

Morphological Study of the Pelvis and Vertebral Column in University Dance Major Students

Estudio Morfológico de la Pelvis y la Columna
Vertebral en Estudiantes Universitarios de Danza

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SUMMARY: The purpose of this study was to investigate the pelvis and spine of university dance major students. The spine and pelvic morphology were measured in 32 students (eight ballet, eight Korean dance, and eight modern dance) and eight general studies students. using dual energy X-ray absorptiometry and Formetric III 4D. First, as a result of measuring the front and rear tilt, a back tilt of the torso was found in all groups. Second, measurement of the left and right tilt of the spine showed a tilt to the right, and the angle and distance of the tilt were $1.25 \pm 1.16^\circ$ and 10.5 ± 9.3 mm, respectively in the ballet major group. Third, the kyphosis angle was the highest in the Korean dance students, exceeding the normal range (ballet: 46° , Korean dance: 54° , modern dance: 47° , general department: 49°). Although, there was no significant difference among the groups, but the spine and pelvic morphology were measured in different forms (shapes) according to the majors. Therefore, according to the major, the movements used to affect the shape of the spine and the pelvis are considered to change. This suggests that follow-up studies are needed. If the displacement is severe due to the movement, pain may occur and it is necessary to study how to identify the pain area when the pain occurs.

KEY WORDS: Spine; Pelvic; Kyphosis angle; Dancer.

INTRODUCTION

Dance is an expressive art that conveys emotions through body movement (Homan & Tylka, 2014). Although there are various types of dance in Korea, they can be divided into ballet, modern dance, and Korean dance (Bastug, 2018). Students in the majors repeat overuse and one-sided movements over a long period of time to improve the degree of completion of their movements, and the use of these movements affects the alignment of the spinal cord (Golomer & Féry, 2001). The spinal cord is in correct alignment when the cervical-lordosis, thoracic-kyphosis, and lumbar lordosis angles are normal (Golomer & Féry).

For dance majors, rapid rotation, sudden change of direction, and practicing technical movements based on excessive flexibility have a negative effect on the alignment of the spinal column, and ulcer deformation causes torsion of the pelvis (Homan & Tylka). In the event of displacement of the pelvis, which is the central part of the body where the connection and balance ability of the upper and lower limbs are mutually occurring, various movements, such as flexion, denunciation, and rotation may be restricted (Lee *et al.*, 2019).

Therefore, if the pelvis is twisted and the spine is displaced, pain such as muscle cramps can occur when performing an action, and dancers exacerbate back pain when they use their feet to turn outward (external rotation, external rotation) such as jumping, or in excessive expansion (hyperextension), and turn-out (Gottschlich & Young, 2011). Specifically, the turn-out positions frequently used by dance majors are likely to cause spinal and pelvic displacement by rotating the hip joint out of the normal range (Malkogeorgos *et al.*, 2013) and the prolonged repetition of dance movements increases the likelihood of backbone, pelvic, and hip injuries (Twitchett *et al.*, 2008).

A previous study compared an art high school dancers majoring in Korean dance between ballet of the pelvic displacement (Bastug). The length of the pelvic bone was measured by X-ray and the possibility of pelvic bone displacement was analyzed for internal displacement and external displacement of the pelvic bone (Jacobs *et al.*, 2012). Another study compared the pelvic displacement of dance majors to ordinary students (Steinberg *et al.*, 2017). The

length and width of the pelvic bone were measured and compared with X-ray (X-ray) imaging and measurements, and the internal rotation, external rotation, and external rotation according to the width of the pelvic bone were compared. The study reported that Korean dance college students had more variations than ordinary students. Students majoring in dance often start dancing in the lower elementary school grades with the aim of entering art middle and high schools or joining a dance troupe.

It is highly likely that the girls who performed dance moves that required excessive flexibility at a young age, practiced dance moves before the age of 10 – 12 (Lee, 2019). When spinal development was complete. Studies on the effects of such excessive use of motion on body imbalance have been reported in various fields. This study aimed to measure the spinal cord and pelvic forms of university students who currently attend university and have practiced dance since they were young and compare them to general studies students to see if the specific behavior characteristics affected the body shape of the students.

Therefore, the purpose of this study was to help each major collect physical alignment data in an effort to facilitate the prescription of appropriate rehabilitation programs for subsequent pain.

MATERIAL AND METHOD



The study was conducted on 32 students with 24 dance majors (eight Korean dance majors, eight modern dance, and eight ballet) and eight general studies students. Each major group was targeted at students with more than 10 years of experience, and the general characteristics of the collected subjects are presented in Table I.

Formetric III 4D. Physical alignment measurements were performed using a three-dimensional image processing device (Formetric III 4D) to measure hip torsion angle. The equipment provides fast and accurate measurements (0.04 to 6 seconds), has no risk of radiation exposure from the use of halogen lamps, and can predict treatment effects with the Simulation Platform function.

It also provides high reproducibility, objective data, and enables the diagnosis of postures and scoliosis through side 2 correction (Hierholzer *et al.*, 1994). First, the subjects took a picture with their top off, their backs facing the camera, and their whole body relaxed. The images are collected in 0.04 seconds, and the photographic analysis of the person to be photographed was automatic. The form is analyzed very accurately on the back surface because the error of the model formed by the filming is only about 0.05 mm.

Dual-energy X-ray absorptiometry. Physical composition tests were conducted using dual-energy X-ray absorptiometry (DEXA, Hologic ZDR 4500, USA) to evaluate the subjects' age, weight (kg), and height (cm). For the measurements, the subjects were measured with all attached metal removed, and top undressed. The test was started 10 minutes after stabilization. The measurement equipment is as shown in Table II.

Table II. Measuring tool and variables.

Measuring tool	
Formetric III 4D	
Dual-energy X-ray Absorptiometer, USA	
Variables	
Body composition	_ Height, Weight, Age _ Height, Weight, Age _ Trunk inclination (°) (mm)
Spine and pelvic form	_ Trunk imbalance (°) (mm) _ Pelvic tilt (°) (mm) _ Pelvic torsion (°) _ Thoracic kyphosis (°)

All the results obtained in this study were calculated using the SPSS/PC 20.0 statistical program. One-way ANOVA was performed to identify the differences in the variables between the groups. If there were significant differences between the groups, then Bonferroni's (least signal selection) test was used for post-validation. The hypothesis significance criterion was an alpha level of 0.05.

Table I. General characteristics of the collected subjects.

Variables	Ballet (n=8)	Korea (n=8)	Modern (n=8)	Normal (n=8)
Career (years)	11.50±1.77	14.00±3.50	11.25±1.58	
Age (years)	21.85±1.34	23.57±1.39	21.57±1.71	22.02±1.15
Weight (kg)	56.57±5.74	54.57±3.30	54.85±3.38	57.57±3.95
Height (cm)	165.14±3.53	163.85±4.74	167.42±5.02	164.85±3.62

RESULTS

The physical composition measurement results for the college students with more than 10 years of experience in dancing showed that the students majoring in ballet were the tallest among the ballet, modern dance, Korean dance, and general studies majors and the Korean dancers weighed the most (Table I).

Four students from the Korean dance group, one from the modern dance group, and one from the general studies group showed forward tilts, whereas the ballet major group was all measured in a backward-moving form. The tilt angle in ballet students was $-3.87 \pm 2.1^\circ$ and $-0.87 \pm 2.85^\circ$ in the Korean dance students with no significant difference between the two groups ($P > 0.19$). There was no significant difference in the distance measurements between the ballet (-32.12 ± 17.34 mm) and Korean dance (-7.87 ± 26.19 mm) groups ($P = 0.23$) (Table III).

A tilt to the right was seen in all groups, seven students in the Korean dance group, five in the modern dance group, two in the ballet majors, and four in the general studies group. Measurements of the left and right tilt angles of the torso showed that the two groups differed a lot from the slope angle to Modern dance students ($1.25 \pm 7.00^\circ$) and Korean dance students ($0.5 \pm 0.53^\circ$), but the difference was no significant ($P = 0.351$). The ballet and Korean dance groups showed the biggest differences between the groups, of the measurements of the left and right tilt distance of the torso, at 10.50 ± 9.30 (mm) and 5.25 ± 3.80 (mm), respectively, with no significant difference in any group ($P = 0.07$) (Table IV).

The angle between the line connecting the left and right pelvis and the horizontal line of the lower pelvis was measured. The results showed that seven people in the Korean dance group, four in the modern dance group, three in the ballet major group, and three in the general studies group had a higher right Posterior Superior Iliac Spine (PSIS) than left PSIS, whereas the right pelvis angle in the Korean dance group was higher than in the other groups. As the angle were $P > 0.53$, no significant difference was found in the groups (Table V).

The angle of rotation of the right pelvis in four students in the Korean dance major group, six in the modern dance group, five in the ballet major group, and four in the general studies group was greater than the angle of the front rotation of the left pelvis. Four students in the Korean dance group, two in the modern dance group, three in the ballet major group, and four in the general studies group showed high rotation angles in the left pelvic front angles. There was no significant difference between the groups, but the torsion of the right pelvis was the most common in the modern dance group ($P > 0.88$) (Table VI).

The average angle of the Korean dance group was $54.37 \pm 9.02^\circ$, higher than the normal range angle of $47^\circ - 50^\circ$. The angles in the other groups were in the normal angle range, and no significant difference between the groups was seen ($P > 0.39$) (Table VII).

Lumbar lordotic angle. The normal angle range is $38^\circ - 42^\circ$ and the mean values of all groups were within the normal angle range, so no significant difference between the groups was seen ($P > 0.85$) (Table VIII).

Table III. Trunk inclination.

	Ballet	Korean dance	Modern	Normal	t	p
Trunk Inclination ($^\circ$)	-3.87 ± 2.10	-3.97 ± 2.10	2.00 ± 2.87	-2.87 ± 3.18	1.684	0.193
Trunk Inclination (mm)	-32.12 ± 17.34	-7.87 ± 26.19	-16.12 ± 24.10	-23.25 ± 26.54	1.500	0.236

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table IV. Trunk imbalance

	Ballet	Korean dance	Modern	Normal	t	p
Trunk imbalance ($^\circ$)	1.25 ± 1.16	0.50 ± 5.3	1.25 ± 7.00	1.00 ± 0.75	1.474	0.351
Trunk imbalance (mm)	10.50 ± 9.30	5.25 ± 3.80	9.75 ± 5.00	9.00 ± 4.98	1.152	0.070

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table V. Pelvic tilt.

	Ballet	Korean dance	Modern	Normal	t	p
Pelvic tilt ($^\circ$)	1.62 ± 0.91	2.25 ± 0.46	2.50 ± 1.92	2.37 ± 1.30	0.748	0.530
Pelvic tilt (mm)	2.87 ± 1.64	3.75 ± 1.38	4.87 ± 2.74	3.75 ± 2.12	1.289	0.236

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table VI. Pelvic tilt.

	Ballet	Korean dance	Modern	Normal	t	p
Pelvic torsion ($^\circ$)	2.62 ± 1.06	2.37 ± 1.76	2.87 ± 1.12	2.87 ± 1.72	0.216	0.885

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table VII. Thoracic kyphotic angle.

	Ballet	Korean dance	Modern	Normal	t	p
Kyphosis angle (°)	46.00±14.36	54.37±9.02	47.62±6.23	49.00±9.25	1.023	0.397

*p < 0.05, **p < 0.01, ***p < 0.001.

Table VIII. Lumbarlordotic angle.

	Ballet	Korean dance	Modern	Normal	t	p
Lordosis angle (°)	37.87±11.61	38.37±6.75	37.50±8.05	41.00±8.46	0.253	0.859

*p < .05, **p < 0.01, ***p < 0.001

DISCUSSION

In a study of pelvic displacement and dance injury in high school students majoring in dance (Bastug), the length of the hip bones of the Korean dance majors and ballet majors was measured by X-rays to compare the degree of pelvis twist. The displacement frequency in the ballet students was about 3.6 % higher than in the Korean dance majors. However, this study found that the pelvic torsion angle of the modern dance students was $2.87 \pm 1.12^\circ$ greater than that of the other groups. In the modern dance students, the pelvic torsion is thought to have been caused by compensation to maintain the stability of the upper body because of the various front, back, left and right spinal movements.

The formetric ? 4D, measurement equipment used in the study, shows the ideal angular range of the thoracic kyphosis angle is 47-50 degrees, and the ideal angle range of the lumbar lordosis angle is 38-42 degrees. Thoracic kyphosis angle and lumber lordosis angle measurements of all groups were within range of normal angle according to the formetric III 4D.

In the case of Korean dance, the speed of movement varies. The movement of Korean dance is characterized by lowering the shoulder bone by pressing down on the breathing and applying force to the abdomen (Liederbach *et al.*, 2008), which indicates an increase in the thoracic kyphosis angle. The reason why the largest tilt angles in the front, back, left and right of the torso were seen in ballet majors is thought to be related to movements such as the Arabesque, which straightens the knees and ankles and raises one leg more than 90 degrees from the ground. Therefore, the spinal cord and pelvis morphology of dance majors were measured in different forms, affected by the movements used by the majors.

In particular, the torsion in ballet majors was greater than in other majors, but there was no significant difference between the majors. We could see that the overuse of hyperextension beyond the normal range in the majors affected spine and pelvic torsion.

There should be no pain caused by bone displacement to improve the expressive ability of motion. The data in this study are thought to help dancers by identifying the shape of the skeleton in case of pain for application in rehabilitation programs.

In future research, detailed research should be conducted to compare the pain levels by dividing the categories of dance majors (traditional dance, creative dance). Also, if the presence and degree of pain and the performance of rehabilitation experience are investigated and supplemented by a survey of ballet majors who showed the most noticeable defects, the physical alignment data of the majors in this study will help design appropriate rehabilitation programs by measuring, comparing, and analyzing the shape of the spinal cord and pelvis of students in each major.

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RESUMEN: El propósito de este estudio fue investigar la pelvis y la columna vertebral de estudiantes universitarios de danza. Se realizaron mediciones morfológicas de la columna y la pelvis en 32 estudiantes (ocho de ballet, ocho de danza coreana y ocho de danza moderna) y ocho estudiantes de estudios generales. utilizando absorciometría de rayos X de energía dual y formétrico ? 4D. Primero, como resultado de medir la inclinación delantera y trasera, se encontró una inclinación del torso hacia atrás en todos los grupos. En segundo lugar, la medición de la inclinación izquierda y derecha de la columna mostró una inclinación hacia la derecha, y el ángulo y la distancia de la inclinación fueron $1,25 \pm 1,16^\circ$ y $10,5 \pm 9,3$ mm, respectivamente, en el grupo principal de ballet. En tercer lugar, el ángulo de cifosis fue el más alto en los estudiantes de danza coreana, excediendo el rango normal (ballet: 46° , danza coreana: 54° , danza moderna: 47° , departamento general: 49°). Aunque no hubo diferencia significativa entre los grupos, la morfología de la columna y la pelvis se midió en diferentes formas (formas) según las carreras. Por lo tanto, según la especialidad, se considera que cambian los movimientos utilizados afectando la forma de la columna y la pelvis. Esto sugiere que se requieren estudios de seguimiento. Si el desplazamiento es severo debido al movimiento, este puede generar dolor y es necesario estudiar cómo identificar el área de dolor cuando ocurre.

PALABRAS CLAVE: Columna; Pélvis; Ángulo de cifosis; Bailarina.

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