

# Statistical Analysis of Organ Morphometric Parameters and Weights in South Iranian Adult Autopsies

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## Abstract

Organ weight is one important indicator to discern normal from abnormal condition in forensic pathology as well as in clinical medicine. The present study aimed to investigate morphometric parameters and organ weights of southern Iranian adults, which can be fundamental sources to be compared to abnormal cases.

Morphometric parameters and weights of 6 organs (heart, liver, kidney, spleen, appendix, and brain), which were harvested from 501 southern Iranian adults (385 males and 116 females) during ordinary postmortem examination, were measured.

All the organs were heavier in males than in females. Heart, brain, spleen, and right kidney were significantly heavier in males compared to females, but no significant difference was observed between the 2 sexes regarding the weights of the rest of the organs. Moreover, brain and heart became heavier as one got older and most organs were heavier in middle-aged individuals compared to other age groups. Furthermore, various types of correlations were observed between different organs' weights and body parameters.

These results can be useful anatomical data for autopsy investigations, clinical practices, and research in southern Iran.

**Abbreviations:** BMI = body mass index, SPSS = Statistical Package for the Social Sciences.

**Keywords:** internal organ, morphometric parameters, southern Iran, weight

## 1. Introduction

Organ weight and its morphometric parameters are one of the most important indicators of possible organ defects or diseases, discerning normal organs from abnormal ones in forensic pathology and clinical medicine.<sup>[1]</sup> Therefore, many studies have evaluated the normal range of body and organ morphometric parameters, such as organ size, weight, and volume, in different ethnic groups all over the world.<sup>[2-6]</sup> However, few studies have evaluated the morphometric sizes of internal body organs.<sup>[7]</sup> In one study, Sheikhezadi et al<sup>[8]</sup> evaluated normal weights of internal organs in Tehran, north of Iran. However, such data have not been reported for south Iranian populations. Thus, this prospective study aims to determine the normal range of organ

morphometric parameters and weights in south Iranian populations.

## 2. Materials and Methods

Six body organs, including brain, heart, liver, right and left kidneys, appendix, and spleen were extracted for morphometric and weight investigation from autopsies of individuals aged  $\geq 15$  years in south Iranian cadaver referred to General Forensic Administration of Fars province since February 2012 to September 2015.

In this study, only healthy organs without any pathological finding that could lead to any change in organ size or weight within 24~48 hours of death and without any putrefaction were evaluated. All body parameters, such as age, height, body weight, and body mass index (BMI), were measured.

Examination of 5668 consecutive cases of autopsies performed in General Forensic Administration of Fars province from 2012 to 2015 revealed that only 501 cases, including 385 males and 116 females, fulfilled the above-mentioned criteria.

The normal procedure when examining each organ was to cut the organ as close to the anatomical boundary as possible and have its periorgan tissues stripped off. Heart was extracted from the origin of aorta and pulmonary trunks. Then, all the materials in the 4 chambers of the heart were washed out. Ligaments attached to liver and the contents of gallbladder were totally removed. The capsules and fat tissues surrounding both kidneys were also stripped off. Brain was extracted from the pyramids of medulla. Afterwards, vertical and horizontal lengths of each organ were measured. For liver, anterior-posterior length and volume were measured using floating method, and volume

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variance and organ weights were measured using electronic weighing machine (BW-15, CAS, Seoul, Korea). After that, pathological changes were grossly examined and when any gross abnormality was found, histological section was done for microscopic examination to exclude the case from the study. After all, mean and standard deviations for organ weight and size parameters were calculated.

A group of females were matched to a group of males on the basis of the similarity of height, body weight, and age. The differences between the 2 sexes regarding organ weight and size parameters were determined by student *t* test and the level of significance was set at  $\alpha = 0.05$ . Besides, Pearson correlation was applied to determine the relationship between body indices and organ weight. Linear regression analyses were also used to assess the correlation between each variable and organ weight. To clarify the change in organ weight according to age group, the subjects were categorized into 8 age groups with 10-year intervals. Then, organs' weights were compared using analysis of variance (F-test) at the significance level of 0.05. It should be noted that the significant level was adapted according to Duncan post-hoc test. All data analyses were carried out using Microsoft Excel 2013, Minitab 17.0, and SPSS statistical software, version 21.0 (SPSS Inc., Chicago, IL). The study was approved by ethics committee of Legal Medicine Research Center, Legal Medicine Organization of Iran, Tehran, Iran.

### 3. Results

Totally, 501 cases within the age range of 15 to 98 years, including 385 males and 116 females, fulfilled the required criteria to be involved in the study. The mean age of the males ( $45.32 \pm 19.55$  years) was nearly the same as that of the females ( $44.89 \pm 20.37$  years) and the difference was not statistically significant ( $P = .84$ ). Additionally, the males were significantly taller than females ( $P = .001$ ), but no significant difference was

observed between the two sexes regarding weight ( $P = .26$ ). However, BMI was higher in females than in males ( $P = .06$ ).

Morphometric parameters (sizes) and weights of the internal organs in males and females have been presented in Table 1. As the table depicts, the brains and hearts were significantly heavier in males compared to females ( $P = .00$ ). Besides, the mean length of appendix was  $94.30 \pm 27.77$  mm in males and  $89.44 \pm 24.17$  mm in females ( $P = .06$ ). The mean weight of the right kidneys was also significantly higher in males than in females ( $P = .039$ ), but this was not the case regarding the left kidneys ( $P = .082$ ). In male individuals, the mean weight of the left kidneys was more than that of the right ones, but the difference was not statistically significant ( $P = .338$ ). The same results were also obtained in females ( $P = .508$ ). Splens' vertical length and weights were significantly higher in males than in females, but the difference in their horizontal length was not statistically significant. Considering liver, a significant difference was observed between the males and females with regard to the anterior-posterior length ( $P = .014$ ). Although vertical length, horizontal length, weight, and volume of livers were higher in males compared to females, the differences were not statistically significant. Although male and female subjects were matched with respect to age, height, and body weight, a significant difference was observed between the 2 sexes regarding the mean weights of hearts, splens, and right kidneys.

There was statistically difference in organs' weights only for spleen and brain between males and females. About brain, Pearson correlation of brain weight and body weight was achieved 0.263 with *P* value of .000. For spleen and body weight, Pearson correlation of BW and SW = -0.000 and  $P = .995$  were achieved.

The results showed a significant correlation between body weight and brain's weight, right kidney's weight, left kidney's weight, and appendix's length. However, body length showed no correlations with liver's weight. However, the individuals' BMI

**Table 1**  
Morphometric parameters of internal organs in southern Iranian male and female adults.

Items	Total		Male (n=385)		P	Female (n=116)		
	Min-max	Mean $\pm$ SD	Min-max	Mean $\pm$ SD		Min-max	Mean $\pm$ SD	
Age, y	15-98	45.22 $\pm$ 19.73	15-98	45.32 $\pm$ 19.55	0.84	15-98	44.89 $\pm$ 20.37	
Body length, cm	135-195	164.73 $\pm$ 10.0	135-195	172.72 $\pm$ 8.68	0.00	142-186	164.20 $\pm$ 11.24	
Body weight, kg	33-170	70.72 $\pm$ 17.42	33-122	71.30 $\pm$ 16.49	0.26	36-170	68.98 $\pm$ 20.20	
BMI, kg/m <sup>2</sup>	11.17-44.07	24.08 $\pm$ 5.49	11.17- 44.07	23.83 $\pm$ 5.22	0.06	14.02-42.96	25.02 $\pm$ 6.35	
Brain weight, g	900-1951	1352.85 $\pm$ 155.67	900-1951	1374.42 $\pm$ 148.08	0.00	1001-1681	1272.70 $\pm$ 152.36	
Heart weight, g	118-900	343.99 $\pm$ 99.19	118-900	356.82 $\pm$ 102.27	0.00	119-510	316.53 $\pm$ 81.99	
Appendix length, mm	35-237	93.05 $\pm$ 26.94	42-237	94.30 $\pm$ 27.77	0.06	35-195	89.44 $\pm$ 24.17	
Vertical length, mm	52-242	123.49 $\pm$ 23.34	77-242	124.69 $\pm$ 22.42	0.006	52-190	117.83 $\pm$ 23.52	
Spleen	Horizontal length, mm	18-123	76.06 $\pm$ 15.74	44-120	76.96 $\pm$ 13.96	0.08	18-123	73.85 $\pm$ 17.87
Weight, g	35-590	186.22 $\pm$ 99.78	35-590	190.21 $\pm$ 89.97	0.001	50-455	158.96 $\pm$ 85.86	
Vertical length, mm	96-405	250.22 $\pm$ 43.53	96-405	250.40 $\pm$ 44.85	0.87	156-372	249.69 $\pm$ 39.51	
Horizontal length, mm	46-262	156.32 $\pm$ 31.09	46-262	154.89 $\pm$ 31.50	0.073	90-253	160.62 $\pm$ 29.60	
Liver	AP length, mm	31-250	72.32 $\pm$ 19.83	31-250	73.42 $\pm$ 21.10	0.014	31-133	69.06 $\pm$ 15.06
Weight, g	660-3341	1517.45 $\pm$ 354.40	660-2861	1550.96 $\pm$ 337.56	0.15	800-2451	1501.47 $\pm$ 321.83	
Volume, mm <sup>3</sup>	600-3300	1477.76 $\pm$ 359.92	600-3300	1489.83 $\pm$ 353.45	0.169	700-3200	1441.64 $\pm$ 378.18	
Vertical length, mm	50-180	107.93 $\pm$ 12.12	68-180	108.64 $\pm$ 11.84	0.031	50-132	105.76 $\pm$ 12.74	
Horizontal length, mm	32-150	52.48 $\pm$ 9.67	32-73	52.14 $\pm$ 7.20	0.295	32-69	51.31 $\pm$ 7.53	
Right kidney	Weight, g	50-300	154.19 $\pm$ 43.16	50-300	156.80 $\pm$ 43.55	0.039	75-290	147.55 $\pm$ 41.45
Vertical length, mm	40-160	117.99 $\pm$ 11.88	65-160	110.33 $\pm$ 11.50	0.251	40-130	108.87 $\pm$ 12.10	
Horizontal length, mm	32-95	51.72 $\pm$ 8.24	32-80	51.84 $\pm$ 7.96	0.602	32-95	51.35 $\pm$ 9.10	
Left kidney	Weight, g	38-380	157.48 $\pm$ 47.27	54-380	159.91 $\pm$ 46.27	0.082	38-316	151.37 $\pm$ 46.12

AP=anterior-posterior, BMI=body mass index, SD=standard deviation.

**Table 2**

**Pearson's correlation coefficients for the relationship between external body parameters and morphometric parameters of internal organs in Iranian adults.**

Pearson's correlation coefficient	Brain's weight	Heart's weight	Spleen's weight	Liver's weight	Right kidney's weight	Left kidney's weight	Appendix's length
Body weight	0.27	-0.057	-0.012	-0.016	0.150	0.23	0.03
Body length	0.37	0.16	0.09	-0.18	0.11	0.11	-0.04
BMI	0.09	-0.08	-0.11	-0.010	-0.11	-0.13	-0.001
Age	-0.21	0.10	0.01	-0.07	0.07	0.13	-0.06

BMI=body mass index.

was associated with brain's weight. Age also showed a correlation with heart's, spleen's, and both kidneys' weights (Table 2).

Scatter plot and regression line of body parameters (body weight, body height, and BMI) relative to normal internal organ weights in males and females have been presented in Figure 1. Accordingly, as BMI increased, the weights of spleen, left kidney, right kidney, and heart also increased with a positive slope. However, more slight changes were detected in liver weight and body weight relative to BMI and body length, respectively.

Moreover, heart weight increased with increase in age in both males and females. Based on the results, heart was heavier at above 85 years age in comparison to other age groups, but the difference was not statistically significant (Fig. 2). Also, the weights of brain, liver, and kidneys showed more variations in different age groups among males compared to females. The heaviest hearts in females and males were related to >85 years and 76 to 85 years' age groups, respectively. Additionally, the heaviest brains were related to the age range of 46 to 55 years in females and 26 to 35 years age range among males. Besides, the heaviest livers were observed within the age group of 36 to 45 years in females and within the 26–35 years age group among males. In males, the highest weights of the left and right kidneys were related to 46 to 55 and 76 to 85 years' age groups, respectively. In females, however, the highest weights of the left and right kidneys were related to 56 to 65 and >85 years' age groups, respectively. Finally, the highest and lowest spleen weights in males and females were related to the age groups of 36 to 45 and 66 to 75 years, respectively.

#### 4. Discussion and Conclusions

It is highly important to define normal morphometric parameters and weights of internal organs because there are no definite criteria to discern normal organs from abnormal ones.<sup>[2,9]</sup> Most of the hospital-patient cases undergone autopsy may have clinical or morphological evidences of organ failure and such changes in organ sizes and weights lead to exclusion of the case from the study.<sup>[6,10]</sup> Thus, hospital-based autopsies with clinical history of organ failures were excluded from the present study and only the organs without any clinical and morphological abnormalities were included. So far, many studies have reported normal parameters of internal organs in different countries of the world<sup>[11–13]</sup> as well as in north of Iran.<sup>[8]</sup> However, no studies have evaluated the normal ranges of internal organs' weights and sizes in southern Iran. Hence, the present prospective study was performed on all the autopsy cases referred to General Forensic Administration of Fars province during 4 years. In this study, in

addition to internal organs' weights, parameters, such as vertical length, horizontal length, anterior-posterior length, and organ volume, were also measured and compared between males and females. Our cases covered a wide age range in males and females (15–98 years) and with such a good sample size, different statistical analyses could be performed.

The results revealed no statistically significant difference between the 2 sexes concerning body parameters, except for body length. Although the males' body length and body weight were higher compared to the females, the females' BMI was higher compared to the males. Normal weights of brains and hearts were also significantly higher in the males than in the females ( $P=.00$ ). These findings were similar to those obtained by Sheikazadi et al,<sup>[8]</sup> Thamrong et al<sup>[12]</sup>, and other studies performed in Asia, Europe, and the United States.<sup>[2,6,14–16]</sup>

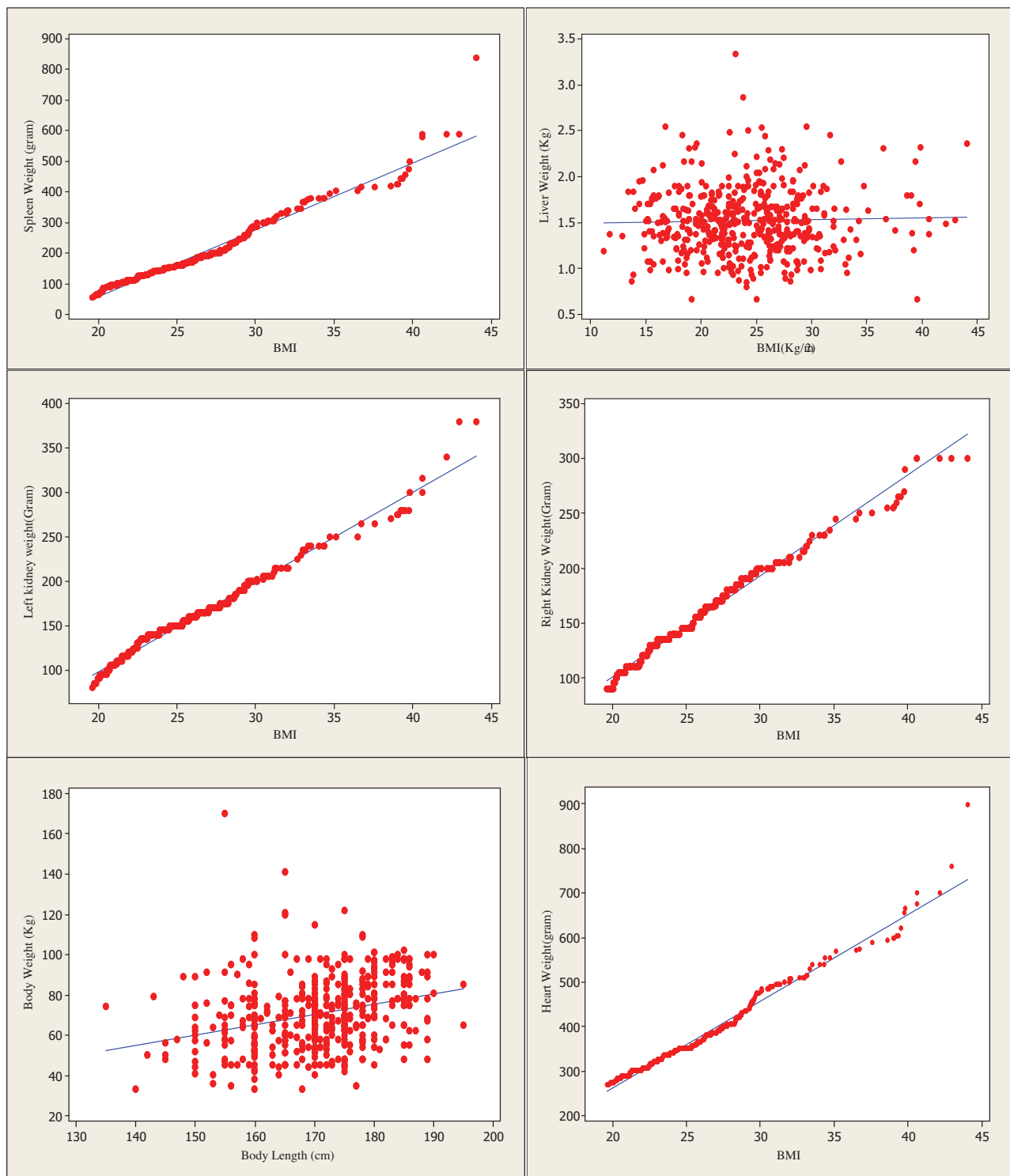
The findings of the present study also showed no significant difference between the 2 sexes with respect to appendix's length.

Kidneys are symmetric organs and their weights are expected to be the same in right and left sides. In the present study, although the left kidneys' weights were higher compared to the right ones in both males and females, their differences were not statistically significant ( $P>.05$ ). This was in agreement with the results of the study by Mathuramon et al.<sup>[13]</sup> Our study results also indicated no statistically significant difference between the males and females regarding the morphometric parameters and weights of the left and right kidneys.

To determine whether organs' sizes and weights are affected by sex, all the measured parameters were compared between males and females. Considering spleen, its vertical length and weight were significantly higher in males than in females, but no significant difference was observed between the 2 sexes regarding its horizontal length ( $P=.08$ ). In Danish people also, no significant difference was reported between the 2 sexes with respect to spleen's weight.<sup>[17]</sup>

The present study results demonstrated no significant difference between the males and females concerning the morphometric parameters of the liver, except for anterior-posterior length that was significantly higher in males than in females ( $P=.014$ ). In one study in Germany, the liver weights were almost similar in males and females.<sup>[18]</sup>

In our cases, brain's weight was positively correlated to body weight, body length, and BMI, but not to age. In addition, the weights of hearts and spleens were only correlated to body length and age. Besides, right and left kidneys' weights were negatively associated with BMI. However, no significant correlation was observed between liver's weight and body parameters. However, appendix was only correlated to body weight. The positive correlation between spleen weight and body length and weight was reported in Danish people, as well.<sup>[17]</sup>



**Figure 1.** Scatter plot and regression line of body parameters (body weight, body height, and body mass index) relative to internal organs' normal weights in southern Iranian male and female cadaver.

Based on the present study results, increase in age led to no considerable changes in liver, spleen, brain, and appendix in both sexes, but heart and kidneys were found to become heavier as the individuals got older. Grandmaison et al<sup>[19]</sup> also mentioned that the heart weight of the white population increased with increase in age. However, one

study conducted on American adults indicated that male hearts did not change in weight from 20 to 70 years of age, whereas female hearts' weights continued to increase during the same period. Thereafter, heart weight decreased in both sexes.<sup>[20]</sup> In Japanese adults, heart weight increased gradually until the age of 90 years. In addition, brain

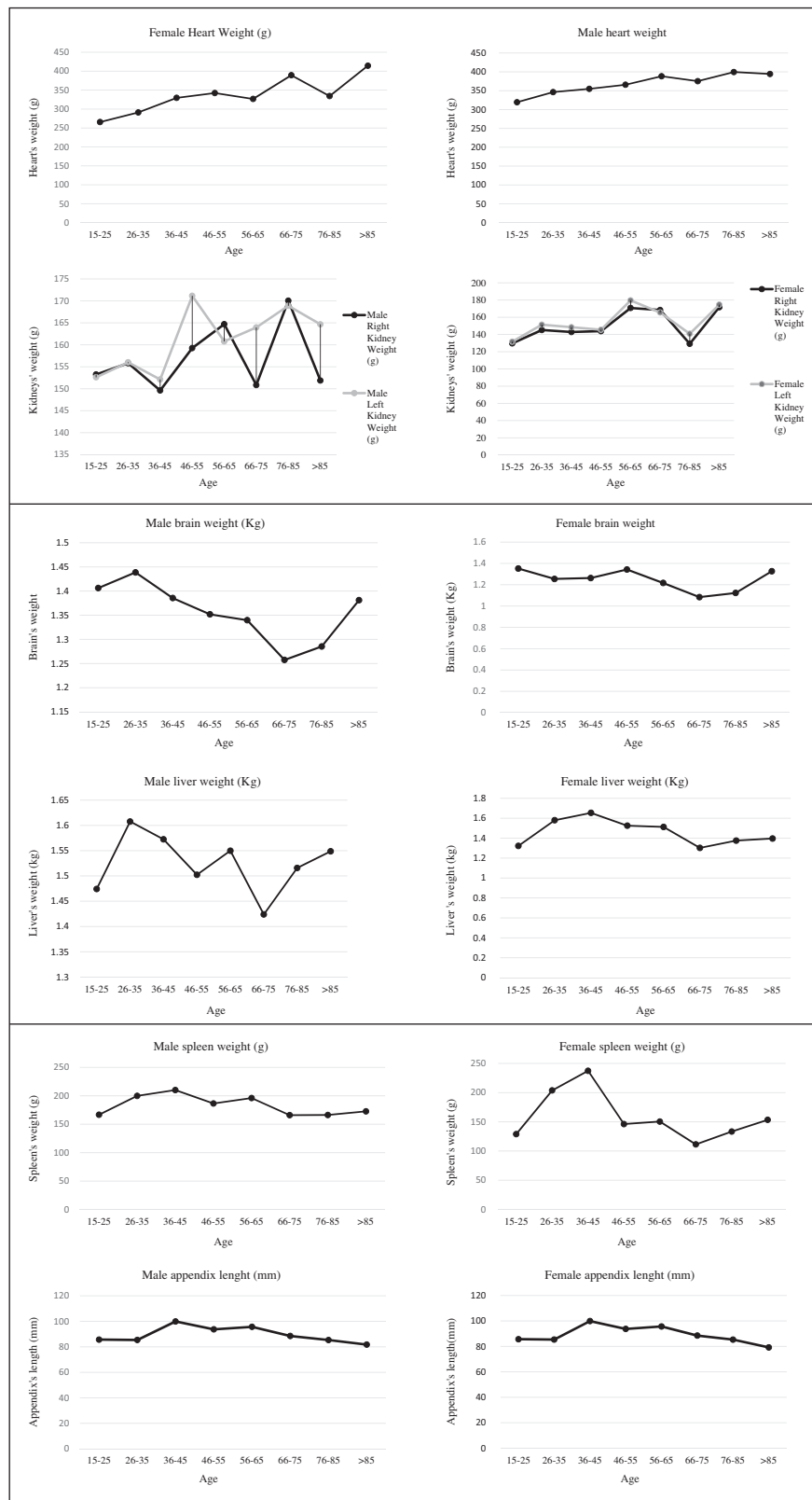


Figure 2. Age-related changes in internal organs' weights in southern Iranian male and female cadaver.

weight remained constant or gradually decreased until the age of 65 years and decreased remarkably afterwards.<sup>[11]</sup> In some other studies, brain's weight decreased with increase in age.<sup>[21,22]</sup>

In our study, spleen's weight was almost constant with a slight increase and decrease during the life span among both males and females. Ogiu et al<sup>[11]</sup> also reported a decrease in spleen weight with increase in age. In north of Iran, Sheikazadi et al<sup>[18]</sup> stated

that almost all the internal organs, except for the heart, attained their peak weights in middle ages and decreased in weight by getting old.

In the present study, among all the organs, left and right kidneys showed a less regular pattern of change in organ weight according to age group in both sexes. Most of the organs showed an increase in weight in middle ages in both males and females. These findings were in agreement with those of other reports.<sup>[18]</sup> In a Japanese population, the weights of livers and kidneys were the highest during the early forties.<sup>[11]</sup>

Overall, the findings of our study may serve as a basis for establishing anatomically normal organs categories in southern Iran. Our findings may also offer a standard for comparison of Iran's different ethnic populations.

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