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Original Research Article

Correlation of Internal Organ Weights with Body Weight and Body Height in Normal Adults in Kerala - An Autopsy Study

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ABSTRACT

Background: Internal organ weight is an important parameter in forensic medicine and pathology for distinguishing normal from pathological organs during autopsy. Organ weights are influenced by age, sex, body weight, height, BMI (Body Mass Index), ethnicity, and environmental factors. Since most available reference values are based on Western populations and limited data exist for the Kerala population, establishing regional reference values is essential for accurate medicolegal interpretation.

Methods: A descriptive autopsy-based study was conducted on 500 individuals aged up to 40 years who underwent medicolegal autopsy at the Department of Forensic Medicine, Government Medical College, Ernakulam, between December 2022 and December 2023. Consecutive sampling was used. Decomposed, charred, unknown, grossly pathological, severely injured organs, and cases treated for more than 24 hours before death were excluded. Organ weights and anthropometric measurements were recorded using a structured proforma and analyzed using SPSS.

Results: In males, the mean weights of the brain, heart, liver, and right kidney were 1301.65 g, 273.92 g, 1361.01 g, and 99.95 g, respectively. In females, the corresponding values were 1295.25 g, 266.99 g, 1336.43 g, and 97.47 g. Most internal organs weighed more in males than females, except the left adrenal gland and thyroid gland, which showed similar or slightly higher values in females. The weights of the brain, heart, lungs, liver, and right kidney demonstrated significant positive correlations with body weight, height, and BMI in both sexes.

Conclusion: This study provides population-specific reference values for internal organ weights among adults in Kerala. The significant relationship between organ weights and anthropometric parameters highlights the importance of using regional standards to improve the accuracy of forensic autopsy interpretation and pathological assessment.

Keywords: Internal Organ Weight, Autopsy, Anthropometry, Body Weight, Body Height, BMI, Forensic Medicine, Kerala.

INTRODUCTION

Organ weight and its morphometric parameters are among the most important indicators for identifying possible organ abnormalities and diseases. Consequently, numerous studies have established normal ranges for organ size, weight, and volume across different ethnic populations. In forensic medicine and pathology, the weight of internal organs plays a crucial role in determining whether an organ is within the normal range or affected by pathological changes. In many cases, an alteration in organ weight may be the only objective finding indicating an underlying disease process or a compensatory response to physiological stress.

Reference values for organ weights are essential for the accurate interpretation of autopsy findings. However, organ weight is influenced by several factors, including age, sex, body weight, height, environmental conditions, dietary habits, hereditary characteristics, and socioeconomic status. Therefore, the use of population-specific reference standards is necessary to ensure reliable forensic and pathological assessment.

In routine practice, pathologists often rely on reference values derived from American and European populations, which may not accurately represent the Indian population. Significant variations in organ weights exist among different racial and ethnic groups, similar to variations observed in body stature and physical characteristics. Furthermore, limited literature is available on normal internal organ weights in the Indian population, particularly in Kerala. Hence, establishing regional reference values for internal organ weights and their relationship with anthropometric parameters is essential for improving the accuracy of medicolegal investigations and pathological diagnosis.

AIMS AND OBJECTIVES

The study aimed to determine the correlation between the weight of internal organs and anthropometric parameters, namely body weight, height, and BMI (Body Mass Index), in autopsy cases up to 40 years of age brought to the mortuary of Government Medical College, Ernakulam, during the study period. The study also aims to evaluate the relationship between internal organ weights and demographic variables such as age and sex, thereby establishing their association in a tertiary care autopsy population.

MATERIALS AND METHODS

Study Design

The study was a cross-sectional study conducted in the mortuary wing of the Department of Forensic Medicine, Government Medical College, Ernakulam. The study was extended for one year from the date of obtaining IEC (Institutional Ethics Committee) clearance.

Inclusion and Exclusion Criteria

The study included subjects aged up to 40 years who died with a short survival period of less than 24 hours before death. Decomposed bodies, charred bodies, and unknown bodies were excluded from the study. Cases with organs showing gross pathological changes or congenital anomalies, cases that had received treatment for more than 24 hours before death, and cases with injuries involving the internal organs were also excluded.

Sample Size Calculation

On year from getting institutional ethics committee clearance.

$$n = \frac{(z_{1-\beta} + z_{1-\alpha/2})^2}{r^2(1 - r^2)}$$

with $z_{1-\alpha/2} = 1.96$, $z_{1-\beta} = 0.84$, and $r = 0.3102$:

$$n = \frac{(1.96 + 0.84)^2}{(0.3102)^2(1 - 0.3102^2)}$$

=75.75

r: correlation coefficient (taken as 0.310 as correlation coefficient of weight of liver and body weight in reference study).

For improving the accuracy of the results of the study, the sample size taken as 500.[1]

Data Collection Procedure

After obtaining approval from the Institutional Ethics Committee and a waiver of consent, all consecutive medicolegal autopsy cases meeting the inclusion criteria were enrolled during the study period. Relevant information was collected from the inquest report, police records, medical records, and interviews with the accompanying police officer and relatives or attendants, and recorded in a structured proforma. Age, sex, body weight, height, and body mass index were documented. Postmortem examination was performed using the modified Letulle's technique, and the brain, heart, lungs, liver, spleen, pancreas, kidneys, adrenal glands, thyroid gland, and uterus with appendages were removed and weighed using a calibrated electronic balance.[2] The weighing machine was calibrated daily, and inter-observer agreement was assessed for every 25th case.

Statistical Analysis

The collected data were entered into Microsoft Excel and analysed using SPSS version 27.0, with quantitative variables expressed as mean and standard deviation, qualitative variables as proportions, and Pearson's correlation coefficient used to assess the relationship

between organ weight and body weight, height, and body mass index.

RESULTS

Variable	Category	Number (%)
Sex	Male	385 (77.0)
	Female	115 (23.0)
Age Group (years)	≤5	1 (0.2)
	6–10	4 (0.8)
	11–15	15 (3.0)
	16–20	75 (15.0)
	21–25	83 (16.6)
	26–30	89 (17.8)
	31–35	92 (18.4)
	36–40	141 (28.2)
Residence	Rural	191 (38.2)
	Semi-urban	195 (39.0)
	Urban	114 (22.8)
BMI	Underweight	17 (3.4)
	Normal	331 (66.2)
	Overweight	134 (26.8)
	Obese	18 (3.6)
Treatment before death	Yes	75 (15.0)
	No	425 (85.0)
Most common cause of death	Hanging	343 (68.6)

Table 1. Demographic and Clinical Profile of the Study Population (n=500)

Table 1 illustrates the demographic and clinical characteristics of the study population. Males constituted 77% of the cases, while females accounted for 23%. The highest proportion of subjects belonged to the 36–40 years age group (28.2%). Most participants had a normal BMI (66.2%), and hanging was the leading cause of death.

Parameter	n	Mean ± SD	Range
Age (years)	500	28.87 ± 8.02	4–40
Height (cm)	500	161.21 ± 8.10	108–184
Body weight (kg)	500	61.52 ± 11.40	17–156
BMI (kg/m²)	500	23.57 ± 3.51	10.58–46.08
Brain (g)	500	1300.14 ± 74.26	989–1565
Heart (g)	500	272.28 ± 58.78	77–490
Right lung (g)	500	316.73 ± 59.23	114–652
Left lung (g)	500	319.46 ± 51.29	101–698
Liver (g)	500	1355.21 ± 140.75	610–2895
Spleen (g)	500	77.12 ± 20.44	39–192
Pancreas (g)	500	76.64 ± 17.12	48–189
Right kidney (g)	499	99.37 ± 14.75	45–260
Left kidney (g)	500	101.49 ± 15.25	41–280
Right adrenal (g)	500	9.06 ± 2.51	2–31
Left adrenal (g)	500	9.29 ± 1.97	2–31
Thyroid (g)	500	14.65 ± 2.38	5–26
Uterus & appendages (g)	115	60.48 ± 13.66	45–158

Table 2. Morphometric Characteristics and Organ Weights

Table 2 presents the overall anthropometric characteristics and internal organ weights of the study population. The average body weight was 61.52 kg, while the liver had the highest mean weight (1355.21 g) after the brain (1300.14 g). One right kidney was excluded because of congenital agenesis, leaving 499 observations for the right kidney.

Organ	n	Mean ± SD (%)	Range (%)
Brain	500	2.18 ± 0.45	0.91–6.29
Heart	500	0.45 ± 0.09	0.27–0.86
Right lung	500	0.53 ± 0.11	0.28–1.30
Left lung	500	0.53 ± 0.11	0.25–1.40
Liver	500	2.26 ± 0.40	1.39–5.80
Spleen	500	0.13 ± 0.04	0.04–0.31
Pancreas	500	0.13 ± 0.04	0.07–0.35
Right kidney	499	0.17 ± 0.04	0.10–0.38
Left kidney	500	0.17 ± 0.04	0.10–0.38
Right adrenal	500	0.02 ± 0.00	0.01–0.04
Left adrenal	500	0.02 ± 0.00	0.01–0.05
Thyroid	500	0.02 ± 0.01	0.01–0.06
Uterus & appendages	115	0.11 ± 0.03	0.06–0.31

Table 3. Organ Weights as Percentage of Body Weight

Table 3 illustrates organ weights expressed as a percentage of total body weight. The liver contributed the largest proportion of body weight (2.26%), followed closely by the brain (2.18%). The adrenal glands and thyroid contributed the smallest proportions.

Organ	Male (n=385) Mean ± SD	Female (n=115) Mean ± SD
Brain	1301.65 ± 73.57	1295.25 ± 76.56
Heart	273.92 ± 58.01	266.99 ± 61.18
Right lung	318.72 ± 60.21	310.27 ± 55.68
Left lung	320.53 ± 50.22	315.97 ± 54.68
Liver	1361.01 ± 138.82	1336.43 ± 145.82
Spleen	77.36 ± 21.03	76.33 ± 18.47
Pancreas	76.98 ± 17.67	75.51 ± 15.22
Right kidney	99.95 ± 15.04*	97.47 ± 13.65
Left kidney	102.41 ± 15.80	98.52 ± 12.94
Right adrenal	9.12 ± 2.58	8.90 ± 2.26
Left adrenal	9.28 ± 2.03	9.30 ± 1.78
Thyroid	14.64 ± 2.39	14.65 ± 2.37
Uterus & appendages	—	60.48 ± 13.66

Table 4. Sex-Wise Comparison of Mean Organ Weights

Table 4 compares organ weights between males and females. The mean weights of the brain, heart, lungs, liver, spleen, pancreas and kidneys were higher in males. Only the left adrenal gland and thyroid gland showed slightly higher mean values among females.

Age Group	Brain	Heart	Right Lung	Left Lung	Liver	Right Kidney	Left Kidney
6–10	1166.75	152.75	194.25	192.75	1015.75	79.25	79.75
11–15	1257.00	260.27	321.27	311.40	1374.60	96.47	97.27
16–20	1286.00	259.84	305.40	307.56	1321.53	95.86	98.73
21–25	1288.17	261.93	314.33	321.27	1335.90	98.07	100.70
26–30	1309.29	272.56	312.20	316.56	1358.02	98.24	100.07
31–35	1311.80	276.70	322.46	322.86	1367.78	100.84	103.39
36–40	1311.91	287.99	327.72	330.33	1387.37	100.57	101.58

Table 5. Age-Wise Trend of Mean Organ Weights

Table 5 demonstrates the age-wise progression of organ weights. The brain weight increased rapidly during childhood and plateaued in adulthood, whereas the heart, lungs and liver generally showed progressive increases, reaching their highest mean values in the 36–40 years age group.

Organ	Body Weight r (p)	Height r (p)	BMI r (p)
Brain	0.493 (0.001)	0.196 (0.001)	0.523 (0.001)
Heart	0.520 (0.001)	0.181 (0.001)	0.550 (0.001)
Right lung	0.333 (0.001)	0.289 (0.001)	0.260 (0.001)
Left lung	0.340 (0.001)	0.277 (0.001)	0.284 (0.001)
Liver	0.572 (0.001)	0.296 (0.001)	0.525 (0.001)
Spleen	0.132 (0.003)	0.046 (0.302)	0.161 (0.001)
Pancreas	0.188 (0.001)	0.133 (0.003)	0.141 (0.002)
Right kidney	0.392 (0.001)	0.254 (0.001)	0.318 (0.001)
Left kidney	0.392 (0.001)	0.231 (0.001)	0.321 (0.001)
Right adrenal	0.255 (0.001)	0.128 (0.004)	0.230 (0.001)
Left adrenal	0.208 (0.001)	0.106 (0.018)	0.215 (0.001)
Thyroid	0.356 (0.001)	0.099 (0.027)	0.401 (0.001)
Uterus & appendages	0.067 (0.477)	0.155 (0.099)	0.024 (0.798)

Table 6. Correlation of Organ Weights with Body Weight, Height and BMI

Table 6 summarises the relationship between organ weights and anthropometric parameters in the overall study population. The liver showed the strongest correlation with body weight (r=0.572), while the heart demonstrated the strongest correlation with BMI (r=0.550). The uterus with its appendages did not show significant correlation with body weight, height or BMI.

Parameter	Male	Female
Body weight	All organs except spleen	All organs except pancreas, left kidney and uterus
Height	All organs except spleen and thyroid	Brain, heart, lungs, liver, right kidney and thyroid
BMI	All organs	All organs except pancreas, left kidney and uterus

Table 7. Sex-Wise Pattern of Significant Correlations

Table 7 highlights the sex-specific correlation patterns observed in the study. In males, almost all organs showed significant associations with body weight and BMI, whereas thyroid failed to correlate with height. In females, significant correlations were observed mainly for the brain, heart, lungs, liver and right kidney, while the uterus with its appendages consistently showed no significant relationship with the measured anthropometric parameters.

DISCUSSION

The present study provides reference values for internal organ weights in the Kerala population and demonstrates their relationship with body weight, height, BMI, age, and sex. Since organ weights vary across populations due to environmental, dietary, genetic, and socioeconomic factors, region-specific reference standards are essential for accurate interpretation of autopsy findings.

Brain

The mean brain weight was 1300±74.26 g, with mean values of 1301.65±73.57 g in males and 1295.25±76.56 g in females. These findings are comparable with those reported by Tanna et al.,[3] while Liza John et al.[4] and Kohli et al.[5] reported comparatively lower female brain weights. The highest brain weight in the present study was observed in the 36–40-year age group, similar to Singh et al.[6] although Puttaswamy,[7] Muthuramon et al.[8] and Narongchai et al.,[9] reported peak values in younger age groups. Brain weight showed a strong positive correlation with body weight, height, and BMI, consistent with Narongchai et al.,[9] Muthuramon et al.,[8] and Gholamzadeh et al.[10]

Heart

The mean heart weight was 272.28±58.78 g, representing approximately 0.45% of body weight, closely matching the findings of Mubbunu et al.[1] Heart weight increased progressively with age and reached its maximum in the 36–40-year group, similar to observations by Liza John et al.,[4] Deepika et al.,[11] and Kohli et al.[5] Unlike other organs, heart weight tends to remain elevated after attaining peak values, possibly because of increasing epicardial fat and age-related cardiovascular changes, as reported by Liza

John et al.,[4] Muthuramon et al.,[8] Puttaswamy[7] and Deepika et al.[11] A significant positive correlation was observed between heart weight and body weight, height, and BMI, supporting previous findings by Deepika et al.,[11] Narongchai et al.,[9] and Mubbunu et al.[1]

Lungs

The mean weights of the right and left lungs were 316.78±75.31 g and 319.48±74.96 g, respectively. Both lungs were heavier in males, consistent with previous reports by Tanna et al.,[3] Singh et al.,[6] and Mubbunu et al.[1] Unlike classical anatomical descriptions that report the right lung to be heavier, the left lung showed a slightly higher mean weight in the present study, a finding also noted by Narongchai et al.[9] Lung weights increased with age and demonstrated significant positive correlations with body weight, height, and BMI, in agreement with Narongchai et al.,[9] and Mubbunu et al.[1]

Liver

The liver had a mean weight of 1355.35±245.69 g, with higher values in males than females. These findings are comparable with those reported by Mubbunu et al.,[1] and Gholamzadeh et al.[10] although somewhat higher than those observed by Kohli et al.[5] Liver weight increased with advancing age within the study population and showed significant positive correlations with body weight, height, and BMI, supporting observations by Narongchai et al.[9] and Deepika et al.[11]

Spleen

The mean spleen weight was 77.12±34.88 g, which is lower than values reported in several Indian studies, including Kohli et al.,[5] but comparable with Narongchai et al.[9] Spleen weight showed only weak associations with age and anthropometric parameters, suggesting greater physiological variability compared with larger solid organs.

Pancreas

The pancreas weighed 76.64±17.74 g on average, with males showing slightly higher values than females. These findings are close to those reported by Muthuramon et al.[8] and Narongchai et al.[9] Unlike the major organs, pancreatic weight demonstrated only modest correlations with body weight, height, and BMI, indicating relatively limited dependence on anthropometric variables.

Kidneys

The mean weights of the right and left kidneys were 99.38±18.29 g and 101.52±18.60 g, respectively, with the left kidney consistently heavier than the right. This observation agrees with Tanna et al.,[3] Singh et al.,[6] and Narongchai et al.[9] Both kidneys exhibited positive correlations with body weight, height, and BMI, although the correlation was stronger for the right kidney. These findings reinforce the influence of body habitus on renal size.

Adrenal Glands

The mean weights of the right and left adrenal glands were 9.07±2.39 g and 9.28±2.45 g, respectively, with the left adrenal being marginally heavier, consistent with Narongchai et al.[9] Unlike larger organs, adrenal gland weight demonstrated limited correlation with body weight, height, BMI, and age, suggesting greater anatomical stability within the studied age group.

Thyroid Gland

The thyroid gland had a mean weight of 14.64±4.55 g, with nearly identical values in males and females. This finding is lower than the classical reference range but is comparable with Narongchai et al.[9] Thyroid weight showed only weak correlations with anthropometric parameters, indicating that factors other than body size may play a greater role in determining thyroid weight.

Uterus and Appendages

Among female subjects, the mean uterine weight increased with age, consistent with reproductive maturation. The observed values were comparable with those reported by Tanna et al.[3] and Singh et al.[6] although physiological variations related to reproductive status may account for minor differences.

CONCLUSION

This study established the reference weights of major internal organs in individuals below 40 years of age and demonstrated that organ weights are generally higher in males than females. Most organs showed significant positive correlations with body weight, height, and body mass index, although a few exceptions were noted, particularly for the spleen, pancreas, and adrenal glands. Overall, the organ weights observed were comparable

with findings from other Indian studies, indicating that body weight, height, and BMI are useful predictors of internal organ weights in the study population.

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