Research Article

Reliability And Validity Of Smartphone Application For The Measurement Of Sagittal Shoulder Angle, Cranio Horizontal Angle And Cranio Vertebral Angle

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Abstract

Background: In terms of measuring angles there is much clinical significance to the use of angle measurements to monitor the objective physical characteristics of a patient, track their rehabilitation and to prevent injuries with work activities. A number of software applications are available for the purpose listed above; one of these; the APECS Smartphone Application, and the application will be discussed in this study. FHP is defined as the forward displacement of the head in relationship to the body's plumbline (center of gravity) and often associated with excessive extension of the upper cervical spine; flattening of the lower cervical spine; rounding of the upper back; and elevation and forward displacement of the shoulders. There are many complications associated with forward head posture; therefore, accurately measuring head posture has become a critical part of everyday clinical practice when assessing a patient and developing & implementing a successful treatment plan., therefore it was the purpose of this study to develop and validate a cost effective & reliable method that is readily available to measure all 3 types of angles (sagittal shoulder angle, cranio-horizontal angle, cranio-vertebral angle) associated with forward head posture and to allow for easy evaluation of patients' forward head posture. **Subjects & method:** A total of 50 subjects (30 Males and 20 Females) were recruited in this study. Subjects were selected according to predefined inclusion and exclusion criteria. All angles were measured in the standing position. Sagittal plane Measurements for each participant were recorded to objectively evaluate SSA, CHA, & CVA using APECS smartphone application and Surgimap system software. **Results:** Intra-rater reliability of each reading of APECS showed good results, i.e. ICC value of SSA = 0.98, CHA=0.97 and CVA=0.98 and this study revealed that APECS Smartphone application were highly significant for measuring sagittal shoulder angle, cranio-horizontal angle and cranio-vertebral angle in standing position. **Conclusion:** A significant correlation was found between postural angles measured using the APECS smartphone application and Surgimap system software which supports that APECS is a highly reliable and valid clinical tool for assessing and evaluating sagittal shoulder angle, cranio horizontal angle and cranio vertebral angle in standing position.

Keywords: APECS smartphone application, Surgimap system software, SSA, CHA, CVA

1. Introduction

Posture refers to the capacity to sustain an appropriate alignment between various parts of the body in relation to environment demands & activities, ensuring stability. Maintaining proper posture promotes optimal body mechanics with minimal exertion, thereby supporting musculoskeletal balance [1]. Posture refers to an individual's unique manner of sitting, and moving, and is often described as the alignment of the spine in a neutral position. Maintaining proper posture is crucial for overall health & well-being [2]. Proper posture maintains musculoskeletal balance. Poor posture can lead to muscle imbalance causing incorrect relationship between different parts of the body [3]. Posture refers to the balanced alignment of muscles & bones, serving to safeguard the body's support structures from gradual damage or deformity, whether during activity or rest.[4] Postural angles are measurablevariables usedtoassess posture, differing from linearmeasurementsthatquantifyposturaldeviation by calculatingthedistances between two anatomical landmarks.[5] Postural measurement is common in many healthcare professionals because atypical postures often present with several diagnosis.[6] In physiotherapy practice, angle measurements are commonly used to assess joint alignment and range of motion. These measurements play a vital role in clinical diagnosis by providing insights into physical conditions, evaluating the progress of rehabilitation, and helping to prevent injuries [2, 7]. To assess the alignment of the cervic2a1l 0

and shoulder regions, the study utilized three angular measurements. These angles, observed from a lateral perspective, include the Sagittal-shoulder angle, the Cranio-horizontal angle, and the Cranio- vertebral angle.

The Sagittal-shoulder angle (SSA) can be determined at the point where a horizontal line drawn from the spinous process at cervical vertebra #7 (C-7) meets another line that runs through the middle of the greater tuberosity (the bony projection on the upper end of the humerus closest to the shoulder) to the posterior aspect of the acromion. The size of the SSA indicates the degree to which the shoulder is in a forward position. If the angle is small, that indicates that the shoulder is more rounded and is situated in a forward position relative to the location of C-7 on the spine. [8, 9].

Cranio-horizontal angle(CHA) is defined by two lines: the first line runs horizontally through the tragus of the ear, and the second line connects the tragus to the outer canthus of the eye. The angle formed by these two lines represents the relationship between the head and neck, thus providing insight into the position of the upper cervical spine. (Raine and Twomey)

Vaghela NP e. al reported a significantly increase in cranio-horizontal angle (CHA) during standing posture when participants carried a school bag weighing 18 of body weight, compared to standing without a bag. [8]. The cranio-vertebral angle (CVA) is defined as the intersection of a line drawn through the spinous process of C7 and the tragus of the ear. It is an important tool used to monitor cervical alignment with the thorax. The cranio-vertebral (CV) angle is indicative of whether an individual has an increased amount of forward head posture (FHP), and while this method is widely regarded as a reliable and valid measure of FHP, there is no exact procedure for measuring the cranio-vertebral angle. However, there are numerous studies that have established the reliability and validity of the cranio-vertebral angle by showing the correlation between FHP and other factors related to FHP. [10]. FHP is a prevalent cervical abnormality that may contribute to several medical issues, such as headaches, neck pain, tempero-mandibular joint disorder, vertebral dysfunctions, soft- tissue tightness & tenderness, as well as impaired movement of scapula & shoulder blades [3]. A previous study stated that Greater FHP was associated with lesser cranial angle (CVA) and increased cranial-horizontal angle (CHA) [11].

The APECS AI Posture Measurement and Correction system has been shown to be an efficient and cost-effective method of evaluating a person's posture. [12]. In recent years, there has also been a Clinical study on the use of smartphone applications as a new method to measure angles using digital photos. This new method has been found to have high reliability [7]. There are many software applications available to measure angles; some of the best known software applications for measuring angles are the Surgi Map application, and the online Surgi Map angle measurement tool has become a valuable measurement tool in the medical field and has been used extensively in the evaluation of joint angles as well as digital image analysis in the research field. [2].

Surgimap is computer software that enables geometric calculations of alignments. Captures and displays X-ray image files, allowing surgeons to implement preset angle corrections Surgimap provides as "traffic light" code estimate of final alignment quality with green (good), yellow (normal) and red (bad) final alignments [13]. Studies prior found that Surgimap software was a reliable way to measure adolescent spinal angles from a variety of standing angles using digital photography [2]

2. Material & Method

In this cross-sectional study, 50 participants (30 males and 20 females) with age (18-28) from university were considered based on inclusion criteria. After that a written informed consent was obtained from each participant prior to their participation. Those Participants was not included in the study if they were under 18 or over 28 years of age, had a recent history of systemic illness, or exhibited any visual, auditory, or communication impairments, as well as musculoskeletal, cardiorespiratory, neurological disorders or any co-morbidities.

Procedure Positioning

Participants were positioned facing a blank wall, standing with their feet shoulder- width apart and aligned in the sagittal plane in relation to the camera. They were asked to maintain a relaxed and natural stance with their arms resting by their sides. They were also asked to evenly distribute their weight across feet bilaterally & to maintain their eyes focused with straight ahead. This posture was held consistently for all angle measurements.

Procedure for intra-rater reliability: Measurement Procedure:
Sagittal plane image of each subject was taken on every session to objectively access the SSA, CHA & CVA through Smartphone's camera with APECS application used for analysing photographs. The distance between the smartphone's camera & Subject is of 1.5m on a fixed base. The camera height was adjusted at the level of subject's shoulder and a self-balanced position was chosen to maintain the Neutral Position of head & neck posture of subjects & a proper exposure of neck (C7 spine) and shoulder were considered. The rater palpated & positioned the adhesive markers (i.e. on the external canthus of Right eye, Right ear tragus, C7 Spinous process, & over the Midpoint between greater tuberosity of humerus & posterior aspect of acromion). The following angles were evaluated for the posture analysis, described as; the SSA was defined as the angle created by two lines: one horizontal to the C7 spinous process and the second from a midpoint on the humerus tuberosity to a posterior point on the acromion. To measure the CHA, the intersection was at the meeting point of both the horizontal line through the tragus of the ear and the external canthus of the eye. To measure the CVA, the intersection of a line horizontal to the C7 spinous process and the tragus of the ear was taken as an intersection point. After the placement of adhesive markers on the anatomical sites and smartphone images of the marked sites were taken, the images were used in the APECS smartphone application and angles were measured.

Procedure for Criterion Validity:
We used a digital camera to take a Sagittal Plane photograph of all the subjects in each session. The camera was fixed at a distance of 1.5 meters from the subject with the lens being aligned with the height of the shoulder. Subject were given instructions to maintain a neutral stance when photographing them with respect to the heights of their heads and to have a Neutral Neck Posture during the photograph. After the exercise was completed, the images were analyzed using the Surgimap digitizing system.

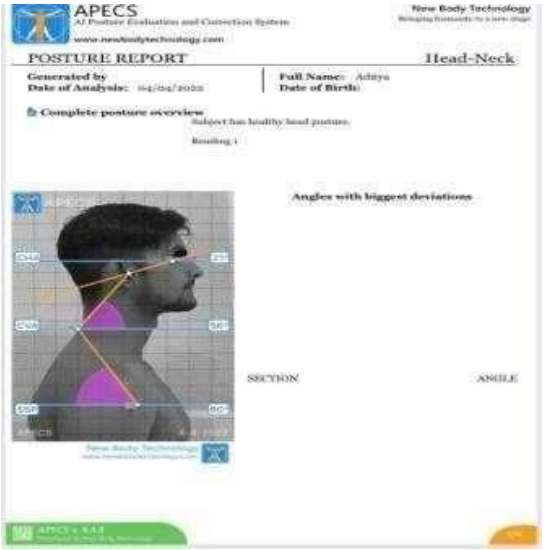

Figure 1: Measurement of SSA, CHA and CVAthrough APECS Smartphone Application

Figure 2: Measurement of SSA, CHA and CVAthrough Surgimap System Software

Data Analysis

Out of 50 participants, 30 males & 20 females were considered in the study. Demographic details of each participant (such as age, gender, height, weight, BMI), were taken into considered, then descriptive statistics was performed in order to assess the mean and standard deviation. Data was analysed using the statistical Package SPSS 22.0 & the level of significance was set at $P<0.05$. Shapiro-wilk test was considered to find out the Normality. For Reliability, Intra class correlation (ICC) was considered and Spearman's correlation coefficient was taken into considered for variables between APECS and Surgi map to find out the Validity.

3. Result

Demographic Details

50 Subjects were recruited (30 males & 20 Females) with a mean age of 21.72(±2.10) year old. Considering 60% was male & the 40% was Female. The mean height of the participants recorded was 166.64(±7.26) cm and the weight recorded was 59.9 (±8.79) kg respectively. The average BMI of the participants recorded was 21.45 (±2.02) kg/m^2. The variables had no significant differences within the group. A demographic data descriptive analysis is shown in Table no.1

Categories	Mean ± SD
Age (Yrs)	21.72 ± 2.10
Gender (M, F)	25 ± 5
Height (cm)	166.64 ± 7.26
Weight (kg)	59.9 ± 8.79
BMI (Kg/m^2)	21.45 ± 2.02

Table No. 1: Shows Demographic characteristics and Descriptive statistics mean (± SD) values.

Reference values of reliability and validity:

The Bland & Altman Scale was used to Classify the intraclass correlation Co- efficient (ICC) of reliability values (>.75 for good reliability, .40-.75 for moderate reliability and <.40 indicates poor reliability) and for the validity values (>.65 for good validity, .50-.65 for moderate validity and <.50 for poor validity) respectively. Reference values for interpretation of ICCs of reliability and validity shown in Table no. 2.

Reliability and Validity	Good	Moderate	Poor
Intra-rater reliability	>.75	.40 - .75	<.40
Criterion validity	>.65	.50 - .65	<.50

Table No.2: Shows reference values for interpretation of ICCs for Intra-rater reliability and criterion validity

Intra-rater reliability:
Descriptive Data in the form of mean (±SD) of SSA, CHA and CVA angles determined by the same rater at different times are illustrated in Table No. 3. With 95% confidence interval, ICC value among the three readings of SSA and CVA of 0.995 with level of significance 0.000, & ICC value among three readings of CHA of 0.994 with level of significance (p-value) of 0.000 which is less than 0.05, gives an excellent Intra-rater reliability.

Variables	Read 1	Read 2	Read 3	ICC	P-value
SSA	57.75 ± 3.73	57.98 ±3.75	57.79 ± 3.69	0.995	0.00
CHA	19.36 ± 3.19	19.19 ± 3.21	19.37 ± 3.17	0.994	0.00
CVA	50.82 ± 3.14	50.82 ± 3.06	50.85 ± 3.16	0.995	0.00

Table No. 3: Shows Intra-rater reliability of APECS Smartphone Application for SSA, CHA and CVA

Correlation between APECS Smart phone application and Surgimap System Software.
Correlation between the readings of APECS Smartphone application and Surgimap system software were found to be highly significant with Correlation co-efficient of SSA, CHA and CVA is 0.995, 0.991 and 0.986 with level of significance (p-value) 0.000 respectively is shown in table no. 4. As the correlation co-efficient of SSA, CHA, CVA is more than 0.7 and almost nearer to 1, with p-value <0.05, which shows an excellent validity.

Variable s	Correlation Co-efficient	P Value
SSA	0.995	0.000

CHA	0.991	0.000
CVA	0.986	0.000

Table No .4: Shows correlation between different angles measured by APECS Smart Phone application and Surgimap system software

4. Discussion

The purpose of this study was to establish the reliability and validity of a smart phone application designed for the clinical assessment of posture that measures the SSA, CHA, and CVA. The method for measuring angles was designed to have a higher degree of intra-rater reliability and validity. In addition, Angle measurement is conducted using only simple digitizing software and does not necessitate the use of complex methods. In many studies, angle measurements are taken by placing 3 markers, but in this study, measurements were taken in a comprehensive manner by placing four markers.

Mamania JA, et al. (2017) reported that both Smartphone applications and software measure angles in a comparable manner, with the primary difference being that software requires a desktop or laptop computer, whilst the Smartphone is portable. The outcomes demonstrated both strategies [40]. In all regards, the Smartphone application and digitizing software have proven to be superior. These results demonstrate that Smartphone applications for evaluating postural angles are highly valid. Thus, it supports this study.

Intra-rater reliability for the measurement of postural angles has been shown to be higher than inter-rater reliability according to the research of Helmya NA et. al. The source of the higher intra-rater reliability is likely to be because of the consistent placement of all subjects when measuring and/or the use of the same rater to measure all subjects. [4]. As such, the current findings strongly support this study. The purpose of the APECS Smartphone application is to assess SSA, CHA, and CVA angles for cervical and shoulder postural assessments in the sagittal plane. Thus, this study used the application to measure these angles. The methodology included the following steps: 1) Preparation of subject and camera locations, 2) Palpation and marking of anatomical landmarks, and 3) Capture of photographs with the subject. Shaghayeghfard et al. indicated that this was done while standing.

Intra-rater consistency of the digitization method

For Sagittal shoulder angle, it has been determined that using established methods and indicators is a reliable way for assessing posture. The mean value of reading 1 of the SSA is 57.75 (3.73), reading 2 is 57.98 (3.75), and reading 3 is 57.79 (3.69), and the ICC value is 0.995 with p-value<0.05 which is highly significant. The findings of this study revealed that the APECS application exhibits high Intra-rater reliability. For Cranio Horizontal Angle: First CHA reading has a mean value of 19.36 (3.19), Second reading has a mean value of 19.19 (3.21), and Third reading has a mean value of 19.37 (3.17); the ICC value is 0.994 with p-value <0.05 which shows highly significant. This study demonstrated that the intra-rater reliability of the APECS Smartphone application is greater.

For Cranio Vertebral Angle, the mean values of CVA readings 1, 2 & 3 are 50.82 (3.14), 50.82 (3.06), and 50.85 (3.16), respectively, and the ICC value is 0.995 with p-value<0.05 which shows highly significant. This study demonstrated that is a greater intra-rater reliability of APECS Smartphone application. These results are consistent with earlier research, which reported strong Intra-rater reliability values ranging from 0.91 to 0.93 with strong Significant level.

The HPSCI introduced by Wilmarth & Hilliard, a non- invasive tool for measuring the craniovertebral (CV) angle offers an affordable means of evaluating head posture. Research by Willford et al. confirmed that the HPSCI provides stable & consistent intra-rater measurements over several days of trials in a group of 27 individuals without disabilities. Despite its reliability, the instruments accuracy is constrained by the lack of reference markings between anatomical landmarks. [2]. The APECS smartphone application, on the other hand, measures angles more accurately than manual devices by first placing markers at specific locations on the body, with the application then independently reading each angle. Data gathered from this application thus corroborate the findings presented in this paper. There are numerous pathologies associated with the cervical region that can produce musculoskeletal dysfunction in the musculature around the cervical spine and create postural modifications throughout the cervical spine; the most commonly reported

modification is forward head posture, which may lead to both imbalanced musculature and decreased range of motion within the cervical spine.

Validity criterion:
The correlation between APECS Smartphone application readings and Surgimap system software readings is found to be very significant, with p values of 0.95, 0.94, and 0.94 for SSA, CHA, and CVA, and ICC values of 0.98, 0.98, and 0.98 for SSA, CHA, and CVA, respectively. The study found that the APECS Smartphone application is significantly trustworthy and valid for measuring the SSA, CVA, and CHA in standing posture and it is used as a convenient tool for postural evaluation, thus it gives similar effect and strongly supports this study.

Limitation of the study

1. Smaller was the sample size.
2. Limited study duration.
3. Study is limited on subjects aged 18-25 years
4. Different Age group population was not included in the study
5. Sample was not taken in sitting position
6. Study Limited on Healthy Subject only

Future Recommendation

1. The sample size is able to be increased
2. The gender ratio within the population will be able to be determined
3. The inter-rater reliability of the study will be able to be measured
4. We can compare angles between the different age groups in the sample population
5. The additional postural angle measurements can also be compared to each other

Practical Application:

1. SSA, CHA and CVA seems to be practical and convenient method for assessing
2. APECS Smartphone application simple, non-invasive technique and cost effective.
3. Researchers and physical therapist could use this application for evaluation.
4. Other applications sophisticated
5. Smartphone is portable so easily used.

Conclusion
From the analysis of this Study, it can be concluded that the APECS Smartphone Application readings are highly significant when correlated with the Surgimap system software readings, it states that APECS application was significantly reliable and valid for measuring the sagittal shoulder angle, Cranio-horizontal angle and Cranio-vertebral angle in standing posture.

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Conflict Of Interest:
There are no Conflicts of interest

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