Effect of smartphone application on pain, disability and forward head posture on young adults with excessive usage of a smartphone: A pilot study

A K Akodu,[1] PhD; **O Ipinnimo,**[2] PhD; **A A Osuntoki,**[3] PhD

[1] *Department of Physiotherapy, College of Medicine, University of Lagos, Nigeria*
[2] *Department of System Engineering, University of Lagos, Nigeria*
[3] *Department of Biochemistry, College of Medicine, University of Lagos, Nigeria*

Corresponding author: *A K Akodu (akoduashiyat@gmail.com; aakodu@unilag.edu.ng)*

Background. Excessive usage of smartphones has been linked to forward head posture (FHP) leading to musculoskeletal disorders of the spine.
Objective. To determine the effect of smartphone applications on pain and disability levels in the neck, shoulder, lower back and FHP among young adults with excessive smartphone usage.
Methods. In this randomised controlled pilot study, 31 young adults (24 female and 7 male, aged 21.35 (standard deviation 1.74 years) who exhibited excessive smartphone usage were enrolled. They were recruited from the College of Medicine, University of Lagos in Nigeria and randomly allocated to three groups: smartphone application (SPA) only, SPA with ergonomic advice (SPA+EA) and EA only. Outcome assessments were conducted before, at 4 weeks, and after 8 weeks of the intervention.
Results. The outcome of this study revealed significant improvements in the assessed variables across all three groups (SPA, SPA+EA, EA) post intervention, including FHP (p=0.0001, p=0.003, p=0.002), pain intensity in the neck (p=0.01, p=0.02, p=0.0001), neck disability level (p=0.0001, p=0.0001, p=0.0001), functional disability (p=0.001, p=0.001, p=0.007) and shoulder pain disability (p=0.0001, p=0.001, p= 0.0001). However, no significant between-group differences (p>0.05) were noted in the outcomes across the groups, except for FHP (p=0.027) at the end of the 8th week of intervention.
Conclusion. It was concluded that the SPA group was more effective in improving FHP, though all the groups displayed significant effects in all the outcomes.

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Prolonged usage of smartphones, otherwise known as smartphone addiction, is common among young adults, with a prevalence of 53%.[1] This trend is notable among students in higher institutions who spend extended periods on mobile devices, whether for socialising, leisure or academic activities.[2] Some smartphone users show problematic behaviours similar to substance use disorders, termed as addiction.[3] These behaviours involve an obsession with mobile communication and excessive time spent on smartphones, resulting in adverse effects on relationships and contributing to anxiety disorders.[3]

The prolonged use of smartphones is on the rise, especially with phones being equipped to perform multiple functions. This has led to increased dependence on smartphones for various activities, such as communication, educational purposes via voice or video calls, messaging, chatting and downloading applications for additional functions.[4] Kwon *et al*.[2] observed that smartphones have become crucial for the youth, serving as a source of entertainment, leisure, information and education, especially for university students. A previous study reported that overuse of smartphones can cause significant stress on the cervical spine, potentially altering the curvature of the cervical vertebrae and increasing the level of discomfort in the neck muscles.[5] This invariably causes an abnormal forward protrusion of the head, where the head extends beyond the sagittal plane and leans anteriorly in relation to the human body. This is known as forward head posture (FHP) and is considered the most common postural deformity among smartphone users, with a prevalence of 58.4% among undergraduates in a Nigerian university.[5] FHP places stress on the neck bones and muscles[6] and can lead to many musculoskeletal issues, such as neck and shoulder deformity,[5] upper back pain, increased spinal curvature and dyskinesis of the scapular region.[7]

Smartphone applications have shown promise in bridging service delivery gaps and reducing the influx of patients to a hospital, especially in geographically remote regions in low- to middle-income countries (LMICs) lacking medical personnel and access to physiotherapy treatment.[8] Smartphone applications have evolved in the last 20 years. These are software programmes specifically designed to operate on smartphone devices, commonly referred to as 'applications' or 'apps'.[9] The adoption of such applications among medical device manufacturers continues to grow and it is estimated that the large market for smartphone applications has attracted regulators and innovators.[10] The enormous size of this market is due to the practical flexibility that apps can provide. These growing technologies also offer new opportunities to connect with patients and improve healthcare outcomes. In general, studies on the clinical effectiveness of apps have not kept up with the pace of app development.[11] A previous study showed that smartphone messaging helps to improve patient engagement outside the clinic or hospital and facilitates self-management of chronic conditions.[12] The study by Mbada *et al*.[13] confirmed that app-based solutions may also be useful in this regard. Technology-delivered rehabilitation services can also give patients a sense of personal self-sufficiency and confidence that can allow them to self-manage their condition.[14] As the use of mobile devices is now very common in both advanced and developing countries, it is therefore necessary to research the efficacy of smartphone application interventions using smartphone health applications.[15]

Literature is sparse on the effect of smartphone applications on symptoms of musculoskeletal disorders among Nigerian and African populations.

The present study aimed to determine the effect of a smartphone application (CerviTech) on reducing pain and disability in the neck, shoulder, lower back and FHP among undergraduates with excessive usage of smartphones.

Methods

Participants

This was a blinded randomised controlled pilot study registered with the Pan African Clinical Trial Registry (registration number: PACTR202001512959209). Thirty-seven smartphone-addicted undergraduates were enrolled for this pilot study, but only 31 participants completed the study. They were recruited from different departments within the College of Medicine, University of Lagos. The study's sample size estimation was determined using an effect size of 0.50[16] and a power of 80% using a G*Power software calculator (Heinrich-Heine-Universitat Dusseldorf).[17] The pilot study commenced in February 2022 and was completed in May 2022. The participants were undergraduate students who scored above 30 on the smartphone addiction questionnaire, signifying excessive smartphone usage, and were using an Android operating system. Excluded from the study were undergraduates with a history of specific spinal pathology as a result of cancer, tuberculosis and trauma of the spine, and with previous neck, shoulder and back surgeries, confirmed through their past medical history.

The Health Research and Ethics Committee approved this study (ref. no. CMUL/HREC/01/22/1001). Written informed consent was obtained from participants. The anonymity of their data was guaranteed, and no harm or risk was associated with involvement in the study. Participants were informed about the objective of the study and were assessed for eligibility by the research assistant using the study selection criteria.

Randomisation

Forty undergraduates with excessive usage of smartphones were enrolled in this study, three of whom were ineligible based on the selection criteria.

Thirty-seven eligible participants were allotted randomly into three distinct groups: two intervention groups, the smartphone application (SPA) only group (n=13 participants) and the SPA with ergonomic advice group (SPA+EA) (n=12 participants), as well as 12 participants in the control group (EA only). The randomisation process involved a computer-generated number, facilitated by the research assistant using permutated blocks of three, and was predetermined before the participant enrolment. The allotted groups were concealed in non-transparent envelopes that were numbered repeatedly. The envelopes were organised by a research assistant who was not involved in the study and were safely secured. An envelope was selected and opened by one of the study team members, and the participant was allotted to one of the three groups.[18]

Only 31 of the 37 participants completed the study. Six participants did not complete the study owing to travel commitments and non-compliance. Dropout instances were detailed in the flow chart after the completion of the study using the Consort 2010 flow diagram (Fig. 1), which presents the enrolment, assignment and follow-up of the study participants. To ensure proper blinding, the assignment of participants was implemented by a member of the research team who did not take part in the baseline assessment and in educating participants on the intervention. Participants and the data analysts were blinded to interventions to minimise bias.

Assessment of outcome variables

A qualified physiotherapist (AK) supervised the intervention protocols. Participants in the three groups were assessed using outcome measures, including the numerical pain rating scale (NPRS), neck disability index, Oswestry disability questionnaire, shoulder pain disability index and photographic method before the intervention, at 4 weeks and 8 weeks post intervention. Participants' demographic data (age, sex, height, weight and body mass index (BMI)) were recorded before the commencement of this pilot study.

Angular measurement of FHP (craniovertebral angle)

The participants from each group were instructed to sit in an anatomical position with the head erect. The plumb line was positioned 2 m from the participants. A tripod stand (Weifeng tripod stand) with a maximum operating height of 1675 mm and minimum operating height of 660 mm supported a Nikon D3200 camera (model number S/no 9245595) set a short distance away from the plumb line. The points (tragus of the participant's ear and the seventh cervical vertebrae) were clearly marked using paper tape. Participants were instructed to bend and straighten their cervical spine to facilitate accurate marking of these points. The plumb line was supposed to drop in front or align with the tragus of the ear and in front of the acromion process. A side-view photograph of the participants was taken with a digital camera.[19,20]

Photograph analysis

The participant's pictures were uploaded into Corel Draw X7 software version 17.0.0.491. To assess the craniovertebral angle, a straight line was drawn from the spinous process of the seventh cervical vertebra using the angular dimension of the Corel draw X7 software and an oblique line was drawn through the tragus of the ear to the spinous process of the seventh cervical vertebra. The craniovertebral angle formed at the point where these two lines met (the spinous process of the seventh cervical vertebra) was measured and recorded.[19,20]

Intervention

Thirteen participants in the SPA group downloaded the smartphone application (CerviTech) and installed it on their Android phones. They were instructed to use the smartphone application for a period of 8 weeks whenever they were on their smartphones. The activity of the participants on the smartphone application was remotely monitored via phone calls and short messaging services every week to ensure adherence and usability.

The 12 participants in the SPA+EA group also downloaded the app on their Android phones and were additionally guided on maintaining proper posture while using their smartphones with the aid of an ergonomic educational leaflet. Participants were instructed to use the smartphone application and ergonomic educational leaflet for a period of 8 weeks. Similarly, participants' activity was remotely monitored through phone calls and short messaging services every week to ensure adherence and usability.

Finally, the 12 participants in the EA group were guided on maintaining proper posture while using their smartphones with the aid of an ergonomic educational leaflet[21] for a period of 8 weeks. The usage of the ergonomic educational leaflet while handling the smartphone was remotely monitored via phone calls and short messaging services every week to ensure adherence and usability.

Description of questionnaires (outcome measures)

Numerical pain rating scale: This tool was used to assess the pain severity of the participants. The construct validity of the NPRS was revealed to be greatly correlated with the visual analogue scale in individuals suffering from chronic pain at a range of 0.86 to 0.95.[22]

The Shoulder Pain and Disability Index (SPADI)

The participants' shoulder pain-related disability was assessed using this scale. The test-retest reliability of the SPADI total combined subscale scoring ranges from 0.64 to 0.66. Additionally, internal consistency was observed to range from 0.86 to 0.95.[23]

Oswestry Disability Index (ODI)

The functional disability of the participants was assessed using this scale. It has an internal consistency value of 0.87.[24]

Neck disability index (NDI)

The neck disability of the participants was assessed using this scale, which has an intra-class coefficient value range of 0.50 - 0.98.[25]

Short Version Smartphone Addiction Scale (SAS-SV)

The use of smartphones among participants was assessed using this tool, which has a total score of 60, and an average score of 30. Scores obtained were used to classify participants into excessive (>30) and non-excessive (≤30) users.[2] This scale has a high Cronbach's α of 0.911, a sensitivity value of 0.875 and a specificity value of 0.886.[2]

Component of the smartphone application (CerviTech)

The CerviTech application was downloaded from the Google Play Store and it has the following features:

- It provides real-time tracking of the neck angle of smartphone users in relation to the standard neck posture.
- It incorporates a push notification button which activates an instant response to signals from the accelerometer reading.
- The application allows the setting of goals for each user and provides standard isometric neck exercises.[26] (Figs. 1 and 2)
- It is a downloadable application that is compatible with the Android operating system.

Component of the ergonomic educational leaflet

- Take a 20-minute break when using a mobile device.
- Hold your phone in an upright manner while keeping your neck straight and support the arm when holding the smartphone with the other hand.
- The mobile device should be placed on a stack of books or a stand case, and try to raise its height to eye level or slightly below.
- Landscape orientation is recommended when browsing or watching content on mobile devices.
- Adopt a simple method of micro pauses in the form of stop-drop-flop,
- Use an external keyboard device to type on a tablet/smartphone for a longer period.[21]

Data analysis

Data were analysed using Statistical Package for Social Science (SPSS) version 25 (IBM SPSS Inc., USA) and Microsoft Excel 2007 version. A normality test was conducted using the Shapiro-Wilk test and summarised using descriptive statistics (means and standard deviations or frequencies and percentages). Inferential statistics using relevant parametric (analysis of variance (ANOVA)) and non-parametric tests (Kruska-Wallis test) were used to determine the significant difference across the three groups. The least significant difference post hoc analysis was conducted to determine where the significance lay in each of the groups (SPA, SPA+EA, EA). The Wilcoxon sign rank test (non-parametric) and the paired **t**-test (parametric) were used to determine pre- and post-intervention changes for each group. The Freidman test (non-parametric) and ANOVA were used to determine the significant difference across the weeks across the groups. The level of significance was set at $p<0.05$ at a 95% confidence interval (95% CI).

Result

Thirty-seven participants with excessive use of smartphones (mean (standard deviation (SD)): 39.26 (6.75)) took part in this study. However, only 31 participants (aged 21.35 (1.74) years, $n=24$ (77.42% female)) completed this study. They comprised 10 (32.3%) participants in the SPA group, 11 (35.5%) participants in the SPA+EA group and 10 (32.3%) participants in the EA group (control). The Consort flow chart depicts the study procedure (Fig. 3).

The three groups were comparable (Table 1).

The ANOVA test was used to assess changes in FHP pain in the neck and lower back among the SPA, SPA+EA, and EA groups post intervention. Results revealed a significant difference for FHP ($p=0.027$) with an effect size of 0.227 across the groups at the end of the 8th week (Table 2). Results from the Kruskal-Wallis test showed no significant differences in all the outcomes: neck disability ($p=0.059$), functional disability of the lower back ($p=0.059$) and shoulder pain disability ($p=0.373$) across the groups at 8 weeks post intervention (Table 3).

A post hoc analysis using the least significance difference (LSD) revealed that the significant differences in FHP lay between the SPA and SPA+EA groups ($p=0.016$) and the SPA and EA groups ($p=0.022$).

Table 4 shows comparisons of the changes in FHP and pain levels in the neck and lower back within the groups, while Table 5 shows the results of the changes in disability in the neck, functional disability for lower back, and shoulder pain using the Freidman test. Comparing across weeks, we noted a significant improvement in FHP ($p=0.0001$, 0.003, 0.002) as well as decreased neck disability ($p=0.0001$, 0.0001, 0.0001), neck pain ($p=0.010$, 0.020, 0.0001), functional disability of the lower back ($p=0.001$, $p=0.001$, $p=0.007$) and shoulder pain disability ($p=0.0001$, 0.001, $p=0.0001$) for the SPA, SPA+EA and EA groups, respectively.

Table 6 shows the comparison of the measures at baseline and after the 8-week intervention period. A paired t-test revealed significant improvement ($p=0.001$) in the FHP and pain in the neck ($p=0.003$, $p=0.009$, $p=0.0001$) in all groups (SPA, SPA+EA and EA). Significant differences were also noted for pain in the lower back ($p=0.045$) in the SPA group only. However, for the neck disability, functional disability of the lower back and shoulder pain disability, there was significant improvement ($p<0.05$) (using the Wilcoxon's sign rank test) across all the outcomes post intervention (Table 7).

Discussion

This study determined the efficacy of the smartphone application, CerviTech, in reducing the level of pain and disability in the neck, shoulder and lower back, as well as improving the FHP among undergraduates with excessive usage of smartphones.

There was a noticeable improvement in the outcomes (FHP, pain intensity, functional disability, neck disability and shoulder pain disability) across the three groups. These findings demonstrate the efficacy of the interventions used in the treatment of undergraduates with musculoskeletal disorders resulting from excessive use of smartphones. This report corroborates the outcomes of an earlier study on the effect of therapeutic intervention on pain, disability and FHP among patients with neck pain.[27] A previous study posited that strengthening, proprioceptive and stretching exercises promote an increase in the stability of neck muscles, which confirms their effectiveness in the treatment of neck dysfunction.[28]

In our study, we showed that undergraduates who use smartphones excessively have symptoms associated with neck, shoulder, and lower back pain and abnormalities in FHP. This finding is supported by a study by Kim *et al*.[29] who stated that the rise in the neck and lumbar flexion angle is greater in individuals who use smartphones for prolonged periods. Another study by Park *et al*.,[30] showed that rounded shoulders are strongly associated with FHP. Furthermore, Kim and Koo[31] and Ahmed *et al*. [32] reported that pain and fatigue of the neck and shoulder muscles worsen with prolonged smartphone use.

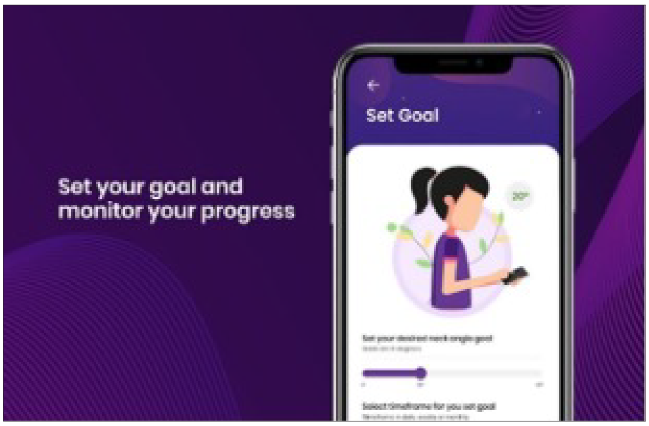

Fig. 1. Goal setting screen.

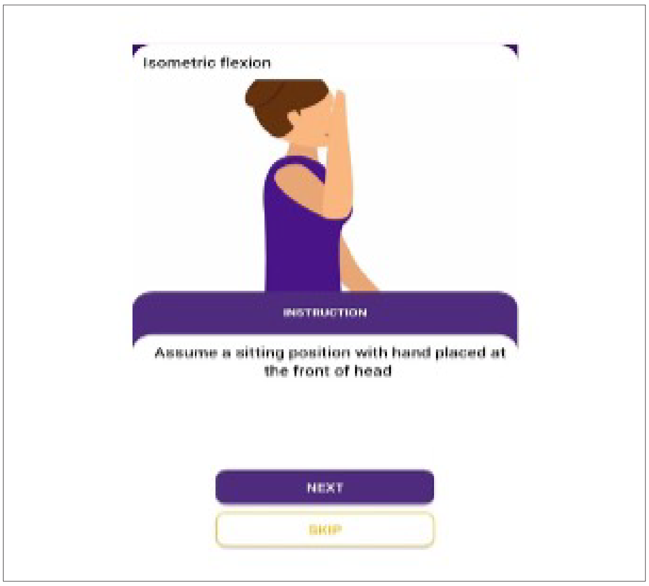

Fig. 2. Animated isometric flexion exercise screen.

The report of significant improvement in the outcome variables (FHP, pain, neck disability, functional disability of the lower back, shoulder pain disability) in the smartphone application group shows the efficacy of the smartphone application employed in this study, in cooperation with therapeutic features ranging from 'real-time neck angle calculation, push notifications, goal setting and exercises' that can aid the rehabilitation of FHP as well as alleviate the pain and disability levels of the neck, shoulder and lower back among individuals addicted to smartphone use that have already displayed features of musculoskeletal disorders. This assertion is buttressed by the fact that technology-delivered rehabilitation services can provide patients with a sense of personal self-sufficiency and confidence that can allow them to self-manage their condition.[33]

The findings of our study revealed improvement in all the assessed outcome variables in both the SPA+EA and EA groups. This could be attributed to the combination of the two rehabilitation programmes and the ergonomic advice, which offered clear and explicit guidance on maintaining proper posture when making use of digital devices. This aligns with the findings by Jung *et al.*,[34] which showed the effect of smartphone usage on posture and pulmonary function and proposed the importance of maintaining proper posture while using the smartphone.

The outcome of this study displayed an improvement in FHP among the participants in the three groups. The SPA group demonstrated a much-improved outcome in FHP when compared to SPA+EA and EA groups. This might be due to extra features present in the smartphone application, such as push notifications, goal setting and some exercises, which serve as motivation and therapy to users. Notably, adolescents often lack the self-monitoring and planning required for the implementation and sustenance of healthy habits.[35] The smartphone application operates by running in the background while the participant uses their smartphone. Push notifications are sent to users to serve as reminders, prompting

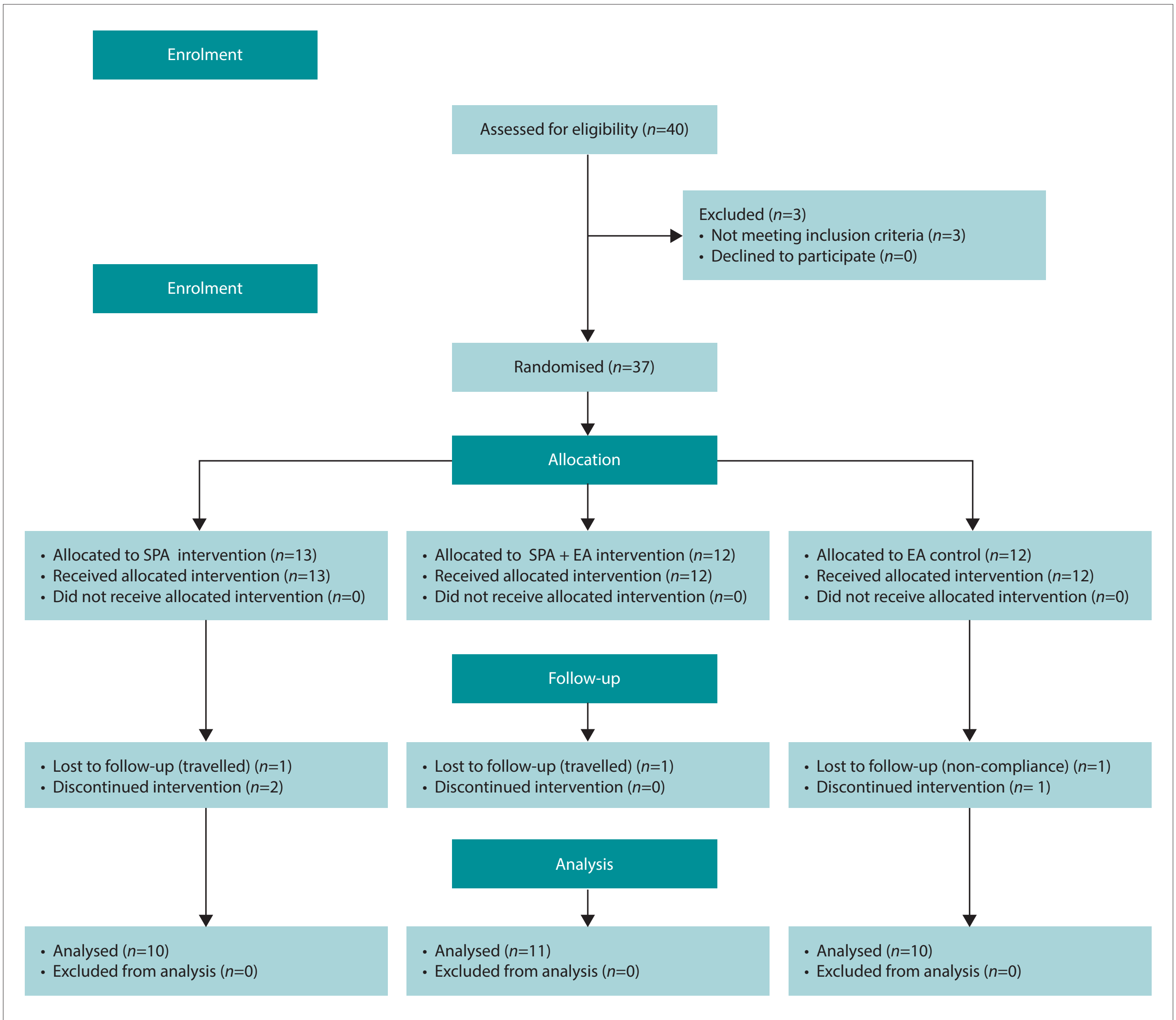

Fig. 3. Flow of participants. (SPA = smartphone application; EA = ergonomic advice.)

Table 1: Physical characteristics of the participants

Variables	All participants X (SD) *n*=31	SPA X (SD) *n*=10	SPA+EA X (SD) *n*=11	EA X (SD) *n*=10	F	*p*-value
Age (years)	21.35 (1.74)	21.00 (1.95)	21.00 (1.90)	21.82 (1.08)	0.861	0.432
Weight (kg)	65.16 (14.16)	63.17 (9.32)	61.09 (11.76)	68.45 (19.22)	0.818	0.451
Height(m)	1.68 (0.10)	1.70 (0.09)	1.65 (0.08)	1.68 (0.13)	0.590	0.560
BMI (kg/m^2)	22.98 (4.56)	22.05 (3.78)	22.37 (3.20)	24.16 (5.86)	0.749	0.481
SAS	39.26 (6.75)	38.92 (6.19)	40.09 (5.96)	38.36 (7.76)	0.193	0.826

X = mean; SD = standard deviation; SPA = smartphone application group; SPA+ EA = smartphone application and ergonomic advice group; EA = ergonomic advice group; BMI = body mass index; SAS = smartphone addiction scale.
*P< 0.05

Table 2: Outcome comparisons among participants in the three groups during three assessment periods

Variables	SPA X (SD) *n*=10	95% CI	SPA+EA X (SD) *n*=11	95% CI	EA X (SD) *n*=10	95% CI	η^2	F	*p*-value
Baseline									
HP	44.52 (3.93)	42.02 -47.02	40.99 (5.26)	37.46 - 44.53	40.12 (5.74)	36.27 - 43.97	0.140	2.52	0.097
Pain N	3.92 (2.81)	2.13 -5.70	2.36 (2.34)	0.79 - 3.93	4.64 (1.43)	3.67 - 5.60	0.155	0.07	0.073
Pain L	1.83 (2.37)	0.33 - 3.34	0.73 (1.27)	-0.13 - 1.58	1.36 (2.38)	-0.23 - 2.96	0.050	0.81	0.453
End of 4th week									
FHP	49.67 (4.64)	46.72 -52.62	46.83 (4.74)	43.65 -50.01	45.26 (4.35)	42.33 -48.18	0.151	2.75	0.08
Pain N	1.33 (1.83)	0.17 -2.49	1.27 (1.56)	0.23 - 2.32	2.64 (1.63)	1.54 - 3.73	0.131	0.11	0.113
Pain L	1.08 (1.93)	-0.14 - 2.31	0.18 (0.40)	-0.09 - 0.45	1.00 (1.84)	-0.24 -2.24	0.068	1.13	0.337
End of 8th week									
FHP	53.89 (4.70)	50.53 -57.25	48.49 (4.90)	45.19 -51.78	48.63 (4.92)	45.11 -52.15	0.227	4.12	0.027*
Pain N	1.20 (1.93)	-0.18 -2.58	0.27 (0.47)	-0.04 -0.59	1.10 (1.60)	-0.04 - 2.24	0.086	0.29	0.285
Pain L	0.80 (1.48)	-0.26 - 1.86	0.09 (0.30)	-0.11 - 0.29	0.70 (1.64)	-0.47 - 1.87	0.066	0.98	0.387

X = Mean; SD = standard deviation; SPA = smartphone application group; SPA+EA = smartphone application and ergonomic advice group; EA = ergonomic advice group; FHP = forward head posture; Pain N = pain in the neck; Pain L = pain in the low back; η^2 = Et squared.
*P<0.05

Table 3: Disability level comparisons among participants in the three groups during the assessment period

Variables	SPA Median (IQR) *n*=10	95% CI	SPA+EA Median (IQR) *n*=11	95% CI	EA Median (IQR) *n*=10	95% CI	η^2	H-value	*p*-value
Baseline									
ND	16.25 (5.50 - 32.22)	8.34 - 28.77	8.0 (4.0 - 10.0)	4.20 - 10.23	16.0 (9.55 - 20.0)	8.23 - 17.98	0.171	6.282	0.043*
FDL	14.00 (2.00 - 24.0)	5.23 - 19.77	4.0 (4.0 - 10.0)	1.64 - 5.27	12.0 (0 - 16.0)	3.94 - 14.24	0.185	5.435	0.066
SPD	11.92 (5.14 - 38.02)	7.42 - 31.87	2.31 (0 - 7.69)	0.57 - 9.23	16.54 (9.80 - 34.04)	12.56 - 32.89	0.229	10.43	0.005**
End of 4th week									
ND	5.0 (1.50 - 14.0)	1.54 - 13.79	4.0 (0 - 7.50)	1.29 - 7.06	10.0 (5.0 - 14.0)	4.65 - 12.40	0.071	3.853	0.146
FDL	4.0 (0.0 - 20.50)	0.98 - 13.36	2.0 (0 - 7.50)	0.41 - 3.22	4.0 (0 - 8.0)	1.31 - 6.33	0.121	3.211	0.201
SPD	4.62 (2.31 - 26.92)	1.41 - 22.95	0 (0 - 4.62)	-0.03 - 4.22	7.69 (4.62 - 17.49)	3.56 - 18.47	0.132	7.990	0.018*
End of 8th week									
ND	1.0 (0 - 8.0)	0.11 - 7.09	0 (0 - 2.0)	-0.34 - 2.19	4.44 (1.50 - 6.50)	1.95 - 6.23	0.157	5.649	0.059
FDL	1.0 (0 - 12.50)	0.03 - 9.97	0 (0 - 2.0)	-0.22 - 0.59	1.0 (0 - 6.50)	0.35 - 5.25	0.184	5.668	0.059
SPD	0.39 (0 - 11.35)	-1.41 - 12.80	0 (0 - 3.08)	-0.09 - 2.23	1.54 (0 - 7.88)	-1.70 - 13.30	0.075	1.972	0.373

SD = standard deviation; SPA = smartphone application group; ND = neck disability; FDL = functional disability; SPD = shoulder pain disability; SPA+EA = smartphone application and ergonomic advice group; EA = ergonomic advice group.
*P<0.05
**P<0.01

them to correct their abnormal neck posture while handling the phone. Also, seeing the displayed neck angle calculated in real-time could have motivated the users, encouraging compliance with the smartphone application. Similarly, the WhatsApp messages sent as reminders weekly could have also ensured that participants adhered to use of the smartphone app during the study.

A recent study acknowledged the effectiveness of smartphone applications with notifications containing instructions as well as

Table 4: Pain level and FHP comparisons among participants in the three groups across the three assessment periods

Variables	Baseline, mean (SD)	End of 4th week, mean (SD)	End of 8th week, mean (SD)	F	η^2	*p*-value
SPA						
FHP	44.52 (3.93)	49.67 (4.64)	53.89 (4.70)	12.42	0.45	0.0001***
Pain N	3.92 (2.81)	1.33 (1.83)	1.20 (1.93)	5.36	0.26	0.010*
Pain L	1.83 (2.37)	1.08 (1.93)	0.80 (1.48)	0.82	0.05	0.451
SPA+EA						
FHP	40.99 (5.26)	46.83 (4.74)	48.49 (4.90)	6.90	0.32	0.003**
Pain N	2.36 (2.34)	1.27 (1.56)	0.27 (0.47)	4.46	0.23	0.020*
Pain L	0.73 (1.27)	0.18 (0.40)	0.09 (0.30)	2.09	0.12	0.142
EA						
FHP	40.12 (5.74)	45.26 (4.35)	48.63 (4.92)	7.64	0.35	0.002**
Pain N	4.64 (1.43)	2.64 (1.63)	1.10 (1.60)	13.72	0.49	0.0001***
Pain L	1.36 (2.38)	1.00 (1.84)	0.70 (1.64)	0.29	0.02	0.748

SD = standard deviation; SPA = smartphone application group; FHP = forward head posture; Pain N = pain in the neck; Pain L = pain in the lower back; SPA+EA = smartphone application and ergonomic advice group; EA = ergonomic advice.
*$P<0.05$
**$P<0.01$
***$P<0.001$

Table 5: Outcome comparisons among participants in the three groups during the three assessment periods

Variables	Baseline, mean (SD)	End of 4th week, mean (SD)	End of 8th week, mean (SD)	F-value	η^2	*p*-value
SPA						
ND	18.56 (16.08)	7.67 (9.64)	3.60 (4.88)	17.00	0.25	0.0001***
FDL	12.50 (11.45)	7.17 (9.74)	5.00 (6.94)	14.21	0.10	0.001**
SPD	19.64 (19.24)	12.18 (16.95)	5.70 (9.93)	17.00	0.12	0.0001***
SPA+EA						
ND	7.21 (4.49)	4.18 (4.29)	0.93 (1.88)	16.00	0.34	0.0001***
FDL	3.45 (2.70)	1.82 (2.09)	0.18 (0.60)	13.56	0.33.	0.001**
SPD	4.90 (6.45)	2.09 (3.16)	1.07 (1.73)	14.97	0.14	0.001**
EA						
ND	13.11 (7.26)	8.52 (5.77)	4.09 (2.99)	18.54	0.31	0.0001***
FDL	9.09 (7.66)	3.82 (3.74)	2.80 (3.43)	9.80	0.23	0.007***
SPD	22.72 (15.13)	11.02 (11.09)	5.80 (10.48)	19.54	0.26	0.0001***

SD = standard deviation; SPA = smartphone application group; ND = neck disability; FDL = functional disability; SPD = shoulder pain disability; SPA+EA = smartphone application and ergonomic advice group; EA = ergonomic advice group.
**$P<0.01$
***$P<0.001$

instructional videos in enhancing home therapeutic interventions among patients.[36] The success obtained could be related to technology, internet accessibility, and participant compliance.[37] Indeed, studies have confirmed that smartphone applications with notifications, alarms and reminders are more helpful to patients for adherence to intervention than those without such features. These are more beneficial than regular messaging services, telephone calls or educational leaflets.[38] This supports the idea that self-management apps are designed to provide the ability to manage the multidimensional aspects of chronic pain.[10]

The present study confirmed that all participants experienced neck pain and disability, which is in accordance with the results from a study by Akodu *et al.*,[27] but there was a considerable decrease in neck pain and disability across the three groups in this study after the 8-weeks intervention. This may be due to the kind of therapeutic interventions incorporated in the CerviTech smartphone application, supported by studies by Akodu *et al.*[39] and Shoukat *et al.*,[40] that employed isometric exercises in the management of neck pain and disability in patients with non-specific neck pain as well as a study by Kong *et al.*[41] on the effect of neck exercise on FHP among smartphone users. Moreover, regarding the ergonomic advice given to participants, Prashant *et al.*[42] reported that ergonomic advice was effective in reducing pain and disability of the neck. This is in accordance with the findings by Pillastrini *et al.*[43] on the effect of ergonomic advice on work-related posture and low back pain.

The observed improvement may be attributed to using WhatsApp and push notifications in the CerviTech app to remind participants, ensuring their adherence. Mbada *et al.*[13] employed similar reminder methods and reported their effectiveness in ensuring adherence in an intervention study involving a smartphone application.

In the present study, all participants experienced shoulder pain disability. Similar observations were reported by Akodu *et al.*[1] and Berolo *et al.*[44] who revealed that undergraduates with excessive usage of smartphones had scapular dyskinesis and shoulder pain disability. The intervention improved shoulder pain disability in the three groups at the end of 8 weeks. This effect may be due to the real-time neck angle calculation, push notification, and the embedded shoulder exercises in the SPA and SPA+EA groups. These features encouraged effective use of the app during smartphone use. Also, clear ergonomic advice with specific instructions on how to assume proper posture while handling smartphones played a role.

Findings from our study revealed a clinical but not significant improvement in pain in the lower back across the three groups during the three periods of assessment. However, there was significant improvement in the SPA group in the 8th week post intervention. This may simply be due to the exercise features such as isomeric flexion and extension exercises to the neck, prone head lift and scapular retraction cooperated in the smartphone app, emphasising the neck and shoulder rather than the lower back. It also buttresses the superiority of the smartphone application (SPA) group to the other groups (SPA+EA and EA), but significant improvement existed in the functional disability of the

Table 6: Analysis of Outcome Variables (FHP and PAIN) of Participants in the three groups across 2 periods of assessment

Variables	Baseline, mean (SD)	End of 8th week, mean (SD)	t-value	*p*-value
SPA				
FHP	44.52 (3.93)	53.89 (4.70)	7.546	0.0001****
Pain N	3.92 (2.81)	1.20 (1.93)	3.947	0.003**
Pain L	1.83 (2.37)	0.80 (1.48)	2.333	0.045*
SPA+EA				
FHP	40.99 (5.26)	48.49 (4.90)	-5.892	0.0001***
Pain N	2.36 (2.34)	0.27 (0.47)	3.202	0.009**
Pain L	0.73 (1.27)	0.09 (0.30)	2.055	0.067
EA				
FHP	40.12 (5.74)	48.63 (4.92)	-5.986	0.0001***
Pain N	4.64 (1.43)	1.10 (1.60)	6.914	0.0001****
Pain L	1.36 (2.38)	0.70 (1.64)	1.206	0.259

SD = standard deviation; SPA = smartphone application group; FHP = forward head posture; Pain N = pain in the neck; Pain L = pain in the lower back; SPA+EA = smartphone application and ergonomic advice group; EA = ergonomic advice.
*$p<0.05$
**$P<0.01$
***$P<0.001$

Table 7: Outcome comparisons among participants in the three groups at the end of the 8th week

Variables	Baseline Mean rank	End of 8th week Mean rank	Z-test	*p*-value
SPA				
ND	2.85	1.15	-2.666	0.008**
FDL	2.75	1.35	-2.524	0.012*
SPD	2.85	1.15	-2.666	0.008**
SPA+EA				
ND	2.73	1.27	-2.680	0.007**
FDL	2.59	1.36	-2.539	0.011*
SPD	2.73	1.41	-2.524	0.012*
EA				
ND	2.95	1.10	-2.807	0.005**
FDL	2.65	1.45	-2.319	0.020*
SPD	3.00	1.05	-2.803	0.005**

SPA = smartphone application group; ND = neck disability; FDL = functional disability; SPD = shoulder pain disability; SPA+EA = smartphone application and ergonomic advice group; EA = ergonomic advice group.
*$p<0.05$
**$P<0.01$

lower back of participants in all the three groups post intervention. This may simply mean that the features of the app as well as the content of the ergonomics still had an impact on functional disability levels among the participants. As this is a new intervention and invention, comparisons with previous studies were not possible.

This study was limited in the area of sample size as it is a pilot study so the results cannot be generalised, a larger study will be carried out in future to produce a more robust finding.

Practical and scientific implication

It is therefore advisable that physiotherapists encourage the use of this CerviTech smartphone application for people who present with FHP or complain of neck pain, shoulder pain as well as lower back pain, especially in individuals using a smartphone because this will help to prevent and treat FHP abnormality, pain, disability of the neck and shoulder and lower back. Also, the smartphone application and ergonomic advice should be recommended for any individual using a smartphone to prevent abnormal posture of the spine while making use of the phone. This will go a long way in reducing the risk of musculoskeletal disorders of the spine resulting from abnormal smartphone use.

Conclusion

This study found that participants who used smartphone application only had enhanced improvements in FHP compared with the groups using the smartphone application with ergonomic advice and the ergonomic advice alone. However, all groups showed remarkable improvement in all outcomes at 8 weeks post intervention.

Declaration. None.
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Conflicts of interest. The authors declare that we have initiated the patent application process for the smartphone application.

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