Normal Internal Organ Weight of Thai Adults Correlated to Body Length and Body Weight

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Objective: *Examine the relationship between the internal organ weight with body weight and body length.*
Material and Method: *Analysis of data from 250 autopsies from the Ramathibodi Hospital from August 2003 to February 2005. The cases were from sudden unnatural death including accident, homicide and suicide and excluded decomposed bodies, fire related deaths and cases where medical treatment had been given. The age ranged from 15 to 88 years and there were 51 females and 199 males. Parson's correlation coefficient was used to examine the relationship between the internal organ weight with body weight and body length.*
Results: *The mean ± standard deviation (SD) were represented by males and females respectively; 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.*
Conclusion: *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.*

Keywords: *Internal organ weight, Body weight, Body length*

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In an autopsy, the internal organ weight (IOW) including the body weight (BW) and body length (BL) is one of the criteria regularly used. The increase or decrease of IOW compared to the BW and BL are well recognized in many diseases[1,2]. The normal adult IOW has been studied in the United States, Western Europe, Japan and some other countries[1-14]. Only a few studies that covered continental Asia were reported from Japan[9-11]. In Thailand, we often use references of normal adult IOW from either United States or European countries.

The report from Japan in 1977 published a statistical analysis of the organs weight of normal Japanese. The collected data was from the Medico-Legal Society. In 1989 another report of weight ratio of organs from 750 judicial autopsy cases. Finally, in 1992, the latest report by the Medico-Legal Society of Japan reported the weight and size of internal organs of normal Japanese[10]. While Thailand and Japan are in the same continent, there are many factors that could be different between normal Thai and Japanese IOW. Some of the environmental factors, such as dietary habits, taste, composition of food, daily water intake and climate conditions or environment, culture and tradition, and the influence of genetic factors. The organ weight can be a good diagnostic criterion of autopsy if normality is accurately defined.

Usually, the deaths due to natural diseases and medical treatments, such as intravenous infusion

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or blood transfusion affect the IOW [1]. In addition, the post mortem changes especially decomposition and the deaths due to fire have some effects on the IOW as well[2]. So, in the present study, the authors excluded all the natural manner of death cases, and also excluded any unnatural manner of death cases, which had been treated and/or decomposed. The unnatural death cases included accident, suicide and homicide. The objectives of the present study were to update the table of organ weights of Thai adults and to formulate a standard reference range of values, taking into account the variables of age, sex, weight and height. The present study did not include the weight of the pancreas, adrenal gland and thyroid gland and was limited to a Thai and Southeast Asian population.

Material and Method

From August 1, 2003 to February 28, 2005, 250 forensic autopsies were performed at the Department of Pathology, Faculty of Medicine, Ramathibodi Hospital. The BW, BL and the organ weights were collected from post-mortem records of 199 adult males and 51 adult females (age range 15-88 years). All the subjects selected were Thai adults who died of injury with short survival time (< 15 minutes) and all those who showed any macroscopic evidence of disease or histological abnormalities were excluded. In addition, fire related death, cased of decomposition and those that had been treated were excluded. The BW and BL were measured by the mortuary technicians but were supervised by the forensic pathologist responsible for the autopsy. The BL (or height) was measured from the head to the heel. All the bodies were weighed naked with the same weighing machine (KERN & SOHN GramBlt TB-TM SNR 2564664 -10 c/+40 c kg from Germany). All of them were refrigerated at the same temperature (4°C) before weighing. As the delay between death and autopsy can alter organ weights, all autopsies were performed by forensic pathologists within 24 hours after death. The weighed organs included the heart, the lungs, the liver, the spleen, the kidneys, and the brain. The hearts were weighed after being dissected and washed to remove clotted blood from the chambers. The weighing machines used were of the same type (CHATILLON, capacity 9 Kilos x 10 gram. 3 x 10 from New York - USA). They were calibrated daily before the beginning of autopsy with a reference weight of one kilogram. They were reset before each weighing during autopsy. The studied cases were 110 accidental cases, including 80 traffic accidents, 28 fall and two electrocutions, 80 suicidal cases including 60 hangings, 15 fall and five overdoses and 60 homicidal cases including gunshots, sharp and blunt force injuries. The average normal IOW was computed to find the correlation between IOW with BW and BL by using the statistical methods.

The data were collected in a Microsoft Excel file before being analyzed by the SPSS program; the SPSS program for windows was used in the analysis of the IOW, BL and BW. The data was divided into 2 groups by gender, male and female. Kolmogorov - Smirnov was used to determine the normality of IOW. The mean, standard deviation, variance, maximum and minimum were applied for the BW, BL and IOW. (Brain, heart, lung, liver, spleen and kidney). Then, the graph of the scatter plot was done to see the trend to predict the relationship between two variables, which were between BW and IOW and between BL and IOW. Finally the Pearson's correlation coefficient was performed in analyzing the relationship between BWand IOW and between BL and IOW. A p-value of less than 0.05 was considered statistically significant.

Simple linear regression was performed using the fitted equation; ($\hat{y} = a + bx$) between the internal organs (dependent) and BW, BL (independent) variables. - *y* axis depends upon three values: ***a*** is a "constant" and is the value of *y* when x is zero; ***b*** is the "slope" of the line, the amount by which the *y* value increases (or decreases, for negative slope) for each unit of increase in the x value; ***x*** is, the value of x itself

Results

From the total of 250 autopsies, there were 199 males and 51 females. The consideration variables in the present study were age, BW, BL, and IOW, including weight of brain, heart, lung, liver, spleen and kidney.

In some of the IOW in the present study, the number of organs were not complete. There were some missing organs because of many reasons such as traffic accident, fall from a height etc. and is shown in Table 1.

Although the range of ages in the present study are 15-88 in males and 17-71 in females, that could effect the IOW but there was no relationship between age and IOW after the correlation test. Therefore, BW and BL were used in the correlation and regression analysis.

Table 3 shows the norm of IOW of Thai adults for 250 people.

In Table 4, correlation between IOW and BW are shown in the value of the r and p, there were brain, heart and lung of females that p values were higher

Table 1. The number and percent of internal organs of males and females (n = 250)

	Male (n = 199)		Female (n = 51)	
	n	Percent	n	Percent
Brain	191	96.0	47	92.2
Heart	198	99.5	50	98.0
Lung	199	100.0	50	98.0
Liver	199	100.0	50	98.0
Spleen	197	99.0	51	100.0
Kidney	197	99.0	50	98.0

than = 0.05, therefore they were not related with the BW.

Also in Table 5, correlation between IOW and BL shows the value of the r and p, and there were all of the IOWof males, p values were higher than 0.05, therefore they were not related with BL. In females, the correlation of liver, spleen and kidney with the BL shown that, p values were higher than 0.05, therefore they were not related with BL.

Table 4 shows the positive relation between IOW and BW in males of significance at 99%CI, there are brain, heart, liver, spleen and kidney, only lung weight was significant at $p < 0.05$.

Table 2. Mean, standard deviation, minimum and maximum of age (years), BW and BL of male and female

	Male		Female	
	Mean ± SD	Min-Max	Mean ± SD	Min-Max
Age (y)	35 ± 14	15-88	36 ± 13	17-71
BW	60.42 ± 12.04	37.5-155	52.54 ± 9.7	33-75
BL	166.49 ± 6.49	150-186	156.6 ± 5.46	145-167

Table 3. The norm of IOW (gram) is shown in the form of mean ± standard deviation of males and females (n = 250)

	Male (n = 199)	Female (n = 51)
	Mean ± SD	Mean ± SD
Brain	1339.2670 ± 160.6188	1165.5745 ± 184.0571
Heart	311.4394 ± 66.7032	278.6 ± 160.6
Lung	910.3015 ± 347.7125	675.8 ± 255.5833
Liver	1439.0452 ± 365.8608	1214.4 ± 275.8006
Spleen	103.2487 ± 46.8209	92.9 ± 48.84
Kidney	260.7614 ± 68.9068	230 ± 42.7618

Table 4. Correlation between internal organ weight and body weight of males and females (n = 250)

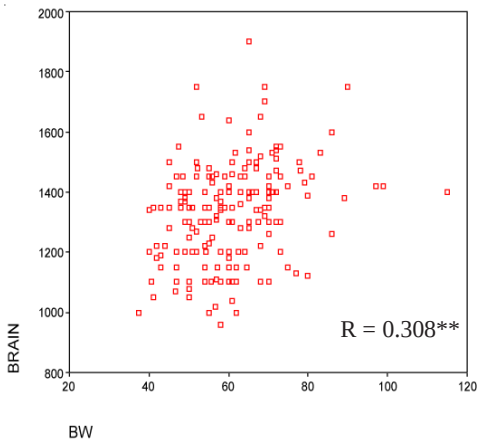
	Male (n = 199)		Female (n = 51)	
	r	p-value	r	p-value
Brain-BW	0.308**	0.000	0.232	0.116
Heart-BW	0.507**	0.000	0.015	0.917
Lung-BW	0.183*	0.000	0.174	0.228
Liver-BW	0.477**	0.000	0.496**	0.000
Spleen-BW	0.337*	0.000	0.360**	0.009
Kidney-BW	0.453**	0.000	0.461**	0.001

* Significant at p value < 0.05, ** significant at p value < 0.01

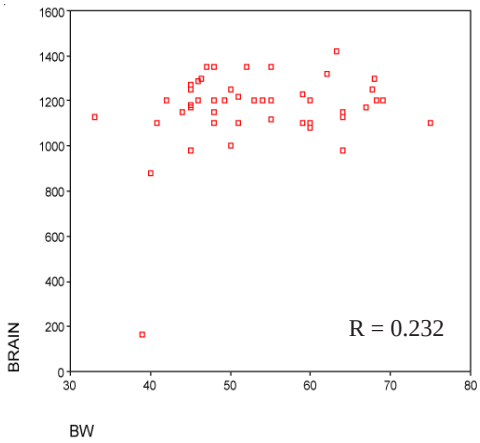
In females, there are 3 organ weights that have positive correlations to BW, liver, and kidney and are significant at $p < 0.01$ and spleen weight positive relation with body weight at $p < 0.05$.

The relationships between IOW and BW is shown in the scatter diagram of male and female.

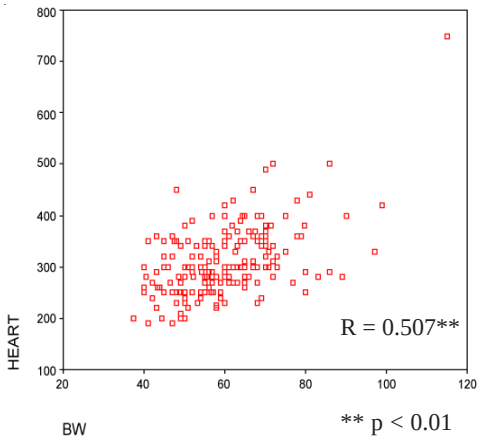
Brain weight - Body weight (male)



(female)

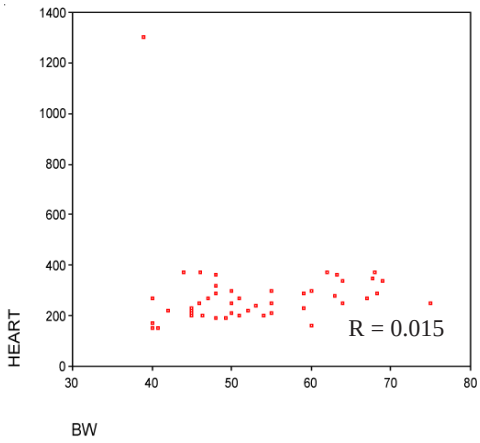


Heart weight - body weight (male)

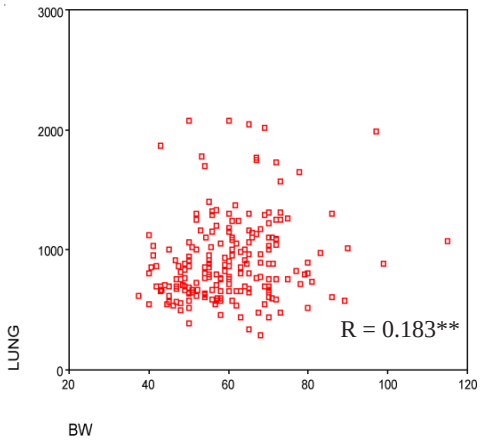


** $p < 0.01$

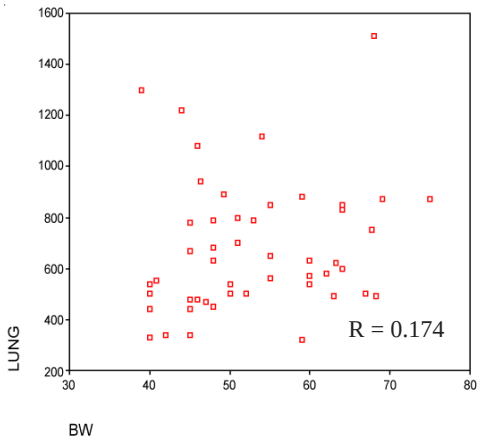
(female)



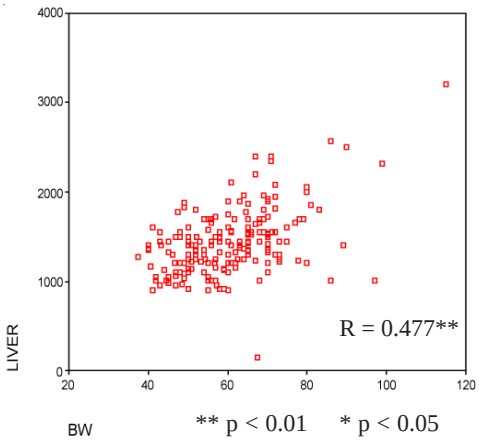
Lung weight - body weight (male)



(female)

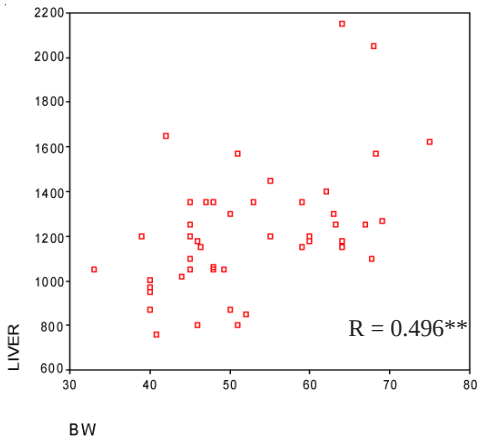


Liver weight - body weight (male)

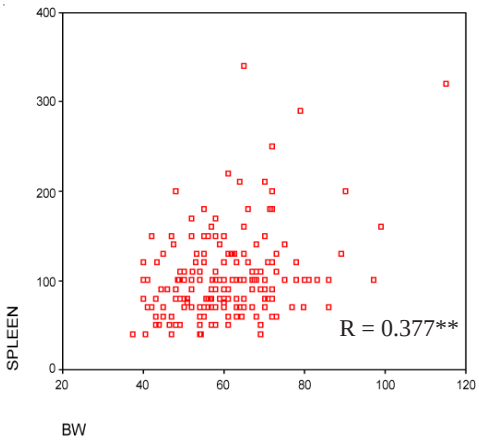


** p < 0.01 * p < 0.05

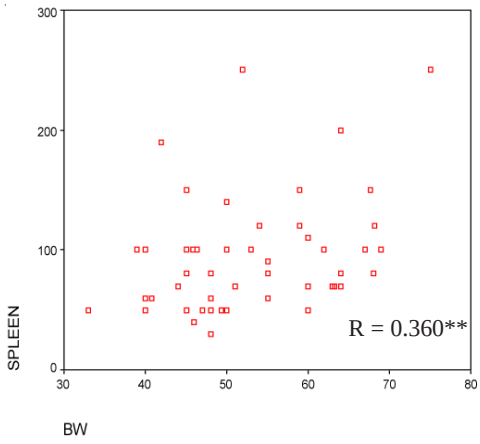
(female)



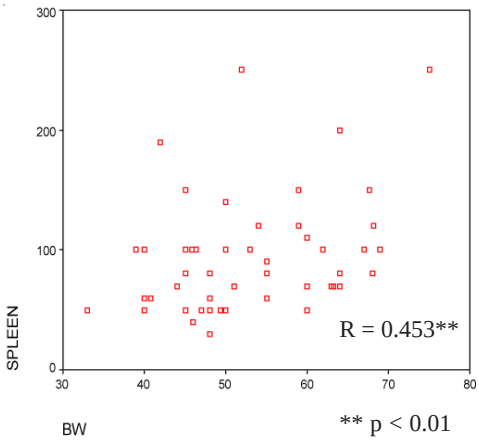
Spleen weight - body weight (male)



(female)



Kidney weight - body weight (male)



** p < 0.01

(female)

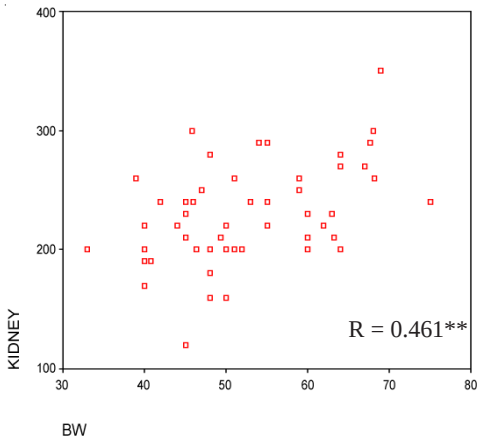


Table 5. Correlation between internal organ weight and body length of males and females (n = 250)

	Male (n = 199)		Female (n = 51)	
	r	p-value	r	p-value
Brain-BL	0.118**	0.009	0.281	0.056
Heart-BL	0.111	0.118	0.132	0.360
Lung-BL	0.170*	0.016	0.043	0.767
Liver-BL	0.238**	0.001	0.075	0.602
Spleen-BL	0.139	0.051	0.115	0.420
Kidney-BL	0.140*	0.050	0.155	0.283

* significant at p value < 0.05, ** significant at p value < 0.01

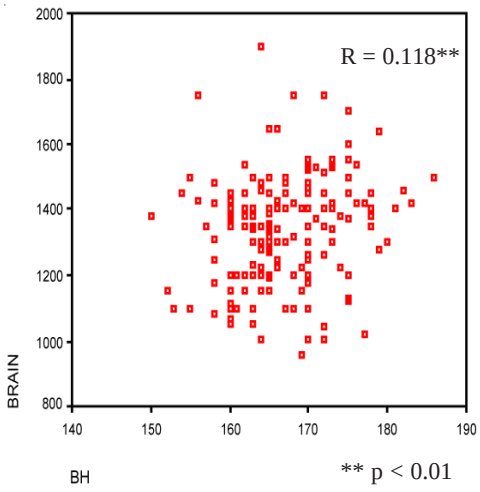
Table 5 shows the positive relation between IOW and BL in males of significant at levelat p < 0.01, there are brain and liver, kidney weight and lung that are significant at p < 0.05. There was no correlation in females. The relationships between IOW and BL are shown in the scatter diagram of males and females.

Table 6 and 7 show the regression equation of the correlation valuables and relating the two variables by slope (b); the variables of y when x increase 1 unit.

Discussion

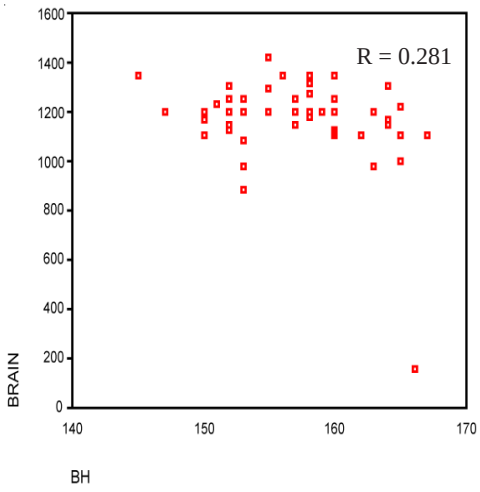
Values of organ weight obtained by autopsy should not be compared between the different conti-

Brain weight - Body length (male)

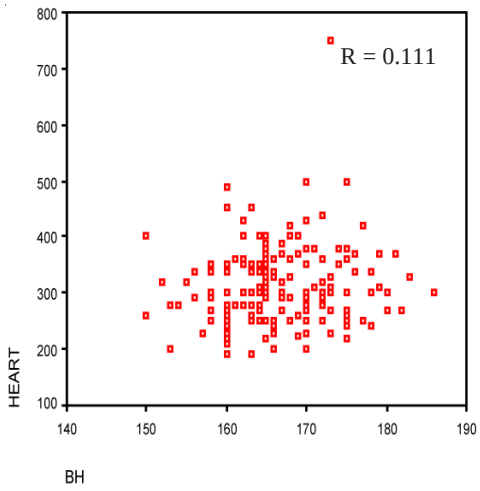


** p < 0.01

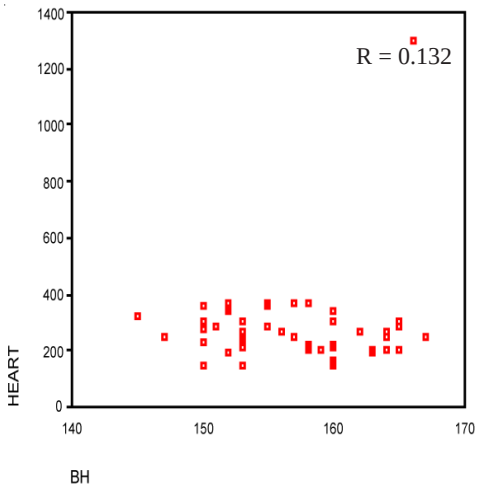
(female)



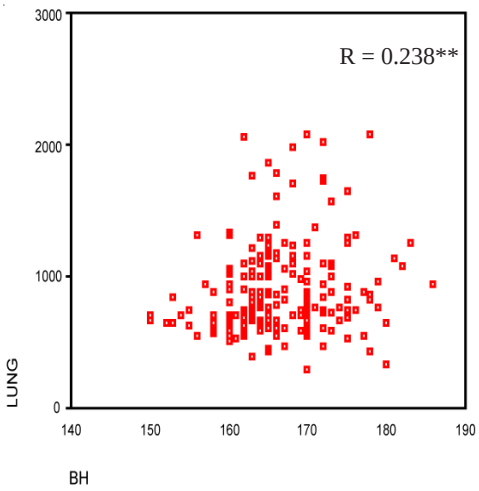
Heart weight - body length (male)



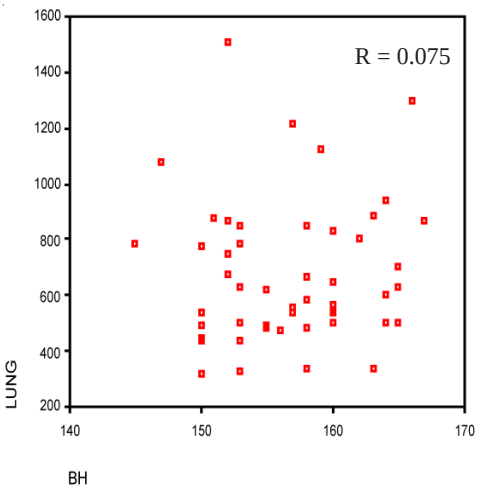
(female)



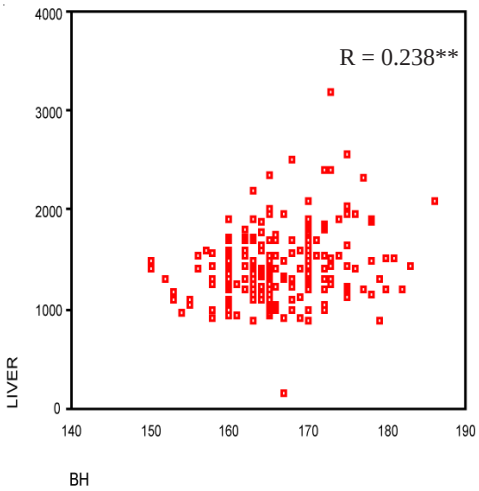
Lung weight - body length (male)



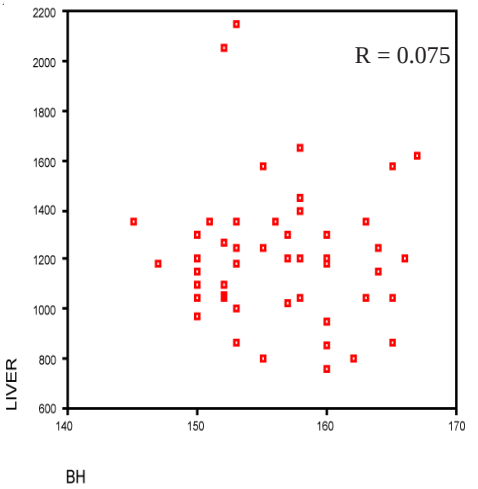
(female)



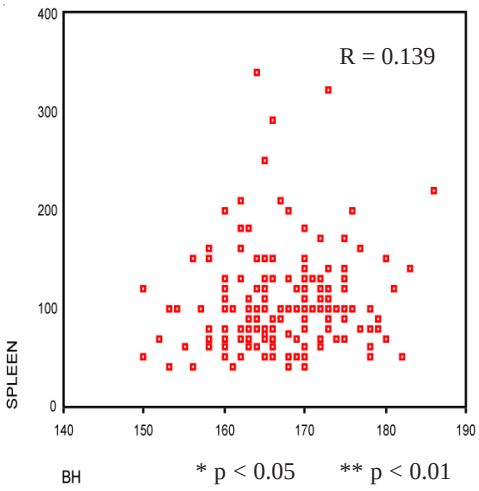
Liver weight - body length (male)



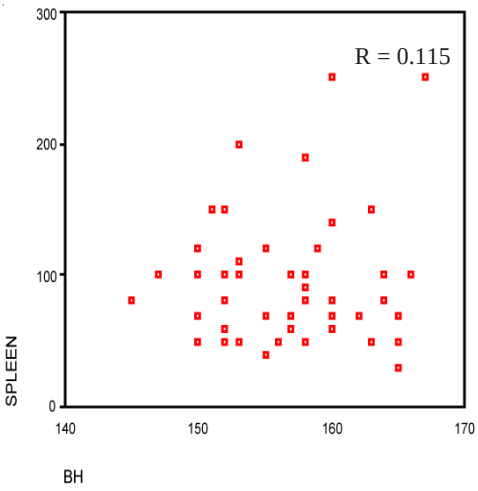
(female)



Spleen weight - body length (male)



(female)



* p < 0.05 ** p < 0.01

Kidney weight - body length (male) (female)

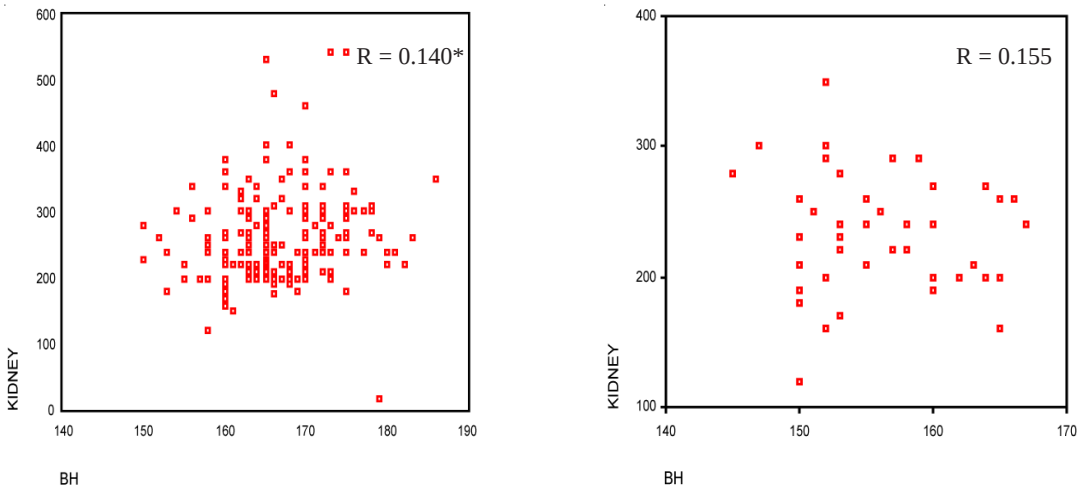


Table 6. Regression equation of internal organ weight and body weight of males and females

	Male		Female	
	$\hat{y} = a + bx$	R^2	$\hat{y} = a + bx$	R^2
Brain-BW	Brain w = 1086.697 + 4.166 (BW)	0.095	-	
Heart-BW	Heart w = 142.535 + 2.801 (BW)	0.257	-	
Lung-BW	Lung w = 589.554 + 5.251 (BW)	0.034	-	
Liver-BW	Liver w = 561.829 + 14.522 (BW)	0.228	Liver w = 484.407 + 13.901 (BW)	0.246
Spleen-BW	Spleen w = 24.021 + 1.316 (BW)	0.114	Spleen w = -1.921 + 1.805 (BW)	0.130
Kidney-BW	Kidney w = 104.823 + 2.583 (BW)	0.205	Kidney w = 123.841 + 2.015 (BW)	0.213

X = body weight, Y = internal organ weight

Table 7. Regression equation of the relationship between internal organ weight with body length of males and females

	Male		Female
	$\hat{y} = a + bx$	R^2	$\hat{y} = a + bx$
Brain-BL	Brain w = 542.933 + 4.778 (BL)	0.035	-
Heart-BL	-	-	-
Lung-BL	Lung w = -609.161 + 9.126 (BL)	0.029	-
Liver-BL	Liver w = -797.561 + 13.436 (BL)	0.057	-
Spleen-BL	-	-	-
Kidney-BL	Kidney w = 13.071 + 1.488 (BL)	0.020	-

X = body weight, Y = internal organ weight

nents or countries reference tables. Indeed the use of incorrect tables may lead to a wrong judgment on the pathological features of the organ, especially in forensic cases where histology is not always performed. This implies the necessity to establish updated country reference tables from appropriate autopsy material that must be without any pathological change secondary to disease. A non hospital population of deceased persons subjected to an autopsy would consequently provide this type of control material because the

organs in patients succumbing to a wide variety of morbid anatomical lesions or disease processes as would be the case in hospital autopsies cannot in any case be considered as normal. Such control autopsy material is easily available in a forensic medicine cases especially from cases of sudden unnatural death, excluding fire related death.

With regards to the values for brain weight, the present study found that brain weight is positively correlated with both BW and BL in males, but not in females. The findings agree with the studies of Zschoch[12] for BW in both sexes, but for the BL only in males, whereas Chrzanowska[18] agreed with the correlation to the BL. From the present study, the result of the brain weight in males was 1339.27 $\pm$ 160 gram and 1165.57 $\pm$ 184 gram in female, which are consistent with many studies[14-20]. In the present study, the authors included 60 cases that died of hanging and showed a slight increase in the brain weight. This was supported by Hamilton and McMahon[21] who presented the brain weight of those who died by hanging to be significantly higher than those who died of natural causes or an overdose.

The heart weight in males in the present study was positively correlated to the BW but not BL and agreed with the studies of Zschoch and Klemm[12], Hanzlick and Rydzewski[22], Coard and Jackson[23]. The female group in the present study showed no relationship with the BW or BL and was supported from Hangartner et al[24] contrary to the findings of Zeek[25]. Comparison of the present data with previous studies showed the heart weight in the female group of the present study to be heavier than in the male group. This might be due to undiagnosed systemic hypertension or more epicardial fat tissue.

The lung weight in the present study was positively correlated with BW and BL for male but not female, possibly due to inter-individual variation and terminal pulmonary edema and congestion, which differ from one individual to another.

The liver weight was positively correlated with BW for both sexes, but only positively correlated with BL for the male group. The possible explanation could be the same as the lung in the females. The present results on spleen weight were positively correlated with BW for both sexes, but not correlated to BL. This was partly supported by Sprogoe-Jakobsen S. and Sprogoe-Jakobsen[26] and Myers J, and Segal[27].

The mean kidney weight from the present study was 260 $\pm$ 68 grams for males and 230 $\pm$ 42 grams for females, and seemed to correspond to most of the others[28-31]. The kidney weight was positively correlated to the BW for both sexes, but only correlated to the BL for the males. In the present study, the 51 females group was too small when compared with the male group of 199 cases. Additional cases, especially females are needed for a future study and possibly might have significant statistical evaluation for the correlation to BL.

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ความสัมพันธ์ระหว่างน้ำหนักตัวและความสูงกับอวัยวะภายในและค่าปกติของน้ำหนักอวัยวะภายในของคนไทยที่คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี

ธำรง จิรจริยาเวช, คฤตสา อวยสวัสดิ์, สีตลา แสงกาญจนวนิช, มนต์ทิพย์ เทียนสุวรรณ, วิชาญ เปี้ยวนิ่ม, วรชัย ศิริกุลชยานนท์

การศึกษาหาค่าปกติของน้ำหนักอวัยวะภายใน คือ สมอง หัวใจ ปอด ตับ ม้าม และไต ในคนไทย โดยศึกษาจากศพจำนวน 250 ศพ ชาย 199 ศพ และ หญิง 51 ศพ จากโรงพยาบาลรามาธิบดี โดยได้คัดจากอายุ 15-88 ปี ที่เสียชีวิตผิดธรรมชาติ เช่น อุบัติเหตุ ฆ่าตัวตาย หรือถูกทำร้ายให้ตาย โดยตัดจำพวกศพที่เน่าเปื่อย ถูกไฟเผาไหม้ หรือเคยผ่านการรักษาในโรงพยาบาลมาก่อนตาย และใช้การวิเคราะห์โดยใช้วิธีทางสถิติเพื่อหาค่าปกติ และหาความสัมพันธ์ระหว่างอวัยวะภายใน กับน้ำหนักตัว และส่วนสูงของศพ พบว่า น้ำหนักเฉลี่ย $\pm$ ส่วนเบี่ยงเบนมาตรฐานในผู้ชายและผู้หญิงตามลำดับ คือ สมอง 1339 $\pm$ 160/1165 $\pm$ 184 กรัม, หัวใจ 311 $\pm$ 66/278 $\pm$ 160 กรัม, ปอด 910 $\pm$ 347/675 $\pm$ 255 กรัม, ตับ 143.9 $\pm$ 365/1214 $\pm$ 275 กรัม, ม้าม 103 $\pm$ 46/92 $\pm$ 48 กรัม และไต 260 $\pm$ 68/230 $\pm$ 42 กรัม ส่วนในการหาความสัมพันธ์ระหว่างอวัยวะภายในและน้ำหนักตัวนั้น พบว่าในผู้ชายทุกอวัยวะภายในมีความสัมพันธ์กับน้ำหนักตัวอย่างมีนัยสำคัญทางสถิติที่ $p < 0.05$ แต่ในผู้หญิงพบว่า มีเฉพาะ ตับ ม้าม และไต ที่มีความสัมพันธ์กัน ส่วนในความสัมพันธ์กับส่วนสูงนั้นพบว่าในผู้ชายพบมีเพียง สมอง ปอด ตับ และไต ที่มีความสัมพันธ์กันทางสถิติที่ $p < 0.05$ ในขณะที่ไม่พบความสัมพันธ์ในผู้หญิงในทุกอวัยวะ