The short-term effect of smartphone usage on the upper-back postures of university students

Maria Elizabeth Cochrane¹, Muziwakhe Daniel Tshabalala¹, Nkateko Climax Hlatswayo¹, Rosina Mahlatse Modipana¹, Pertunia Phuti Makibelo¹, Exaggerate Potego Mashale¹ and Lerato Caroline Pete¹

Abstract: The purpose of the current study was to determine the short-term effects of smartphone usage on the upper-back postures of university students. Sixty-three students completed a self-administered questionnaire and photographic postural analysis. Smartphone usage significantly affected shoulder protraction on the non-dominant side (p = 0.000); thoracic kyphosis (p = 0.000); lateral neck flexion (p = 0.029 left and p = 0.001 right) and pelvic obliquity (p = 0.000 left and right). The results indicate that smartphones negatively affect the postures of university students and may result in severe long-term clinical implications such as chronic neck-, thoracic- and low back pain, headaches and decreased concentration.

Subjects: Allied Health; Rehabilitation Medicine; Physiotherapy and Sports Medicine; Rehabilitation Medicine; Physiotherapy

Keywords: smartphones; posture; upper-back; university students

1. Background
Texting, emailing, scheduling appointments and browsing the internet on smartphones consumes approximately three and a half hours of university-students’ time per day (Berolo, Wells, & Amick, 2011). Smartphones are also used as an adjunct to teaching and learning activities in academic institutions, and the use and development of mobile applications (apps) are rising (Kalra & Singh, 2011). Smartphone usage among University students has become common place, with these phones replacing traditional learning materials such as textbooks, class notes and computers. However, using smartphones may adversely affect posture, which will in turn lead to pain, biomechanical dysfunction and poor concentration. In this study, the short term effects of smartphone usage were determined using photographic images of University students’ postures before and after smartphone use. It was found that smartphones significantly affected the neck, shoulder, trunk and pelvis after only five minutes of smartphone use. Clearly, the increased time spent on smartphones and the adverse effects of smartphone usage on posture is cause for concern. Students should be made aware of the potential health risks associated with smartphone use as well as be provided with strategies to avoid adopting incorrect postures when using their smartphones.

ABOUT THE AUTHOR
Dr Cochrane & Mr Tshabalala are senior lecturers at the Sefako Makgatho Health Sciences University. Both authors have a special interest in rehabilitation, specifically with regard to the assessment and management of biomechanical- and neurological dysfunction. Mr Hlatswayo, Ms Modipana, Ms Makibelo, Mr Mashale & Ms Pete were students at the Sefako Makgatho Health Sciences University during the conduction of the study. The study was conducted as part of ongoing research on health risks that affect University students.

PUBLIC INTEREST STATEMENT
Smartphone usage among University students has become common place, with these phones replacing traditional learning materials such as textbooks, class notes and computers. However, using smartphones may adversely affect posture, which will in turn lead to pain, biomechanical dysfunction and poor concentration. In this study, the short term effects of smartphone usage were determined using photographic images of University students’ postures before and after smartphone use. It was found that smartphones significantly affected the neck, shoulder, trunk and pelvis after only five minutes of smartphone use. Clearly, the increased time spent on smartphones and the adverse effects of smartphone usage on posture is cause for concern. Students should be made aware of the potential health risks associated with smartphone use as well as be provided with strategies to avoid adopting incorrect postures when using their smartphones.
As a result of the increased usage of their smartphones, university students commonly report pain in the neck, shoulders and at the base of the thumb, which can be attributed to the postures assumed by the students during smartphone usage and the type of smartphone they use (Liang & Hwang, 2016; Trudeau, Young, Jundrich, & Dennerlein, 2012). Over time maintaining unideal postures while using a smartphone may lead to physiological and biomechanical changes in body structures and the musculoskeletal system (Chany, Marras, & Burr, 2007; Trudeau et al., 2012).

Performing small repetitive motions (such as texting) associated with using smartphones in a sustained unideal posture during these motions, reduces circulation to muscle tissue (Kim & Kim, 2015). A reduction in circulation will limit sufficient nutrient supply to the muscles, which will result in the experience of localised pain and fatigue (Kim & Kim, 2015). If localised fatigue persists for more than 30 minutes, and there is a decrease in the maximum voluntary contractions of the muscle tissues, the effectiveness of the corticospinal-output may decrease (Paillard, Maitre, Chaubet, & Borel, 2010). The reduction in corticospinal-output may result in reduced motor-neuron activity and will affect the control of movement (Paillard, 2012; Paillard et al., 2010).

Maintaining an unideal posture may result in the development of postural syndromes such as excessive thoracic kyphosis and a poking chin, which in turn will result in inadequate muscle contractions, weakening of postural muscles and fatigue (Chany et al., 2007). Decreased activity in postural musculature (as a result of unideal posture maintenance) may result in over-utilization of mobiliser muscles, which will lead to the experience of pain, stiffness and discomfort (Comerford & Mottram, 2001; Hoffman & Gabel, 2013). People with poking chin postures, who use their smartphones for prolonged periods of time, have been reported to suffer from pain and fatigue associated with the use of a smartphone (Kim & Koo, 2016).

Postural changes, along with the associated local- and global musculoskeletal problems that have been reported in the literature, are causes for concern because the young age of the majority of smartphone users can lead to sustained unideal postures in adulthood. If the extent of the problem is not explored and addressed, students may develop postural syndromes and musculoskeletal problems which might hinder the extent to which they can perform their professions and participate in recreational- and leisure activities. Hence, the aim of the study was to:

(1) Determine the effects of using a smartphone for five minutes on the upper back postures of university students.

2. Methodology
A cross-sectional observational study design was implemented to enable standardisation of the sampling- and data collection procedures (Carlson & Morrison, 2009; Ferreira, Duarte, Maldonado, Bersanetti, & Marques, 2011). Sixty-three (63) physiotherapy students who owned a smartphone for more than six months and who provided informed consent were recruited to participate in the study. Students who had undergone any surgical- or medical procedures of the upper back, neck, shoulders and hands were excluded from the study. Permission to conduct the study was obtained from the Sefako Makgatho Health Sciences University (SMU) Ethics Committee (Ethics approval number SMUREC/H/231/2016).

A self-administered questionnaire (Appendix A) was completed by all the students and thereafter, photographic postural analysis was conducted. The postural analysis was conducted in the audio-visual laboratory of the SMU using the standardised camera placement illustrated in Figure 1. A photograph was taken of each student’s sitting posture prior to using a smartphone and a second photograph was taken after the students had used a smartphone for five minutes (Figure 2).

Posterior postural analysis was conducted, pre- and post-smartphone use, by marking anatomical landmarks with reflective markers and measuring the distance(s) between the markers with
the Digimizer 4 photographic analysis software program (Do Rosario, 2014; Stolinski et al., 2017). The distance between C7 and the acromion was measured for both shoulders, to determine shoulder protraction. The distance between C7 and T7 was measured to determine if the participants’ thoracic curvature increased (i.e. became more kyphotic). The angle between the base of the skull, the C7 vertebrae and the acromion was measured (left and right) to determine if lateral neck flexion occurred as a result of smartphone usage. The distance between T7 and the inferior angle of the scapula was measured to determine the amount of scapula abduction. The distance between the T7 and T12 was measured to determine lower thoracic kyphosis and the distance between T12 and the posterior superior iliac spines (PSIS) (left and right) were measured to determine if pelvic obliquity occurred during smartphone usage.
In order to analyse the collected data the SPSS version 20.0 statistical package was used. Descriptive statistical analysis was performed on the data obtained from the self-administered questionnaire. The two-sample t-test was used to determine the difference between all the measurements before and five minutes after smartphone usage. Pearson’s correlation coefficients were estimated as $\alpha = 0.05$ for all tests.

3. Results

The general demographic information of the students who participated in the study are presented in Table 1. Fifty-eight (58) of the 63 students (92.36%) indicated that they were right-hand dominant. The profiles of the students and their smartphone usage are presented in Table 2. Table 3 displays the results from the two-sample t-test for the photographic postural analysis that was collected during the adoption of the pre- and post-smartphone postures. Statistically significant changes were observed for all measurements, with the exception of shoulder protraction on the right-hand (dominant) side.

4. Discussion

The demographic profile of the physiotherapy students who participated in the current study is similar to national and international reports in the literature (Maharaj, 2008; Naylor, Norris, & Williams, 2014). Students use smartphones for different purposes, such as academic benefit; social networking; communication; and entertainment (Liang & Hwang, 2016; Trudeau et al., 2012). The results obtained from students in the current study indicate similar trends of smartphone usage, with texting and chatting identified as the most popular and time consuming smartphone activity. Nearly half the students (57.1%) reported using their dominant (right) hands during the execution of the smartphone-related activities. A high percentage of students (49.2%) indicated that they experienced discomfort as a result of smartphone use. These findings are in line with published research by Gold et al. (2012), who also found that smartphone usage result in the increased experience of discomfort. Although the current study only investigated the short-term effect of smartphone use on posture, Gold et al. (2012) found that the prolonged experience of discomfort may lead to musculoskeletal dysfunction and disorders.

The results of the photographic postural analysis indicate that there was a significant increase ($p = 0.000$) in the amount of shoulder protraction on the left hand side (non-dominant) hands of the students. Increased shoulder protraction results in dysfunction of the scapula during upper limb movement, which may result in the inability of students to utilize the arm optimally (Andersen, Andersen, Zebis, & Sjødaard, 2014). Prolonged shoulder protraction and scapular dysfunction could also result in acute- and chronic neck pain, which could lead to the development of headaches and, in extreme cases, to the development of chronic migraines (Andersen et al., 2014). Shoulder protraction is directly related to the amount of abduction of the scapula, i.e. in order for the inferior angle of the scapulae to abduct the shoulders need to move “forward” into either a flexed or protracted position (Paine & Voight, 2013). The results of the current study indicate that the distance between the 7th thoracic vertebrae and the inferior border of the scapula increased significantly on the left and the right sides ($p = 0.000$), which corroborates the measurement from the C7 to the acromion process.

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Table 1. General demographic information of students (n = 63)

| Characteristics                  | M* ± SD** | Range |
|----------------------------------|-----------|-------|
| Gender (♂:♀)                     | 28:35     | N/A***|
| Age                              | 22.7 ± 0.365 | 18-32 |
| Year of Study                    | 2.90 ± 1.241 | 1-4   |
| Number of years of smartphone use| 6.33 ± 2.820  | 1-10  |

*M: Mean; **SD: Standard Deviation; ♂: Male; ♀: Female; ***N/A: Not Applicable.
Thoracic kyphosis is the term used to describe an increase in the amount of upper back flexion. The cumulative effect of the thoracic vertebrae’s shape results in a natural kyphotic posture in adults (Middleditch & Oliver, 2005). However, when excessive thoracic kyphosis is present (>40º kyphosis) it will influence upper limb function, cervical range of motion and will result in pain in the neck and back (Falla, Jull, Russell, Vicenzino, & Hodges, 2007; Middleditch & Oliver, 2005). The results obtained from both the low- and high thoracic kyphosis measurements in the current study indicated a significant increase in the amount of thoracic kyphosis (p = 0.000 for both low- and high thoracic kyphosis) after five minutes of smartphone use. Xie, Szeto, Madeleine, and Tsang (2018) reported a similar increase in thoracic kyphosis after 10 minutes of smartphone usage (Xie et al., 2018).

The angles measured between the anatomical landmarks of the base of the skull, C7 and the acromion process provided information regarding the degree of lateral neck flexion. Irrespective of the side to which the neck is flexed, prolonged lateral neck flexion will result in chronic neck pain and ligament instability (Steilen, Hauser, Woldin, & Sawyer, 2014). Not only will prolonged neck flexion lead to the experience of pain, but it also negatively influences proprioception and sensation of the neck (Lee, Lee, & Park, 2015). The decrease in proprioception and sensation may result in the experience of dizziness, disorientation and nausea (Lee et al., 2015). The results that we obtained indicate that there is a statistically significant amount of lateral flexion that occurs during smartphone use among physiotherapy students (left: 0 = 0.029; right: p = 0.001).

The final analysis for the current study was the measurement of pelvic obliquity during smartphone use. The left and right measurements from T12 to the posterior superior iliac spines showed statistically significant changes in the pelvic obliquity after smartphone use. Pelvic obliquity may lead to pain in the low back and the upper thoracic region (because the spinal column is a closed-kinematic chain) (Son, Park, & Park, 2014).

5. Conclusion
When the postural analysis is considered as a whole, it is evident from the results that the use of a smartphone affects the upper back postures of university students negatively. The results that were obtained are in line with published research by Gold et al. (2012) and Liang and Hwang (2016) who indicated that using a smartphone affects posture negatively. The increased amount of time spent using smartphones will have an even greater effect on posture, and it might have severe long term effects if the students are not made aware of the unideal postures they adopt during smartphone use.
For future research, it is recommended that dynamic postural analysis, with the use of three-dimensional movement analysis apparatus is conducted. The use of dynamic postural analysis will detect subtle changes in the spine during the first five minutes of smartphone use.

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Author details
Maria Elizabeth Cochrane1
E-mail: maria.cochrane@smu.ac.za
ORCID ID: http://orcid.org/0000-0002-6473-5271
Mziwakhe Daniel Tshabalala1
E-mail: mziwakhe.tshabalala@smu.ac.za
ORCID ID: http://orcid.org/0000-0002-7774-6113
Nkateko Climax Hlatswayo1
E-mail: nlhatswayonc@yahoo.com
Rosina Mahlatse Modipana1
E-mail: kgothmatsi@gmail.com
Pertunia Phuti Makibelo1
E-mail: pertuniapkhle@gmail.com
Exaggerate Potego Mashale1
E-mail: potego.sage@gmail.com
Lerato Caroline Pete1
E-mail: leratopete@yahoo.com

1 Department of Physiotherapy, Sefako Makgatho Health Science University, 1 Molotlegi Road, Ga-Rankuwa, Pretoria 0001, South Africa.

Table 3. Two sample t-test comparing the differences between the pre- and post-smartphone use postures

| Markers                                                                 | Pre-smartphone use M (SD) | Post-smartphone use M (SD) | *p*-Value | Correlation Coefficient | Significance of Correlation (*p-value) |
|------------------------------------------------------------------------|---------------------------|---------------------------|-----------|------------------------|----------------------------------------|
| Distance between C7 and acromion (L)                                   | 887.77 (79.950)           | 910.60 (96.102)           | 0.000***  | 0.941                  | 0.000***                               |
| Distance between C7 and acromion (R)                                   | 890.01 (68.894)           | 861.38 (154.681)          | 0.068     | 0.642                  | 0.000***                               |
| Distance between C7 and T7                                            | 781.38 (125.013)          | 720.23 (132.458)          | 0.000***  | 0.819                  | 0.000***                               |
| Angle between base of skull, C7 and acromion (L)                      | 108.85 (4.405)            | 107.58 (4.720)            | 0.029*    | 0.512                  | 0.000***                               |
| Angle between base of skull, C7 and acromion (R)                      | 108.32 (4.407)            | 110.88 (7.193)            | 0.001**   | 0.542                  | 0.000***                               |
| Distance between T7 and inferior scapula left                          | 380.56 (67.490)           | 403.84 (77.628)           | 0.000***  | 0.958                  | 0.000***                               |
| Distance between T7 and inferior scapula right                         | 389.72 (54.133)           | 412.79 (58.653)           | 0.000***  | 0.933                  | 0.000***                               |
| Distance between T7 and T12                                           | 547.75 (73.425)           | 591.72 (84.649)           | 0.000***  | 0.897                  | 0.000***                               |
| Distance between T12 and PSIS left                                     | 783.26 (187.015)          | 827.72 (201.845)          | 0.000***  | 0.988                  | 0.000***                               |
| Distance between T12 and PSIS right                                    | 772.90 (182.374)          | 815.97 (200.349)          | 0.000***  | 0.983                  | 0.000***                               |

* = p is the exceedance probability; * = 0.01 < p ≤ 0.05; ** = 0.001 < p ≤ 0.01; *** = p ≤ 0.001
Disclosure
The researchers declare that there is no conflict of interest affecting the publication of this article.

Practitioner Summary
The short-term effect of smartphone use on the upper-back postures of university students was studied. Sixty-three students completed a self-administered questionnaire and photographic postural analysis. Smartphone usage significantly affected shoulder protraction on the non-dominant side; thoracic kyphosis; lateral neck flexion and pelvic obliquity. Smartphone usage affects posture adversely.

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References
Andersen, C. H., Andersen, L. L., Zebis, M. K., & Sjøgaard, G. (2014). Effect of scapular function training on chronic pain in the neck/shoulder region: A randomized controlled trial. Journal of Occupational Rehabilitation, 24(2), 316–324.
Beraldo, S., Wells, R. P., & Amick, B. C., III. (2011). Musculoskeletal symptoms among mobile hand-held device users and their relationship to device use: A preliminary study in a Canadian university population. Applied Ergonomics, 42, 371–378.
Carlson, M. D. A., & Morrison, R. S. (2009). Study design, precision and validity in observational studies. Journal of Palliative Medicine, 12(1), 78–82.
Chany, A. M., Marras, W. S., & Burr, D. L. (2007). The effect of phone design on upper extremity discomfort and muscle fatigue. Human Factors, 49(4), 602–618.
Comerford, M. J., & Motttram, S. L. (2001). Movement and stability dysfunction – contemporary developments. Manual Therapy, 6(1), 15–26.
Do Rosario, J. L. (2014). Photographic analysis of human posture: A literature review. Journal of Bodywork and Movement Therapies, 18(1), 56–61.
Folla, D., Juli, G., Russél, T., Vicenzino, B., & Hodges, P. (2007). Effect of neck exercises on sitting posture in patients with chronic neck pain. Physical Therapy, 87(4), 408–412.
Ferreira, E. A., Duarte, M., Maldonado, E. P., Bersanetti, A. A., & Marques, A. P. (2011). Quantitative assessment of postural alignment in young adults based on photographs of anterior, posterior and lateral views. Journal of Manipulative and Physiological Therapeutics, 34(6), 371–380.
Gold, J. E., Driban, J. B., Thomas, N., Chakravarty, T., Channell, V., & Komaroff, C. E. (2012). Postures, typing strategies, and gender differences in mobile device usage: An observational study. Applied Ergonomics, 43, 407–412.
Hoffman, J., & Gabel, P. (2013). Expanding Panjabi’s stability model to express movement: A theoretical model. Medical Hypothesis, 80(6), 692–697.
Kalra, N., & Singh, P. (2017). Smartphone and medical related App usage among physiotherapy students of Delhi. International Research Journal of Engineering and Technology, 4(5), 1411–1414.
Kim, H. J., & Kim, J. S. (2015). The relationship between smartphone use and subjective musculoskeletal symptoms and university students. Journal of Physical Therapy Science, 27, 575–579.
Kim, S. Y., & Koo, S. J. (2016). Effect of duration of smartphone use on muscle fatigue and pain caused by forward head posture in adults. Journal of Physical Therapy Science, 28(6), 1669–1672.
Lee, S., Lee, D., & Park, J. (2013). Effect of the cervical flexion angle during smart phone use on muscle fatigue of the cervical erector spinae and upper trapezius. Journal of Physical Therapy Science, 27(6), 1847–1849.
Liang, H.-W., & Hwang, Y.-H. (2016). Mobile phone use behaviors and postures on public transportation systems. PloS ONE, 11(2), e0148419.
Mahoraj, S. H. (2009). An investigation of the factors affecting the career choice of selected health-care students (physiotherapy, chiropractic, medicine and occupational therapy) in KwaZulu Natal (Masters diss.). Durban University of Technology.
Middleditch, A., & Oliver, J. (2005). Functional Anatomy of the Spine. London: Elsevier: Butterworth Heinemann.
Naylor, S., Norris, M., & Williams, A. (2014). Does ethnicity, gender or age of physiotherapy students affect performance in the final clinical placements? An exploratory case study. Physiotherapy, 100(1), 9–13.
Paillard, T. (2012). Effects of general and local fatigue on postural control: A review. Neuroscience and Biobehavioral Reviews, 36, 162–176.
Paillard, T., Maître, J., Chabert, V., & Borel, L. (2010). Stimulated and voluntary fatiguing contractions of quadriceps femoris differently disturb postural control. Neuroscience Letters, 477, 48–51.
Paine, R., & Voight, M. L. (2013). The role of the scapula. International Journal of Sports Physical Therapy, 8(5), 617–629.
Son, J. H., Park, G. D., & Park, H. S. (2014). The effect of sacroiliac joint mobilization on pelvic deformation and the static balance ability of female university students with sacroiliac joint dysfunction. Journal of Physical Therapy Science, 26(6), 845–848.
Steilen, D., Hauser, R., Woldin, B., & Sawyer, S. (2014). Chronic neck pain: Making the connection between capsular ligament laxity and cervical instability. Orthopedic Journal, 5(2), 326–345.
Stolinski, L., Kozinoga, M., Czaprowski, D., Tynowekowski, M., Cerny, P., Suzuki, N., & Kotwicki, T. (2017). Two-dimensional digital photography for child body posture evaluation: Standardized technique, reliable parameters and normative data for age 7-10 years. Scoliosis and Spinal Disorders, 12:28(2107).
Trudeau, M. B., Young, J. G., Jundrich, D. L., & Dennerlein, J. T. (2012). Thumb motor performance varies with thumb and wrist posture during single-handed mobile phone use. Journal of Biomechanics, 45, 2349–2354.
Xie, Y. F., Szeto, G., Madeleine, P., & Tsang, S. (2018). Spinal kinematics during smartphone texting – A comparison between young adults with and without chronic neck-shoulder pain. Applied Ergonomics, 68, 160–168.
Appendix A

The Short-term Effect of Smartphone Usage on the Upper-back Postures of University Students – Questionnaire

Please complete the form below by either marking X in the appropriate block or by indicating the appropriate answer in the space provided.

Demographic data
Gender: male ☐ female ☐
Age: ☐

Section A: Profile of Smartphone users
1. Please indicate the type of phone that you use:
   Nokia ☐
   Samsung ☐
   iPhone ☐
   Others specify: _____________

2. How long have you been using it (in years) ☐

3. What activities do you do on your Smartphone:
   Watching video clips ☐
   Texting / Chatting ☐
   Social networking ☐
   Others specify: ________________

4. How long do you spend doing these activities (please indicate the minutes per day):
   Watching video clips ☐
   Texting / Chatting ☐
   Social networking ☐
   Others specify: ______________________

5. With which hand do you use you Smartphone:
   Left ☐
   Right ☐
   Both ☐

Section B: Posture of smartphone users
6. In what position do you prefer to use your Smartphone in:
   Sitting ☐
   Standing ☐
   Lying ☐
   Others specify: ______________

7. For how many minutes do you use your Smartphone daily: ______________

Section C: Complaints following Smartphone usage
8. Do you experience any pain or discomfort during or after you have used your Smartphone?
   Yes ☐
   No ☐
   Unsure ☐
9. If you answered “Yes” to Question 8, please rate on a scale of 1-10 (10 being most painful) the level of pain or discomfort you are experiencing in the following areas:
   Mid Back  [ ]  Upper Back  [ ]  Neck  [ ]  Shoulder  [ ]
   Hand/Arm  [ ]  Other  [ ]

10. Please indicate (in minutes) how long it takes for the pain or discomfort to occur during or after you have used your Smartphone (for each region indicated below):
    Mid Back  [ ]  Upper Back  [ ]  Neck  [ ]  Shoulder  [ ]
    Hand/Arm  [ ]  Other  [ ]

11. Do you experience fatigue or tiredness during smartphone use?
    Yes  [ ]  No  [ ]  Unsure  [ ]

12. Do you experience any headaches following Smartphone use?
    Yes  [ ]  No  [ ]  Unsure  [ ]

13. How frequently do you change your position during your Smartphone use?

14. Do you stretch when using your Smartphone?
    Yes  [ ]  No  [ ]  Unsure  [ ]

~Thank you for your time~
