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VALIDITY AND RELIABILITY OF 'ON PROTRACTOR' SMARTPHONE APPLICATION FOR MEASUREMENT OF CRANIOVERTEBRAL AND CRANIO-HORIZONTAL ANGLE

[1]Jinal A. Mamania
[2]Deepak B. Anap
[3]Dhanashree Tanksale

ABSTRACT

Background: Measuring angles and movement is an important aspect of clinical assessment. Over the years, various methods have been used to measure the angles. Image based smartphone goniometer offers an easy and non-invasive method for measuring craniovertebral and cranial horizontal angle. However, the validity of this approach has not been established yet. The purpose of this study was to investigate the validity and reliability of a smartphone based application, by comparing the results of the application and 'AutoCAD®' software.

Methods: Convenient sampling of asymptomatic participants (Males=4 and females =16) who met the inclusion criteria were examined by two researchers for craniovertebral (CVA) and cranial horizontal angle (CHA) using ON Protractor smartphone application and 'AutoCAD®' software. The third examiner analyzed the anthropometric and descriptive data. Validity and reliability were measured using intraclass correlation coefficients (ICC) and p-value.

Result: Good to excellent Intra-rater and inter-rater reliability was demonstrated for CVA and CHA when ON Protractor mobile application and AutoCAD® were compared, with ICC values 0.879 and 0.991 respectively.

Conclusion: Smartphone mobile application-ON Protractor is a reliable tool to measure craniovertebral and cranial horizontal angle.

Keywords: Smartphone application, smartphone, craniovertebral angle, cranio-horizontal angle, reliability, validity.

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[2]Prof and HOD of Musculoskeletal Department,
Dr. Vitthalrao Vikhe Patil Foundation's College of Physiotherapy, Ahmednagar.
[3]Graduate Student,
Dr. Vitthalrao Vikhe Patil Foundation's College of Physiotherapy, Ahmednagar.

CORRESPONDING AUTHOR

[1]Jinal A. Mamania

Post Graduate Student,
Dr. Vitthalrao Vikhe Patil Foundation's College of Physiotherapy, Ahmednagar.
Email: jinalmamania22@gmail.com

INTRODUCTION

Mobile phone addiction can also be called as "compulsive use" of a mobile [1]. It was estimated that by the end of 2015, in India, the number of smartphone users extended up to 788 million with the availability of 32 to 74 million smartphones in Indian market. Telecom Regulatory Authority of India figures had given an estimation of approximately 850 million wireless subscribers in India on 30 June 2011, against a total national population of 1.2 billion (Census India 2011) [2]. The values as mentioned earlier give us an idea regarding increasing popularity of usage of smartphones in India.

This increasing popularity of smartphones can be used for better purposes; especially in health care profession. Usage of "tools" for examination or assessment, diagnosis and follow-up is a common phenomenon in the medical field. In physiotherapy, for assessment, along with hands-on skills, various other tools are required; this includes-hammer, inch-tape, goniometer, tuning fork etc.

Clinically, a universal goniometer is used to measure the range of joints. Goniometer, due to low cost, portability and reliability, is used for measurement of joint range of motions (ROM) and considered as a standard method for ROM determination [2,3]. One of the limitations of this technique is that the physicians have to use both hands for the examination and in this case, maintaining the stability of the limbs is too difficult and can lead to some problems in reading the angles [3]. There are various software's available for measuring angles [4,5]. Another software used for measuring angles is *AutoCAD*®. The present software has turned out to be a boon and is now being utilized in the medical field as well for measuring joint angles (e.g., a degree of hallux valgus deformity [6], a degree of lumbar lordosis) [7]. The software is also used for research purposes wherein digital -photo analysis is being done.

The advent of smartphones has brought a wide range of clinical measurement applications within reach of most clinicians. The majority of smartphones have various built-in sensors such as accelerometers, magnetometers, and gyroscopes that make the phone capable of detecting joint position and measuring joint ROM [8].

The use of smartphone application as a digital goniometer has significant benefits, such as availability, a free application or substantial cost of implementation; and easy measurement. Hence, the examiner is not occupied with both hands, but will just have to place markers and measure the joint angle and it also enables the patients to evaluate their process of healing and the efficacy of treatment at home [3].

Hence, the aim of this research was to analyze the validity and reliability of *ON Protractor* smartphone app for measuring the craniovertebral and cranio-horizontal angle, to compare the joint angles measured and to investigate and set the inter-rater validity and reliability using '*ON Protractor* mobile application' with joint angles measured using '*AutoCAD*®' software.

METHODOLOGY

In this study, anthropometric and descriptive variables related to age, gender, weight, height, and BMI were included. Following recruitment, the participants were made to understand the purpose of the study in the language best understood by them concisely and clearly.

20 asymptomatic participants (males= 4, females= 16) were included in the study. Participants were recruited from Dr. Vithalrao Vikhe Patil's College of Physiotherapy. The participants aged between 20-25years and willing to participate in the study were included.

Ethical approval for the study was granted by the Ethics Committee of Dr. Vitthalrao Vikhe Patil Foundation's College of Physiotherapy (Ethical approval ID-DVVPF's/COPT/2017/EC-4). Each participant was given an information sheet and provided written informed consent for participation. Participants were informed that participation in the study was voluntary and they could withdraw if required. They were also assured that their data would be kept confidential.

Apparatus

Craniovertebral angle and cranial horizontal angle was measured using *ON Protractor* mobile application using Nexus 5x cell phone and *AutoCAD*® software. The application is freely available in Google app store. This application allows to take a picture and draw an angle by touching the screen at the reference points on the markers. The image gets saved in the device.

Similarly, for *AutoCAD*® software the pictures were clicked using Nexus 5x and then inserted into the software and angles were measured.

PROCEDURE

Participants were made to sit on a stool and were instructed to focus at a particular point on their eye level. In method 1, the two angles were measured using smartphone app-ON Protractor, and in method 2, the two angles were measured using *AutoCAD*® software. The research constituted of three researchers-one for measuring angles with ON Protractor app, and another one for measuring angles with *AutoCAD*® software and the third researcher performed the analysis. The angles were measured by the same researcher twice on different days.

Researcher A measured the craniovertebral and cranio-horizontal angle using *ON Protractor* app. Three markers were used: one placed on C7, the second on tragus and the third on canthus. The angle between the line joining C7 to tragus and a vertical line extending from C7 was measured. Also, the line connecting the external canthal angles of the eyes was measured, and photographs were taken [9].

Researcher B measured the same angles by placing the markers on respective sites as mentioned above and captured a picture. The same image was inserted in the *AutoCAD*® *software* and angles were measured. After the entire procedure, analysis was done by the third researcher.

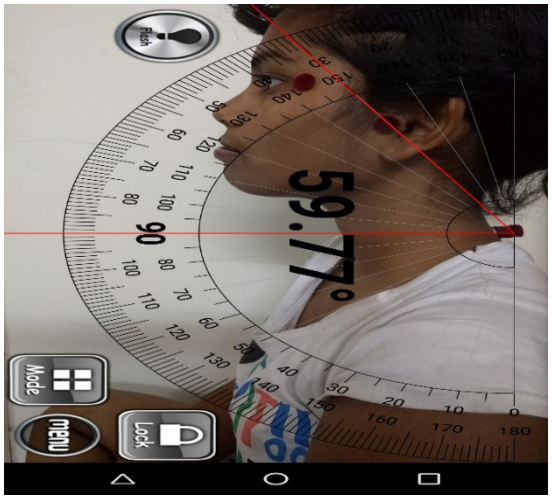


Figure-1a: Craniovertebral angle (CVA) taken using *ON Protractor* mobile application.

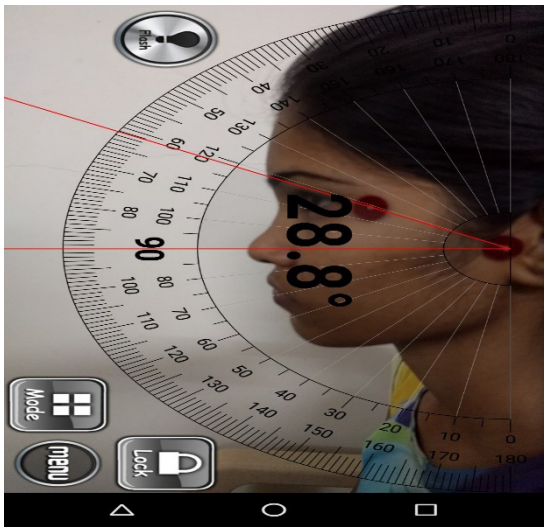


Figure-1b. Cranio-horizontal angle (CHA) taken by using *ON Protractor* mobile application.

RESULTS

Data analysis was done using SPSS 23.0 version of IBM software, and the statistical significance level was set at $p<0.05$. There were 20 participants, 4 males, and 16 females, in this study. The scale from Bland and Altman was used in the classification of the reliability values (≤0.20 poor, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 good, and 0.81–1.00 excellent) [10].

Anthropometric data of the participants are shown in Table 1.

Table 1: Anthropometric data

Anthropometric data	Mean±SD
Age (years)	21.77±1.20
Weight (kg)	52.33±4.33
Height (cm)	158.11±5.10
BMI (kg/m^2)	20.93±0.97

For photographic measurements, high values of agreement (Intraclass correlation coefficient) and 95% confidence intervals were seen for intra-rater reliability when compared with *AutoCAD*® angles.

The intraclass correlation coefficient between the two groups, in trial 1, for the craniovertebral angle is excellent according to scale given by Bland and Altman [10] (Table 2).

Table 2: Intraclass correlation coefficient - *AutoCAD*® v/s *ON Protractor mobile application*

ICC	Lower limit	Upper limit	p-value
0.879	0.685	0.957	0.000

The intraclass correlation coefficient between the two groups, in trial 1, for the cranio-horizontal angle is shown in Table 3. According to the scale by Bland and Altman, it shows excellent reliability.[10]

Table 3: Intraclass correlation coefficient-*AutoCAD*® v/s *ON Protractor mobile application*

ICC	Lower limit	Upper limit	p-value
0.991	0.975	0.996	0.000

Within the group comparison for ON Protractor, a mobile application was also done, i.e., trial one v/s trial 2. Results of craniovertebral and cranio-horizontal angles showed a significant difference. (Table 4 and five respectively). Scale by Bland and Altman indicates that its reliability grade is excellent [10].

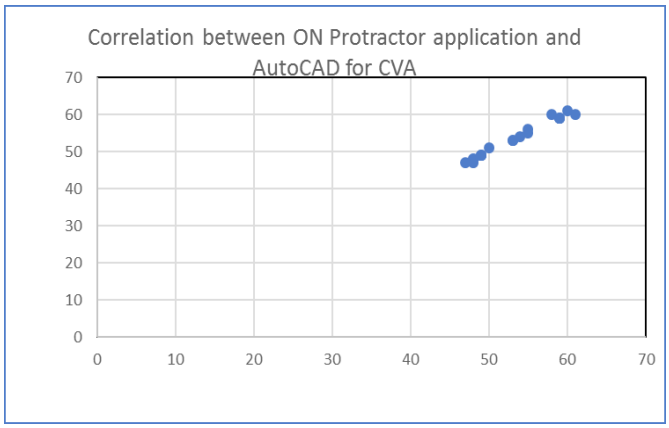
Table 4: Intraclass correlation coefficient- *ON Protractor mobile application*- CVA Trial 1 v/s trial 2

ICC	Lower limit	Upper limit	p-value
0.979	0.947	0.992	0.000

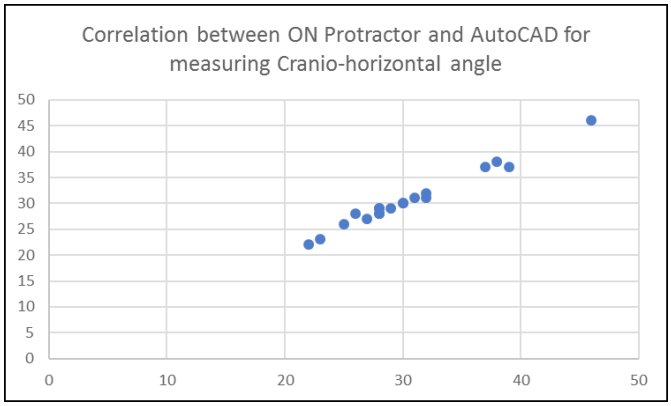
Table 5: Intraclass correlation coefficient- *ON Protractor mobile application*- CHA Trial 1 v/s trial 2

ICC	Lower limit	Upper limit	p-value
0.999	0.997	0.999	0.000

Concurrent validity (r) between *ON Protractor mobile application* and *AutoCAD*® software for craniovertebral angle and the cranio-horizontal angle was found to be 0.99 (Graph1 and 2).



Graph 1: Shows positive correlation between *ON Protractor mobile application* and *AutoCAD*® for measuring the craniovertebral angle.



Graph 2: Shows positive correlation between *ON Protractor application* and *AutoCAD*® for measuring the cranio-horizontal angle.

DISCUSSION

This study evaluated the Inter-rater and intra-rater reliability for ON Protractor mobile application. The novelty of this investigation was that the intra-rater reliability was assessed within two days/ today. This application has been approved for measuring craniovertebral and cranio-horizontal angle and is available in Google app store.

Various disorders of cervical region like-upper cross syndrome, cervical spondylosis, kyphotic posture, PIVD, scoliosis can affect the surrounding musculature leading to postural changes in the cervical region. Amongst these changes, forward head posture is most commonly seen which not only leads to muscle imbalance but also reduces the cervical ROM.

In this study, data analysis between the group and within the group is found to be extremely significant (p=0.000). The present research has added onto our physiotherapy assessment tools as there is a paucity of studies wherein they have compared smartphone application and *AutoCAD*® software.

A smartphone application and software, both measures the angle in a similar way but the major difference is smartphone portable whereas the software requires either computer or laptop. The results showed that both the methods; smartphone app and *AutoCAD*® software had higher agreements on both the angles. These findings indicate the high validity of smartphone application for evaluation of cranial angles.

Behnam Behnoush (2016) and his colleagues conducted a study on-'Smartphone and Universal Goniometer for Measurement of Elbow Joint Motions: A Comparative Study' where a smartphone application and universal goniometer was used for measuring elbow ROM. The results showed that the reliability of measuring the movements was high and for the elbow joint supination was the highest [3].

Wellmon RH et al. conducted a study in 2016, wherein two smartphone applications were compared with the readings of universal goniometer and inclinometer. The basic aim of the study was to validate the two mobile applications. The angles were measured in acute, right and obtuse angle using each instrument. The results concluded that both the applications are reliable enough, but its measurement also depends on the accurate skills of the examiner.[11]

Ferriero et al. (2013) conducted a study on goniometry for knee joint, a photographic-based goniometry. Here, the photos were taken of the knee by placing the markers and were transferred from the camera to the computer and were interpreted by the software. For smartphones, special software, called Dr. Goniometer (Dr. G) was used that automatically performed all the process. They compared the Dr. G software on the smartphone with the conventional photographic-based goniometry in 35 subjects. The results showed that Dr. G software was a reliable method to measure the ROM of knee and is much easier than the conventional method [12].

According to the recent study, Charlton et al. (2014) evaluated the reliability of smartphone to measure the flexion, rotation, abduction and adduction movement of the hip joint. This study was conducted on 20 healthy young men. The final results showed that the smartphone had good - excellent reliability for most of the movements, but it had moderate - good reliability on abduction, adduction and external rotation [13].

Simon J. Otter and colleagues conducted a study on reliability of smartphone goniometer application for measuring 1st metatarsophalangeal joint dorsiflexion. It was a double-blind study wherein metatarsophalangeal joint dorsiflexion was measured using universal goniometer, and the readings were compared with the angles measured using Dr. G smartphone application. The results concluded that the application showed moderate to high intra-rater reliability [14].

Arm abduction range of motion was assessed using an mROM smartphone and internet based application. Antonio[14] and his colleagues conducted a study using this application, wherein readings were taken thrice and were compared for their reliability. Results concluded that mROM smartphone app is reliable tool to measure range of motion [15].

Age can be a major factor that can affect the results. This study included healthy adults aged between 20-25years. Hence a study including higher and lower age group might be considered for future studies.

Also, in this study female to male ratio, i.e. gender effects as a confounding factor, on the reliability of measurements was not considered.

According to the results and limitations mentioned above, it is suggested that studies can be conducted on different age group and gender group to eliminate confounding factors and systemic error.

CONCLUSION

Smartphone mobile application-*ON Protractor* is a reliable tool to measure craniovertebral and cranial horizontal angle.

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