Appropriate Occiput-wall Distance to Screen for a Risk of Kyphosis

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ABSTRACT

Thoracic kyphosis can be occurred in all age groups, particularly in the current era that the number of elderly is dramatically increased and people spend a long time in excessive flexion posture using a computer or social media. Thus a practical cut-off point to indicate individuals at a risk of kyphosis is important to promote effectiveness of community health care service and minimize serious consequences of kyphosis. This study investigated appropriate occiput-wall distance (OWD) to indicate a risk of kyphosis as compared to a standard Cobb's method in 30 participants, aged at least 10 years, who had different degrees of kyphosis. Participants were assessed for severity of kyphosis using OWD and spinal angles using the Cobb's method. The receiver-operating characteristic (ROC) curves were used to determine an appropriate cut-off point of OWD to determine a risk of kyphosis. The findings indicate that the OWD > 5 cm had the best predictive ability for the risk of kyphosis (sensitivity 92.31%, specificity 76.47% with the ability to correctly classify up to 83.33%). The findings offer a clear cut-off point of a simple and practical tool to early detect the abnormality in many target populations such as school children, office workers and community-dwelling people.

Keywords: Kyphosis, Distance from the wall, X-ray examination

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Introduction

Kyphosis is a progressive condition with excessive backward deviation of the thoracic spine more than 40 degrees (Kado *et al*., 2007). It can be occurred in all age groups, particularly in older adults (up to 40%) due particularly to age-related postural changes (Kado *et al*., 2009). Moreover, a current lifestyle with the reduction of physical activities, and using a computer and social media may facilitate the development of kyphotic spine in younger individuals (Guan *et al*., 2015). Having the condition can introduce various adverse health consequences, such as musculoskeletal pain, diminished pulmonary functions, impaired physical functions, increased risk of falls, dysphagia and increased risk of vertebral fractures, depending upon severity of kyphosis (Kado, 2009; Ailon *et al*., 2015). Therefore, a simple and practical cut-off point to determine individuals with or without a risk of kyphosis is crucial to promote effectiveness of community health care service.

Occiput-wall distance or OWD has been used as a simple tool to screen and monitor severity of kyphosis in many epidemiologic studies (Nishiwaki *et al*., 2007; Siminoski *et al*., 2011; Wongsa *et al*., 2012). The method can easily be executed using two rulers to quantify a perpendicular distance from occiput to the wall (Siminoski *et al*., 2011). However, existing evidence applied different cut-off points to indicate a risk of kyphosis, including the OWD greater than 0 cm (Balzini *et al*., 2003; Bari *et al*., 2004; Siminoski *et al*., 2011) and 5 cm (van der Jagt-Willems *et al*., 2015) without clear explanation as compared to a standard method.

Objective of the study

To investigate an appropriate cut-off point of OWD to indicate a risk of kyphosis using a Cobb's method as a gold standard.

Materials and Methods

Study design and population

This study was a part of a major study aiming to investigate concurrent validity of kyphosis measure using distance from the wall when measured using occiput and C7 as a landmark as compared to a gold standard (Cobb's method). Thus, the study was preliminary and cross-sectionally conducted in 30 participants with different degrees of kyphosis (10 participants/group), as determined using OWD (OWD > 0 cm) (Balzini *et al*., 2003), aged at least 10 years with a body mass index (BMI) between: 18.5-29.9 kg/m^2 (Sangtarash *et al*., 2015). The participants were excluded if they presented signs and symptoms that might affect participation in the study or outcomes of the study i.e., abnormal fat mass at the area of upper back, wing scapular, unstable medical conditions, pain or inflammation in the joints, scoliosis, a condition with contraindication for X-ray examinations (i.e., pregnancy), and leg length discrepancy. Protocols of the study were approved by the Khon Kaen University Ethics Committees for Human Research, Khon Kaen, Thailand (HE592270).

Experimental Protocols

The participants were involved in the study for 2 days. On the first day, they were interviewed and assessed for their demographics (i.e., gender, age and BMI) using a questionnaire, and severity of kyphosis using OWD. On the second day within 7 days later, participants were at a hospital to assess for their sagittal spinal angle using a radiologic Cobb's method. Details of the measurements are described below.

Occiput-wall distance

Participants stood upright as tall as possible against the wall with their head in a neutral position (i.e., the inferior orbital margin and superior margin of the acoustic meatus in a horizontal line), their heels, sacrum and back touching the wall (Antonelli-Incalzi *et al*., 2007; van der Jagt-Willems *et al*., 2015). Then the distance between their occiput and the wall was measured using two rulers, in which the first ruler was placed on the landmark (occiput) and another ruler was used to quantify a perpendicular distance from the wall to the landmark (Siminoski *et al*., 2011). The measurement was performed for 3 trials with a period of rest as needed between the trials. The average distance over the 3 trials was used to categorize the participants into 3 groups according severity of kyphosis, including mild ($\leq$5.0 cm), moderate (5.1–8.0 cm), and severe (>8.0 cm) (Balzini *et al*., 2003).

Cobb's method

The participants were filmed for lateral spinal radiograph over the area of the thoracic spine, covering the area from the 1st thoracic vertebra (T1) to the 12th thoracic vertebra (T12), in an upright standing posture with the shoulder and elbow were positioned at 90° of flexion in order to avoid the thoracic kyphosis image to be overlapped by the upper limbs (Teixeira, Carvalho, 2007). Subsequently, a thoracic kyphosis image was uploaded and calculated for Cobb angle by a well-trained physical therapist by drawing a straight line along the upper surface of the 4th thoracic (T4) vertebral end-plate, and the other line along the lower surface of the 12th thoracic (T12) vertebral end-plate (Azadinia *et al*., 2014). Then the SurgimapSpine software (SurgimapSpine version 1.2, Nemaris Inc, 306 East 15th Street, 1R New York, New York 10003) will automatically generate the Cobb angle based on the intersection of the 2 lines, and the average angle over the 3 trials was used for data analysis (Wu *et al*., 2014; Suwannarat *et al*., 2017).

Statistical Analysis

Statistical analyses were performed using the SPSS program (SPSS Statistics version 17.0, IBM Corporation, 1 New Orchard Road Armonk, NY, USA, serial number: 5068054). The descriptive statistics (mean ± standard deviation [SD]) were used to explain demographics and findings the study. The Chi-square test and the one-way analysis of variance (ANOVA) were used to analyze the different findings among the 3 groups for categorical and continuous variables, respectively. The receiver-operating characteristic (ROC) curves were further utilized to explore an optimal cut-off point, sensitivity, specificity and ability to correctly classify of the OWD to indicate a risk of kyphosis of the participants when compared to the findings from the Cobb's method. A level of significant difference was set at $p<0.05$.

Results

Most participants were females, with an average Cobb angle at 39.15±10.00 degrees. Table 1 presents demographics and findings of the study. Except for BMI, the participants showed significant difference of all variables among the groups ($p<0.001$, Table 1). Data from the ROC curves indicated that the use of OWD greater than 5 cm was able to detect a risk of kyphosis with the ability to correctly classify at approximately 83% (Table 2).

Table 1 Demographics and severity of kyphosis of the participants

Variable	Participants (10 participants/group)			p-value
	≤ 5.0 cm	5.1-8.0 cm	> 8.0 cm	
Gender: male/female (n) [a]	3/7	8/2	1/9	0.004*
Age (years) [a]	70.1±17.1	31.2±18.3	68.3±19.2	<0.001*
Body mass index (kg/m^2) [a]	23.22±2.7	23.17±2.3	24.90±4.3	0.407
Occiput-wall distance (cm) [a]	2.73±0.9	6.47±0.8	10.03±1.4	<0.001*
Cobb angle (degrees) [a]	29.23±1.8	36.83±4.0	51.37±4.8	<0.001*

Note: [a]Data are presented using mean±standard deviation, and compared using the Chi-square test and the one-way analysis of variance (ANOVA), * significant differences

Table 2 Cut-off points, sensitivity and specificity of occiput-wall distance (OWD) for the risk of kyphosis

OWD (cm)	**Average distance** (mean±SD)	**Sensitivity** (%)	**Specificity** (%)	**Correctly Classified** (%)
≤ 5.0	2.73±0.9	100.00	35.29	63.33
5.1-8.0	6.47±0.8	92.31	76.47	83.33
> 8.0	10.03±1.4	38.46	100.00	73.33

Discussion

Apart from treatments, a simple and practical assessment to early detect and screen individuals at a risk of kyphosis is crucial to minimize harmful consequences of the kyphosis. Therefore, this study investigated an appropriate cut-off point of OWD to indicate a risk of kyphosis as compared to a standard Cobb's method. Consider the situation where participants were already correctly classified into a group with or without kyphosis using data from the Cobb's method, the results suggests that the OWD greater than 5 cm was more appropriate to screen individuals at a risk of kyphosis (sensitivity 92.31%, specificity 76.47% with the ability to correctly classify up to 83%) than that greater than 0 cm (Table 2).

Normal thoracic angles range between 20 and 40 degrees, and the thoracic curvature greater than 40 degree is commonly regarded as a threshold for kyphosis (Kado *et al*., 2007). The increment of thoracic spinal angle results in increased perpendicular distance from the occiput to the wall when an individual stood against the wall due to

compensatory distance of spinal kinematic linkage. Findings of the current study indicated that participants with OWD > 0 cm had an average spinal (or Cobb) angle at 29 degrees which is accounted as normal thoracic curvature (Table 1). Those with OWD > 5 cm had a thoracic angle approximately 37 degrees which is closely to a threshold of having kyphotic spine (Kado *et al*., 2007). However, for OWD > 8 cm, the results indicated that the participants already had thoracic kyphosis (the average Cobb angle was 51 degrees, Table 1). Therefore, the findings indicated the use of OWD > 5 cm to screen individuals with a risk of kyphosis (correctly classify 83.33%, Table 2).

Community health care service is emphasized nowadays as an important tool to promote equitable access to health care service and health for all. Findings of the study offer a clear cut-off point to indicate a risk of kyphosis using a simple and practical tool which is a crucial integral part of kyphosis managements. The finding may benefit standardization and promote effectiveness of primary care service for kyphosis management in many target populations such as school children, office workers and community-dwelling people. However, gender and age are important risk factors for kyphosis, thus the findings may be confounded by the significant difference among the groups for these variables. A further study that includes a greater number of participants may help to minimize or clearly indicate effects of these confounding factors. In addition, a study to formulate a predictive formula to convert data from OWD to thoracic angle may promote data comparison among the studies that assess severity of kyphosis using OWD and spinal angles.

Conclusions

This study investigated appropriate OWD to indicate a risk of kyphosis as compared to a standard Cobb's method in 30 participants. The findings suggested the use of OWD greater than 5 cm to screen a risk of kyphosis. The findings confirm the use of a simple and practical tool to promote standardization and effectiveness of primary care service for kyphosis management, particularly in a current era that many individuals face with a risk of kyphosis.

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