Original Article

JER

https://doi.org/10.12965/jer.1836280.140

Journal of Exercise Rehabilitation 2018;14(4):643-647

Incidence analysis of axial and lower extremity deviations based on the physical characteristics between domestic and foreign college students

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This research was performed to identify the incidence and to determine the effects of risk factors of axial and lower extremity deformities. One hundred forty-seven domestic college students (102 males and 45 females) and 72 foreign students (33 males and 39 females) were subjects in this study. Data collecting was performed by questionnaire and visual postural evaluation. For backpack shoulder dominance, higher incidences of genu varus (P=0.043) and lower incidence of leg length discrepancy (LLD) (P=0.001) were found in both shoulder carrier, while the incidence of lordosis was higher in left (P=0.001) and both (P=0.012) carrier in domestic students. The incidence of genu varus (P=0.022) and scoliosis (P=0.002) were significantly lower in both shoulder carrier in foreign students. For dominant arm, the incidence of forward head (P=0.001) and of lordosis (P=0.029) were significantly higher in left handedness both in domestic students and in foreign students. As the body mass index increases, the incidence of protruding abdomen (P=0.001) and lordosis (P=0.009) showed significant increase, but, the incidence of kyphosis (P=0.022) and scoliosis (P=0.001) decreased in domestic students, and same tendency for lordosis (P=0.001) and for scoliosis (P=0.001) in foreign students. As a whole, in domestic students, female students revealed significantly high (P=0.004) incidence of genu recurvatum compared to significantly low (P=0.022) incidence of LLD. However, no significant incidence difference found in foreign students. Male students showed significantly low incidence (P=0.001) of LLD and high incidence (P=0.014) of lordosis. In foreign students, female students also showed significantly low incidence (P=0.032) of LLD in foreign students compared to their counterparts.

Keywords: Axial and lower extremity deformity, Shoulder dominance, Handedness

INTRODUCTION

Incidence of musculoskeletal diseases has increased in recent years. Musculoskeletal diseases are one of the main health problems around world and have great consequences for public health because of the large amount of their health and social resources. Nevertheless, epidemiological studies on the incidence and impact of musculoskeletal diseases compared with systemic diseases are infrequent (Carmona et al., 2001).

Axial and lower extremity deviations must be diagnosed in their beginning stages to prevent severe deformity because early diagnosis and detection of the abnormality increases the chance of correction (Eden-Kilgour and Gibson, 1990; Gunnoe, 1990). Left untreated, a mild condition can become so severe that it could cause back pain and damage to internal organs, and even require corrective surgery (Eden-Kilgour and Gibson, 1990; Francis and Bryce, 1987).

The most controversial issues relating to postural deviations continue to be those of risk factors. Etiologies of some axial and lower extremity deviations are generally classified as idiopathic. However, most researchers agree that gender (Mattila et al., 2007) and age (Palmer and Goodson, 2015) are the most common risk factors. Some researchers suggested that handedness (Walker and Perreault, 2015; Williams et al., 2002), backpack shoulder dominance (Grimmer et al., 2002), and height and weight (Viester et al., 2013) might be possible risk factors of axial and lower extrem-

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Received: May 28, 2018 / Accepted: July 14, 2018

pISSN 2288-176X
eISSN 2288-1778

ity deviations.

Spinal deformities might be considered to relate to the lower extremities, such as knee or hip flexion and extension positions (Itoi, 1991). However, no study has reported on the relationship between spinal and lower extremities based on the nationality.

Therefore, the purpose of this study was to determine the incidence of axial and lower extremity deviations and identify the effects of risk factors (backpack shoulder dominance, handedness, body mass index [BMI], nationality, and gender) on the development of axial deformities (forward head, protruding abdomen, kyphosis, lordosis, scoliosis) and lower extremity deformities (genu valgus, genu varus, genu recurvatum, leg length discrepancy).

MATERIALS AND METHODS

Participants

One hundred forty-seven (102 males and 45 females) domestic college students and 72 (33 males and 39 females) foreign students were subjects in this study. Physical characteristics of the subjects are listed in Table 1.

Data collecting

Subjects with a history of related disorders or injury to vertebrae or lower extremity were barred from participation. All subjects were asked wear tight-fitting stretch swimming suits only. No socks were permitted for the data collecting. The subjects were asked to answer each question on the questionnaire including nationality, backpack shoulder dominance, handedness, gender, age, height, and weight.

Experimental procedures

The visual postural examination of the spine and lower extremity was conducted from anterior, posterior, lateral, and prone positions. From the anterior view, height of the shoulder on both side was observed. From the posterior view, any sign of scoliosis, genu valgus, genu varus, or genu recurvatum was observed. From the lateral view, any sign of forward head, protruding abdomen, kyphosis, lordosis was observed. From the prone position, observation was performed if there is leg length discrepancy. This procedure was established and validated by Wen et al. (1998).

Table 1. Physical characteristics of subjects

Variable	Domestic		Foreign	
	Male (n=102)	Female (n=45)	Male (n=33)	Female (n=39)
Age (mo)	273.71±13.72	255.13±14.09	266.93±16.12	263.67±23.55
Height (cm)	176.44±5.39	163.16±3.31	179.73±4.34	165.05±5.87
Weight (kg)	73.14±10.97	56.11±7.72	76.03±9.65	59.18±5.16
BMI (kg/m^2)	23.42±2.74	21.05±2.62	23.49±2.36	21.75±1.91

Values are presented as mean±standard deviation.
BMI, body mass index.

Statistical analysis

A logistic regression was used to identify the association of genu valgus, genu varus, genu recurvatum, leg length discrepancy, forward head, protruding abdomen, kyphosis, lordosis, and scoliosis. Independent variables were nationality, gender, backpack shoulder dominance, handedness, and BMI converted from the height and the weight. Each spinal and lower extremity deformities were considered as dependent variable in the study. Data were

Table 2. Backpack shoulder dominance

Variable	Domestic			Foreign		
	95% CI	Odds ratio	*P* for trend	95% CI	Odds ratio	*P* for trend
Genu valgus						
LF	0	1.000	0.997	0	0.001	0.999
BOTH	0	1.000	1.000	0.040–1.166	0.216	0.075
Genu varus						
LF	0.776–22.378	4.167	0.096	0	0.001	0.999
BOTH	1.047–17.396	4.268	0.043*	0.028–0.762	0.147	0.022*
Genu recuvatum						
LF	0.046–3.210	0.383	0.377	0	0.001	0.999
BOTH	0.131–1.990	0.511	0.333	0.356–32.033	3.375	0.289
Leg length discrepancy						
LF	0.243–1.700	0.643	0.373	0.504–29.261	4.333	0.182
BOTH	0.083–0.463	0.198	0.001*	0.032–4.319	0.371	0.429
Forward head						
LF	0.269–3.088	0.912	0.882	0.107–13.300	1.190	0.887
BOTH	0.696–3.660	1.596	0.270	0.378–7.351	1.667	0.500
Protruding abdomen						
LF	0.579–6.254	1.903	0.289	0	0.001	0.999
BOTH	0.373–2.896	1.040	0.940	0.101–5.796	0.765	0.795
Kyphosis						
LF	0	0.001	0.998	0	1.000	1.000
BOTH	0.465–6.202	1.698	0.423	0	1.000	1.000
Lordosis						
LF	2.880–54.254	12.500	0.001*	0.053–5.129	0.524	0.579
BOTH	1.477–22.539	5.769	0.012*	0.160–2.184	0.591	0.431
Scoliosis						
LF	0.026–1.691	0.210	0.143	0	0.001	0.999
BOTH	0.326–2.161	0.840	0.718	0.016–0.393	0.078	0.002*

CI, confidence interval; LF, left shoulder carrying; BOTH, both shoulder carrying.
*$P<0.05$, significant difference.

https://doi.org/10.12965/jer.1836280.140

analyzed with IBM SPSS Statistics ver. 20.0 (IBM Co., Armonk, NY, USA) and statistical significance was set at $P<0.05$ for all tests.

RESULTS

Table 2 shows the result of the effects of backpack shoulder dominance on the incidence of each spinal and lower extremity deviations. As shown in the Table 2, subjects carrying the backpack on both shoulder showed significantly higher incidence of genu varus ($P=0.043$) and lower incidence of LLD ($P=0.001$) than right shoulder carrying in domestic students. Subjects carrying the backpack on the left shoulder ($P=0.001$) and on both shoulder ($P=0.012$) showed significantly higher incidence of lordosis, respectively than right shoulder carrying in domestic students. In contrast, subjects carrying the backpack on both shoulder showed significantly lower incidence of genu varus ($P=0.022$) and scoliosis ($P=0.002$) than right shoulder carrying in foreign students.

The result of the effects of dominant arm on the incidence of each spinal and lower extremity deviations is presented in Table 3. According to the Table 3, in domestic students, subjects with left hand dominance showed the significantly higher incidence of forward head ($P=0.001$) while incidence of lordosis was significantly higher ($P=0.029$) in left hand dominance subjects than their counterparts in foreign students.

Table 4 represents the result of the effects of BMI on the incidence of each spinal and lower extremity deviations. In domestic students, as the BMI increases, the incidences of protruding abdomen ($P=0.001$) and lordosis ($P=0.009$) showed significantly high increases while significantly low decrease in kyphosis ($P=0.022$) and in scoliosis ($P=0.001$). However, incidence of lordosis ($P=0.001$) significantly increased and the incidence of scoliosis ($P=0.001$) significantly decreased in foreign students.

The incidence difference between nationality and gender are shown in Tables 5 and 6. As a whole, in domestic students, female students revealed significantly higher ($P=0.004$) incidence of genu recurvatum and significantly low incidence of LLD ($P=$

Table 4. Effects of body mass index on the incidence of each spinal and lower extremity deviations

Variable	Domestic			Foreign		
	95% CI	Odds ratio	*P* for trend	95% CI	Odds ratio	*P* for trend
Genu valgus	0	1.000	0.991	0.762–1.435	1.046	0.783
Genu varus	0.681–1.047	0.844	0.123	0.919–1.610	1.216	0.171
Genu recuvatum	0.761–1.147	0.934	0.515	0.471–1.210	0.755	0.243
Leg length discrepancy	0.906–1.136	1.014	0.803	0.515–1.276	0.810	0.364
Forward head	0.981–1.277	1.119	0.095	0.779–1.388	1.040	0.790
Protruding abdomen	1.471–2.564	1.942	0.001*	0.561–208.129	10.801	0.115
Kyphosis	0.579–0.958	0.745	0.022*	0.489–1.239	0.779	0.291
Lordosis	1.057–1.475	1.249	0.009*	1.325–3.263	2.079	0.001*
Scoliosis	0.474–0.746	0.595	0.001*	0.168–0.603	0.318	0.001*

CI, confidence interval.
*$P<0.05$, significant difference.

Table 3. Dominant arm (left shoulder carrying)

Variable	Domestic			Foreign		
	95% CI	Odds ratio	*P* for trend	95% CI	Odds ratio	*P* for trend
Genu valgus	0	0.001	0.998	0	0.001	0.998
Genu varus	0.928–9.513	2.971	0.067	0.410–6.470	1.630	0.488
Genu recuvatum	0	0.001	0.998	0.058–5.202	0.548	0.600
Leg length discrepancy	0.488–2.247	1.048	0.905	0.243–10.106	1.567	0.637
Forward head	1.805–9.468	4.133	0.001*	0.410–6.470	1.630	0.488
Protruding abdomen	0.056–1.133	0.252	0.072	0.316–18.241	2.400	0.398
Kyphosis	0.153–3.741	0.757	0.733	0.058–5.202	0.548	0.600
Lordosis	0.718–5.522	1.991	0.186	1.159–15.225	4.200	0.029*
Scoliosis	0.109–1.393	0.390	0.147	0.862–9.530	2.867	0.086

CI, confidence interval.
*$P<0.05$, significant difference.

Table 5. Relationship between deformity incidence and nationality

Variable	Domestic			Foreign		
	95% CI	Odds ratio	*P* for trend	95% CI	Odds ratio	*P* for trend
Genu valgus	0	0.001	0.998	0.529–15.026	2.818	0.225
Genu varus	0.082–1.812	0.385	0.227	0.216–3.135	0.824	0.776
Genu recuvatum	1.776–21.127	6.125	0.004*	0	0.001	0.998
Leg length discrepancy	0.190–0.881	0.409	0.022*	0.203–8.236	1.292	0.787
Forward head	0.155–1.065	0.407	0.067	0.073–1.311	0.310	0.111
Protruding abdomen	0	0.001	0.997	0	0.001	0.998
Kyphosis	0.111–2.682	0.547	0.457	0	0.001	0.998
Lordosis	0.265–2.331	0.786	0.664	0.006–0.436	0.053	0.006
Scoliosis	1.115–6.668	2.727	0.028	0	0.001	0.998

CI, confidence interval.
*$P<0.05$, significant difference.

Table 6. Relationship between deformity incidence and gender

Variable	Male			Female		
	95% CI	Odds ratio	*P* for trend	95% CI	Odds ratio	*P* for trend
Genu valgus	0.571–74.309	6.516	0.131	0	0.001	0.997
Genu varus	0.473–4.614	1.477	0.502	0.577–17.314	3.162	0.185
Genu recuvatum	0	0.001	0.998	0.179–1.933	0.588	0.382
Leg length discrepancy	0.016–0.319	0.073	0.001*	0.059–0.884	0.229	0.032*
Forward head	0.278–1.823	0.712	0.478	0.126–2.328	0.542	0.410
Protruding abdomen	0.151–1.478	0.474	0.201	0.234–1.658	0.912	0.254
Kyphosis	0	0.001	0.998	0.577–17.314	3.162	0.185
Lordosis	1.256–7.867	3.143	0.014*	0.024–1.886	0.211	0.164
Scoliosis	0	0.001	0.998	0.608–3.902	1.540	0.363

CI, confidence interval.
*$P<0.05$, significant difference.

0.022) compared to male students. However, no significant incidence difference found in foreign students.

Male students showed significantly low incidence of LLD ($P=0.001$) and high incidence of lordosis ($P=0.014$) in foreign students, Female students also showed significantly low incidence of LLD ($P=0.032$) in foreign students compared to domestic students.

DISCUSSION

The results of this study revealed that subjects carrying their backpack on both shoulder showed higher incidence of genu varus and lordosis in domestic students. High incidence of genu varus might be explained that the reason of high incidence is not due to backpack but traditional sitting-on life style of Korean people even though Western life style is stabilized in their current daily life. High incidence of lordosis also might be caused by the influence of heavy backpack load during junior to high school days. This result is consistent with the report by Grimmer et al. (2002) suggesting that backpacks should be positioned high on the trunk to minimize antigravity stresses on body tissues and loads should be limited to 10% of their body weight. Subjects with left hand dominance showed significantly high incidence of forward head in domestic students and lordosis in foreign students. Even the small percentile of left-handed subject, this result coincides with the results of the research by Williams et al. (2002) explaining that physiological and mechanical modifications to muscle structure and composition from long term preferential use of one hand.

In this study, it was found that students with high BMI showed no significant difference on lower extremity but on axial spine. Especially, students with high BMI showed high incidence of lordosis and low incidence of scoliosis. Even the relationship between BMI and musculoskeletal deformities has been focused in studies on low back pain (Shiri et al., 2010) it could be argued that high BMI is associated with deformities in other body regions such as neck, shoulder, and lower limbs (Viester et al., 2013). Even it is difficult to compare the incidence of musculoskeletal deviations due to the absent of research between nations the reason of high incidence of genu recurvatum in female students seems to the weakness of muscle force on the lower extremity because of insufficient of physical activities. Low incidence of LLD in foreign students compared to domestic students might be attributed to their standing-up life style.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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