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Research Paper

Estimation of Gender and Age Based on Three-dimensional Computed Tomography Scan Indices of the Twelfth Thoracic Vertebrae and the First and Fifth Lumbar Vertebrae in Iranian Adults

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ABSTRACT

Background: Gender identification is a crucial starting point in creating a biological profile for human skeletal remains because it reduces the number of possible matches by 50%. The vertebrae (especially the chest and back) can also be some of the best-preserved skeletal elements in some areas of forensics and archeology. In the present study, gender and age were assessed based on the measurement of three-dimensional computed tomography (CT) scan indices of the Twelfth thoracic (T12) vertebrae and the first and fifth lumbar (L1 and L5) vertebrae in Iranian adults.

Methods: The present study was a descriptive study carried out on 200 participants over 18 years of age in 2020. Individuals measuring thoracic and lumbar vertebrae diameters (T12 and first and fifth lumbar vertebrae) by three-dimensional computed tomography (CT) scan (Toshiba, Japan, 16-Slice) with multiplanar reconstruction (MPR) and volume rendering were placed in two sagittal and horizontal sections.

Results: The mean age of male and female participants was 34.62±9.63 years and 34.10±9.70 years, respectively, which were not significantly different (P=0.789). The present study showed that the mean indices for T12, L1 and L5 vertebrae were significantly higher in males (P>0.05). The results also showed that T12, L1, and L5 indices of nuts are not good predictors for age estimation.

Conclusion: Based on the results, the indices of the T12 vertebrae and the L1, and L5 vertebrae can be used to determine gender, but these indices are not a good criterion to estimate age and do not have the necessary accuracy to predict the age variable.

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1. Introduction

Identifying isolated and skeletal remains has long been a challenge for forensic pathologists, especially in cases of mass catastrophes or high-intensity explosions [1]. Determining gender, age, height, and ethics, known as biological characteristics, reduces the potential for victims in forensic research and thus provides useful clues to personal identification [2]. Gender identification is a critical starting point in establishing a biological profile for human skeletal remains because it reduces the number of possible matches by 50% [3]. Age estimation is vital and practical in both anthropology and forensics [4]. The pelvis and skull, which show prominent features of gender differentiation, are reliable indicators for estimating gender in cases where a complete skeleton is available for identification. In the presence of a complete skeleton, gender can be assessed with high accuracy. This estimate is 98% for the pelvis and skull together and 95% for the pelvis alone [5]. The vertebrae (especially the thoracic and lumbar) can also be some of the best-preserved skeletal elements in some areas of forensics and may be a promising tool for gender assessment in forensic and archaeological applications [6, 7]. Gender and age differences are evident in the biomechanics of the spine, especially in the thoracic and lumbar regions. The anatomical differences between the thoracic and lumbar spines in the two genders are well described, and based on these anatomical differences, men have far more dimensions than women [8-10]. In physical anthropology, morphological and metric indices of spinal bones and delicate vertebral components are used for gender differentiation [11, 12]. Identifying the differences in spine dimensions between men and women is very helpful in determining gender and age in the field of forensic medicine. In this regard, each component of the spine at any stage, especially in the thoracic and lumbar regions can help in identifying gender and age in cases where it is not possible to assess gender and age (such as severe trauma) [13-15]. Accordingly, this study aimed to evaluate gender and age estimation based on the measurement of three-dimensional computed tomography (CT) scans of the twelfth thoracic (T12) vertebrae and the first and fifth lumbar (L1 and L5) vertebrae in Iranian adults.

2. Materials and Methods

The present study was a descriptive study conducted on 200 participants over 18 years of age in both genders in 2020. Individuals measuring thoracic and lumbar vertebrae diameters (T12 and L1 and L5 vertebrae) by three-dimensional CT scan (Toshiba, Japan, 16-Slice) with multiplanar reconstruction (MPR) and volume rendering were placed in two sagittal and horizontal sections. Finally, the evaluated indices in both genders in different age groups were statistically compared and the diagnostic accuracy of each was evaluated to distinguish between the two genders and ages. Figure 1 shows the main indices [3].

Statistical issues

Descriptive results were presented as Mean±SD or percentage. Independent t-test was used to compare the two means, analysis of variance (ANOVA) was used for quantitative comparison, and the Chi-square test was used to compare qualitative variables. The pearson correlation test was used to examine the correlation between quantitative variables. A linear regression model was used to control the confounders. The significance level was considered less than 0.05. SPSS software, version 21 was used to analyze the data.

3. Results

The mean age of men and women was not significantly different (P=0.789). Table 1 presents the mean age of the participants by gender.

Some main indices were assessed in this study, including TDM: Transverse process distance; ADM: The maximum distance between articular; EPWu: Upper-end plate width; EPDu: Upper-end plate depth; FDS: Foramen diameter (depth); FDC: Foramen diameter (width); PW: Pedicle width; SPL: Spinal process length; VL: Vertebral length; VBHa: The anterior height of the vertebral body; PH: Pedicle height; APH: Articular process height; SPH: Spinal process height (Figure 1).

The mean indices bead related to T12 in the participants were evaluated using t-test. The results showed that the mean indexes of TDM, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa and PH were significant and all were higher in men (P<0.05). However, the mean indices of APHs, APHi, and SPH were not significantly different between men and women (P>0.05). Table 2 presents the mean and standard deviation of the mean indices, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs, APHi, and SPH for the T12 vertebrae in both genders.

Table 1. Mean age of the participants by gender

Variables		n	Mean±SD	Minimum	Maximum	P
Age	Female	50	34.10±9.70	18	59	0.789
	Male	50	34.62±9.63	19	63	
	Total	100	34.36±9.62	18	63	

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Examination of the mean indices of TDM, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs, APHi and SPH for L1 vertebrae in both women and men showed that the mean indices of TDM, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs and SPH were significantly higher in men than women (P<0.05). The mean APHi index was not significantly different between the two genders (P>0.05). Table 3 presents the Mean±SD of the mean ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs, APHi and SPH for the L1 vertebrae in both genders.

Examination of the mean indices of TDM, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs, APHi and SPH for L5 vertebrae in both genders showed that the mean indices of TDM, ADM, EPWu, EPDu, FDS, FDC, PW, VL, VBHa and SPH were statistically significantly higher in men than women (P<0.05). It should be noted that the mean indices of SPL, PH, APHs and APHi were not significantly different between men and women (P>0.05). Table 4 presents the Mean±SD of the mean indices of TDM, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs, APHi and SPH for L5 vertebrae in both genders.

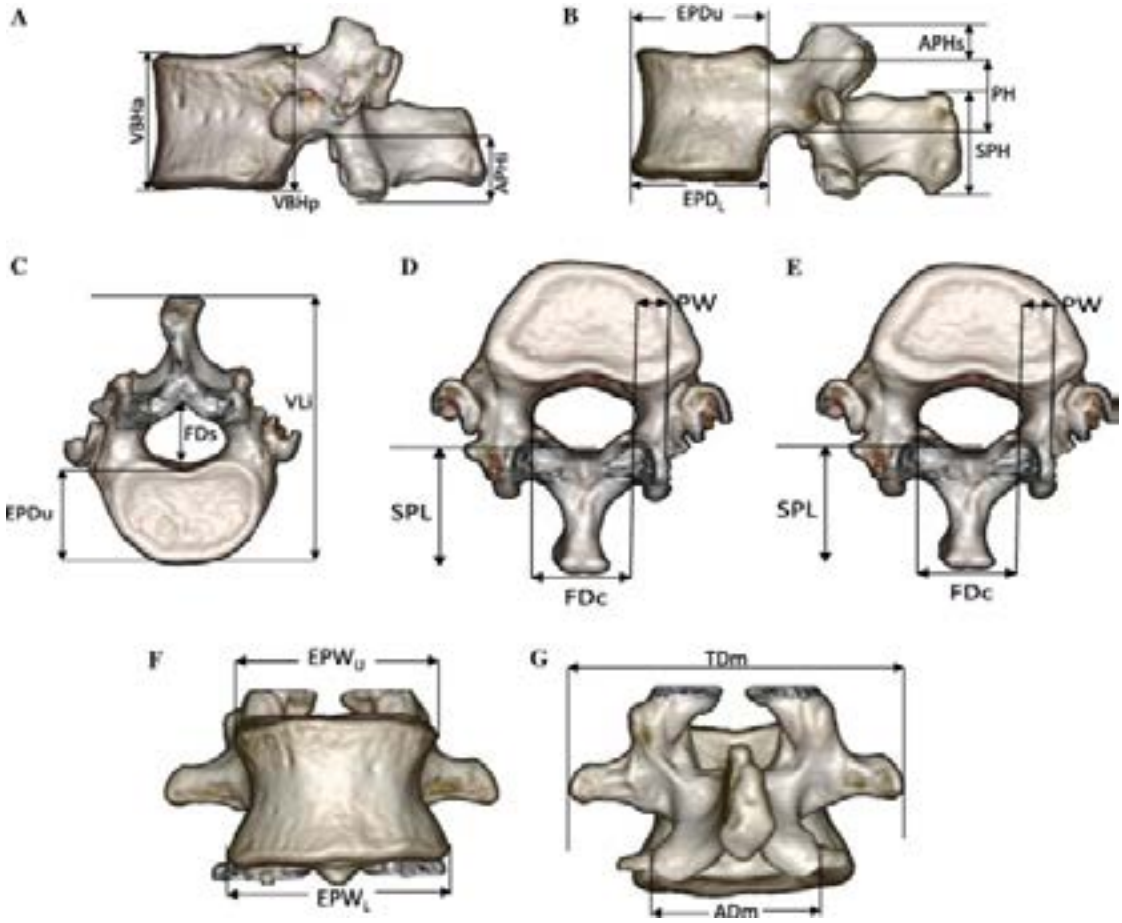

Figure 1. Reconstructed three-dimensional (3D) images of the vertebra showing all the studied measurements, A & B): Lateral view; C): Inferior aspect; D & E): Superior aspects; F): Anterior view; G): Posterior view) [3]

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Table 2. Comparison of ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs, APHi and SPH for the twelfth thoracic (T12) vertebrae in both genders

Index	Gender	Mean±SD	P	Index	Mean±SD	P
TDM	Female	43.56±4.190	<0.001	SPL	18.36±3.895	0.001
	Male	49.04±6.707			21.34±4.623	
ADM	Female	25.72±2.634	<0.001	VL	61.90±6.469	<0.001
	Male	27.80±2.935			69.16±7.975	
EPWu	Female	35.68±3.577	<0.001	VBHa	23.88±3.450	0.004
	Male	41.22±4.339			26.44±5.023	
EPDu	Female	26.82±2.537	<0.001	PH	13.42±2.689	0.046
	Male	29.62±3.368			14.52±2.764	
FDS	Female	16.00±2.185	<0.001	APHs	7.92±2.165	0.068
	Male	17.34±2.006			8.60±1.443	
FDC	Female	22.02±2.567	<0.001	APHi	20.02±3.684	1.000
	Male	23.88±2.336			20.02±5.434	
PW	Female	6.92±1.614	0.041	SPH	16.48±4.713	0.106
	Male	7.64±1.860			17.90±3.955	

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Abbreviations: TDM: Transverse process distance; ADM: The maximum distance between articular; EPWu: Upper-end plate width; EPDu: Upper-end plate depth; FDS: Foramen diameter (depth); FDC: Foramen diameter (width); PW: Pedicle width; SPL: Spinal process length; VL: Vertebral length; VBHa: The anterior height of the vertebral body; PH: Pedicle height; APHs: Articular process height superior; APHi: Articular process height inferior; SPH: Spinal process height.

Table 3. Comparison of TDM, ADM), EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, PHs, APHi and SPH for the first lumbar vertebrae in both genders

Index	Gender	Mean±SD	P	Index	Mean±SD	P
TDM	Female	66.88±5.717	<0.001	SPL	21.14±4.071	<0.001
	Male	72.52±9.015			25.02±4.506	
ADM	Female	25.88±3.842	<0.001	VL	65.66±6.173	<0.001
	Male	29.04±3.458			73.84±6.637	
EPWu	Female	37.28±3.494	<0.001	VBHa	26.34±4.369	0.043
	Male	43.34±3.931			28.36±5.413	
EPDu	Female	28.04±2.843	<0.001	PH	12.92±2.664	0.024
	Male	31.38±3.168			14.22±3.012	
FDS	Female	16.16±1.557	0.013	APHs	8.14±1.948	0.03
	Male	17.06±1.973			9.28±1.807	
FDC	Female	22.50±2.742	<0.001	APHi	22.94±3.899	0.458
	Male	24.42±2.425			22.14±6.503	
PW	Female	5.84±1.283	<0.001	SPH	19.32±4.133	0.014
	Male	7.26±1.562			21.52±4.674	

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Abbreviations: TDM: Transverse process distance; ADM: The maximum distance between articular; EPWu: Upper-end plate width; EPDu: Upper-end plate depth; FDS: Foramen diameter (depth); FDC: Foramen diameter (width); PW: Pedicle width; SPL: Spinal process length; VL: Vertebral length; VBHa: The anterior height of the vertebral body; PH: Pedicle height; APHs: Articular process height superior; APHi: Articular process height inferior; SPH: Spinal process height.

Table 4. Comparison of DM, ADM, EPWu,EPDu, FDS, FDC, PW, SPL,VL, VBHa, PH, APHs, APHi and SPH)for the fifth Lumbar Vertebrae in both genders

Index	Gender	Mean±SD	P	Index	Mean±SD	P
TDM	Female	86.18±5.920	<0.001	SPL	21.50±4.824	0.157
	Male	93.62±7.197			22.86±4.824	
ADM	Female	43.18±6.432	<0.001	VL	68.48±6.135	<0.001
	Male	48.26±7.128			75.38±7.309	
EPWu	Female	46.04±3.505	<0.001	VBHa	29.52±7.638	0.107
	Male	50.06±4.766			31.88±6.832	
EPDu	Female	31.12±2.537	<0.001	PH	11.26±2.048	0.066
	Male	34.38±3.063			12.08±2.346	
FDS	Female	15.54±2.279	<0.001	APHs	9.08±2.248	0.139
	Male	17.52±3.079			9.72±2.041	
FDC	Female	29.12±3.567	<0.001	APHi	18.92±4.020	0.574
	Male	33.00±5.292			18.44±4.477	
PW	Female	11.24±2.162	0.012	SPH	15.14±3.326	0.002
	Male	12.46±2.573			17.46±4.062	

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Abbreviations: TDM: Transverse process distance; ADM: The maximum distance between articular; EPWu: Upper-end plate width; EPDu: Upper-end plate depth; FDS: Foramen diameter (depth); FDC: Foramen diameter (width); PW, pedicle width; SPL, spinal process length; VL, vertebral length; VBHa: The anterior height of the vertebral body; PH: Pedicle height; APHs: Articular process height superior; APHi: Articular process height inferior; SPH: Spinal process height.

Table 5. Cut-off point and area under the curve (AUC) for twelfth thoracic (T12)

Index	Cut off Point	Sensitivity	Specificity	AUC	P
TDM	Female<43.5<Male	82.0	60.0	0.779	<0.001
ADM	Female<26.5<Male	66.0	64.0	0.703	<0.001
EPWu	Female<36.5<Male	90.0	70.0	0.854	<0.001
EPDu	Female<27.5<Male	78.0	60.0	0.749	<0.001
FDS	Female<16.5<Male	70.0	52.0	0.664	0.005
FDC	Female<22.5<Male	78.0	56.0	0.719	<0.001
PW	Female<7.5<Male	52.0	68.0	0.622	0.036
SPL	Female<19.5<Male	70.0	62.0	0.699	0.001
VL	Female<65.5<Male	72.0	66.0	0.773	<0.001
VBHa	Female<24.5<Male	66.0	72.0	0.714	<0.001
PH	Female<13.5<Male	66.0	60.0	0.651	0.009
APHs	Female<7.5<Male	72.0	50.0	0.620	0.039

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Abbreviations: TDM: Transverse process distance; ADM: The maximum distance between articular; EPWu: Upper-end plate width; EPDu: Upper-end plate depth; FDS: Foramen diameter (depth); FDC: Foramen diameter (width); PW: Pedicle width; SPL: Spinal process length; VL: Vertebral length; VBHa: The anterior height of the vertebral body; PH: Pedicle height; APHs: Articular process height superior; AUC: Area under the curve.

Table 6. Cut-off point and area under the curve (AUC) for the first lumbar (L1)

Index	Cut off Point	Sensitivity	Specificity	AUC	P
TDM	Female<68.5<Male	76.0	72.0	0.743	<0.001
ADM	Female<26.5<Male	72.0	68	0.791	<0.001
EPWu	Female<40.5<Male	76.6	88.0	0.889	<0.001
EPDu	Female<29.5<Male	76.0	70.0	0.787	<0.001
FDS	Female<16.5<Male	66.0	64.0	0.684	0.011
FDC	Female<23.5<Male	66.0	80.0	0.782	<0.001
PW	Female<6.5<Male	70.0	60.0	0.753	0.012
VL	Female<68.5<Male	76.0	68.0	0.815	<0.001
VBHa	Female<27.5<Male	48.0	78.0	0.651	0.009
PH	Female<13.5<Male	56.0	64.0	0.635	0.020
APHs	Female<8.5<Male	64.0	60.0	0.669	0.004
SPH	Female<19.5<Male	70.0	50.0	0.639	0.016

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Abbreviations: TDM: Transverse process distance; ADM: The maximum distance between articular; EPWu: Upper-end plate width; EPDu: Upper-end plate depth; FDS: Foramen diameter (depth); FDC: Foramen diameter (width); PW: Pedicle width; VL, vertebral length; VBHa: The anterior height of the vertebral body; PH: Pedicle height; APHs: Articular process height superior; SPH: Spinal process height; AUC: Area under the curve.

Table 7. Cut-off point and area under the curve (AUC) for the fifth lumbar (L5)

Index	Cut off Point	Sensitivity	Specificity	AUC	P
TDM	Female<86.5<Male	80.0	64.0	0.800	<0.001
ADM	Female<45.5<Male	64.0	66.0	0.669	0.001
EPWu	Female<48.5<Male	70.0	76.0	0.773	<0.001
EPDu	Female<32.5<Male	72.0	72.0	0.786	<0.001
FDS	Female<16.5<Male	56.0	70.0	0.688	0.001
FDC	Female<29.5<Male	78.0	66.0	0.731	<0.001
PW	Female<11.5<Male	64.0	54.0	0.63	0.023
VL	Female<70.5<Male	78.0	68.0	0.767	<0.001
VBHa	Female<28.5<Male	74.0	60.0	0.683	0.002
SPH	Female<15.5<Male	66.0	58.0	0.672	0.003

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Abbreviations: TDM: Transverse process distance; ADM: The maximum distance between articular; EPWu: Upper-end plate width; EPDu: Upper-end plate depth; FDS: Foramen diameter (depth); FDC: Foramen diameter (width); PW: Pedicle width; VL, vertebral length; VBHa: The anterior height of the vertebral body; PH: Pedicle height; APHs: Articular process height superior; SPH: Spinal process height; AUC: Area under the curve.

Table 8. The relationship between the mean age and indices for twelfth thoracic (T12) vertebrae and the first and fifth lumbar (L1 and L5) vertebrae

Variables	Index	Beta	Lower Bound	Upper Bound	P
T12	TDM	0.204	-0.163	0.572	0.272
	ADM	-0.122	-0.876	0.632	0.748
	EPWu	0.352	-0.252	0.956	0.250
	EPDu	-0.167	-1.169	0.836	0.742
	FDS	0.668	-0.606	1.942	0.300
	FDC	-0.019	-0.894	0.855	0.965
	PW	0.086	-1.153	1.324	0.891
	SPL	0.835	-0.062	1.732	0.068
	VL	-0.226	-0.902	0.450	0.508
	VBHa	0.286	-0.238	0.809	0.281
	PH	-0.712	-1.538	0.114	0.090
	APHs	-0.129	-1.307	1.048	0.827
	APHi	0.095	-0.354	0.545	0.674
	SPH	-0.394	-0.885	0.096	0.114
L1	TDM	-0.116	-0.409	0.177	0.433
	ADM	0.028	-0.566	0.621	0.927
	EPWu	0.215	-0.552	0.982	0.579
	EPDu	-0.338	-1.444	0.767	0.545
	FDS	-0.908	-2.378	0.562	0.223
	FDC	0.434	-0.579	1.447	0.397
	PW	-0.585	-2.289	1.119	0.497
	SPL	0.244	-0.791	1.280	0.640
	VL	0.396	-0.504	1.297	0.384
	VBHa	-0.284	-0.782	0.214	0.260
	PH	0.367	-0.508	1.242	0.407
	APHs	-0.046	-1.197	1.105	0.937
	APHi	-0.064	-0.477	0.348	0.758
	SPH	-0.202	-0.692	0.289	0.416

Variables	Index	Beta	Lower Bound	Upper Bound	P
L5	TDM	0.089	-0.234	0.412	0.586
	ADM	0.301	-0.016	0.618	0.062
	EPWu	0.272	-0.308	0.851	0.353
	EPDu	-0.195	-1.205	0.816	0.703
	FDS	-0.463	-1.384	0.458	0.321
	FDC	0.398	-0.041	0.837	0.075
	PW	0.443	-0.511	1.397	0.358
	SPL	0.812	0.094	1.531	0.027
	VL	-0.255	-0.889	0.380	0.427
	VBHa	-0.091	-0.359	0.177	0.500
	PH	-0.938	-1.935	0.059	0.065
	APHs	0.688	-0.277	1.652	0.160
	APHi	0.084	-0.373	0.540	0.717
	SPH	-0.021	-0.584	0.542	0.941

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Abbreviations: TDM: Transverse process distance; ADM: The maximum distance between articular; EPWu: Upper-end plate width; EPDu: Upper-end plate depth; FDS: Foramen diameter (depth); FDC: Foramen diameter (width); PW: Pedicle width; SPL: Spinal process length; VL:Vertebral length; VBHa: The anterior height of the vertebral body; PH: Pedicle height; APHs: Articular process height superior; APHi: Articular process height inferior; SPH: Spinal process height; T12, twelfth thoracic; L1, the first lumbar; L5, the fifth lumbar.

Cut-off point and area under the curve (AUC) using receiver operating characteristics (ROC) analysis for mean indices of ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs, APHi and SPH were done for T12, L1 and L5 in Tables 5, 6 and 7.

The relationship between the mean age of the study participants and the mean of the indices for T12, L1, and L5 vertebrae was investigated using linear regression. The results showed that none of the indices had a significant relationship with age for T12 and L1 indices (P>0.05). For L5 vertebra, the results showed that only SPL index had a significant relationship with age (P=0.027) (Table 8).

4. Discussion

The anatomical differences between the thoracic and lumbar vertebrae in the two genders are well described, and based on these anatomical differences, men have far more dimensions than women [8-10]. In the present study, gender and age were assessed based on the measurement of three-dimensional CT scan indices of the T12 vertebrae and L1 and L5 vertebrae in 200 Iranian adults with equal numbers regarding gender. In summary, the results showed that the mean indices of TDM, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, and PH of T12 were significantly higher in males. However, the mean indices of APHs, APHi, and SPH were not significantly different between men and women. The mean indices of TDM, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs, and SPH of L1 vertebra were significantly higher in men compared to women. The mean APHi index was not significantly different between the two sexes. For L5 vertebrae, the mean indices of TDM, ADM, EPWu, EPDu, FDS, FDC, PW, VL, VBHa, and SPH were statistically significantly higher in men and women. It should be noted that the mean indices of SPL, PH, APHs, and APHi were not significantly different between men and women.

In a study conducted by Zheng et al. the evaluations showed that the measurements of EPWu, PHL, and EPDm indices with 88.6% accuracy could distinguish between the two genders [16]. In our study, these indices were much higher in men than women, which lead to the correct diagnosis of gender. Because for T12, sensitivity and specificity of 90% and 70% for EPWu, sensitivity and specificity of 78% and 60% for EPDu, as well as sensitivity and specificity of 66% and 60% for PH were obtained. For L1, sensitivity and specificity of 76.6% and 88% for EPWu, sensitivity and specificity of 76% and 70% for EPDu, as well as sensitivity and specificity of 56% and 64% for PH were obtained. For L5, sensitivity and specificity of 70% and 76% for EPWu, and sensitivity and specificity of 72% and 72% for EPDu were calculated. In this regard, the study conducted by Dine et al. confirmed our results and revealed that the anthropometric indices of the T12 vertebra and L1 vertebra and the posterior height of the vertebral body (VBHp)/ VBHa ratio of the lumbar vertebra played a vital role in the distinction between the genders. The accuracy of gender determination by measuring the anthropometric indices of the T12 vertebra was 93.1% and the L1 vertebra was 68% and this accuracy was 96.3% by combining the indices of both vertebrae. However, in the study conducted by Dine et al, the accuracy of diagnosis was higher than our study. In our study, only for EPWu in T12 with 90% sensitivity and 70% specificity, the highest differentiation power was obtained [3].

In another study, the indexes of the L1 were assessed to determine gender and age. In a study conducted by Ramadan et al, a statistically significant difference was found in all lumbar vertebral indices in men compared to women (except vertebral length and lumbar vertebral fracture [LVF]), a significant correlation for age and all dimensions of the first vertebra was found (except for TD, lumbar vertebral fracture [LVF], TDm, and PW indices). The relationship between age and SPH was weak. The accuracy of gender determination by measuring the indexes of the L1 vertebra was 84.6%, but these indices were not useful for determining the age [17]. These results were close to the results of our study because in our study for L1 vertebrae, sensitivity and specificity of 76.6% and 88% for EPWu and with sensitivity and specificity of 76% and 70% for EPDu and also sensitivity and specificity of 56% and 64% for pH were obtained.

In a study conducted by Sheng-BoYu et al, the accuracy of gender determination with the help of the T12 vertebra was 62.7% to 85.3%. The diameter of the vertebral foramen (FDs, FDc), PL, and AH and the maximum distance between iADm and the distance between the mammary dimensions (MD) and SL were larger in men than in women and the ratio of BHa to BHp (Ha/Hp) was not significant between the two genders [18]. In our study, the FDS and FDC indices in men were on average higher than in women and therefore were consistent. Another vertebra has been used to determine gender. For example, in a study conducted by Tsubaki et al, the indexes of the tenth thoracic vertebra (T10) and the sixth and seventh ribs of the chest were used to determine gender, and diagnostic accuracy was used to determine gender based on the combination. The indices of the tenth thoracic vertebra (T10) and the sixth and seventh ribs of the thorax were 88.8% [19].

In a study, the accuracy of determining the ender of the indexes of L1 and L5 vertebrae ranged from 81.2% to 85.1%, and this accuracy was 92.2% for the indexes of all lumbar vertebrae [20]. This study was conducted by Summer J. Decker et al. and reported promising results in gender diagnosis. In a study conducted by Cameriere et al, on children and adolescents, they estimated age using the fourth cervical vertebra. The posterior and anterior portions of the fourth vertebra were recorded in radiological findings. The posterior part was triangular in younger individuals and quadrangular in older individuals. This means that estimating age was achieved even with the help of the appearance of the vertebrae [21].

5. Conclusion

Based on the results, the vertebrae indices can be used to identify gender: TDM, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, and PH indices of T12 and TDM, ADM, EPWu, EPDu, FDS, FDC, PW, SPL, VL, VBHa, PH, APHs, and SPH of L1 nut and TDM, ADM, EPWu, EPDu, FDS, FDC, PW, VL, VBHa, and SPH of L5 in gender determination are helpful, but the T12 vertebrae and L1 and L5 vertebrae (except the SPL index) are not good criteria to estimate age.

Ethical Considerations

Compliance with ethical guidelines

This research followed the principles of the Declaration of Helsinki. Written informed consent was obtained from all the patients. This study was extracted from the medical thesis of Ramin Emami and was approved by the Ethics Committee of the Iran University of Medical Sciences (ethical Code: IR.IUMS.FMD.REC.1399.015).

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Authors' contributions

All authors equally contributed to preparing this article

Conflict of interest

The authors declared no conflict of interest

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