Validity of Kinovea Computer Program in Measuring Cervical Range of Motion in Frontal Plane

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Abstract

Purpose: This study was conducted to investigate criterion validity of Kinovea computer program in measuring cervical range of motion in frontal plane compared with the CROM, as a gold standard valid and reliable tool in healthy subjects.

Subjects: Sixty-four normal physical therapy intern students (54 male and 10 female) participated in this study. Their age ranged from 20-24 years with mean (22.42 ± 0.84) and BMI mean (28.60 ± 1.40).

Methods: Digital camera and laptop with installed Kinovea software were used. The cervical ROM of Rt. and Lt. side bending for each participant were measured using Kinovea computer program three times by examiner (B) to detect the intrarater reliability. The gained measurements by the highest intrarater reliability examiner were compared with the gained measurements by the CROM to detect the validity of Kinovea computer program.

Results: The correlation analysis between the cervical Rt. side bending and Lt. side bending measured angles using KCP and the CROM revealed that there was strong positive correlation between the two measurements where the r-value equals (+0.97, +0.95) respectively at p < 0.05.

Conclusion: The Kinovea software program was valid method in measuring active cervical range of motion in frontal plane.

Key Words: Validity – Kinovea – Cervical range of motion.

Introduction

Physiotherapists and other healthcare providers may routinely perform an assessment of the Active Cervical Range of Motion (ACROM) to assess the level of impairment associated with neck pain as well as the results of treatment [1]. Active cervical range of motion in frontal plane may be limited due to pain or neck muscle spasm.

Measurements of cervical AROM have been extensively reported in the past decade employing simple methods (universal goniometers) as well as sophisticated systems (electro-, magneto- and ultrasonography-based). Many valid tools are currently available to measure cervical AROM. They include inclinometers, measuring tape, goniometers and Cervical Range of Motion device (CROM) [2].

The systematic review of Williams et al., showed that the CROM is one of the most used and recent tools among clinicians which has good validity for all cervical movements (ICCs=0.82-0.98) and good reliability (ICCs=0.58-0.99) when compared to a gold standard (X-ray). However, it is a relatively expensive instrument which limits its use to certain contexts and it is only useful for the assessment of the cervical spine [3,4].

Kinovea Computer Program (KCP) is a software that able to measure passive and active ROM of the joints of the body; the overview function is a summary image of the video [5]. It is a free and open source solution for video analysis. Those who are in medical field could also find this software useful. It can be mainly used in the sports field by athletes and coaches. The examiner can measure the distance, speed, line length on a particular video with the help of KCP. The analyzed data can be exported to Excel and simple text [6].

Validity is an indication of how sound your research is. More specifically, validity was applied to both the design and the methods of the research. Validity in data collection means that the findings truly represent the phenomenon that the examiners are claiming to measure. Validity of measurement defined as the degree to which an instrument measures what it is supposed to measure which was the main concern of the current study [7].
Assessment of ROM is a key concern for the physical therapist when evaluating a patient presenting with cervical disorders. Valid and reliable assessment tools are necessary. Goiometers and inclinometers were used to measure cervical ROM. The CROM device is one of the most used and recent tools among clinicians which has a good validity and reliability. However, it is a relatively expensive instrument. Instrumental movement analysis can provide more specific information about quantitative measurement strategies, which is most applicable in research setting. However, the value of such kinematic analysis in clinical decision making, evaluation of treatment efficacy and research firstly requires the establishment of its validity and reliability.

The aim of this study was to investigate criterion validity of KCP in measuring cervical AROM in frontal plane compared with the CROM, as a gold standard valid and reliable tool in healthy subjects.

Subjects and Methods

This study was conducted in the Faculty of Physical Therapy, Cairo University 2015. One shot comparative study design was used in this study to investigate criterion validity of KCP in measuring cervical AROM in frontal plane compared with the CROM, as a gold standard valid and reliable tool in healthy subjects. Sixty four healthy physical therapy intern students (54 male and 10 female) participated in this study, their age ranged from 20 to 24 years and BMI less than 30. They were selected by convenient sampling. Each subject was given full explanation, verbal instructions concerning the purpose and procedure of the current study and the participants signed a consent form with local ethics guidelines prior to participating. All volunteers did not receive monetary rewards or compensation for their time and participation to this study. All volunteers were assessed by the same instruments and the same observers. Ethical approval was obtained from the faculty.

Inclusion criteria:

Sixty four normal subjects (physical therapy intern students) with asymptomatic neck pain and ROM deficits. Age of participants 20-24 years. Both genders (54 male and 10 female). BMI less than 30.

Exclusion criteria:

Previous pain or muscle spasm 3 month before measurements. Previous history of musculoskeletal or neurological problems of the neck region. Previous history of cervical trauma, bone pathologies, arthritis, cervical rib, forward head posture or other inflammatory disorders. Any patient with the diagnosis of spasmodic torticollis was excluded.

Instrumentations:

1- CROM:

The CROM device consists of a plastic frame placed on the head over the nose and the ears, secured by a velcro strap. Two independent inclinometers, one in the sagittal plane and one in the frontal plane, are attached to the frame and indicate the position of the head with respect to the line of gravity. The third was compass goniometer which was positioned in the horizontal plane and indicates the position of the head in rotation, with respect to a reference position.

2- Digital camera:

• Zoom, photo quality, high speed, and video samples Astounding 26x zoom NIKKOR ED glass lens with lens-shift Vibration Reduction.
• 16.1-megapixel CCD image sensor delivers excellent image quality.

3- Tripod stand:

The digital camera was placed on adjustable tripod stand for standardization. Its height 1.5 meter and the distance between the tripod and the feet of participant was 1.5 meter.

4- Kinovea software program:

Kinovea is video analysis software dedicated to sport. It targets primarily medical professionals, the coaches and athletes. The supported files are displayed. You can save the videos easily and access it later in need. The video can be analyzed in slow motion so the video can be seen by frame by frame. Lines and arrows can be added on the video with the drawing tool. KCP was installed on the computer before applying the measurement procedure.

5- Computer system:

HP PAVILION G6 LAPTOP
Processor CPU Speed 2.5, cache memory 3MB, RAM memory FSB 1333 MHZ, RAM up to 8 GB, hard drive capacity 750, rotational speed 5400RPM, graphic card, HD Bright view LED-backlit with 1366 x 768 screen resolution, size 15.6 inch.

Laptop was used for the Kinovea measurement analysis.

6- Markers:

Round markers of 1.5cm in diameter were glued on special bony land marks.
7- **Chest belt:**

   It was used for fixation and standardization.

**Selection of the examiner for the validity study:**

Three physical therapist examiners (A, B and C) assessed the cervical AROM measurements in frontal plane. They had graduated from the same university; Faculty of Physical Therapy, Cairo University. The three examiners assessed the cervical Rt. and Lt. side bending three times. The intrarater reliability was calculated for each examiner with the Intraclass Correlation Coefficient (ICC). Each examiner tested all participants on three separate occasions with a 48 hour period separated [9].

Between the three examiners A, B and C the one with the highest intrarater reliability (highest ICCs) was chosen to undertake the validity study [4].

**Evaluation procedure:**

- Physical examination for the neck region was done before the experiment to exclude any disease or neurological deficits that may affect the cervical ROM measurements. History.
- Inspection from front, lateral and posterior aspects of the neck region.
- Palpation for the neck region and related areas.
- Special tests (compression-distraction-Adeson) test were applied in doubt cases to confirm and give accurate decision about the participant inclusion.
- Group muscle test for neck muscles.

**A- Camera setup:**

   The position of the camera was fixed for standardization all over the experiment and was determined on the basis of the position of the subjects. The position of the subject is marked also and the distance between the participant feet and the tripod was measured by the tape measurement to avoid any changes affect the measurement.

**B- Application of markers:**

   The participant wore 2 elastic headbands to affix head markers. Markers were placed on sternal notch, the vertex and center of the forehead on the same line with the vertex [10].

**Measurement procedure:**

   Each subject was sitting on a stool close to a wall while maintaining good upright balanced posture, with both feet on the floor, with normal lumbar lordosis, hands on thighs, and with 90 degrees in the hip and knee joints.

   Each subject was requested to assume a neutral head position, with the purpose of positioning the head’s center of mass in a vertical plane through the atlantooccipital joints with the nose pointing forward in line with the sternum and bellybutton [11,12]. Each subject was given full explanation, verbal instruction concerning the purpose and procedure of the study. The digital camera was steady to record the movements before the start of the measurements.

**A- Measuring Cervical side bending ROM using KCP:**

   Sternal notches is the axis of the angle between two lines. The first is the line segment between the sternal notch marker and the forehead marker. The second is the vertical line on the sternal notch marker. Cervical side bending movements were done to the Rt. and Lt. side [13].

   The position for each marker was indicated with a washable ink pen for accurate replacement then the marker was glued on the ink pen [13].

   **The examiner was sitting behind the camera taking the video:**

- The examiner asked the participant to do lateral flexion on the Rt. side then hold 5 seconds at the end of the range Fig. (1). The examiner asked the participant to return to the neutral position.
- From neutral position the examiner asked the participant to do lateral flexion on the Lt. side then hold 5 seconds at the end of the range.
- The procedure was repeated three times to get the mean average.
- Cervical AROM was calculated as angular displacement from neutral to Rt. side and from neutral to Lt. side in frontal plane for side bending.
- The examiner recorded the measured angles after doing the KCP measurement analysis of each video for each participant using KCP.

**B- Measuring Cervical side bending ROM using the CROM device:**

   Each participant was seated in a nonswing standard four-legged chair with fabric-covered back and seat short back support (below the shoulders level) [14]. The examiner stood in front of the participant offered instructions, corrected any substitution patterns and record the CROM readings from the frontal plane angle meter at points of movement [15].

- Chest belt for good stabilization.
- The CROM was placed on the participant head.
The examiner asked the participant to start from the neutral position.

From neutral position the examiner asked the participant to do lateral flexion on the Rt. side and hold 5 seconds at the end of the range.

The examiner asked the participant to return to the neutral position.

From neutral position the examiner asked the participant to do lateral flexion on the Lt. side and hold 5 seconds at the end of the range Fig. (2).

The examiner manually adjusted the participant's neck after assuming the neutral position; the frontal goniometer was on zero position.

The procedure was repeated three times to calculate the mean \[\text{[16]}\].

Another recorder (physical therapy intern student) read the CROM readings to confirm the readings.

Each participant bent his or her head first Rt. then Lt. without elevating his or her shoulder.

The examiner asks the participant to return to the neutral position.

C- Analysis the Range of Motion using KCP as Follow:

The examiner connected the camera with the laptop in which the KCP was installed.

The examiner apply the analysis for each cervical AROM measurements in frontal plane.

The procedure was repeated three times then the mean average of the measured angles using KCP were recorded.

The analysis of each participant were saved on computer in a separate file.

Statistical analysis:

1- Descriptive statistics (mean and standard deviation) for measurements of the cervical lateral flexion to the Rt. and Lt. side bending ROM using KCP.

2- Intra-class Correlation Coefficient (ICC) was used to estimate the intrarater reliability.

3- Pearson’s correlation coefficient between KCP and the CROM was used to estimate the criterion validity of KCP. Pearson’s correlation attempts to draw a line of best fit through the data of two variables, and the Pearson correlation coefficient, \( r \), indicates how far away all these data points are to this line of best fit. Its value can range from –1 for a perfect negative linear relationship to +1 for a perfect positive linear relationship. A value of 0 (zero) indicates no relationship between two variables. \( 0.1 < |r| < 0.3 \) means small correlation, \( 0.3 < |r| < 0.5 \) medium/moderate correlation and \( |r| > 0.5 \) large/strong correlation [12]. The confidence Interval was (CI=95%) with \((p<0.05)\) for all tests. For the reliability part of the study, intra and interrater reliability were estimated with the Intraclass Correlation Coefficient (ICC). ICC is a statistic designed to measure the size and direction of the association between two variables [17]. The data were analyzed by SPSS version 20.

Results

In this study, 64 subjects (54 male and 10 female) were assigned into one group and as shown in in Table (1), their mean age was \(22.42 \pm 0.84\) years, their mean weight was \(73.78 \pm 6.43\) kg, their mean height was \(160.23 \pm 6.17\) cm and their mean BMI was \(28.60 \pm 1.40\). ICC >0.4 was regarded as moderate and ICC >0.7 as high correlation [17].

Fig. (1): Cervical Rt. side bending with KCP.

Fig. (2): Cervical Rt. side bending with CROM.
As shown in Table (2); the average measures of ICC between examiner A, B and C and ICC (0.781, 0.789, 0.779) respectively. p-value was 0.0001 for examiner A, B and C. As shown in Table (3); the mean of the cervical Rt. Side bending angles measured using Kinovea was (43.26±5.3), while the mean of the cervical Rt. Side bending angles measured using the CROM was (43.41±5.16). The correlation analysis between the cervical Rt. side bending angles measured using KCP and the CROM revealed that there was strong positive correlation between the two measurements where the r-value equals (+0.97) and had an associated probability value of (0.0001).

As shown in Table (3); the mean of the cervical Lt. Side bending angles measured using Kinovea was (41.98±5.06), while the mean of the cervical Lt.side bending angles measured using the CROM was (42.09±5.06). The correlation analysis between the cervical Lt. Side bending angles measured using KCP and the CROM revealed that there was strong positive correlation between the two measurements where the r-value equals (+0.95) and had an associated probability value of (0.0001).

For a measurement instrument to be useful, the two most important factors that must be established are reliability and validity which affecting the objective measurements [9]. Because limited studies are available on the KCP, the validity of this software program were necessary to be evaluated for cervical AROM in frontal plane.

Examiner B was chosen to detect the validity of KCP because examiner B is the most experienced one with the higher ICC for intrarater reliability. When cervical Rt. and Lt. Side bending AROM were measured using KCP and compared with the measurements done using the CROM by the same examiner (examiner B). The findings of this study showed that KCP was valid method in measuring cervical AROM in frontal plane compared with the CROM as valid and reliable tool.

In the current study, the CROM was used for measuring cervical AROM measurements. It was chosen because previous studies proved that it’s the most objective one commonly used to measure cervical AROM. It determines the physical and functional outcome of patient with cervical disorders and physical disabilities in kinematics data and in three planes sagittal, frontal and transverse [16].

De Koning et al., [18] did a computerized literature search in Medline, Cinahl and Embase from 1982 to January 2007. The search identified a total of 33 studies, investigating three different types of measurement instruments to determine active neck ROM. A systematic computerized literature search of databases revealed three different types of instruments that are practical to use when measuring active neck ROM in patients with nonspecific neck pain: Visual estimation, tape measurements, different types of goniometers/inclinometers. It was concluded that a single inclinometer and CROM are recommended to measure active neck ROM based on their best ratings for clinimetric properties and practicality in subjects with nonspecific neck pain. Visual estimation should not be used to measure active neck ROM.

Ivan et al., [19] evaluate the intra and interobserver reliability of some of the most important performance indicators in table tennis using KCP; the subjects used in the study were 10 highly experienced Italian coaches, members of the third national level (the highest level). The subjects were shown the first set of the men’s singles table tennis final, at the 29th Olympic Games in China (2008). The observer watched the video in the same way as previously described and the data was transferred in an Excel sheet, to allow further analysis. It is

**Discussion**

This study is the first to examine the validity of KCP in measuring cervical AROM in frontal plane. Professionals dealing with cervical disorders have been seeking a valid and reliable instrument for measuring all cervical motions [11].
important to note that in both the inter-observer and intra-observer analysis, the various indicators were carefully illustrated and a training session was held, before conducting the data collection. Once the data collected was compiled in Excel, an evaluation of its reliability was conducted by using statistical software.

The results of the current study in agreement of the study done by Fernández et al., [20] who investigated the concurrent validity and reliability of a low-cost, high-speed camera-based method for measuring the flight time of vertical jumps by using an alternative method (the HSC-Kinovea method). Flight time is the most accurate and frequently used variable when assessing the height of vertical jumps. The flight time and height of vertical jumping using a low-cost high-speed Casio Exilim FH-25 camera (HSC). 25 subjects performed a total of 125 vertical jumps on an infrared (IR) platform while simultaneously being recorded with a HSC at 240 fps. Subsequently, 2 observers with no experience in video analysis analyzed the 125 videos independently using the open license Kinovea 0.8.15 software. The flight times obtained were then converted into vertical jump heights, and the Intraclass Correlation Coefficient (ICC), Bland-Altman plot, and Pearson correlation coefficient were calculated for those variables. The results showed a perfect correlation agreement (ICC=1, \( p<0.0001 \)) between both observers’ measurements of flight time and jump height and a highly reliable agreement (ICC=0.997, \( p=0.0001 \)) between the observers’ measurements of flight time and jump height using the HSC-Kinovea method and those obtained using the IR system, thus explaining 99.5% (\( p=0.0001 \)) of the differences (shared variance) obtained using the IR platform.

As a result, besides requiring no previous experience in the use of this technology, the HSC-Kinovea method can be considered to provide similarly valid and reliable measurements of flight time and vertical jump height as more expensive equipment. This could help them to better control their training programs as performance in the vertical jump is known to be an excellent indicator of explosive strength in the lower limbs and the degree of neuromuscular fatigue.

The results of the current study in agreement of the study done by Abdelreheem et al., [9] who investigated the intra-rater and inter-rater reliabilities of the KCP for the measurement of dominant wrist joint range of motion in healthy participants. One hundred normal participants participated in this study, aged from 20-35 years old. Selected from both sexes (55 male and 45 female). They were recruited from the student and the employees of Al-Haram Hospital, Physical Therapy Department. Subjects were selected according to the following criteria: (A) Aged from 20-35 years old, (B) All subjects were normal, (C) Not less than grade 3 wrist muscles test. Any subject with history of musculoskeletal or neurological problems of the dominant upper extremity, and previous upper limb surgery were excluded. The results of that study revealed that the KCP was reliable in both inter and intra-rater reliability for wrist joint ROM measurement.

The results of the current study in agreement of the study done by Elwardany et al., [21] who study the interrater and intrarater reliability of free video analysis software KCP in measuring cervical flexion and extension AROM. Sixty five normal physical therapy intern students participated in this study. The cervical ROM of flexion and extension for each participant were measured using Kinovea computer program three times by three examiners (A,B and C). Results revealed that for the intrarater reliability, the ICC between the first and second trials by Rater B for flexion and extension were 0.985 and 0.995. The ICC between the second and third trials were 0.932 and 0.993. The ICC between the first and third trials were 0.920 and 0.986 respectively. For the interrater reliability, the ICC between Rater A & B for flexion and extension were 0.991 and 0.992. The ICC between Rater A & C were 0.988 and 0.9938. The ICC between Rater B & C were 0.993 and 0.997 respectively. Kinovea computer program had an excellent intrarater and interrater reliability in measuring cervical flexion and extension range of motion at \( p<0.05 \). The Kinovea software program was reliable in measuring cervical range of motion in sagittal plane.

Munoz et al., [22] determine the interrater, intrarater reliability and the criterion validity and of the free software video analysis (KCP) for hamstring flexibility in adolescents compared with the digital inclinometer, as a valid and reliable tool. Fifty four adolescents from a local school participated in the study. Active Knee Extension (AKE) and Hip Joint Angle (HJA) (formed between the pelvis and the femur during the end point of maximum forward reach with the knees in voluntary full extension) were measured with digital inclinometer and were simultaneously recorded with a video camera. Each video was downloaded to a computer and subsequently analyzed using KCP 0.8.15, a free software application for movement analysis. HJA and AKE measurements were per-
formed by 2 examiners. All subjects completed the 2 tests and were simultaneously recorded with a video camera. The data from the video recordings were compared with the examiner data to detect the validity of KCP. To test the intrarater reliability, the examiner reviewed the video 1 month after the initial examination and made a new assessment; 1 month is generally considered sufficient to limit test-retest bias. All of the measures showed excellent reliability; ICC for intrarater reliability of AKE and HJA was 0.98 and 0.91 respectively. ICC for intrarater reliability of AKE and HJA was 0.98 and 0.98 respectively. The results of this study demonstrate that KCP can be used as an acceptable tool for measuring hamstring flexibility. The ICC was lower in the inter and intra rater reliability of KCP in that study than the current study. These differences may be attributed to different sample, technique, procedure and the long separate time between the two measurements (1 month) for the intrarater reliability but in the current study the short time intervals separate between measurements was 2 days.

The advantages may include the following: It is possible to analyze all the movements, thus managing to capture details that may help to improve the examiner results. The examiner will be able to complete a full study of the videos, detecting errors or details of the procedures that could be improved. Possibility to compare or synchronize two videos to observe the procedure differences. The examiner can apply image and zoom adjustments to the movements to capture every little detail. The examiner can do observation, measurement, comparison of videos. Bidimensional analysis, the presently described technique is free, open-source, no need for special lab to while using KCP. Easy and fast to use. It is low cost modality. It needs minimal training [6,21,23].

There are many advantages and disadvantages of KCP. The disadvantages of KCP may include the following; it is 2D not 3D program that can be used for analyzing the movements at the same time, the examiner will not see all the flaws unless you are looking specifically for it, prohibiting stream copy in many case. It is difficult to be downloaded and computer science specialist may be needed. The therapists who will use it needed to be trained before measuring ROM. There is need to have camera and laptop with installed Kinovea [21,23].

Strengths and limitations:

First, the selected examiners were physiotherapist. Second, the three examiner’s initial prepara-
tion (training) with KCP represents strength. Third, the selected participants in the current study were physical therapy intern students so they understand the instructions and the procedure well and performing the procedure in an excellent manner.

Fourth, standardization of the procedures also helped minimize random errors. To achieve this, all participants were stabilized with chest belt in order to avoid compensation. Also, the given instructions were the same instructions before each measurement for all participants and the environment was identical during all the data collection process: Same rooms, same orientation or the participants (facing east), same chairs. All subjects were tested in a standardized seated position using marker placements and nongoniometric estimation techniques.

The assessment of validity and reliability of a new ROM measurement tools is so important, as the existing tools have many disadvantages beginning from the size, price, availability ending with the reliability and the ability of physiotherapist to deal with it, so KCP now become reliable measurement tool that can be used in the physical therapy field [9].

Limitation:

The current study was limited by small sample size.

Recommendations:

Further studies with large sample size. Validity of KCP in measuring cervical AROM in all directions were recommended.

Conclusion:

The Kinovea computer program was valid in measuring cervical AROM in frontal plane.

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Validity of Kinovea Computer Program in Measuring Cervical Range


الملخص العربي

الهدف: أجريت هذه الدراسة بهدف تحديد مدى صدق نتائج القياس ببرنامج كينوفيا للمدى الحركي للرقية في المستوى الآمائي.

الأشخاص: 64 شخصًا صبحًا من طببة متابعة العلاج الطبيعي (42 ذكر - 22 أنثى) تتراوح أعمارهم بين (20-24) سنة بمتوسط (22.4±1.1) ومعدل كتلة الجسم (68.6±6.4).

الطريقة: قد أجريت هذه الدراسة باستخدام كاميرا رقمية وكاميرا محمولة بإعطاء برنامج كينوفيا. وقد قياس المعدل الحركي للرقية في المستوى الآمائي ببرنامج كينوفيا بواسطة محتوى (ب) لدرسة مدى الثبات للمقيم ثم مقارنة قياسات المحتوى ذا أعلى درجة ثبات (ب) مع قياسات المعدل الحركي للرقية في المستوى الآمائي مع قياسات جهاز السي روم.

النتائج: أظهرت النتائج أن معايير الارتباط بين قياسات المدى الحركي للرقية بين منصور ويسارا ببرنامج كينوفيا وبيجلاسي روم كانت قوية موجبة في الوضوء وتحديد، حيث كان معايير الارتباط بين برنامج كينوفيا وبيجلاسي روم لحالة إحصائية عند مستوى ب٠.٠٥ أقل من ٠.٠٠٠.

الخلاصة: يعتبر برنامج كينوفيا له مصداقية في قياس المدى الحركي للرقية في المستوى الآمائي.