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Kyphosis and Carrying Angle: Prevalence and correlation between anthropometric features

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Abstract

Introduction: Kyphosis is the spinal curve that causes the top of the back to seem abnormally rounded. Carrying angle can be measured with the upper limb being fully extended. The study aim was determining the mean and correlation between kyphosis and carrying angle with demographic factors in medical students of Guilan University of Medical Sciences.

Materials and Methods: In this observational study, we assessed asymptomatic young adults in their first three years of enrollment in medical school. The participants had neither current nor a history of spinal or upper arm injuries. Kyphosis and carrying angle were measured by using the Debrunner kyphometer and goniometer, respectively. We also measured anthropometric features such as weight and height.

Results: We studied 217 medical students (M/F= 1.17/1), with a mean age of 21.43±2.06. Kyphosis has a statistically significant negative correlation with height, weight, and carrying angle of both dominant and non-dominant upper limbs. We found kyphosis to be greater in female than in male participants. Carrying angle was greater in the dominant upper limb than the non-dominant upper limb. Dominant upper limb carrying angle was also positively correlated with height and weight.

Conclusion: In asymptomatic young adults with no history of spinal diseases, anthropometric features such as height and weight impact kyphosis angle. It seems that kyphosis is greater in females. Severe changes in kyphosis angle may cause loss of sagittal orientation. We suggest that people at risk of kyphosis be screened in early adulthood to prevent the increase of kyphosis and its subsequent complications.

Keywords: Kyphosis, Carrying angle, Asymptomatic young adults, Anthropometric features

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Introduction

The back is described as the posterior aspect of the body and provides the trunk with a musculoskeletal axis (1); The main component of the back is the vertebral column which consists of 33 vertebrae and is divided into cervical, thoracic, lumbar, sacral, and coccygeal regions (1).

In the coronal plane, the vertebral column is positioned in the body's midline. When viewed in the sagittal plane, it has a number of curvatures. The primary curvature is an outward curve reflecting the embryo's kyphotic posture. This kyphotic curve remains in adults' thoracic and sacral regions (1).

The two secondary curvatures, which are formed in the cervical and lumbar regions, are inward curves; they occur as one holds up its head and stands upright, respectively. These, along with the primary curves, bring the body's center of gravity into a vertical line, which leads to maintaining an upright bipedal stance with the least amount of muscular energy (1,2).

The spinal curve that causes the top of the back to seem abnormally rounded is described as kyphosis (2). Kyphosis has several etiologies; it can occur due to developmental anomalies such as Scheuermann's disease, or it can be congenital(3). Secondary etiologies include trauma, degenerative disc disease, inflammatory disease, muscular and neuromuscular diseases, tumors and pathologies, osteoporotic burst or compression fractures(4). Kyphosis may also develop due to iatrogenic reasons such as inappropriate surgical procedures resulting in the flatback phenomenon or post-laminectomy syndrome (5). Regardless of the etiology, the eventual outcome is loss of sagittal orientation resulting in back pain, instability of the spinal structure, or clinical deformity.

Several factors may alter the thoracic kyphosis degree. These include anthropometric features (6,7), BMI (8), gender and age (6), performing exercise (9,10),

Mid-High-Heeled Footwear (11), transporting an infant (12) or a backpack (13,14).

Most of the papers studying kyphosis are related to scoliosis, lumbar lordosis, or other deformities related to the etiology and surgery of kyphosis (15–17). Some studies showed that the spinal column could be considered a linear chain linking the head to the pelvis. With the change of each vertebral curve, the rest of the curves try to change along to maintain the linear chain and orientation of the spinal column (18). Another body anthropometric feature that may also impact thoracic kyphosis is elbow carrying angle; neither its average value has been studied in our community nor its correlation with thoracic kyphosis.

When the elbow joint is fully extended, the forearm and arm will not align in a straight line. The long axis of the extended forearm lies at an angle to the long axis of the arm. This angle, which opens laterally, is called the carrying angle and is about 10° in the male and 13° in the female. The angle disappears when the elbow joint is fully flexed (19).

The presence of anthropometric information in different races and regions of the world about the natural range of thoracic kyphosis and the carrying angle may be helpful to the clinicians in planning the correction of skeletal deformities and assessing the related pathological conditions. Medical clinical procedures are based on descriptive and epidemiology data. There is no epidemiological information on the prevalence of kyphosis and the carrying angle in Guilan province, especially among medical students. On the other hand, the sitting patterns of most of the students are incorrect when they are studying. To our knowledge, no study has yet evaluated the thoracic kyphosis and elbow carrying angle and the relationship between them in the medical students. Therefore, this study investigates the carrying angle, kyphosis, and their relationship with demographic factors in the first three years of asymptomatic medical students.

Materials and Methods

This observational study was carried out on 217 asymptomatic young adults who were randomly recruited from their first three-year medical students. The participants consisted of 100 females and 117 males, and their ages ranged from 18 to 32 years old. Inclusion criteria were: medical students in the first three years of their study, absence of current or history of spinal column or upper arm fracture or disease. Exclusion criteria were: history of spinal column or upper arm fractures or diseases.

The study was approved by the ethics committee of Guilan University of Medical Science (No: IR.GUMS.REC.1397.162). The purpose of the study was explained to all of the participants, and they signed an informed consent form.

Kyphosis was measured using Debrunner kyphometer and the carrying angle using goniometer following the methods, which will be explained in the following.

The Debrunner kyphometer consists of two parallel arms connected with a 1° scale protractor. The reliability and validity of this device are considered to be high, with intra-rater reliability of 0.98 compared to the Cobb angle (20). On each of the other ends of these two arms is a block that will be placed on spinous processes of the upper and lower limits of the thoracic spine, and the kyphosis degree appeared subsequently on the protractor to be read. The spinous processes were localized by palpation. The examiner localized the C7 spinous process; the subject was asked to look down and then look forward again slowly. The most prominent process at the lower end of the neck is the C7, and a marking was done by a pen. The T12 spinous process was then localized by counting down the spinous processes with the subject asked to lean forward and round its back outward and towards the examiner. The T12 is about four vertebrae beneath the end point of scapula. Again, a marking was done with a pen. Following the marking, the subject was asked to stand barefoot in a neutral posture with the arms swinging at the sides and was then asked to look forward. The end blocks of the upper and lower arms were directly placed over the C7 and T12 spinous processes, respectively; the kyphosis angle that appeared on the protector was read subsequently. Each measurement procedure was repeated twice, and if any of the three measurements differed by more than 5°, all three markings and measurements were repeated. The average was the primary value (20).

In order to measure the carrying angle, the subject was asked to stand in anatomical position; the elbow extended completely and the forearm supinated fully. The goniometer's upper arm and lower arm were aligned with the direction of the subject's upper arm and forearm, respectively. Then, the angle on the measurement plate placed on the elbow was read. The measurement was done on each side three times to minimize measurement errors, with the average being the primary value (21). Height and weight were recorded for BMI assessment. All the information was recorded for further evaluations.

The research team received the same measurement protocol instruction from the anatomic faculty member (M. Faghani), including skeletal anatomy review; instruction in finding landmarks by palpation; illustration of how to place the kyphometer and read the kyphosis angle on the device's protractor; illustration of how to place the goniometer and read the carrying angle on the instrument's measurement plate.

The data are represented as mean ± standard deviation (SD). Statistical analysis was performed using SPSS 21 (SPSS Inc, Chicago, IL, USA). Analysis of the difference between mean values of the groups was performed using T-test and One Way ANOVA. A P value smaller than 0.05 was considered meaningful. The correlation between qualitative and quantitative variables was assessed through Chi-square and Pearson's Correlation Coefficient, respectively. The difference between the groups in terms of kyphosis and carrying angle and clinical parameters and the correlation and relationship between kyphosis and carrying angle and the dominant upper limb were analyzed.

Results

217 medical students, including 117 men (53.9%) and 100 women (46.1%), participated in this study. The participants were 18-27 years (21.43 ± 2.06). 129 participants had a BMI of 19-25 (table1). 89.9% of the participants were right-handed, and 10.1% were left-handed. The mean and SD of carrying angle in the dominant upper limb was 14.26 ± 4.5 (max 26.67, min 4.33).

Table 1. Demographic information of medical students of Guilan University of Medical Sciences in this study.

Variable	Condition	Number	Percent
Gender	Male	117	53.9%
	Female	100	46.1%
Age	21 or less	126	58.1%
	More than 21	91	41.9%

Mean Age ± SD (min – max)		21.43±2.06 (27-18)	
BMI	19≥	29	13.4%
	25 – 30	45	20.7%
	30<	14	6.5%
Mean BMI ± SD (min-max)		23.22±3.82 (15.97-40.56)	
Mean Height ± SD (min-max)		171.4±9.29 (195-152)	
Mean Weight ± SD (min-max)		68.55±14.28 (42-122)	
Dominant Upper Limb	Right	195	89.9%
	Left	22	10.1%

We found a statistically significant difference between the degree of the carrying angle of the dominant and non-dominant upper limbs using T-test (t= 5.4, P= 0.0001); the carrying angle was found to be greater in the dominant upper limb (Mean±SD=14.26±4.5) compared to the non-dominant upper limb (Mean±SD=12.11±3.74).

Using Chi-square, the data revealed a statistically significant relation between kyphosis and gender (P=0.0001), but no relation between kyphosis and age (P=0.456) or BMI (P=0.606). Kyphosis was found to be greater in women than men (Table 2).

Table 2. Comparison of kyphosis in medical students according to demographic characteristics.

Variables	Groups	Kyphosis>25°		Kyphosis<25°		P value
		Number	Percent	Number	Percent	
Gender	Male	33	28.2%	84	71.8%	P=0.0001
	Female	76	76%	24	24%	
Age (years)	21≥	66	52.4%	60	47.6%	P=0.456
	21<	43	47.3%	48	52.7%	
BMI	19≥	13	44.8%	16	55.2%	P=0.606
	19-25	67	51.9%	62	48.1%	
	25-30	24	53.3%	21	46.7%	
	30≤	5	35.7%	9	64.3%	
Dominant Limb	Right	98	50.3%	97	47.7%	P=0.982
	Left	11	50%	11	50%	

We found a negative correlation between kyphosis and height (P=0.0001) and weight (P=0.0001) of the participants; a decrease in both height and weight was correlated with an increase in kyphosis (Table 3). In addition, we found that the increase in the weight (P=0.0001) and height (P=0.0001) of the medical students in this study was correlated with an increase in the carrying angle of the dominant upper limb (Table 3).

Table 3. The correlation between kyphosis, dominant upper limb carrying angle with some quantitative variables of demographic characteristics.

Variables		Kyphosis angle	Dominant Upper Limb Carrying Angle
Age (year)	Pearson Correlation	-0.124	-0.1
	P-Value	P=0.069	P=0.144
	correlation	No correlation	No correlation
BMI	Pearson Correlation	-0.006	0.132
	P-Value	P=0.93	P=0.053
	correlation	No correlation	No correlation
Height (cm)	Pearson Correlation	-0.45	0.4
	P-Value	P=0.0001	P=0.0001
	correlation	Negative correlation	Positive correlation
Weight (kg)	Pearson Correlation	-0.237	0.309
	P-Value	P=0.0001	P=0.0001
	correlation	Negative correlation	Positive correlation

The analysis of data with Pearson's Correlation Coefficient revealed a negative correlation between the kyphosis and the carrying angle of the both dominant (P=0.0001) and non-dominant (P=0.01) upper limbs of the participants; which means the increase of kyphosis was correlated with the decrease of the carrying angle in both dominant and non-dominant upper limbs of the participants (Figure1).

As a means to predict kyphosis using multivariate regression, all variables related and correlated to kyphosis were put into a prediction model. The results showed that the height and the dominant upper limb carrying angle have an intervening and predictive role (Table 4). Therefore kyphosis can be predicted using the following formula:

Kyphosis= 81.28 -0.311×height(cm)- 0.327×dominant upper limb carrying angle.

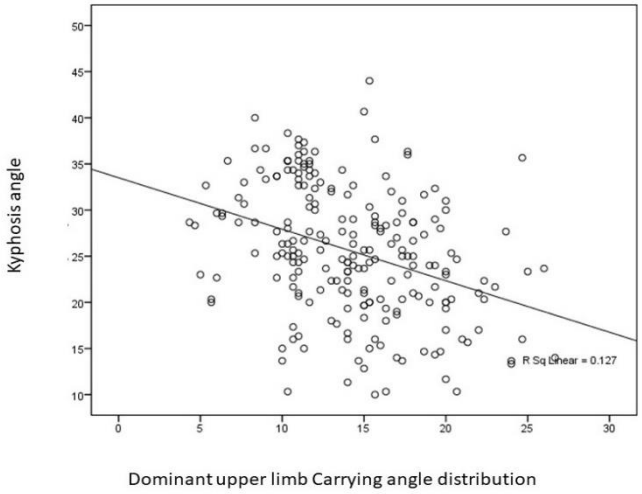

Figure 1. Distribution diagram and regression line of Kyphosis Angle with Dominant Upper Limb Carrying Angle Distribution.

Table 4. Correlation of the demographic characteristics and kyphosis in adjusted and unadjusted multiple logistic regression model.

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	**81.289**	**9.141**		**8.893**	**0.000**
Height (cm)	**-0.311**	**0.062**	**-0.409**	**-5.055**	**0.000**
Weight (kg)	**0.036**	**0.038**	**0.073**	**0.957**	**0.340**
The angle of deviation of the dominant hand (degrees)	**-0.327**	**0.137**	**-0.209**	**-2.385**	**0.018**
The angle of deviation of the non-dominant hand (degrees)	**-0.018**	**0.155**	**-0.010**	**-0.118**	**0.906**

a. Dependent Variable: Kyphosis angle

Discussion

This study assessed the kyphosis angle and carrying angle of 217 medical students aged 18-27 years. The relation between these two parameters and other anthropometric features was examined. The participants' demographic information included their age, gender, height, weight, BMI, and dominant limb. Statistical analysis using the T-test, revealed a statistically significant difference in the carrying angle of the dominant upper limb compared to the non-dominant upper limb (t= 5.4, P= 0.0001). This finding was in line with the results of Yilmaz et al, who found that the carrying angle of the dominant arm was significantly higher than the non-dominant upper limb, regardless of gender (22).

Our study also suggests that gender, BMI and age has a statistically significant relationship with the degree of kyphosis (P=0.0001). One review study had findings that conflicted with our results, in that they found no differences between genders and kyphosis (23). This difference can be attributed to the study population, as ours only included medical students, in their first three years of enrollment, in a single university. In contrast,

Zappalá et al. (23) analyzed 34 studies in a meta-analysis with participants of various ages and ethnicity. Their study was mainly aimed at the relationship between thoracic curvature and age, gender, and race.

A strong negative correlation between the kyphosis and the carrying angle in both dominant and non-dominant upper limbs was noted. Also, a negative correlation was found between kyphosis and height and weight and a positive correlation between the carrying angle and the height and weight. Kyphosis was greater in female participants, and the carrying angle was greater in the dominant upper limb than in the non-dominant upper limb. The findings of Ruparelia et al. was similar to our study (24) who found that height had a significant correlation with carrying angle. Some studies showed that abnormal behavior such as carrying heavy objects or heavy backpacks in children, incorrect sitting or standing position can effect on the human posture (12,13). Of note, different industries can make products by using the country's anthropometric and ergonomic features to make the better equipment needed by offices, schools, and universities. Awareness of body posture changes in children and adolescents may help prevent the occurrence of musculoskeletal diseases, back pain, and degenerative changes in the spine.

One exciting aspect of our results was the predictive model for kyphosis, which was achieved through multivariate regression. The model, which shows the predictive and intervening role of height and dominant upper limb carrying angle, can potentially be helpful in application after assessing its accuracy and reliability in follow-up studies. One such potential use could predict the thoracic kyphosis in a clinical setting where neither radiographic studies nor Debrunner kyphometer is available.

There were some limitations to this study, including the small population, which only included young medical students in a single center. Conducting the study in a larger population with a broader range of ages would result in different outcomes.

Conclusions

Overall, our findings indicate that the carrying angle of the dominant upper limb is greater than the non-dominant upper limb, gender has a statistically significant relation with kyphosis degree, and the kyphosis angle is negatively correlated with carrying angle of both upper limbs. Our findings in this study show that height and weight have a negative correlation with kyphosis and a positive correlation with the carrying angle of the dominant upper limb. We suggest that people who are at risk of developing kyphosis should be assessed during early adulthood to prevent kyphosis angle from increasing, as well as to reduce the potential complications the increase of kyphosis and carrying angle can cause, such as loss of sagittal orientation, back pain, instability of the spinal structure, and clinical deformities.

Author contribution

MF supervised and managed the project and also edited and revised the manuscript. **DRN** , **ShR** , **AK** collected the data and wrote the primary draft of the manuscript.

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Conflict of interest

There are no potential conflicts of interest.

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