Int. J. Morphol.,
35(4):1209-1213, 2017.

Post-Mortem Organ Weights at a Medico-Legal State Facility in the eThekwini Region

Peso de Órganos Post-Mortem en un Servicio Médico Legal en la Región eThekwini

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GOVENDER, S.; LAZARUS, L.; DE GAMA, B. Z. & SATYAPAL, K. S. Post-mortem organ weights at a medico-legal state facility in the eThekwini region. *Int. J. Morphol., 35(4)*:1209-1213, 2017.

SUMMARY: Organ weights may be influenced by various demographic parameters and environmental conditions, and they differ among populations. Numerous studies have been conducted in the Northern hemisphere, with paucity of literature regarding organ weights of many Southern hemispheric populations. This study aimed to document post-mortem organ weights of decedents in the eThekwini region, and to determine the influence of age, sex, population grouping and body length on the weight of these organs. The study utilised 500 decedent organs (n=500), obtained from a medico-legal state mortuary in the eThekwini region, KwaZulu-Natal, South Africa. It entailed gross examination and weighing of the thoracic viz. heart, right and left lungs, and abdominal organs viz. liver, spleen as well as the right and left kidneys. All organs attained maximum or peak weights at various age intervals, with the heart continuing to increase in weight until 80 years of age. Organ weights illustrated statistical significance with age. The heart, lungs and liver were the only organs that showed statistical significance with sex. However, mean spleen weights were higher in females than in males, while the weights of both kidneys were higher in males. Organ weights of White decedents were higher than those of other population groups. There was a positive correlation between body length and all organ weights. Post-mortem organ weights of the present study are comparably higher than those reported in the Northern hemisphere. Therefore, organ weights reported from one geographic location may not be applicable to another and may lead to erroneous references ranges and possibly hinder interpretation during autopsy settings.

KEY WORDS: Anthropometry; Autopsy; eThekwini region; Organ weight.

INTRODUCTION

The use of organ weight at autopsy aids forensic pathologists in the detection of gross anatomical abnormalities and pathology (Sheikhazadi *et al*., 2010). Furthermore, deviations from the "normal" range of organ weights may aid the pathologist in the interpretation of cause of death (Singh *et al*., 2004; Kohli & Aggarwal, 2006; Tanna *et al*., 2011). Organ weights are also a crucial factor during cardiothoracic and abdominal organ transplantation surgeries (Chan *et al*., 2011; Reed *et al*., 2014). However, a number of parameters are noted to influence organ weight.

Demographic parameters such as the age, sex, population grouping and the body length of an individual; as well as environmental conditions have an influence on organ weights (Kohli & Aggarwal; Prakash *et al*., 2013; Kumar *et al*., 2014). These factors vary vastly throughout the world and therefore, organ weight ranges should be formulated for each target population, allowing for the correct interpretation of cause of death (Wong *et al*., 2008). A review of anatomical textbooks and available literature, indicates extensive data with regard to the Northern hemisphere. However, there is paucity in the available literature with regard to the Southern hemisphere and regions within South Africa in specific.

Therefore, this study aimed to document post-mortem organ weights of the heart, lungs, liver, spleen and kidneys of decedents in the eThekwini region, and to determine the influence of age, sex, population grouping and body length on the weight of these organs.

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MATERIAL AND METHOD

Standard autopsy protocol and procedures were implemented on 500 decedents (n=500). These decedents were obtained via convenience sampling from a medico-legal state mortuary in the eThekwini region, KwaZulu-Natal, South Africa (Ethics Number: BE522/14). Each organ underwent gross examination and was subsequently weighed on a calibrated electronic scale. The "wet weight" of all the organs was recorded. "Wet weight" refers to the state of the organ as soon as it is removed from the body cavity. The exclusion criteria were as follows: i) decedents with an incomplete demographic profile, ii) decedents with significant injury to surrounding tissue, and iii) organs that were decomposed. The heart weight was recorded after dissection and removal of clotted blood from within its chambers. It should be noted that the liver was weighed without the gallbladder and the kidneys without the adrenal glands and ureters. Body length was measured from the heel of the foot of the decedent in the supine position, to the crown of the head.

The obtained organ weights were correlated with the age, sex, population grouping and the body length of the decedent. Decedents were categorised into 10 year age intervals: 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, 91-100. Of the 500 decedents, 395 were males and 105 were females; with a population grouping of 417 Black Africans, 11 Coloured, 42 Indians and 30 Whites.

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, Version 23.0). The following statistical tests were used: The Pearson product-moment correlation, One- way Anova with Tukey HSD comparison and Independent Sample T- test, as well as frequency tests. Descriptive statistics were utilised to determine the mean and standard deviation. A p- value of less than 0.05 was considered statistically significant.

RESULTS

This study documented post-mortem organ weights and the influence of parameters such as: age, sex, population grouping and the body length of decedents on these organ weights. The corresponding values are shown in the tables below.

The mean organ weights of the examined organs are reflected in Table I. In the thorax, mean weights of the right lung were heavier than the left lung. In the abdomen, mean weights of the left kidney were heavier than the right kidney (Table I).

Table I. Mean organ weights (g).

Organ	n	Mean	SD
Heart	500	328.93	101.87
Right lung	500	581.73	266.51
Left lung	500	485.92	239.06
Liver	500	1376.62	435.36
Spleen	500	153.50	91.19
Right kidney	500	146.67	55.86
Left kidney	500	154.32	55.84

Age. A Pearson product-moment correlation test was utilized to assess the relationship between age and organ weight. There was a statistically significant correlation between the age of the decedent and all the organ weights ($p<0.001$, n=500) (Table II). In the thorax, the heart weight showed a moderate positive correlation (r=0.530) with age, with the right and left lung having a weak positive correlation (r=0.322 and 0.295). The heart attained peak weight at the 71-80 year age interval which was later than that of the lungs, which attained peak weight at the 61-70 year age interval (Table II). All the abdominal organs viz. liver, spleen and kidneys attained peak weight at the 41-50

Table II. Correlation of age with organ weight.

	Age			
Organ	Peak weight (g)	Peak age interval (years)	Pearson correlation (r value)	Pearson Product-moment correlation (*p* value)
Heart	438.0	71-80	0.530	<0.001*
Right Lung	720.70	61-70	0.322	<0.001*
Left Lung	573.11	61-70	0.295	<0.001*
Liver	1550.67	41-50	0.319	<0.001*
Spleen	196.87	41-50	0.181	<0.001*
Right Kidney	146.67	41-50	0.230	<0.001*
Left Kidney	154.32	41-50	0.246	<0.001*

*statistically significant values.

year age interval and showed a weak positive correlation with age (Table II).

Sex. An independent samples t-test was conducted to compare the weight of the organs between males and females. There was a statistically significant difference between sexes of all the thoracic organs and one abdominal organ i.e. liver (p=0.006) (Table III). These organs illustrated heavier organ weights in male decedents than female decedents. The spleen and the kidneys were the only organs that showed no statistically significant difference between sexes (p>0.05). The weight of the spleen was seen to be heavier in female decedents (161.63g) than in male decedents (151.34g). However, the weight of the male kidneys was heavier than the females (Table III).

Table III. Correlation of organ weight between sexes.

Organ	Sex		Independent Samples T-Test (*p* value)
	Male	Female	
Heart	335.90	302.70	0.013*
Right Lung	608.32	481.68	<0.001*
Left Lung	505.86	410.90	<0.001*
Liver	1408.68	1256.04	0.006*
Spleen	151.34	161.63	0.305
Right Kidney	148.29	140.59	0.210
Left Kidney	155.97	148.11	0.200

*statistically significant values.

Population Grouping. A one-way Anova test was conducted to compare the influence of population grouping on organ weight. There was a statistically significant influence between population groups and all of the organs with the exception of the right kidney (p=0.115) (Table IV). The left kidney showed a marginal significance between groups (p=0.043). In the eThekwini region, decedents of White population grouping illustrated significantly higher organ weights in comparison to the other population groups of the sample population.

Body Length. A Pearson product-moment correlation test was utilized to assess the relationship between the body length of the decedent and organ weight. There was a statistically significant correlation between the body length of the decedent and all organ weights (p<0.001, n=500) (Table V). According to Table V, all the organs illustrated varying correlations with body length. In the thorax, the heart (r=0.613) illustrated a moderate positive correlation and the right (r=0.451) and left lungs (r=0.417) illustrated a weak positive correlation. In the abdomen, the liver (r=0.580) illustrated a moderate positive correlation, while the spleen and both kidneys illustrated weak positive correlations Table V).

Table V. Correlation of body length with organ weight.

Organ	Body Length	
	Pearson correlation (r value)	Pearson product-moment correlation Test (*p* value)
Heart	0.613	0.001*
Right Lung	0.451	0.001*
Left Lung	0.417	0.001*
Liver	0.580	0.001*
Spleen	0.256	0.001*
Right	0.370	0.001*
Left Kidney	0.398	0.001*

*statistically significant values.

DISCUSSION

After a review of the available literature, it is apparent that there is paucity of information regarding the Southern hemisphere and the various regions of South Africa in specific. Standard references for organ weights are based on Northern hemispheric populations, with the bulk of studies from the Asian countries. However, this is of little value to the Southern hemispheric population groups as this would lead to erroneous interpretations, in autopsy settings.

Table IV. Correlation between population groups with organ weight.

Organs	Population Groups				One way Anova Test (*p* value)
	Black African	Coloured	Indian	White	
Heart	319.71	353.64	339.43	433.40	<0.001*
Right Lung	571.35	613.09	553.90	753.43	0.005*
Left Lung	478.71	486.91	455.21	628.73	0.004*
Liver	1333.58	1384.36	1468.26	1843.87	<0.001*
Spleen	145.85	120.82	181.29	233.00	<0.001*
Right Kidney	145.05	125.09	155.33	164.97	0.115
Left Kidney	152.19	136.36	162.38	179.3	0.043*

*statistically significant values..

This study documented mean organ weights for the selected sample population. Mean organ weights were higher than those observed by previous Northern hemispheric populations (Singh *et al*.; Kim *et al*., 2009; Molina & DiMaio, 2012a,b, 2015a,b). However, the study by Chirachariyavej *et al*. (2006) in a Caucasian population group documented higher organ weights than that observed in the current study.

According to a study by Singh *et al*. the heart is the only organ that showed a continual increase in weight with age. Previous studies have documented increasing heart weights over the age of 60 years (Singh *et al*.; Mathuramon *et al*., 2009; Sheikhazadi *et al*.); this differed from the current study as the heart weights increased until the 71-80 year age interval (Table II). Numerous authors have attributed the continual increase in the weight of the heart, to the deposition of epicardial fat as well as hypertension (Mathuramon *et al*.; Molina & DiMaio, 2012a, 2015a). Epicardial fat tissue may account for an increase of 20 % of the heart weight (Rabkin, 2007). The lung weights showed statistically significant differences when compared to age. In the present study, both lungs attained peak weight at the 61-70 year age interval, which was later than that reported by previous authors (Sheikhazadi *et al*.; Prakash *et al*., 2013). The weight of the liver in the present study showed a statistically significant correlation with age (Table II). Previous studies had documented increasing liver, spleen and kidney weights up to the fourth decade of life (Singh *et al*.; Narongchai & Narongchai, 2008), which is consistent with the present study, which documented the peak weights at the 41-50 year age interval.

In the present study, a significant difference of organ weight between sexes was noted for the heart and both lungs (Table III), concurring with previous studies (de la Grandmaison *et al*., 2001; Singh *et al*.; Chirachariyavej *et al*.). According to previous studies the weight of the male spleen is heavier than females (de la Grandmaison *et al*.; Singh *et al*.; Kim *et al*.; Sheikhazadi *et al*.). However, a study by Sprogøe-Jakobsen & Sprogøe-Jakobsen (1997) analysed weights of the spleen with equal numbers of males and females and found no significant differences between the two, hence in agreement with this study. In the present study, spleen weights did not have a statistically significant difference between sexes, with the weight of the female spleen being (161.63 g) heavier than in males (151.34 g). An assumption for this phenomenon may be due to decedents having underlying portal hypertension that may or may not be associated with pregnancy as the majority of the decedents were in the child-bearing age interval (21-30 years). In the kidneys, there was no statistically significant difference with regard to sex ($p=0.210$ and $p=0.200$). However, males had an overall higher organ weight than females in this study (Table III). This corroborated with studies by de la Grandmaison *et al*.; Singh *et al*.; Kim *et al*. and Sheikhazadi *et al*.

Young *et al*. (2009) documented no statistical differences of organ weight due to population grouping. On the contrary, this study yielded a statistically significant difference between organ weight and population groups (Table IV). Results of this study reflected White decedents having an overall higher heart weight than other population groups (Table IV). One may attribute such findings to better nutrition, physical activity and greater physical stature of individuals when compared to the other population groups in South Africa (Opie & Seedat, 2005). White decedents had an overall higher lung weight, while the Indian decedents had the lowest lung weights in the population groups. One may assume that this may be due to the high prevalence of smoking in the Indian community (Tanna *et al*.). Chirachariyavej *et al*. stated that variations in pulmonary oedema and congestion differ from person to person. Post-mortem lung weights may also depend on the individual's lung volume, congestion and oedema prior to death (Mathuramon *et al*.). In this study, all the abdominal organ weights of White decedents were significantly heavier than the other population groups in the sample population.

Regarding body length, the findings of the present study documented a significant correlation between all organ weights for both sexes (Table VI). However, Mathuramon *et al*. documented a significant correlation in males only. Molina & DiMaio (2012a; 2015a) also found a positive correlation of body length to heart weight but found an inadequate or no association for the prediction of heart weights. However, this was not investigated in the present study. Regarding the lungs, the taller the individual the greater the need for increased ventilation (Frisancho, 1977). This may be justified by the *r* values for the heart and lungs in Table VI, which showed strong and moderate positive correlations with body length.

CONCLUSION. The use of organ weights at autopsy is one of the leading criteria considered in the interpretation of the cause of death of a decedent.The present study reported the organ weights from a select population group in the eThekwini region within South Africa. Organ weights illustrated statistically significant differences with the age, sex, population grouping and the body length of the decedents. In comparison, the organ weights reported from the Northern hemisphere were lower than that of our study. Therefore, the ranges from the Northern hemisphere may not be applicable to the population grouping of the eThekwini region and South Africa, as they may lead to erroneous judgements of the pathological and non-pathological features of organs. Organ weights for a given population may aid both regional pathologists and clinicians, in the accurate interpretation of the cause of death of a decedent and during surgical intervention.

ACKNOWLEDGEMENTS. The authors gratefully acknowledge the assistance Dr. S.M. Aiyer, Acting Chief State Forensic Pathologist.

GOVENDER, S.; LAZARUS, L.; DE GAMA, B. Z. & SATYAPAL, K. S. Peso de órganos post-mortem en un servicio médico legal en la región eThekwini. *Int. J. Morphol., 35(4)*:1209-1213, 2017.

RESUMEN: El peso de los órganos puede estar influenciado por diversos parámetros demográficos y condiciones ambientales; además estos difieren entre las poblaciones. Se han realizado numerosos estudios en el hemisferio norte, con escasa información en la literatura sobre el peso de órganos en poblaciones del hemisferio sur. Este estudio tuvo como objetivo documentar el peso de órganos post mortem en la región eThekwini y determinar la influencia de la edad, sexo, agrupación de la población y longitud corporal sobre el peso de los órganos. Para el estudio se utilizaron 500 órganos (n = 500), obtenidos del Servicio Médico Legal de la Región eThekwini de KwaZulu-Natal, Sudáfrica. Se estudiaron el peso y tamaño de las vértebras torácicas, el corazón, pulmones derecho e izquierdo, órganos abdominales, como el hígado, bazo, además del peso de los riñones derecho e izquierdo. Los pesos medios de órganos registrados para la población de la muestra fueron: corazón (328,93 g), pulmón derecho (581,73 g), pulmón izquierdo (485,92 g), hígado (1376,62 g), bazo (153,50 g), riñón derecho (146,67 g) y riñón izquierdo (154,32 g). Los órganos alcanzaron pesos máximos a diferentes intervalos de edad: el corazón continuó aumentando de peso hasta los 80 años de edad (438.00 g), mientras que los pulmones alcanzaron un peso maximo a los 61-70 años (720.70 g / 573.11 g). Los órganos abdominales, como el hígado (1550,67 g), el bazo (196,87 g) y los riñones (146,67 g / 154,32 g), alcanzaron todos el peso máximo entre los 41-50 años de edad. Todos los pesos de los órganos mostraron diferencias estadísticamente significativas de acuerdo a la edad. En el corazón, los pulmones y el hígado se observó una diferencia estadísticamente significativa de acuerdo al sexo. Sin embargo, los pesos medios del bazo fueron mayores en las mujeres que en los hombres, mientras que el peso de ambos riñones fueron mayores en los hombres. El peso de los órganos de los cadáveres de la muestra fue mayor al peso que en otros grupos de población. Al comparar los diferentes grupos de población, el riñón derecho fue el único órgano en el que no se observó una diferencia estadísticamente significativa. Hubo una correlación positiva entre la longitud corporal y los pesos de los órganos. Los pesos de los órganos post-mortem, del presente estudio, son comparativamente mayores a los reportados en el hemisferio norte. Por lo tanto, información sobre el peso de órganos de una ubicación geográfica determinada puede no ser aplicable a otra y puede conducir a una interpretación errónea durante la autopsia.

PALABRAS CLAVE: Antropometría; Autopsia; Región eThekwini; Peso de órganos.

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Received: 20-12-2016
Accepted: 06-04-2017