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Smartphone usage duration is not associated with increased pain or proprioception deficit in young adults with chronic mechanical low back pain: a cross-sectional study

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Abstract

Background: Smartphone use has been associated with pain in the upper quadrant; however, the relationship between usage duration and low back pain is still unclear. This study investigated the association between continuous smartphone use up to 30-min and back pain severity and proprioception acuity in patients with chronic low back pain. Fifty-eight patients with chronic mechanical LBP played a game for 10- and 30-min. In each session, pain and back repositioning errors were measured at baseline and immediately after task completion.

Results: Pain significantly but slightly increased following smartphone use, regardless to the duration (after 10 min: mean increase = 0.75 ± 1.17, *P* value < 0.001, 95% CI 0.44–1.06; after 30 min: mean increase = 0.96 ± 1.93, *P* value < 0.001, 95% CI 0.44–1.46). However, changes in perceived pain scores were not significantly different between the two tested durations (*P* value = 0.42). Proprioception repositioning error was not significantly different within the same testing session (mean change = 0.08 ± 1.83, 0.13 ± 1.77, *P* value = 0.73, 0.58, 95% CI − 0.40–0.56, − 0.60–0.33, for the 10 and 30 min, respectively). The changes in proprioception were not significant between the two-tested durations (*P* value = 0.56). Further, smartphone addiction did not significantly affect changes in pain and proprioception after game playing, regardless of the duration (*P* > 0.05).

Conclusions: These findings show that smartphone use slightly increases back pain immediately after continuous use; with no effect on back proprioception within the duration tested in this study. Changes in pain and proprioception were not influenced by smartphone addiction.

Keywords: Smartphone, Chronic low back pain, Proprioception, Reposition error

Background

Low back pain (LBP) is a common musculoskeletal dysfunction in adults. It has a lifetime prevalence of 85.5%, with 3.9 to 10.2% of the patients develop chronic low back pain (CLBP) [1, 2]. Patients suffer from pain, impaired proprioception and reduced back mobility and function [3–5]. Patients with CLBP may need regular health care services; resulting in a substantial socioeconomic burden [6].

The risk of CLBP may increase with a few demographic, psychosocial, physical, and work-related factors [1, 7–9].

The prolonged use of electronic devices has been proposed as a risk factor for increased LBP [10, 11]. There is evidence that the increased use of hand-held devices, such as a smartphone, is associated with altered trunk posture and muscle activation [12]. Further, back

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proprioception acuity has been shown to decrease in healthy adults who used a smartphone while walking [13]. There are a few limitations in the studies that investigated the association between the duration of smartphone use and increased pain severity and proprioception deficit. For example, these studies were of a small sample size or were retrospective [11, 14]. Therefore, this study investigated the association between smartphone usage duration and immediate changes in back pain severity and proprioception acuity in patients with CLBP.

Methods

This is an observational cross-sectional study that was conducted at the Biodex isokinetic laboratory, Faculty of Physical Therapy, Cairo University, Egypt. The protocol for this study was approved by the local institutional Ethics committee (P.T. REC/012/001875). This protocol has been registered at clinicaltrials.gov (NCT03517410).

Participants

College under- and post-graduate students who had mechanical CLBP were recruited for this study by invitation and announcements at the local institute. CLBP was diagnosed based on history and physical examination according to the guidelines of the American College of Physicians and the American Pain Society [15]. Briefly, patients were interviewed and inquired about pain location, characteristics, and exacerbating and relieving factors as well as potential red flags. Moreover, physical examination was done to confirm the mechanical nature of LBP.

Patients were included in the study if their age ranged between 18 and 29 years old and had LBP for more than 3 months, with at least one episode within the past year. Further, participants needed to have experience in smartphone use for at least 1 year. In addition, participants needed to be familiar with the “subway surfers” game. This is a popular game among young adults that was selected to standardize the task done during testing. The subway surfer game requires continuous user’s attention and interaction.

Participants were excluded if they had radicular pain as indicated by positive straight leg raising and slump tests , had any systemic disease that may affect the spine (such as ankylosing spondylitis), a history of spinal trauma, memory loss, or cognitive dysfunction. Moreover, participants were excluded if they reported an increased back pain with regular sitting for less than an hour.

Procedures

Eligible patients had the aim of the study and all testing procedures explained, and if they accepted to participate in the study, an informed written consent was signed. Initially, patients’ basic demographics and average daily smartphone use were collected. Then, smartphone addiction was assessed using the Smartphone Addiction Scale Short Version (SAS-SV), which is a valid and reliable tool for assessing smartphone addiction. This scale ranges from 10 to 60 points; with scores ≥34 indicating addiction [16].

For each patient, back pain severity and proprioception deficits were assessed at two separate sessions, within a 1-week interval. In each session, each participant was given a standardized phone (Lenovo A1000) and was asked to play the “subway surfers” game continuously for 10 or 30 min, while sitting on a standardized chair with no arms support. These durations were selected based on a previous study that reported pain increase in the neck associated with similar durations [17]. Besides, these durations seem reasonable for continuous game playing by most of the population.

The order of mobile use duration was randomized using simple a randomization method. During testing, patients were left to choose the self-preferred sitting posture; as long as they did not lean to support trunk weight on their laps. The researcher observed and documented the assumed trunk and hand postures during game playing.

Assessment

Pain severity measurement

The primary outcome for this study was the change in pain severity after game playing. Pain severity was assessed using the visual analog scale (VAS). This scale is a 10-cm line labeled with zero at one end (indicating no pain) and 10 at the other end (indicating excruciating pain). Participants were instructed to mark their current level of pain across the line. The distance (in millimeters) from the lower limit was measured using a ruler. VAS is a valid and reliable (interclass correlation coefficient (ICC) = 0.87) method for chronic pain assessment [18–20], with a change of 2 cm is considered the minimal clinically important difference (MCID) in LBP [21].

Repositioning error (RE) measurement

The secondary outcome for this study was back position sense acuity as quantified by the angle of active lumbar flexion repositioning error. This angle was measured using the Biodex System 3 Pro Isokinetic Dynamometer (Biodex Medical Inc., Shirley, New York, NY, USA). Biodex dynamometry is a valid (ICC = 0.99) and reliable (ICC = 0.99) tool for assessing joint position sense [22, 23]. In the current study, active reposition sense was assessed as it reflects functional use and is not influenced by the measuring device’s external pressure on the body [24].

Calibration of the Biodex system was performed as described in the device’s manual. Then, each participant sat on the Biodex back extension chair, with the lower back snuggly fitted against the lumbar pad. Participants' knees were secured in place using two anterior curved leg pads. Legs were kept relaxed and hanging vertically with both feet rested on the footpad. The upper trunk was fastened to the back of the chair using a belt, while both thighs were fastened to the chair using straps. To measure repositioning acuity, for each participant, the assessor determined the available back range of motion (ROM) starting from the 0° position (erect neutral sitting with hips flexed 90°) to maximum flexion. Proprioception was then tested between zero neutral position to 30° of flexion [22, 25].

A training session for proprioception testing was done before actual data collection in order to familiarize the participants with the procedures. Then, data were collected at baseline (pre-task assessment) and immediately after task completion (post-assessment). During each testing session, the movement was tested three times and the average was calculated. All testing was done while participants were blindfolded, and no verbal feedback was given. Testing started by asking the participant to flex the trunk until the machine stopped the movement when the target 30° flexion angle was reached. Then, the position was held for 5 s while the patient was instructed to memorize the position in order to reproduce it as precisely as possible. The participant then actively returned to the starting zero position before he/she flexed the trunk at a speed of 5°/s to reach the target angle again. Upon reaching that angle, they pressed the hold button. The isokinetic device recorded and saved the actually reached angle and the angle of repositioning error (RE) was calculated automatically as the difference between the two angles [22, 25].

Statistical analysis

VAS pain score as well as the Biodex software data were tabulated in an excel sheet before they were analyzed using the SPSS version 21 (IBM incorporation, Illinois, USA). Continuous variables were presented as mean ± standard deviation (SD). Qualitative variables were presented as count (%). Changes in pain VAS score and proprioception acuity (RE) between baseline and post-task values were calculated. Data were tested for normality using Shapiro-Wilk test. Since data were normally distributed, changes in pain and proprioception acuity between the two-testing duration were compared using paired *t* test. Further, the magnitude of change in VAS and RE in the two tested duration was compared between addict (addiction score ≥ 34) and non-addict participants (addiction score < 34) using an independent sample *t* test. Finally, the association between changes in VAS and RE (in the two tested durations) and addiction scores was tested using Pearson's correlation coefficient. A significant level was set at $P < 0.05$ throughout all analyses.

Results

After screening 75 patients against the eligibility criteria, 58 patients completed the study (12 males (20.7%) and 46 females (79.3%)). The mean (±SD) age was 22.4 ± 2.6 years, BMI was 24.3 ± 2.4 kg/m^2, and smartphone addiction score was of 35.0 ± 10.0. Participants' flow through the study as well as the average daily smartphone use duration and time until first use are described in Supplementary file 1. Based on addiction scores, 29 patients were classified as addicts and 29 as non-addicts. Comparing changes in VAS and RE based on addiction showed no significant differences between the two subgroups ($P >$ 0.05, Table 1). Further, in 10 min task duration, the correlations between smartphone addiction scores and changes in VAS and RE were 0.04 and − 0.15, respectively. For a 30-min task, the correlation for changes in VAS was −0.02 while that for the RE was 0.14. All correlations were non-significant and weak ($P > 0.05$)

Pain and RE were not significantly different at the baseline of the two-tested durations (P = 0.10 and 0.34, respectively). Pain severity significantly increased after using a smartphone ($P < 0.05$), regardless of the duration (Table 2, Fig. 1). On the other hand, RE angle did not change significantly after game playing, regardless of task duration (Table 3, Fig. 2). On the opposite hand, the magnitude of change in pain severity and RE angle between the two-tested durations were not significant ($P >$ 0.05) (Tables 2 and 3, Figs. 1 and 2).

Discussion

This study investigated the association between smartphone usage duration and changes in back pain severity and proprioception acuity in patients with mechanical

Table 1 Differences in the change magnitude of visual analog scale (VAS) and angle of repositioning error (RE) between the addict and non-addict participants

Change magnitude		Group	Mean	95% CI		P value
				Lower	Upper	
10 min	**VAS**	**Addict (*n* = 29)**	.78 ± 1.00	−.56	.68	.842
		Non-addict (*n* = 29)	.72 ± 1.34			
	RE	**Addict (*n* = 29)**	−.20 ± 1.62	−1.52	.39	.242
		Non-addict (*n* = 29)	.37 ± 2.00			
30 min	**VAS**	**Addict (*n* = 29)**	.79 ± 1.44	−1.34	.70	.530
		Non-addict (*n* = 29)	1.11 ± 2.34			
	RE	**Addict (*n* = 29)**	−.17 ± 1.76	−1.03	.85	.855
		Non-addict (*n* = 29)	−.09 ± 1.82			

Table 2 Pain severity as measured by the visual analog scale (VAS) score

VAS score	Mean ± SD	***P*** value	95% CI	Difference between the two tested durations	
				P value, 95% CI	
10-min (*n* = 58)					
	Baseline	1.48 ± 1.77	< 0.001[a]	0.44–1.06	.42[b] (− 0.30–0.72)
	Post-task	2.23 ± 2.03			
	Change magnitude	0.75 ± 1.17			
30-min (*n* = 58)					
	Baseline	1.91 ± 1.86	< .001 [a]	0.45–1.46	
	Post-task	2.87 ± 2.33			
	Change magnitude	0.96 ± 1.93			

CI confidence interval, *VAS* visual analog scale
[a]Changes between baseline and post-task assessment for the tested task duration
[b]Comparison between the magnitude of pain change between the 10- and 30-min task duration

CLBP. Smartphone use significantly increased back pain severity as measured by VAS, regardless of the usage duration; however, this increase was not clinically significant (less than the MCID) [21]. On the other hand, changes in pain severity were not significantly different between the two-tested task durations. Proprioception acuity, as measured by the angle of repositioning error, did not change with the device usage, regardless of the duration. Finally, addiction score was not associated with significant differences in the magnitude of change in pain and proprioception, regardless of task duration.

To our knowledge, there are no other studies that investigated the immediate effects of continuous smartphone use by objective measurements. However, two observational cross-sectional studies found no association between self-reported back pain severity and the duration of smartphone use [11, 14]. The lack of association was attributed to the dynamic posture assumed by users [11]. In th the current study, participants self-selected the preferred sitting posture during smartphone use, yet they were not allowed to support trunk weight on laps or arm-rest. Preferred posture was purposively selected to prevent changes in perceived pain associated with assuming static posture [26, 27].

In the current study, proprioception sense was tested within 5 min after the smartphone use, which is a safe testing duration before the recovery of muscle and proprioception following muscle fatigue [28, 29]. As pain severity and proprioception deficits are correlated [5], the

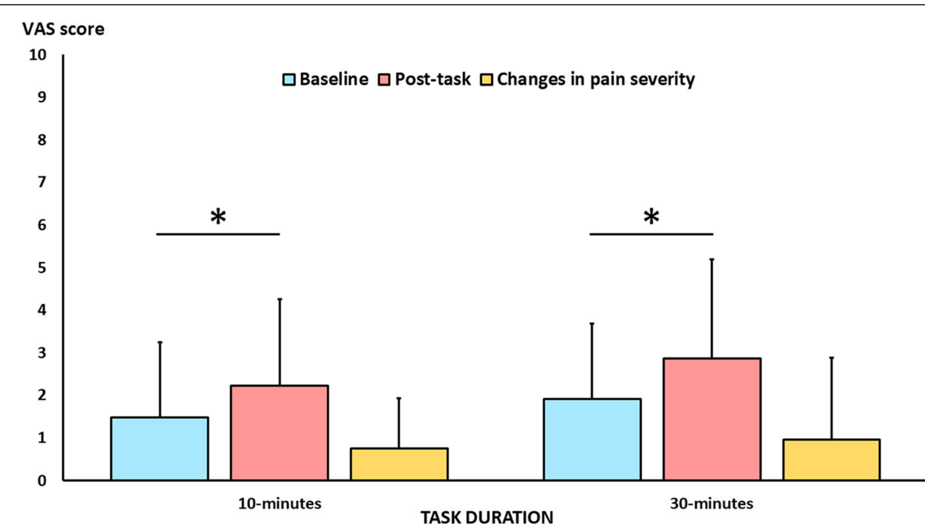

Fig. 1 Pain severity as measured by VAS. Severity is shown at baseline and after each task duration. Changes in pain severity or each tested duration is also shown. (*) indicates within task significant differences ($P < 0.05$)

Table 3 Lumbar active position sense acuity as measured by the repositioning error angle (RE)

Angle of repositioning error	Mean ± SD	***P*** value	95% CI	Difference between the two-tested durations ***P*** value, 95% CI
10-min (*n* = 58)				.56[b] (− 0.93–0.51)
Baseline	2.62 ± 1.27	.73[a]	− 0.40–0.56	
Post-task	2.71 ± 1.59			
Change magnitude	0.08 ± 1.83			
30-min (*n* = 58)				
Baseline	2.87 ± 1.45	.58[a]	− 0.60–0.34	
Post-task	2.74 ± 1.21			
Change magnitude	0.13 ± 1.77			

CI confidence interval
[a]Changes between baseline and post-task assessment for the tested task duration
[b]Comparison between the magnitude of proprioception acuity change between the 10- and 30-min task duration

non-significant changes in proprioception acuity could be attributed to the subtle changes seen in pain severity.

This finding contradicts the reported positive significant correlation between the angle of back repositioning error and smartphone use for texting while walking on a treadmill [13]. The latter task is a dynamic gait requiring more postural muscle control to maintain balance. Further, an electronginometer was used to measure active repositioning sense. Moreover, the executed task (texting while walking) was found to alter gait kinematics, and subsequently, the sensory input to the body [30].

Limitations

To our knowledge, this is the first study to investigate the association between smartphone continuous use up to 30-min in patients with CLBP and perceived back dysfunction. However, a few limitations exist. First, patients were tested in the morning, while most of them reported increase in pain severity occurred near the end of the day. Second, our participants had mild pain at baseline, and patients with more severe back pain may react differently to the same tested tasks. Third, the maximum duration tested was 30 min, and longer durations may also have different effects. Fourth, the sample size was not calculated, as this was a preliminary study with no previous data available. Finally, no healthy control group was tested to exclude other confounding factors; however, this study was a same-subject repeated measures design, which is expected to minimize the effects of inter-subjects' variability. Further, all participants were asked about pain induced by the sitting position to exclude those who could be adversely affected by the sitting posture. Future studies are needed to address these limitations and to test the effect of smartphone usage duration in different age groups and in patients with different LBP etiologies and severity.

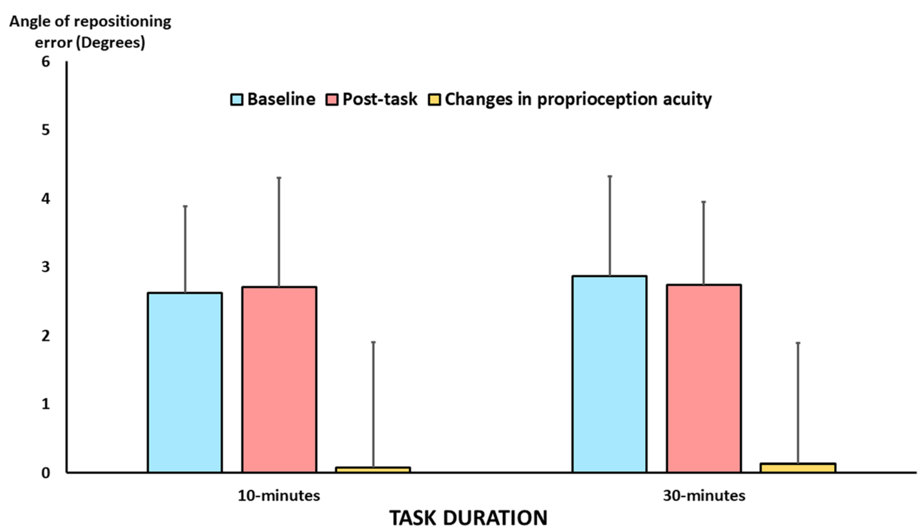

Fig. 2 Proprioception acuity as measured by angle of repositioning error (RE) is shown at baseline and after each task duration. Changes in acuity for each tested duration is also shown

Conclusions

Continuous smartphone usage up to 30 min for playing games slightly increases back pain severity in young adult patients with CLBP; however, the pain increase is independent of the playing duration. There is no evidence to support the increased proprioception deficit with the continuous use of the smartphone for the same period. On the other hand, there is no evidence that smartphone addiction influences the changes in pain or proprioception after using a smartphone for game playing.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s43161-020-00010-y.

Additional file 1: Figure S1. A flow diagram showing subjects' selection, testing as well as data analysis

Abbreviations

BMI: Body mass index; CI: Confidence interval; CLBP: Chronic low back pain; ICC: Interclass correlation coefficient; LBP: Low back pain; MCID: Minimal clinically important difference; ROM: Range of motion; SAS-SV: Smartphone addiction scale short version; VAS: Visual analog scale

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Authors' contributions

MW: conception of the research idea, design of the work, acquisition, analysis, and interpretation of data; drafted the work, approved the submitted version, and have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

DO: design of the work, acquisition, analysis, and interpretation of data; approved the submitted version and have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

ARY: conception of the research idea, design of the work, acquisition, analysis, and interpretation of data; revised manuscripts; approved the submitted version; and have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The protocol for this study was conducted in accordance to the guidelines and is approved by the local institutional ethics committee (P.T. REC/012/001875). This protocol has been registered at clinicaltrials.gov (NCT03517410). Eligible patients had the aim of the study and all testing procedures explained, and if they accepted to participate in the study, an informed written consent was signed.

Consent for publication

Not applicable

Competing interests

The authors (MW, DO, ARY) declare that they have no competing interests to declare.

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