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Reliability and Validity of Video Raster stereography in Measuring Pelvic Parameters

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ABSTRACT

Background: Video Rasterstereography device (VRD) has been developed for optical back shape measurement and for biomechanical analysis of spinal and pelvic geometry. The validity and reliability of this device have not previously been examined to pelvic parameters. **Objectives:** To estimate the the validity and reliability of VRD for measuring pelvic parameters in healthy subjects. **Material and Methods:** Thirty healthy subjects from both genders, their age ranged from 19-35 years with a mean of (26.9±4.9) years participated in this study. Two investigators examined the participants by using VRD two hours apart each other on the same patient in the same day. Each investigator made a series of three measurements for each participant to measure pelvic torsion, lateral tilting and inclination; they were examined also by X-ray to test the validity of VDR. **Results:** Significant correlation was found between rasterstereograph and X ray measurements for all pelvic parameters where Pearson's correlation for pelvic torsion, lateral tilting and inclination were (r=0.867, 0.996 and 0.930 respectively). Intra-class correlation coefficient (ICC) that used to investigate intra and inter tester-reliability of all pelvic parameters had value >0.95. **Conclusion:** VRD is a valid and reliable method in a three dimensional evaluation of pelvis and constitute a valuable additional tool to clinical examination and can reduce the harmful effect of repetitive radiograph.

Key words: validity, reliability, pelvic parameters, Video Rasterstereography device.

INTRODUCTION

The pelvis is considered to be the base for the spine, and its anteroposterior orientation affects the sagittal spinal geometry, especially lumbar lordosis. Increased anterior pelvic tilt results in a larger lumbar lordosis, increased slope angle and compensatory increases the thoracic and cervical curves above so that the head is maintained above the feet. Accordingly, a change in the shape or orientation of any anatomic segment will modify the shape and/or orientation of adjacent segments of the spine and pelvis[3].

The relationship between the pelvic parameters and overall spinal alignment may emerge as essential in the evaluation of spinal deformity. The most important thing to have is optimal congruence between pelvic and spinal parameters to achieve an economic posture placing the axis of gravity in a physiologic position. To analyze sagittal balance of a subject, it is fundamental now to include not only the spatial position of the pelvis but also its shape. Correlations between spinopelvic parameters have suggested that, the pelvis is involved in the etiology or pathogenesis of adolescent idiopathic scoliosis, spondylolisthesis[9] lumbar degenerative diseases[1].

Leg-length inequality (LLI) and its effects on the pelvis are considered clinically significant factors in low back pain presentations. The effects of LLI on the pelvis are understood to create torsion in the sagittal and/or frontal planes. The torsion is created by the movement of the innominate anterior on the side of the short leg and posterior on the long leg side. The effects of pelvic torsion create numerous compensatory changes such as postural scoliosis. So pelvic parameters (pelvic tilting, torsion, obliquity) are important clinical outcomes at various situations as scoliosis, back dysfunction and Leg-length inequality conditions[4].

The most extended means of assessment of pelvic parameters have been the use of frequent X-ray examinations that offer static two dimensional analysis for 3-D motion with disadvantages of radiation hazards. Radiological evaluation seems to be superior external evaluation method although it needs standard reference point to be defined and disadvantage of exposure to radiation make hazards of exposure[10]. This fact has raised fears of cancer risk and of possible negative effect on the future health of the patient and the clinician. For this

reason, it is imperative to minimize the use of radiographs and introduce a non-invasive method for assessment.

The new invention of formetric rasterstereography devices are the most advanced tools. It produces graphical, clinical and 3-D motion analytical information about the spine, the pelvis and the posture. The rasterstereography provides clinical information to enhance diagnosis, develop treatments, and document treatment outcomes. It meets the objective developing and producing a radiation-free, fast, and reliable device to complement x-ray measurement systems by using the combination of 3D-shape measurements and biomechanical modeling to reconstruct and display the spine structure and calculate the key spinal and pelvic parameters[7].

A multitude of light sections was projected on the patient's back from a different direction than that of the optical measurement unit. The measurement time was typically reduced to 1/25th of a second, and all sections were simultaneously registered. The patient was examined in a relaxed standing posture. The automatic anatomical landmark localization (vertebra prominence or the spinae iliacae in the pelvic region) was the basis for an automatic reconstruction of the sagittal back and pelvis shape. It was a novel method using ordinary pictures, a digital camera and a slide projector.

One of the disadvantages of all static imaging devices for posture analysis was that it is only possible to get a snap-shot of the posture. Often this snap-shot is influenced by muscular, anatomical and even psychological factors that can result in an undulation of the real posture. So, there is still a need to investigate the intra-rater and inter-rater reliability of the rasterstereography, otherwise the data will be collected are meaningless[5].

The validation of rasterstereography in comparison to radiograph has not been documented in the literature for assessment of pelvic alignment. So, the aims of the study were to investigate rasterstereography device as a tool for measuring pelvic parameters by comparing its measurements with radiological X ray measurements. Also, to investigate inter-tester reliability by comparing the measurements of two investigators, and intra- tester reliability by comparing the repeated measurements of the main investigator of rasterstereography. Accordingly, to develop a noninvasive, objective and 3-dimensional back surface analysis method for assessment of pelvic parameters without exposure to radiation.

SUBJECTS AND METHODS

Subjects

Thirty healthy subjects (19 males and 11 females) from both genders participated in the study after approval by Ethical Committee of the Faculty of Physical Therapy; Cairo University. Participants were recruited from volunteers among students, employees and staff from the Faculty of Physical Therapy. Their age ranged from 19 to 35 years. Informed consent was obtained from all participants. The exclusion criteria were true leg length discrepancy, previous spinal surgery, associated pathologies that may interfere with maintaining an erect standing posture such as cerebellar or inner ear disorders, back pain, fractures or deformities of the lower extremities or the spine[14].

Instrumentation

I- ***X Ray photogrammetry***

Siemens DRX3724HD X-ray machine with tilting table and 12 inch image intensifier, T.V. monitor permitted a final check before exposure was used in the study. The cassettes used were 40 x 30 cm, Kodak X – omatic, regular screen[21].

II- ***Rasterstereography***

Formetric II, Diers International GmbH, Schlangenbad, Germany was used in the study. It was a method based on photogrammetric principles that makes three-dimensional surface analysis. Formetric system includes scan system that including projector and camera, computer, laser printer and isolating transformer[7].

Procedure

I- X Ray procedure

Patients were asked to stand in stocking feet with their feet 6 to 8 inches apart and with knees and hips straight and weight distributed equally on both feet .The technician confirmed that patients' feet were a femoral head–width apart, perpendicular and equidistant to the bucky frame, and that buttocks were lightly touching, but not supported by the bucky frame, (a plumb line was used to assess the levelness of the x-ray. Patients were positioned so that a line connecting their heels would be parallel to the X-ray cassette. All measurements were made on clinically obtained, coronal plane anterior-posterior exposure pelvis radiographs taken on 91-cm (36-in.) film at a 183-cm (72-in.) tube to film distance[13].

II- Formetric Rasterstereography procedure

Each participant was positioned in front of the black background screen at a distance of two meters from the measurement system (more exactly: from the centre of the projection lens). Subject's back surface including upper buttocks lied completely bare to avoid disturbing image structures. For standardization of patient position during rasterstereography measurements, the volunteers were examined in a relaxed, undressed, standing position, shoulders in neutral position, sight directed ahead. They were repeatedly measured in a standardized end expiratory respiratory position and without postural deviation[20,12]. Every investigator made a series of 3 pictures for each volunteer for intra tester reliability test. Before a series was taken, the volunteer was asked to walk 30 paces in the testing area, in an attempt to standardize the postural condition of the participant. The same standing posture for both formetric and radiological laboratory was achieved by standardizing of foot positioning. The volunteers were directed to stand with their feet against specifically placed wooden boards. To insure the best position of the subject, a permanent mark was made on the floor for best lateral and longitudinal position of the person in the form of foot print using marker. Any postural sway was prohibited by avoiding a rigidly erect standing posture by asking person to take relaxed standing position[14].

For inter and intra rater reliability test of measurements, two qualified investigators of 10 years of experiences measured pelvic torsion, lateral pelvic tilting and pelvic inclination on formetric device. Both of them firstly performed a pilot

study to ensure adequate training in utilizing the formetric[9]. The second investigator measured all pelvic diameters two hours later from the measurements of first investigator for the same patient in the same day to validate inter-tester reliability[12].

Data analysis and statistical design

Pearson correlation coefficient was used to compare the measurements of rastersterepgraphy with those of X-ray of pelvic torsion, lateral pelvic tilting and pelvic inclination. Intra-class correlation coefficient (ICC) was used to measure intra-and inter rater reliability of measurements. According to Rosner ICCs less than: ±0.40, indicate poor reliability; ±0.40–0.70, fair reliability; ±0.70- 0.85, good reliability and ±0.85–1.00, excellent reliability[16].The sample size was estimated after conducting a power-analysis[9]. The Level of significance was set at P≤ 0.05).

RESULTS

1. Correlation Analysis

Inspection of table (1), the correlation analysis between the x-ray and rasterstereograph revealed that there was a strong correlation between both, where the r-value equals 0.867, 0.996, and 0.930 for pelvic torsion, laterals pelvic tilting and pelvic inclination respectively. (P-value = 0.0001.) (Table (1) and figures (1, 2, 3)).

Table (1): Pearson correlation coefficient between X-ray and rasterstereograph.

	Pelvic torsion	Lateral pelvic tilting	Pelvic inclination
r-value	-0.867	+0.996	+0.930
P-value	0.0001*	0.0001*	0.0001*

* Significant at α 0.05, r -value: correlation coefficient

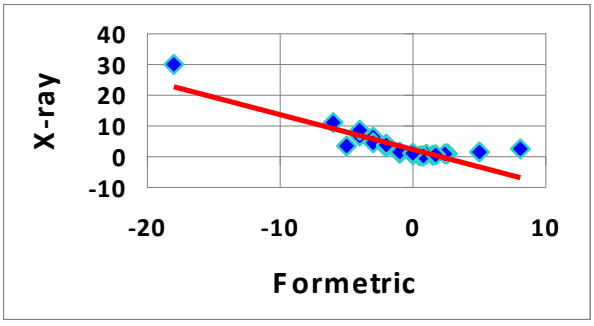

Fig. (1): Correlation between X-ray and formetric rasterstereograph of pelvic torsion.

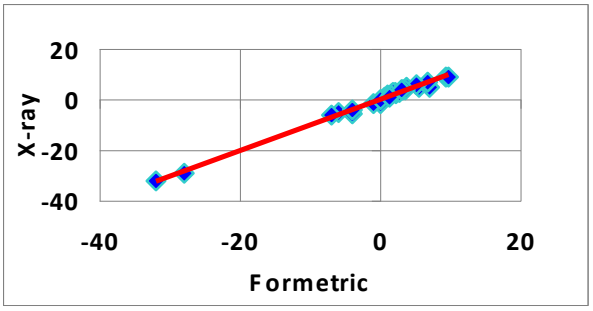

Fig. (2): Correlation between X-ray and formetric rasterstereograph of lateral pelvic tilting.

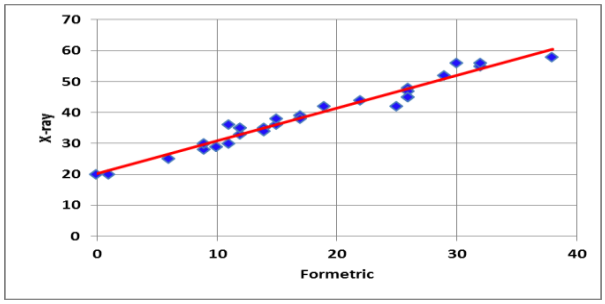

Fig. (3): Correlation between X-ray and formetric rasterstereograph of pelvic inclination.

2. Intra-tester Reliability

Inspection of table (2), the results revealed that, the highest intra-reliability for 1st investigator was 0.997 for lateral pelvic tilting and the lowest was 0.989 for pelvic inclination. While for 2nd investigator, the highest intra-tester reliability was 0.999 for lateral pelvic tilting and the lowest was 0.996 for pelvic torsion. (P-value = 0.0001).

Table (2): Intra-tester reliability for the pelvic torsion, lateral pelvic tilting and pelvic inclination for the two investigators.

Variables	Intra-class correlation coefficient	
	1st investigator	2nd investigator
Pelvic torsion	0.990	0.996
Lateral pelvic tilting	0.997	0.999
pelvic inclination	0.989	0.998

α 0.05

3. Inter-tester Reliability

Inspection of table (3), the results revealed that, the highest inter-tester reliability of the main investigator was found for pelvic torsion with a value 0.999 while the lowest was found for lateral pelvic tilting with a value 0.997. (P-value = 0.0001).

Table (3): Inter-tester reliability for the pelvic torsion, lateral pelvic tilting and pelvic inclination.

Variables	Intra-class correlation coefficient
Pelvic torsion	0.999

Lateral pelvic tilting	0.997
Pelvic inclination	0.998

DISCUSSION

Rasterstereography is an inexpensive, fast, radiation and contact free method to detect and measure the human posture. It is characterized by a high accuracy and gives additional information about spinal parameters. The rasterstereography measurement can be maintained as permanent records of patients in physical therapy and allow the therapist to review and compare pelvic parameters changes in a quantified manner.

The formetric rasterstereograph devices are very helpful tools for physical therapists to evaluate many different disorders that can affect human posture. Based on the findings of the present study, the measurements obtained from rasterstereography were highly correlated with X ray measurement of lateral pelvic tilting (r-value = -0.86), pelvic torsion (r-value = + 0.99) and pelvic inclination (r-value = + 0.93) of normal subjects. These results suggested acceptance of null hypotheses that stated that there was no significant difference between two measurements of normal subjects. These highly correlated measurements may reduce the risk of radiation to persons who need repeated X-rays examinations.

To our knowledge no previous study investigating the validity of Formetric device concerning the measurement of pelvic parameters was found. The findings of this study were in agreement with the concept of many studies that investigating formetric validity for other regions as Hackenberg et al. 2003 who demonstrated an excellent correlation between X-ray measurements and measurements made with rasterstereography of patients with severe idiopathic scoliosis. 5.8 mm for the lateral deviation and 4.8˚ for vertebral rotation. Following posterior correction the accuracy was good. The root mean square difference was 4.5 mm for the lateral deviation and 4.3˚ for vertebral rotation. Using the parameters of lateral vertebral deviation and vertebral rotation, rasterstereography accurately reflected the radiograph measured progression of idiopathic scoliosis[7]. Weiss and Elobeidi confirmed that video rasterstereography can be used for prognostication of a kyphosis patient. They found significant Pearson correlation of 0.78 between Average Kyphosis angle assessed by X ray and kyphosis angle assessed by rasterstereography[20].

Intraclass correlation coefficient (ICC) was performed to indicate intra rater reliability for pelvic torsion, lateral pelvic tilting, pelvic inclination of normal subjects where 0.990, 0.997 & 0.989 respectively for main investigator. ICC was performed to reveal inter rater reliability between the two investigator where 0.999 for pelvic torsion, 0.997 for lateral pelvic tilting & 0.998 for pelvic inclination.

The results of the current study demonstrated that all ICC values for all pelvic parameters have ranged from 0.989 to 0.990. Interpreting ICC and defining values of ICCs which could be considered as the minimum for acceptable reliability was an arbitrary process. Various authors have made recommendations. For example, Hayes et al., 2001 had suggested that ICC value of 0.4 – 0.75 was considered as good reliability and > 0.75 was considered as excellent reliability[8]. While Jordran et al. considered the lower limit of accepted reliability to be higher than 0.6.This explains that the lower limit of acceptable ICC value is dependent upon the purpose of the study according to the authors' point of view[9]. This could be attributed to both high accuracy and precision of optoelectronic system utilized, as well as the short duration and automatic localization of anatomic landmarks[20].

In contrast to validity which has not been investigated before on pelvic parameters , the reliability of formetric device was conducted on only one study for patients of low back pain dysfunction , so the results of current study were in agreement with previous study of [17] who tested only intra-tester reliability of three repeated trials of pelvic parameters revealed high mean of Pearson correlation and ICC which ranged from 0.62 to 0.99 for pelvic inclination, torsion and tilting[17].

According to the literature review, there were a variety of methodological concerns with reported reliability studies in the literature. For example, many investigations utilized only one examiner and it was possible that this examiner could have made gross mistakes from one examination to the next, causing poor intra-examiner reliability. Statistically, therefore, more than one examiner was needed to average any artificially low or high intra-examiner data, which would provide a more reasonable mean. It has been suggested that a minimum of two examiners each performing an analysis at least twice was needed for any conclusions to be drawn about inter- and intra-examiner reliability[8]. In the current study, this recommendation has been followed.

In this study, a very high reproducibility of measurement with respect to the intra tester reliability was demonstrated. These results agreed with the reliability of other studies which tested reliability on other region as: [6], who found ICC of kyphotic angles were from 0.98 to 0.99 in a collective of 10 healthy volunteers. Our results concerning the intra tester reliability were approximately the same as those of [6] could be classified as excellent[6]. While ICC of intra and inter rater reliability were excellent, the higher value of ICC of inter rater reliability in comparison to ICC value of intra rater reliability may be attributed to decreasing ability of subjects to follow instruction given to them regarding the maintaining of erect posture with repeated commands.

Further researches are needed for assessment of diseased volunteers with spine disorders or other orthopedic spine pathologies using rasterstereographic method.

CLINICAL IMPLEMENTATIONS

The findings of the current study provides insights into the utilization of Formetric rasterstereography as a part of physical therapy program design for 3-D pelvic assessment without exposure to radiation hazards.

CONCLUSION

Rasterstereography device is non-invasive, valid and reliable method for intertester and intratester examination of healthy volunteers. It can constitute a valuable additional tool to clinical examination in physical therapy clinics and reduce the harmful effect of repetitive radiograph.

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الملخص العربي

صلاحية وموثوقية راستيرستيريوجرافي في قياس معلمات الحوض

الخلفية : لقد تم تطوير جهاز راستيرستيريوجرافي ثلاثي الأبعاد لقياس شكل بصري للظهر ولتحليل النشاط الحيوي في العمود الفقري والحوض . لم يسبق فحص مدى صلاحية وموثوقية هذا الجهاز لمعلمات الحوض . **الأهداف :** لتقدير مدى صلاحية وموثوقية ستيريوجرافي لقياس معلمات الحوض في الاشخاص الاصحاء . **المواد والأساليب :** قد اشترك في هذه الدراسة ثلاثون من الأصحاء من كلا الجنسين ، تراوحت أعمارهم بين 19-35 سنة بمتوسط (26.9±4.9) سنة.وقد قام باختبار المشاركين اثنين من الباحثين وذلك باستخدام جهاز الستيريوجرافي وكانت المدة بين قياساتهما ساعتين على نفس المريض في نفس اليوم . وقد قام كل باحث بسلسلة من ثلاثة قياسات لكل مشارك لقياس التواء الحوض ، زاوية انحدار الحوض والميل الجانبي للحوض. كما تم افحص المشاركين بالأشعة السينية وذلك لاختبار مصداقية جهاز الستيريوجرافي . **النتائج :** وجد ارتباط كبير بين قياسات جهازي ستيريوجرافي والأشعة السينية لجميع المعلمات الحوض حيث كان ارتباط بيرسون لالتواء الحوض ، زاوية انحداره والميل الجانبي للحوض (ر= 0.867 ، 0.996 و 0.930)على التوالي . وكان معامل الارتباط إينتيركلاس التي تستخدم للتحقيق داخل و بين اختبار موثوقية لجميع المعلمات الحوض لها قيمة > 0.95 . **الاستنتاج :** جهاز راستيرستيريوجرافي طريقة صحيحة وموثوق بها في التقييم ثلاثي الأبعاد للحوض كما انه يشكل أداة إضافية قيمة للفحص الاكلينيكي ويمكن أن تقلل من الأثر الضار للأشعة السينية المتكررة.

الكلمات الرئيسية : صلاحية ، موثوقية ، معلمات الحوض ، وجهاز راستيرستيريوجرافي .