 2.95 ±

Table 1
Baseline characteristics of the study participants.

Parameter	Group 1 (0-degree tablet placement)	Group 2 (45- to 55-degree tablet placement)
Gender	Female 8, Male 1	Female 8, Male 1
Age (years)	20.8 ± 0.7	20.6 ± 0.88
Weight (kg)	56.9 ± 11.1	52.7 ± 5.85
Height (cm)	161 ± 3.6	161.2 ± 3.56
Body mass index (kg/m^2)	21.9 ± 3.7	20.3 ± 2.37
Hand preference	All right-handed	All right-handed

Table 2
Parameters change in the study.

Parameter	Score				Score change (pre–post difference)	
	Group 1: 0-degree tablet position		Group 2: 45- to 55-degree tablet position			
	Pretest	Post	Pretest	Post		
RULA	6	7	4	6	1	2
Between group	0.001*					
Within group	0.039*		0.01*			
CV angle (degree)	50.77 ± 4.52	47.77 ± 3.59	47.11 ± 4.72	46.11 ± 4.4	3	1
Between group	0.003*					
Within group	0.039*		0.067			
FEV_1 (L)	2.95 ± 0.34	2.97 ± 0.33	2.75 ± 0.39	2.73 ± 0.41	−0.02	−0.02
Between group	0.09					
Within group	0.65		0.716			
FVC (L)	3.3 ± 0.48	3.28 ± 0.46	3.04 ± 0.57	3.04 ± 0.53	−0.02	0
Between group	0.088					
Within group	0.354		0.984			
FEV_1/FVC (%)	89.55 ± 6.3	91.22 ± 4.79	91.22 ± 5.44	90.22 ± 3.52	1.67	−1.00
Between group	0.504					
Within group	0.066		0.339			

*Statistically significant difference, $p < 0.05$.

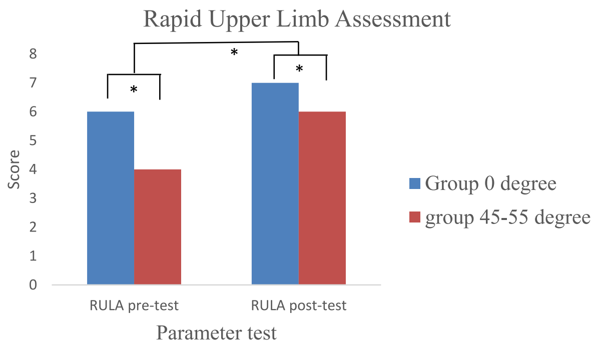

Fig. 1. RULA change graph. *Statistical difference, $p < 0.05$.

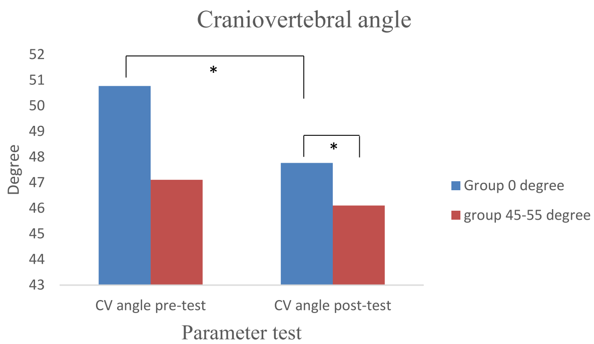

Fig. 2. CV angle change graph. *Statistical difference, $p < 0.05$.

0.34 L in the pretest and 2.97 ± 0.33 L in the posttest, whereas in the 45- to 55-degree group, it was 2.75 ± 0.39 L in pretest and 2.73 ± 0.41 L in posttest (Fig. 3).

There was no significant differentiation in FVC between the 0-degree group and 45- to 55-degree group ($p = 0.088$) or within groups ($p = 0.354$ and $p = 0.984$, respectively). The FVC of the 0-degree group was 3.3 ± 0.48 L in the pretest and 3.28 ± 0.46 L in the posttest, whereas in the 45- to 55-degree group, it was 3.04 ± 0.57 L in the pretest and 3.04 ± 0.53 L in the posttest.

There was no significant change in FEV1/FVC between the 0-degree group and the 45- to 55-degree group ($p = 0.504$) or within groups ($p = 0.066$ and $p = 0.339$, respectively). The FVC of the 0-degree group was 89.55 ± 6.3 L in the pretest and 91.22 ± 4.79 L in posttest, and in the 45- to 55-degree group, 91.22 ± 5.44 L in the pretest and 90.22 ± 3.52 L in the posttest.

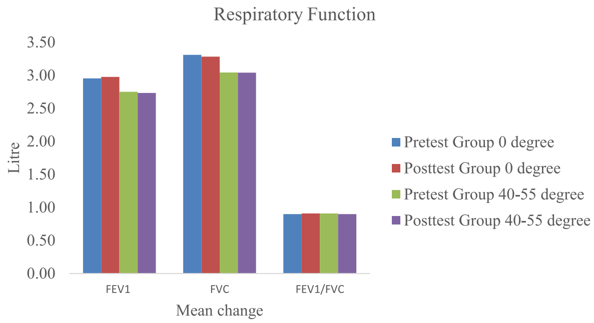

Fig. 3. Respiratory function change graph. *Statistical difference, $p < 0.05$.

4. Discussion

We conducted a randomized controlled trial to investigate the effect of tablet tilt placement while writing (copy writing a health sciences reviewer article) on ergonomic and respiratory function. The RULA can be employed to measure ergonomic risk in tablet users. The results revealed that undergraduate students using a tablet for 2 h had a high ergonomic risk of ergonomic dysfunction which promotes muscle fatigue and poor posture.

Fatigue can be occurred after the continuous use of a tablet for 2 h and it may cause change in posture. From the starting position, both evaluated groups had a low–medium risk from their tablet-use posture. Subsequent to using the tablet continuously for 2 h, both groups had a high ergonomic risk dysfunction. Tablet position is a factor in the RULA change because placing the tablet at a 0-degree angle causes more flexion in the neck and trunk. The use of a tablet for long periods increases muscle fatigue and leads to a more slumping posture as well as an increased RULA score, which indicates a worsening posture and high ergonomic risk leading to musculoskeletal pain. This result was similar to that reported by Binboga and Korhan [11]. In addition, Xie [12] reported that prolonged tablet use causes reduced movement, and a static posture leads to musculoskeletal disorders of the neck and upper extremities [11,12]. Furthermore, prolonged tablet use can decrease craniovertebral angle and thus lead to forwarded head posture.

Prolonged sitting leads to a slouching posture. Straker et al. [13] reported that tablet-use posture consisted of greater trunk flexion, rounded shoulders, and increased shoulder elevation when compared with the posture associated with desktop computer use. Although both groups in this study exhibited risk, the starting position of 45–55° was associated with a low risk if the time spent utilising the tablet was decreased or interrupted by a change in position. Although there was still a low risk of ergonomic dysfunction, it did not progress to the high-risk category. According to the report of Chiang and Liu [2], head and neck flexion angles were significantly increased (i.e., more erect) when the tablet was positioned at a high tilt angle (such as 60°). Employing a placement with a higher tilt angle may help users to decrease their neck flexion position, leading to a more erect neck and trunk position and hence, an ergonomic posture [2]. The data from this study suggested that head and neck posture can be improved by adjusting a tablet to a higher tilt angle.

CV angle in both groups at 0° tablet placing angle decreased by 3°, which resulted in more neck flexion and a slouching posture. Clearly, the reason for this change was the increase in neck flexion due to the need for eye-tracking to achieve a better viewpoint when the tablet was lying flat on the student's desk. When compared with a tablet placed at a 45- to 55-degree angle, there was no statistically significant difference within groups, as the user did not need to achieve too much neck flexion as the tablet was elevated above the student's desk chair. Analysis of sum score in the RULA was similarly correlated with CV angle, in which prolonged tablet use resulted in increased slumping posture and more neck flexion. According to Ruivo et al. [16], the reduction in shoulder angle indicates that the shoulders moved forward, resulting in rounded shoulders. The slumping posture assumed by long duration tablet use in undergraduate students leads to musculoskeletal disorders [18]. The position of the tablet has a direct effect on the user's point of view; thus, a higher tilt angle actually changes the point-of-view angle [2]. An increase in the tilt angle results in greater neck extension yet no change in CV angle. As reported in this study, there was no statistically significant difference in 45- to 55-degree placement, though we did find a significant difference in the 0-degree angle position. Higher tilt placement helps users to decrease their neck flexion position, leading to a more erect, improved neck and trunk position in addition to an ergonomic posture [2]. The data from this study suggest that head and neck posture can be improved by adjusting the tablet tilt angle through the use of a tablet case, which allows the user to adjust the tablet to the appropriate angle.

There was no change in respiratory function in the groups, either between or within groups. Poor posture after 2 h of continuous tablet use did not affect respiratory function or the respiratory muscle. Placing the tablet on the student chair exerted no effort on the shoulder or forearm and hand muscles, thus reducing the workload of the neck and shoulders. Muscle fatigue was less than that of smartphone use, in which the phone is lifted by hand from a table. The results of this study were not in accordance with that of Kang et al. [21], who reported that holding a smartphone with both hands in the sitting posture placed a high load on the neck and upper extremities that could affect the respiratory muscles [21]. The strengths of this study are that it was conducted in undergraduate students who account for the most studying duration as well as the paperless trend. Moreover, they are the future of the nation. If we discover the cause of poor posture leading to increased ergonomics risk and harm to health, then we can protect and mobilise better health in addition to no chronic pain during physical development. Although this study was conducted in healthy participants, tablet use was shown to affect poor posture and increased ergonomic risk.

The limitations of this study were that it comprised of a low amount of participants as well as a lack of long duration tablet utilization assessment. Inclusion criteria were healthy persons with no deformity or pain at the cervical spine, in addition to no neck or upper-extremity pain. This study assessed the immediate effects so there tended not to be any change in respiratory function. The future study suggests that increase number of participants and increased time of tablet used according to the real used such as study schedule from 8 or 9 a.m. −12 p.m. mean 3–4 h in real. Lon term follow up such as 6 h after prolong tablet used was suggested.

5. Conclusion

Tablet tilt positioning has an effect on poor posture. We detected an ergonomic risk in both groups of this study, with a high-risk RULA score found in the 0-degree tablet position. There was a statistically significant between-group difference in change in forwarded head posture, though the 45- to 55-degree placement position did not alter the forwarded head posture. This means that a higher tilt helped to prevent the forwarded head posture or prevent more neck flexion. Respiratory function did not change in either group, likely because the tablet was placed on the chair, which did not increase the load on respiratory function.

Author contribution statement

All authors listed have significantly contributed to the investigation, development and writing of this article.

Data availability statement

Data will be made available on request.

Additional information

Supplementary content related to this article has been published online at [URL].

Declaration of interest's statement

The authors declare no competing interests.

Acknowledgements

This study was financially supported by the Exercise and Nutrition Innovation and Sciences Research Unit and the Burapha University Research and Development Fund.

References

[1] S. Berolo, R. P Wells, B.C. Amick III, Musculoskeletal symptoms among mobile hand-held device users and their relationship to device use: a preliminary study in a Canadian university population, Appl. Ergon. 42 (2) (2011) 371–378.
[2] H.Y. Chiang, C.H. Liu, Exploration of the associations of touch-screen tablet computer usage and musculoskeletal discomfort, Work 53 (4) (2016) 917–925.
[3] S.H. Toh, P. Coenen, E.K. Howie, L.M. Straker, The associations of mobile touch screen device use with musculoskeletal symptoms and exposures: a systematic review, PLoS One 12 (8) (2017), 0181220.
[4] J.G. Young, M. Trudeau, D. Odell, K. Marinelli, J.T. Dennerlein, Touch-screen tablet user configurations and case-supported tilt affect head and neck flexionangles, Work 41 (1) (2012) 81–91.
[5] S. Thomée, A. Härenstam, M. Hagberg, Computer use and stress, sleep disturbances, and symptoms of depression among young adults–a prospective cohort study, BMC Psychiatr. 12 (2012) 176.
[6] I.M. Jomoah, Work-related health disorders among Saudi computer users, Sci. World J. (2014), 723280.
[7] M. Redmayne, E. Smith, M.J. Abramson, The relationship between adolescents' well-being and their wireless phone use: a cross-sectional study, Environ. Health 12 (1) (2013) 90.
[8] C. Harris, L. Straker, Survey of physical ergonomics issues associated with school childrens' use of laptop computers, Int. J. Ind. Ergon. 26 (3) (2000) 337–346.
[9] P. Nejati, S. Lotfian, A. Moezy, A. Moezy, M. Nejati, The relationship of forward head posture and rounded shoulders with neck pain in Iranian office workers, Med. J. Islam. Repub. Iran (28) (2014) 26.
[10] Z. Shan, G. Deng, J. Li, Y. Li, Y. Zhang, Q. Zhao, Correlational analysis of neck/shoulder pain and low back pain with the use of digital products, physical activity and psychological status among adolescents in Shanghai, PLoS One 8 (10) (2013), 78109.
[11] E. Binboga, O. Korhan, Posture, musculoskeletal activities, and possible musculoskeletal discomfort among children using laptops or tablet computers for educational purposes: a literature review, J. Sci. Educ. Technol. 23 (5) (2014) 605–616.
[12] Y. Xie, G. Szeto, J. Dai, Prevalence and risk factors associated with musculoskeletal complaints among users of mobile handheld devices: a systematic review, Appl. Ergon. 59 (Part A) (2017) 132–142, https://doi.org/10.1016/j.apergo.2016.08.020.
[13] L.M. Straker, J. Coleman, R. Skoss, B.A. Maslen, R. Burgess-Limerick, C.M. Pollock, A comparison of posture and muscle activity during tablet computer, desktop computer and paper use by young children, Ergonomics 51 (4) (2008) 540–555, https://doi.org/10.1080/00140130701711000.
[14] C.A. Thigpen, D.A. Padua, L.A. Michener, K. Guskiewicz, C. Giuliani, J.D. Keener, N. Stergiou, Head and shoulder posture affect scapular mechanics and muscle activity in overhead tasks, J. Electromyogr. Kinesiol. 20 (4) (2010) 701–709, https://doi.org/10.1016/j.jelekin.2009.12.003.
[15] A.K. Akodu, S.R. Akinbo, Q.O. Young, Correlation among smartphone addiction, craniovertebral angle, scapular dyskinesis, and selected anthropometric variables in physiotherapy undergraduates, Journal of Taibah University Medical Sciences 13 (6) (2018) 528–534.
[16] R.M. Ruivo, P. Pezarat-Correia, A.I. Carita, Cervical and shoulder postural assessment of adolescents between 15 and 17 years old and association with upper quadrant pain, Braz. J. Phys. Ther. 18 (4) (2014) 364–371, https://doi.org/10.1590/bjpt-rbf.2014.0027.

[17] J.S. Lewis, R.E. Valentine, The pectoralis minor Length Test: a study of the intra-rater reliability and diagnostic accuracy in subjects with and without shoulder symptoms, BMC Muscoskel. Disord. 9 (8) (2007) 64–73, https://doi.org/10.1186/1471-2474-8-64.
[18] E.H.C. Woo, P. White, C.W.K. Lai, Musculoskeletal impact of the use of various types of electronic devices on university students in Hong Kong: an evaluation by means of self-reported questionnaire, Man. Ther. 26 (1) (2016) 47–53, https://doi.org/10.1016/j.math.2016.07.004.
[19] A.M. Greig, L.M. Straker, A. Briggs, Cervical erector spinae and upper trapezius muscle activity in children using different information technologies, Physiotherapy 91 (2) (2005) 119–126, https://doi.org/10.1016/j.physio.2004.10.004.
[20] J.G. Young, M.B. Trudeau, D. Odell, K. Marinelli, J.T. Dennerlein, Wrist and shoulder posture and muscle activity during touch-screen tablet use: effects of usage configuration, tablet type, and interacting hand, Work 45 (1) (2013) 59–71, https://doi.org/10.3233/WOR-131604.
[21] K.W. Kang, S.I. Jung, Y.L. do, K. Kim, N.K. Lee, Effect of sitting posture on respiratory function while using a smartphone, J. Phys. Ther. Sci. 28 (5) (2016) 1496–1498, https://doi.org/10.1589/jpts.28.1496.