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Original Research Article

Proprioception and balance in healthy adults: A comparison between Smartphone and computer users

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Abstract

Objective: In our digital society, the use of smartphones has increased rapidly in recent years. The impact of prolonged smartphone and computer usage may lead to balance problems and disturbed neck proprioception due to faulty posture of the neck. This study aimed to compare the impact of smartphone and computer usage on neck proprioception and dynamic balancing ability.
Methods: 70 healthy adults were divided into two groups: smartphone (n=35) and computer users (n=35). Neck proprioception was assessed by Head Repositioning accuracy (HRA) test and dynamic balance assessed by Y balance test (YBT). Three trials were performed and the mean values were calculated.
Results: The groups were found to be similar on age, height, and weight and body mass index. There was a significant difference on cervical repositioning and dynamic balance measures between the groups (p-value <0.05). All four cervical spine movements (flexion, extension, right and left rotation) showed significant differences between the groups ($p<0.05$). Computer users had greater affected dynamic balance and neck proprioception than smartphone users.
Conclusion: Prolonged usage of computers (more than four hours per day) could more negatively affect neck proprioception and dynamic balance ability in healthy adults. The results may be used to promote awareness about smartphone and computer use duration and develop programs to prevent negative effects on neck proprioception and balance ability, especially in computer users.
Keywords: Joint position sense, dynamic balance, internet usage.

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1. Introduction

Nowadays, people are getting more dependent on smartphones than ever. [12] 91% of university students in their 20s use smartphones, which is significantly higher than the other age groups. [25]

Smartphones can be used anytime and at anyplace because of their ease of being carried and used. Smartphones are used for various tasks on a day to day basis such as checking social media, doing shopping, watching videos, reading books, etc. [32] which may predispose to musculoskeletal problems. [6,8] As smartphones are typically held downwards in a static position and with an unsupported arm, their overuse can cause abnormal alignment of the neck and shoulders. Since users bend their heads to see the small smartphone screens, there is overloading of the neck and shoulders, and the muscle activity in the neck extensors is increased, thereby leading to increased muscle fatigue and decreased work capacity. [26, 36] Repetitive usage of smartphones for long durations causes repetitive trauma and injury in the neck and shoulder muscle fibers leading to muscle fiber injury. [27] People engaging with the visual display of a smartphone gradually develop forward head posture as a compensatory posture [14] which in turn can cause injury to the structures and ligaments of the cervical and lumbar spine. These structural problems can also lead to decreased proprioception and hence, decreased balance ability. [9, 13]

Computers are known to improve the productivity and efficiency of the work, but their excessive use may lead to headaches, visual problems, musculoskeletal pain, etc. Amongst these, musculoskeletal disorders are the commonest.[4,21,30,33] Severe neck pain has been found to be associated with reduced balancing ability in the past.[10]

Also, it has been reported that pain or inflammation may lead to an abnormal proprioceptive ability and reduction in the joint position sense, thus, leading to posture imbalance.[7] Prolonged computer usage makes the head to move in a forward position (referred to as forward head posture) since the monitor (located below the height of eyesight) is constantly stared, thereby exaggerating the anterior curve of the lower cervical spine and posterior curve of the upper thoracic spine in order to maintain balance.[11,28,39,40] Balancing ability and control of head and eye movements is dependent on afferent inputs from visual, vestibular, and proprioceptive systems of the body.[17]

An adult head weighs 10-12pounds in the neutral position as it tilts forward, the force of neck increases to 27pounds at 15degrees, 40 pounds at 30degrees, 49pounds at 45 degrees, and 60pounds at 60degrees.[16] Hence, constant pressure on cervical spine joints due to forward head posture [29], sends disturbed signals to the brain leading to balance problems and altered neck proprioception.[2,3,22] Cervical proprioception contributes to correct head position and trunk orientation in space[5], and balance control.[20]

People spending long times on smartphones are more likely to have their necks in an incorrect position for long periods than the computer users, which might affect the proprioception input of the neck. This study aimed to compare the impact of long-term use of smartphones and computers on neck proprioception and dynamic balancing ability in healthy adults.

2. Methods

It was an observational study such that a sample of convenience was chosen. The total number of subjects was 70, 35 in each group. Subjects were assigned into Group A (Smartphone users 20 males and 15 females) and Group B (Computer users 20 males and 15 females).

The subjects were selected from the Rehabilitation Center and Department of Computer Science & Engineering, after signing the informed consent. The subjects were selected only if they met the inclusion and exclusion criteria.

2.1 Inclusion criteria

Male or female with the age of 18-35 years with normal BMI. Smartphone or computer usage for four hours or more per day over the past 2 years.

2.2 Exclusion Criteria

Traumatic neck injuries, inflammatory joint disease, history of recent trauma or surgery, neurological disorders, vestibular disorders, underweight and overweight, having any psychiatric disorders, pregnancy or communication problems.

2.3 Ethical approval and consent to participate

The study was approved by the Institutional Ethical Committee. All procedures followed were in accordance with the Jamia Hamdard institutional ethical standards for human experimentation and the Helsinki Declaration. All participants were given an information sheet explaining the study purpose, methodology as well as their rights as research subjects and written consent was obtained.

2.4 Head repositioning accuracy (HRA)

The laser method was applied to measure proprioception by assessing cervical joint position error (JPE). This method has demonstrated good test-retest reliability and has been shown to have excellent correlation with an ultrasound technique for measurement of JPE. [35]

Four cervical spine movements (flexion, extension, right and left rotation) were assessed using the HRA test. [34] A laser was attached to a lightweight headband on the participant's head. The laser was projected at a blank sheet attached on a wall which was 90 cm away from the participant. Participants were seated on a chair with arm and back supported and their heads in a natural straight position. Their feet were placed supported on the floor with knees and hips at 90 degrees.

Participants were asked to maintain this position throughout. They were asked to focus on a blank sheet and mark that point as a target point and asked to memorize that point. Each cervical spine movement was demonstrated to the participant. The participants performed three practice trials for each movement to become familiar with the test. Participants were then asked to keep their eyes closed throughout and perform the movements in a slow, controlled manner. The eyes of the participants were covered to make sure that the participants could not observe the laser pointer. The participants were asked to move to half the reported normal range of motion (flexion = 30 degrees, extension = 35 degrees, right rotation = 40 degrees, left rotation = 40 degrees) to avoid any potential end-range pain or stretch provocation. This range of movement was measured by a goniometer. They were then instructed to return slowly to their target point and indicate verbally upon attaining the starting position. The difference between the starting and relocation positions was recorded. Each movement was performed 3 times and averaged. All participants were given the same instructions and no feedback was given to them. 10 seconds of rest time was allowed between attempts of the same movement and 60 seconds between different cervical spine movements. The values were recorded in centimeter. [34,35]

2.3 Y- Balance Test (YBT)

The Y balance test is a simple, yet reliable test use to measure dynamic balance. The Y Balance Test (YBT), derived from the Star Excursion Balance Test (SEBT), has been reported to be a valid and reliable measure of dynamic balance.[15,18,31,37]

All the participants thoroughly warmed up prior to the commencement of the test. A recovery period of 3-5 minutes was administered following the warm-up and before the beginning of the test. The participants stood on the center platform, behind the red line, and awaited further instructions. With their hands firmly placed on their hips, the test was performed in the following order: Right Anterior, Left Anterior, Right Posteromedial, Left Posteromedial, Right Posterolateral and Left Posterolateral. Reach distances were recorded to the nearest 0.5cm. [18,37]

2.4 Statistical Analyses

The data were analyzed using SPSS version 17.00 software. Subject characteristics were compared between the groups using t-test. t-tests were carried out to compare the mean value of the HRA and Y balance tests between the groups. The level of significance for all statistical tests was set at $p<0.05$. The normality of the data were tested using the Shapiro-wilk test.

3. Results

3.1 Subject characteristics

Table 1, compares the mean values for age, weight, height and BMI of the Smartphone and computer users. There was no significant difference between both groups in the mean age, weight, height and BMI ($p>0.05$).

3.2 Comparison of Head Repositioning Accuracy (HRA) between the smartphone and computer users

All four movements of the cervical spine showed significant differences between Smartphone and computer users (p-value <0.05) (Table 2). Computer users have more cervical joint position error than smartphone users. Smartphone users show better performance than computer users.

3.3 Comparison of Y balance test (YBT) measures between smartphone users and computer users (Table 3)

There were no significant differences in the right composite score (p-value>0.05), whereas the left composite score of YBT showed significant difference between the groups. Computer users demonstrated lesser dynamic balance scores than smartphone users.

Table 1: Comparison of the mean age, weight, height and BMI of smartphone and computer users groups

Variable	Smartphone users mean±SD (n=35)	Computer users mean±SD (n=35)	t-value	p-value
Age (y)	23.0±2.3	23.2±3.7	0.26	0.79
Weight (kg)	62.1±11.1	63.6±11.5	0.55	0.57
Height (cm)	168.4±10.6	168.1±11.6	0.09	0.92
BMI (kg/m^2)	21.6±2.2	21.8±2.6	0.41	0.67

SD: Standard Deviation, p-value: Level of significance

Table 2: Comparison of the mean value of HRA between smartphone and computer users

Variable	Smartphone users mean±SD (cm)	Computer users mean±SD (cm)	t-value	p-value
Flexion	7.7 ± 3.1	10.1 ± 3.4	3.09	0.003*
Extension	6.8 ± 4.6	10.4 ± 6.5	2.62	0.011*
Right rotation	7.0 ± 3.2	9.3 ± 4.3	2.42	0.018*
Left rotation	6.3 ± 2.8	9.8 ± 5.1	3.47	0.001*

SD: Standard deviation, p-value: level of significance,*: significant

Table 3: Comparison of the mean value of Interlimb differences and composite score in the Y Balance Test performance between smartphone and computer users groups

Variable	Smartphone users Mean±SD (cm)	Computer users Mean±SD (cm)	t-value	p-value
Anterior	5.5±3.7	7.5±7.1	1.4	0.142
Posteromedial	8.1±5.7	7.5±5.3	0.4	0.661
Posterolateral	6.5±5.7	8.1±7.2	1.0	0.293
Composite score right	101±11.5	96±13.2	1.6	0.098
Composite score left	99.7±10.3	92.6±10.5	2.8	0.006*

SD: Standard deviation, p-value: level of significance,*: significant

4. Discussion

The aim of this study was to compare the effect of prolonged smartphone and computer use on neck proprioception and balance measures in healthy individuals. The result showed that there is no significant difference between both groups as regard to age, gender, weight, height and BMI. The result of our study showed significant differences on cervical repositioning errors and dynamic balance measures when a comparison was made between both the groups' individuals. Computer users had the largest cervical repositioning error than smartphone users. However, we found that computer users had significantly reduced balance measures as compared with smartphone users. The HRA test and left composite score of YBT showed better performance of the participants with smartphone users than computer users. The results of our study are in agreement with the findings of previous studies.

Adel *et al* studied the effect of smartphone usage on cervical spine proprioception and balance and reported that prolonged smartphone usage could negatively affect the dynamic balance ability and neck proprioception in healthy adults.[1] Lee and Seo conducted research to observe the effect of smartphone addiction on cervical repositioning error and concluded that the severely addicted group had the largest repositioning error, possibly due to disturbed cervical afferent function as a result of sustained tension in the cervical spine muscles during smartphone use which also disturbs the dynamic balancing ability.[25]

Smartphones help people to form networks anytime anywhere they want, regardless of time and space, realizing relationships in a mobile on-live environment which was previously realized at static computer terminal. [38] Smartphone usage can increase the instability of dynamic postural balance leading to fall or injury. Hence, the use of smartphone during walking or in moving vehicles should be avoided. [38] Eric *et al* found that text messaging on smartphone while walking leads to decreased walking velocity and dynamic balance ability. [24]

Factors responsible for maintaining balance include joint proprioception, location of feet on a surface, vision, hearing sense, inner ear and vestibular system, cerebellum function, muscular strength of lower limb, cardiovascular and respiratory functions. Laatar *et al* found that during a smartphone use there is increase the center of pressure displacement thus affecting the standing postural balance of young adults and elderly. [23]

Kim *et al* reported increased cervical flexion angle in a group of prolonged smartphone users than short smartphone users. The commonest posture adopted by smartphone users while looking at their smartphone visual display terminals for a long duration of time is neck flexion. This flexed neck posture causes musculoskeletal problems particularly in the cervical region. [22] Lee *et al* [25] reported head flexion of 33-45 degrees from the vertical when using a smartphone. The head flexion angle was significantly larger for texting than for the other task, and significantly larger while sitting than standing. They also demonstrated that the magnitude of neck flexion was affected by the screen size, location of device and task performance. Task influenced cervical spine posture with the highest cervical flexion occurring while completing a simulated data entry task.

Jung ho Kang *et al* observed the impact of forward head posture on the postural balance of long-term computer users and reported that such a posture might lead to a disturbed balancing ability in healthy adults. Heavy computer users (who used a computer for more than 4 hours per day in the last 2 years) had reduced the values of the angle as compared to non-users. Severely protruded head causes a more decrease in an angle of cervical flexion and transfers of C.O.G. to the anterior direction under both static and dynamic conditions. [19]

Smartphones can be used anytime and at anyplace because of their ease of being carried and used. Smartphones can be used in any position i.e. sitting, standing, lying and walking whereas a computer can be used only in sitting position. A person using a computer remains in a static position for a longer duration than a smartphone user. While using a computer there is the only movement of the eyes, hand, fingers and the rest of the body remains in a static position. So the static position for a longer duration causes continued tension in muscles around the cervical spine. This might possibly explain the results of the present study.

5. Limitations and future perspective

The sample size of the present study was small. The research does not specify differences between laptop and smartphone users. Although this study was conducted on young adults, there may be similar deficits in other groups of people who spend long periods in sustained flexion, such as dentists, graphic designers, and seamstresses. Further research can examine other musculoskeletal disorders related to the cervical and lumbar spine and also examine changes in muscle activity and biomechanics due to the long usage of smartphones and computers.

6. Conclusion

The result of this study showed that the prolonged usage of a computer more than four hours per day could more negatively affect neck proprioception and dynamic balance ability as compared to prolonged smartphone users.

The results may be used to promote awareness about smartphones and computers usage duration and develop programs to decrease its effects on neck proprioception and balance ability. Therefore, this study further emphasizes the importance of good posture education, ergonomic advice, stretching and strengthening exercises in case of computer and smartphone users.

Relevance to clinical practice

These results indicate a greater cervical spine proprioceptive and balance deficit in participants with computer users, which could indicate the need for targeted advice and treatment. As more and more people spend increasing amounts of time on smartphones and computers, proprioceptive and dynamic balance deficits may require treatment to prevent progression and symptoms. Furthermore, advice should be given to patients to spend less time on smartphones and computers or, when using them, to hold the head in a less flexed position.

Conflict of interests

The authors declare that they have no competing interests.

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References

[1]. Alshahrani A, Aly SM, Abdrabo MS, Asiri FY. Impact of smartphone usage on cervical proprioception and balance in healthy adults. *Biomed Res.* 2018; 29(12):2547-52.

[2]. Al-Khlaiwi T, Meo SA. Association of mobile phone radiation with fatigue, headache, dizziness, tension and sleep disturbance in Saudi population. *Saudi Med J* 2004; 25: 732-736.

[3]. AlZarea BK, Patil SR. Mobile phone head and neck pain syndrome: proposal of a new entity. *Headache* 2015; 251: 63.

[4]. AMA. Health effects of video display terminals. Council on Scientific Affairs. JAMA 1987; 257: 1508-1512.

[5]. Armstrong B, McNair P, Taylor D. Head and neck position sense. *Sports Med* 2008; 38: 101-117.

[6]. Arslan A, Tutgun A. Examination of cell phone usage habits and purposes of education faculty students. *J Human Sci* 2013; 10: 20.

[7]. Barrett DS, Cobb AG, Bentley G. Joint proprioception in normal, osteoarthritic and replaced knees. *J Bone Joint Surg Br* 1991; 73: 53-56.

[8]. Berolo S, Wells RP, Amick III BC. Musculoskeletal symptoms among mobile hand-held device users and their relationship to device use: a preliminary study in a Canadian university population. *Applied ergonomics* 2011 Jan 1; 42(2): 371-8.

[9]. Bonney RA, Corlett EN. Head posture and loading of the cervical spine. *Applied Ergonomics* 2002; 33 (5): 415-417.

[10]. Chester Jr JB. Whiplash, postural control, and the inner ear. *Spine* 1991; 7: 716-720

[11]. Cho WH, Lee WY, Choi HK. An investigation on the biomechanical effects of turtle neck syndrome through EMG analysis. *KSPE* 2008; 1: 195-196.

[12]. Ericsson. Ericsson Mobility Report November 2015: Ericsson; 2015 [updated 2015 November cited 10 February 2016]. Available from: http://www.ericsson.com/res/docs/ 2015/mobility-report/ericsson-mobility-report-nov-2015.

[13]. Fernandez-de-Las-Penas C, Alonso-Blanco C, Cuadrado ML, Pareja JA. Forward head posture and neck mobility in chronic tension-type headache: a blinded, controlled study. *Cephalalgia.* 2006 Mar; 26(3): 314-9.

[14]. Gadotti IC, Biasotto-Gonzalez DA. Sensitivity of clinical assessments of sagittal head posture. *J Eval Clin Pract* 2010; 16: 141-144.

[15]. Gribble PA, Hertel J, Plisky P: Using the Star Excursion Balance Test to assess dynamic postural-control deficits and outcomes in lower extremity injury: a literature and systematic review. *J Athl Train*, 2012; 47:339–357.

[16]. Hansraj KK. Assessment of stresses in the cervical spine caused by posture and position of the head. *Surg Technol Int* 2014; 25: 277-279.

[17]. Horak FB. Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? *Age Ageing* 2006; 35: 7-11.

[18]. Hyong IH, Kim JH: Test of intrarater and interrater reliability for the star excursion balance test. *J Phys Ther Sci*, 2014; 26: 1139–1141.

[19]. Kang JH, Park RY, Lee SJ, Kim JY, Yoon SR, Jung KI. The effect of the forward head posture on postural balance in long time computer based worker. *Annals of rehabilitation medicine*. 2012; 36(1):98.

[20]. Kavounoudias A, Gilhodes JC, Roll R, Roll JP. From balance regulation to body orientation: two goals for muscle proprioceptive information processing? *Exp Brain Res* 1999; 124: 80-88.

[21]. Kim DQ, Cho SH, Han TR, Kwon HJ, Ha M, Paik NJ. The effect of VDT work on work-related musculoskeletal disorder. *Korean J Occup Environ Med* 1998; 10: 524-533.

[22]. Kim YG, Kang MH, Kim JW, Jang JH, Oh JS. Influence of the duration of smartphone usage on

flexion angles of the cervical and lumbar spine and on reposition error in the cervical spine. *Phys Ther Korea* 2013; 20: 10-17.

[23]. Laatar R, Kachouri H, Borji R, Rebai H, Sahli S. The effect of cell phone use on postural balance and mobility in older compare to young adults. *Physiol Behav* 2017; 173:293-297.

[24]. Lamberg EM, Muratori LM: Cell phones change the way we walk. *Gait Posture*, 2012; 35: 688–690.

[25]. Lee JH, Seo KC. The comparison of cervical repositioning errors according to smartphone addiction grades. *Journal of Physical Therapy Science*. 2014; 26(4): 595-98.

[26]. Mekhora K, Liston CB, Nanthavanij S, Cole JH. The effect of ergonomic intervention on discomfort in computer users with tension neck syndrome. *International Journal of Industrial Ergonomics* 2000 Sep 1; 26(3): 367-79.

[27]. Ming Z, Pietikainen S, Hänninen O. Excessive texting in pathophysiology of first carpometacarpal joint arthritis. *Pathophysiology* 2006 Dec 1; 13(4):269-70.

[28]. Moore MK. Upper crossed syndrome and its relationship to cervicogenic headache. *J Manipulative Physiol Ther* 2004; 27: 414-420.

[29]. Park J, Kim J, Kim J, Kim K, Kim N, Choi I, Lee S, Yim J. The effects of heavy smartphone use on the cervical angle, pain threshold of neck muscles and depression. *Adv Sci Technol Lett* 2015; 91: 12-17.

[30]. Picavet HS, Schouten JS. Musculoskeletal pain in the Netherlands: prevalences, consequences and risk groups, the DMC (3)-study. *Pain* 2003; 102: 167-178

[31]. Plisky PJ, Gorman PP, Butler RJ, Kiesel KB, Underwood FB, Elkins B. The reliability of an instrumented device for measuring components of the star excursion balance test. *North American journal of sports physical therapy: NAJSPT* 2009 May; 4(2):92.

[32]. Rainie L. Internet, broadband, and cell phone statistics. *Pew Intern Am Life Proj* 2010; 5.

[33]. Rempel DM, Harrison RJ, Barnhart S. Work-related cumulative trauma disorders of the upper extremity. *JAMA* 1992; 267: 838-842.

[34]. Revel M, Andre-Deshays C, Minguet M. Cervicocephalic kinesthetic sensibility in patients with cervical pain. *Archives of physical medicine and rehabilitation.* 1991 Apr 1; 72(5): 288-91.

[35]. Roren A, Mayoux-Benhamou M-A, Fayad F, Poiraudeau S, Lantz D, Revel M. Comparison of visual and ultrasound based techniques to measure head repositioning in healthy and neck-pain subjects. *Manual Ther* 2009; 14: 270-277.

[36]. Schuldt K, Ekholm J, Harms-Ringdahl KA, Nemeth G, Arborelius UP. Effects of changes in sitting work posture on static neck and shoulder muscle activity. *Ergonomics* 1986 Dec 1; 29(12):1525-37.

[37]. Shaffer SW, Teyhen DS, Lorenson CL, Warren RL, Koreerat CM, Straseske CA, Childs JD. Y-balance test: a reliability study involving multiple raters. *Military medicine.* 2013 Nov 1; 178(11):1264-70.

[38]. Sung-Hak CHo, Mun-Hee CHoi, Bong-oH goo. Effect of Smart Phone Use on Dynamic Postural Balance. *J. Phys. Ther. Sci.* 2014; 26: 1013–1015.

[39]. Cho SH, Choi MH, Goo BO. Effect of smart phone use on dynamic postural balance. *Journal of physical Therapy Science.* 2014; 26(7):1013-5.

[40]. Yoo WG, YI CH, Jeon HS, Cynn HS, Choi HS. Effects of the height of ball-baskrest on head and shoulder posture and trunk muscle activity in VDT workers. *Ind Health* 2008; 46: 289-297.