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ORIGINAL RESEARCH

Relation of Weights of the Brain with Age and Sex – An Autopsy Based Study Done in Medical College of West Bengal

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ABSTRACT

Background: Autopsy (necropsy, post mortem examination, thanatopsy) is the meticulous and thorough examination of a person's body after death. An autopsy can be of different types. To the forensic pathologist, Medicolegal autopsy is the most important concern. Study of weight of human body organs plays a significant role in almost all the branches of medical sciences as any deviation in weight from the normal range may suggest some pathological change in the organ. Recording of organ weights is one of regular criteria by the forensic experts during an autopsy. The findings were compared to what is standard or average of a specific organ for a specific age range and particular sex. The determination of weights of brain in particular has significant clinical value.

Materials and Methods: After getting institutional ethical committee clearance, the study conducted over the body of the 570 deceased came for medicolegal autopsy fulfilling the inclusion and exclusion criteria**.**

Results: Total 570 cases had been selected after following the inclusion and exclusion criteria out of which 362 were males and 208 were females. Among the studied 570 cases, 362 (63.5 %) were male and rest (36.5 %) were female. In this study the discussion was mainly on relation of age, sex, body weight, and body length upon the weight of brain.

Conclusion: A database may be deduced from this study regarding normal range of the weight of various organs and their relation with external parameters of the subjects which can be applicable on the population of this region for future reference. In severely mutilated bodies found in mass disasters or in homicidal killing, weights of isolated organs may give an idea about the stature, built and age of the victims helping in identification.

Keywords: Autopsy; Weight; Brain; Age; Sex.

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INTRODUCTION

Autopsy (necropsy, post mortem examination, thanatopsy) is the meticulous and thorough examination of a person's body after death. An autopsy may be of different types. But among them usually following two types are most important.

A] Pathological or Clinical Autopsy

Performed by clinicians or pathologist to diagnose the cause of death where conclusion cannot be arrived during treatment, or to confirm a doubtfully diagnosed case or to study the effect/ effectiveness of treatment. Consent from the relatives of the deceased is mandatory.

B] Medicolegal Autopsy

It is performed as part of official inquiry of a suspicious, sudden, or unnatural death and the information derived from it is to be applied to legal purposes to aid in the administration of justice. It is a special type of examination of a dead body to find out the cause of death examining all the body parts, all the organs, opening all the body cavities to corroborate with the evidences of eyewitnesses as per laws of the land towards admission of justice and prosecution of guilty.[1]

Study of weight of human body organs plays a significant role in almost all the branches of medical sciences as any deviation in weight from the normal range may suggest some pathological change in the organ. Weighing of organs at autopsy not merely an exercise but has great medico-legal importance. Any deviation in weight from the normal range usually indicates some pathological change in the organ and thus helps in interpreting the opinion regarding the cause of death in various pathological conditions.[2]

Recording of organ weights is one of regular work of the forensic pathologists during an autopsy. The findings were compared to the standard or average of a particular organ for a particular age range and specific sex. The determination of weight of brain in particular has vast clinical value. As for example, liver volumes are important not only for determining disease states and disease progression but also in estimating segmental liver volumes for transplant donors and planning the extent of hepatectomy in cancer patients. The spleen commonly increases in size in response to some infection and hematologic or metabolic disorders. A good correlation can be seen between platelet count and spleen volume, and splenic volume detects serious liver disease and correlates with splenic hyper function. Kidney size usually bears a relation to the degree of renal diseases.[3]

A vast variation is seen in the organ weights due to several factors in different regions of the world. The reason for this may be due to the variation in the dietary habits, climatic conditions, usual water intake, ethnicity, customs, and genetic predisposition of different population groups. Hence the normal organ weights of a particular region may not be accurate enough for another.[4]

Human organ weights besides state of nutrition etc. were also reported to be dependent on socio-economic and environmental conditions which are quite different in various parts of India.[5] Hence, the organ weights reported from other parts of India are definitely not applicable directly to the population of West Bengal.[6] As literature available on the internal organ weights for the population of this region, in particular is scanty, hence the present study is an attempt to provide such information. This study was designed to address the issue and to determine a normal weight range of the brain in population of both sexes and different age groups in this locality and also to correlate the visceral weights with variables such as age, body length and body weight.

A scientific study was done on Normal Internal Organ Weight of Thai Adults Correlated to Body Length and Body Weight, analysis with the help of data from 250 autopsies from the Ramathibodi Hospital, Bangkok, Thailand in 2005 by group of scientists led by Thamrong

Chirachariyavej. Excluding the decomposed bodies, fire related deaths and cases where medical treatment had not been given rest of the cases were from sudden unnatural death the age ranged from 15 to 88 years and there were 51 females and 199 males. Pearson's correlation coefficient was used to examine the relationship between the internal organ weight with body weight and body length. The mean + standard deviation (SD) were found for males and females respectively as follows:- Brain 1339 + 160/1165 + 184 gm, heart 311+ 66/278 + 160 gm, lung 910 + 347/675 + 255 gm, liver 1439 + 365/1214 + 275 gm, spleen 103 + 46/92.9 + 48 gm, kidney 260 + 68/230 + 42 gm. The relationship between internal organ weight and body weight showed each internal organ significantly correlated with body weight in males at p-value < 0.05, whereas in females it only correlated to liver, kidney and spleen at p-value < 0.05. For the correlation between internal organ weight and body length, it showed only brain, lung, liver and kidney correlated to the body length in males at p-value < 0.05, but not in females[7]

In 2002, Batra et. al conducted research over 114 male cadavers between the ages of 25 and 88 years to establish the relationship between the volume, weight, and size of the pancreas, spleen, and kidney with body mass index (BMI), body surface area (BSA), age, height, and weight. Results showed that the volume, weight, and size of all the organs were in correlation with the deceased's height, body weight, BMI, and BSA but not with age. The viscera volume, weight, and size showed a better statistical correlation with the BSA, BMI, and body weight than the height.[8]

Organ	Males	Females
Brain (gms)	1213.6	1077.6
Heart (gms)	277.6	215.6
Lung Rt (gms)	365.3	309.6
Lung Lt (gms)	346.6	297.0
Liver (gms)	1205.3	1055.0
Kidney Rt (gms)	113.0	86.3
Kidney Lt (gms)	114.3	89.0
Spleen (gms)	191.6	113.6

A scientific study was done on Normal Internal Organ Weight of Thai Adults Correlated to Body Length and Body Weight, analysis with the help of data from 250 autopsies from the Ramathibodi Hospital, Bangkok, Thailand in 2005 by group of scientists led by Thamrong Chirachariyavej. Excluding the decomposed bodies, fire related deaths and cases where medical treatment had not been given rest of the cases were from sudden unnatural death the age ranged from 15 to 88 years and there were 51 females and 199 males. Pearson's correlation coefficient was used to examine the relationship between the internal organ weight with body weight and body length.The mean + standard deviation (SD) were found for males and females respectively as follows:- Brain 1339 + 160/1165 + 184 gm, heart 311+ 66/278 + 160 gm, lung 910 + 347/675 + 255 gm, liver 1439 + 365/1214 + 275 gm, spleen 103 + 46/92.9 + 48 gm, kidney 260 + 68/230 + 42 gm. The relationship between internal organ weight and body weight showed each internal organ significantly correlated with body weight in males at p-value < 0.05, whereas in females it only correlated to liver, kidney and spleen at p-value < 0.05. For the correlation between internal organ weight and body length, it showed only brain, lung, liver and kidney correlated to the body length in males at p-value < 0.05, but not in females.[9]

In a study titled as "Statistical Analysis for Organ Weights in Korean Adult Autopsies" (2003-2005) in Seoul, Korea done by Yi-Suk Kim et al (2005) in a study revealed that all the

organs in males were heavier than those in females. The statistically controlled variables showed that the organ weights of hearts, spleens, and thyroid glands in males were not different from those in females, and the rest of organs were heavier in males than females. Mean weight of left kidneys was higher than that of right ones with the confidence limit being 95% (P<0.05). All of the organs but heart became lighter in weight, as one got aged. The liver and kidney weights of the middle-aged adults were heavier than those of any other age groups (P<0.05). The weights of all organs except for lungs and brain were more related to body weight than height. These results are considered for useful anatomical data to understand the disease properties in Koreans.[10]

In 2006, two scientists Anil Kohli and N.K Aggarwal done extensive study on Normal Organ weights of Indians. In that study organs were collected from dead bodies within the age group of 18 to 75 years brought for autopsy. The organs taken for the studies did not show any gross pathology and the survival time in the hospital (for admitted cases) varied from 1-2 days. Excluding the cases surviving for more than two days omitted for the chances of any alterations in organ weights due to treatment or disease process setting in during treatment. The following organs were considered - brain, liver, lungs, kidneys and spleen. (11) The study revealed following results:

	MALES			**FEMALES**		
Organs	**Weight in Grams**			**Weight in Grams**		
	Minimum	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
Brain	992.25	1615.95	1342.86	850.5	1360.8	1085.52
Right Lung	198.45	850.5	514.55	170.10	567.0	382.78
Left Lung	141.75	850.5	469.65	141.75	510.3	333.12
Heart	99.225	368.55	283.5	113.4	226.8	184.28
Stomach	85.05	255.15	158.76	99.23	226.80	163.02
Liver	737.10	1,842.75	1241.16	850.50	1417.50	1,084.39
Spleen	70.875	311.85	170.95	56.70	269.33	145.27
Right Kidney	70.875	170.10	103.19	56.70	113.40	87.32
Left Kidney	42.525	170.10	102.91	56.70	113.40	83.63

A study titled as “Correlation of Internal Organ Weight with Body Weight and Length in Normal Thai Adults”, done by Piyanun Mathuramon et al. at Ramathibodi Hospital, Bangkok during the period between 2003-2007, revealed that relationship was found between internal organs weight and body weight and body length of males whereas, in females the weight of internal organs except the kidneys was not related to body length.[12]

In an autopsy-based study to find the relationship between Organ Weights and Body Weight in Adult population of Bhavnagar region done by J.A Tanna et al during 2009-2010 at Sir T. Hospital, Bhavnagar, Gujarat revealed that the weight of brain in that region was noted to be 1.98% -1.76% of body weight, weight of spleen was noted to be 0.26% -0.16% of body

weight The average weights of both the organs found to be higher than data given in the popular textbooks. In addition, the weight of right lung and left Lung was noted to be 0.90% - 0.66% & 0.82% - 0.60% of body weight respectively, which is lower than the textbooks.[13]
In a Study of visceral Organ Weight and Its Correlation to Body Weight in Kumaon Region of Uttarakhand by Chandra Prakash et al done at the department of Forensic Medicine, Govt. Medical College, Haldwani, Uttarakhand from March 2011 to March 2012, Pearson's correlation coefficient was used to see the relationship between the internal organ weights (IOW) with body weight (BW). The mean ± Standard deviation (SD) were represented by males and females respectively: Brain 1115.51 ± 156.42 / 1016.09 + 141.01, Rt Lung 446.57 ± 201.06 / 334 ± 143.76, Lt. Lung 477.85 ± 201.22 / 344.37 + 140, Spleen 149.17 ± 105.61 / 153.09 ± 116.98, Heart 270.28 ± 54.41 / 204.35 ± 57.35, Liver 1419.80 ± 395.27 / 1204.52 ±365.71, Rt Kidney 136.65 ± 62.24 / 111.91 ± 32.29, Lt Kidney 132.42 ± 42.67 / 104.24 ± 33.79. It was found that weight of different organs was positively correlated to body weight in both sexes except in male brain, lung and spleen are not correlated and in female spleen is not correlated. Females had a lower organ weight compared to males. In both sexes, weight of organ was lower than the western population. After attaining the peak, all organ weights declined with the advancing age.[14]
Divyesh K. Vadgama et al (2010) conducted an autopsy based study during the period of February 2010 to November 2010. In that study 449 cases (272 Male, 177 Female) were included. Body weight (BW), Body length (BL), Body mass index (BMI) and Body surface area (BSA) was measured for finding correlation with organ weights. The study revealed that in males, except Spleen weights of 5 organs have positive correlation with BW. In females, weights of all organs except spleen were correlated positively with BW. In males, weights of both lungs had positive correlation with BL and weights of the brain, liver, spleen and both kidneys have negative correlation with BL. In females, heart and both lungs had positive correlation with BL.[15]

MATERIALS & METHODS

After getting the clearance from the institutional ethical committee, examination and weight measurements of the brain of the bodies was done during the process of medicolegal autopsies in Burdwan Police Morgue of Burdwan Medical College over 12 months. This cross-sectional study included following criteria-

Inclusion Criteria

All the bodies came for postmortem examination following complete enumeration method

Exclusion Criteria

I. Decomposed body
II. Evidence of gross pathology and trauma to internal organs,
III. Apparently Malnourished (BMI < 18)
IV. Dead-bodies whose exact age is not documented.

Total 570 cases were included in the study.

RESULTS

Total 570 cases were selected after following the inclusion and exclusion criteria out of which 362 were males and 208 were females. Analysis and tabulation were done by standard statistical methods using appropriate software.

Table 1: Distribution of subjects according to their sex

Sex		Frequency	Percent
	Male	362	63.5
	Female	208	36.5
	Total	570	100.0

Table 2: Distribution of subjects according to their ages

Age (Years)		Frequency	Percent
	0-10	8	1.4
	11-20	100	17.5
	21-30	148	26.0
	31-40	101	17.7
	41-50	92	16.1
	51-60	60	10.5
	61-70	39	6.8
	71-80	18	3.2
	81-90	4	.7
	Total	570	100.0

Table 3: Age group-wise distribution of sex of subjects

		Age groups									Total
		0-10 years	11-20 years	21-30 years	31-40 years	41-50 years	51-60 years	61-70 years	71-80 years	81-90 years	
Sex	**Male**	6	46	84	67	70	47	28	10	4	362
	Female	2	54	64	34	22	13	11	8	0	208
Total		8	100	148	101	92	60	39	18	4	570

Among the studied 570 cases, 362 (63.5 %) were male and 208 (36.5 %) were female. (Table 1). In this study the discussion was mainly on relation of age, sex, body weight, and body length upon the weights of thoracic viscera.

Table 4: One way ANOVA test between different Age groups and weight of Brain (n= 569)

ANOVA					
BRAIN					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	241567.059	8	30195.882	4.444	.000
Within Groups	3811751.329	561	6794.566		
Total	4053318.388	569			

Table 5: Independent sample t-test between Sex and weight of Brain (n= 570)

Group Statistics					
	Sex	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Brain	Male	362	1225.663	85.3812	4.4875
	Female	208	1182.245	75.2653	5.2187

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
BRAIN	Equal variances assumed	4.335	.038	6.098	568	.000	43.4178	7.1206	29.4319	57.4037
	Equal variances not assumed			6.308	476.811	.000	43.4178	6.8828	29.8934	56.9422

Table 6: Correlation coefficient test between weight of Brain and Body weight (n= 570)

Descriptive Statistics			
	Mean	Std. Deviation	N
BRAIN	1209.819	84.4013	570
WEIGHT	61.999	12.2795	570

Correlations			
		BRAIN	WEIGHT
BRAIN	Pearson Correlation	1	.204**
	Sig. (2-tailed)		.000
	N	570	570
WEIGHT	Pearson Correlation	.204**	1
	Sig. (2-tailed)	.000	
	N	570	570
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 7: Correlation coefficient test between weight of Brain and Body Length

Descriptive Statistics			
	Mean	**Std. Deviation**	**N**
Brain	1209.819	84.4013	570

Length	160.328	9.9484	570

Correlations			
		Brain	**Length**
BRAIN	Pearson Correlation	1	.156**
	Sig. (2-tailed)		.000
	N	570	570
LENGTH	Pearson Correlation	.156**	1
	Sig. (2-tailed)	.000	
	N	570	570
**. Correlation is significant at the 0.01 level (2-tailed).			

In this study there is a statistically significant differences of weight of brain between groups as demonstrated by one-way ANOVA F(8,561) = 4.444, p = .000. The Bonferroni post hoc test showed that EXCEPT between few age groups (i.e. 81-90 age group with that of 0-10, 61-70 and 71-80 age group; 71-80 age group with that of 0-10, 11-20, 21-30, 51-60 and 61-70 age group; 61-70 age group with that of 0-10, 11-20, 21-30, 31-40, 41-50, 51-60 age group; 51-60 age group with 0-10, 11-20, 21-30, 31-40 and 41-50 age group; 41-50 age group with 0-10, 11-20, 21-30 and 31-40 age group; 31-40 age group with that of 0-10, 11-20 and 21-30 age group; 21-30 age group with that of 0-10 and 11-20 age group; 11-20 age group with that of 0-10 age group) there is significant differences between weight of the brain and different age groups. (Table 4)

Independent sample t test between sex and weight of the brain showed that the mean weight of the brain among the male is 1225.67gm and that of female is 1182.24gm. 2-tailed p value (0.0) also showed that the differences between weight of brain between male and female is also significant. Levene's Test also showed that the there is significant Variances between two samples (p= 0.038, <0.05) (Table 5)

Correlation coefficient i.e Pearson's r is 0.204 that means weak positive correlation – the persons having more the body weight likely to have greater weight of the brain and the 2-tailed significance value (0.00) also proofs that this correlation is very powerful and (it has enough statistical power to identify even the slightest change). (Table 6)

Correlation coefficient i.e Pearson's r is 0.156 that means weak positive correlation – the persons having more the body length likely to have greater weight of the brain and the 2-tailed significance value (0.00) also proofs that this correlation is very powerful and (it has enough statistical power to identify even the slightest change). (Table 7)

DISCUSSION

Regarding brain weight, average brain wt. in this study in case of male is 1225.66 gm and in female 1182.24 gm (Table 5) which is less than that mentioned in the text book of 'Essentials of Forensic Medicine and Toxicology '–**Dr. J.B. Mukherjee.**[1]

The brain weight in this study is less in males but more in females than that mentioned in the study by **Kohli Anilet al**[11]conducted at Uttar Pradesh (males-1342.86 / females-1085.52 gm),

Brain weight is more in both sexes than in both sexes mentioned in the study in Nagpur **by Batra et al**[8](1213.6 gm, 1077.6 gm).

In male subjects brain weight in this study mean ±SD is1225.66 gm ± 85.38gm and in female 1182.24gm ± 75.26gm (table 5)

Chandra Prakash et al[14] in their Study of Internal Organ Weight and Its Correlation with Body weight observed that The mean ± Standard deviation (SD) of males and females respectively; Brain 1115.51 ± 156.42 gm / 1016.09+141.01 gm,

Mathuramon P. et al[12] has found that the weight of male's brain was 1330.62 ± 127.45 gm and that of the females 1208.71 ± 131.44 gm and these findings are similar to those of **Chirachariyavej T et al**[9]and studies from Europe and United States.

Range of brain wt. (mean ± 2 SD) and range of % BW found are very much similar to the study done by **J.A. Tanna et al** [13] on 'Relation between organ weights and body weight in Adult population of Bhavnagar Region- a post mortem study' (in males 1087 – 1412, and in females 880-1157)

Observation in this study regarding the brain wt. shows similarity to the studies in other parts of the country and within normal limits as mentioned in the Text books.

Chandra Prakash et al[14] observed in their study at Kumaon District of Uttarakhand significant relation in between brain wt. and Body wt. in case of females ('r' 0.663, $p< 0.001$) but not in males ('r' 0.158, $p>0.1$)

In an 'Autopsy Study of Organ Weights in Relation to Body Weight and Body Length of Adult Cases in Jamnagar Region, by **Divyesh K. Vadgama et al**[15]significant correlation between IOW and BW was observed in both sexes (males 'r' 0.115 and females 'r'0.368)

Yi-Suk Kim et al [10] in their study' Statistical Analysis for Organ Weights in Korean Adult Autopsies' observed correlation in between IOW and BW in both sexes (male 'r'0.257, female 'r' 0.330) and also in between IOW and BL in both sexes (r' 0.290 and 0.225).

CONCLUSION

A database can be formed from this study regarding normal range of the weight of various organs and their relation with external parameters of the subjects which can be applicable on the population of this region for future reference. In severely mutilated bodies found in mass disasters or in homicidal killing, weights of isolated organs may give an idea about the stature, built and age of the victims helping in identification.

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