International Journal of Anatomy and Research,
Int J Anat Res 2019, Vol 7(2.2):6521-26. ISSN 2321-4287
DOI: https://dx.doi.org/10.16965/ijar.2019.157

Original Research Article

A PROSPECTIVE STUDY TO COMPARE THE ADULT WEIGHTS OF INTERNAL ORGANS FROM THE COPPERBELT PROVINCE OF ZAMBIA WITH THE REFERENCE INTERNAL ORGAN WEIGHTS LISTED IN THE INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION PUBLICATION 89 (ICRP 89)

Lumamba Mubbunu *[1], Kasonde Bowa [1], Moono Silitongo [1], Volodymyer Petrenko [2].

[1] Copperbelt university, Michael Chilufya Sata School of Medicine-Department of basic Science P.o.Box 71191 Ndola-Zambia.

[2] Ndola Teaching Hospital-Department of Pathology, Postal agency, Ndola- Zambia.

ABSTRACT

The objective of the study was to compare the weight of internal organs of the adult Zambian with the values indicated in ICRP 89. The study involved 115 (83 males and 32 female) forensic autopsies from Ndola Teaching Hospital done over a period of 12 months. In this study, subjects who died due to disease process were not included, only accidental and homicide cases were included in the study. The average weight of the internal organs was compared to ICRP 89 values. One sample t-test was used to determine the significance of the differences in weights. P-values less than 0.05 were considered to be statistically significant. It was observed that the weight of the heart, liver, lungs, kidneys and brain were smaller compared to ICRP 89 values, except the size of the spleen which was statistically the same in the male subjects, while the heart and the spleen was statistically the same in the female subjects. The differences in the weights of internal organs was attributed to the differences in body size between ICRP and NTH subjects.

KEY WORDS: Internal Organ Weight, ICRP, Reference Man.

Address for Correspondence: Lumamba Mubbunu, Copperbelt University, Michael Chilufya Sata, School of Medicine, Department of Basic Sciences, P.O.box 71191 Ndola Zambia.
E-Mail: lumamba84@outlook.com

Access this Article online	Journal Information
Quick Response code	**International Journal of Anatomy and Research**
	ICV for 2016 90.30
	ISSN (E) 2321-4287 | ISSN (P) 2321-8967
	https://www.ijmhr.org/ijar.htm
	DOI-Prefix: https://dx.doi.org/10.16965/ijar
DOI: 10.16965/ijar.2019.157	**Article Information**
	Received: 25 Feb 2019 Accepted: 07 Apr 2019
	Peer Review: 28 Feb 2019 Published (O): 05 May 2019
	Revised: None Published (P): 05 May 2019

INTRODUCTION

The weight of internal organs is one of the factors that is required for calculating safe radiation levels for a defined population [1]. A study by Gharpure and Jhala [2], showed that the weight of internal organs is affected by race, gender, environment and socioeconomic status. As such the weight of internal organs for the population of Zambia may be different from the weight of internal organs used by the International Commission on Radiological Protection in calculating safe radiation exposure levels. Moreover, the dosimetry profile of a given diagnostic radiopharmaceutical is determined by estimating the effective dose and the mean absorbed dose to the critical organ or tissue [3]. Internal radiation has been shown to be affected by race to the tune of 0.5-1.0% per kilogram change in body weight [4]. One way to take care of the differences in inter-racial internal radiation is to calculate dosimetry using country and region specific physiological and anatomical values.

Differences in the weight of the body may give rise to differences in the weight of internal organs. A study by Sing et al [5], showed that the weight of an internal organ can be used to estimate the weight of the body. Similarly, Prakash et al [6] showed that there is a positive correlation between the weight of internal organs and body weight. ICRP standard reference man for the radiological protection is the standard used worldwide for radiation protection calculations [7], however ICRP has left the development of specific reference man to specific countries [1]. This implies the necessity to establish country reference man and woman. This work is intended to be a pilot study to the development of a reference man for Zambia for use in radiological protection calculations.

MATERIALS AND METHODS

The study was undertaken at Ndola Teaching Hospital mortuary. The organs were weighed from selected bodies that satisfied the criteria for inclusion in the study. The bodies were selected from postmortem cases brought to the pathologists for forensic investigations for a period of 12 months. During this period, 115 cases were sampled, all the autopsies that were used in the study were done by the same pathologist. In this study, subjects who died due to disease process were not included; this was because the organs in patients succumbing to a variety of morbid anatomical lesions or disease process were considered to be pathological. Only accidental and homicide cases were included in the study. The assumption was that, subjects who died from accidental and violent deaths were health and their organs would be in a health state and thus ideal for measuring normal internal organ weights [8]. For the purposes of this study, normal organ was defined as an organ from a person who did not have any evidence of any type of disease or infection that would damage that organ: the gross appearance of the organs had to be without any evidence of any type of damage and or pathology.

Inclusion criteria: Cases of accidents and homicide, where there was no evidence of gross pathology or trauma to the internal organs of interest were selected for inclusion. Post-mortem examination was carried out within 24 hours and petrification had not occurred on the body and organs. If the body stayed too long more than 48 hours in the fridges at the mortuary that case was not included. The subjects were of Zambian origin. The post-mortem case was a forensic or medical legal autopsy.

Exclusion criteria: Cases not satisfying the above criteria were excluded.

Data collection: The height of the subject was measured from head to heel using a height measure tape in centimeters. The body of the subject was weighed naked, using a scale 0.0 Kg to 300 kg with accuracy of ±0.01 Kg, the scale was calibrated by the Zambia weight and measure agency and 0.5, 1.0 and 5.0 Kg control weights were used to calibrate the scale every time before it was used. The Internal organs were weighed using a calibrated electronic balance 0.0g to 5000g with accuracy of ±0.1g. The collected data was analyzed using IBM-SPSS program version 23. The subjects were divided into gender: Male and Female. One sample t-test was used to analyze the differences in weights between ICRP reference weights and weights of internal organs from the subjects at Ndola Teaching Hospital. A p-value of $p < 0.05$ was considered significant for the one sample t-test.

The organs that were weighed were: the spleen, liver, heart, kidneys, Lungs and the Brain.

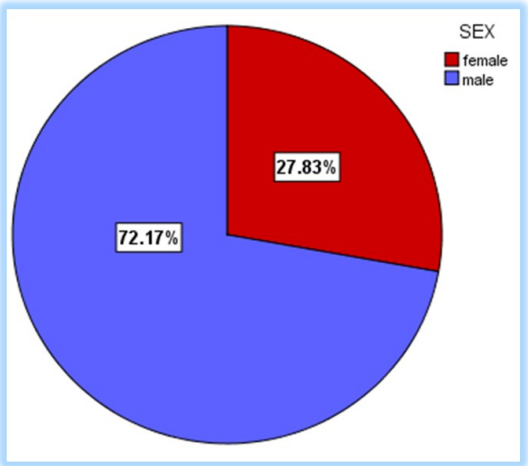
Ethical approval: Ethical clearance was granted by Tropical Diseases Research Center ethical review committee: IRB registration number: 00002911. FWA number 00003729. The study number for this study is TDRC/ERC /01/07/2014.

RESULTS

The study population was made up of subjects who had died in road traffic accidents and homicide forensic cases that were taken to Ndola Teaching Hospital for autopsy. 115 cases were selected for the study 32 females and 83 males figure 1 shows the proportion of male to female subjects while figure 2.0 show the age distribution of the subjects. See table 1 for the average weight, height and age of the study population,

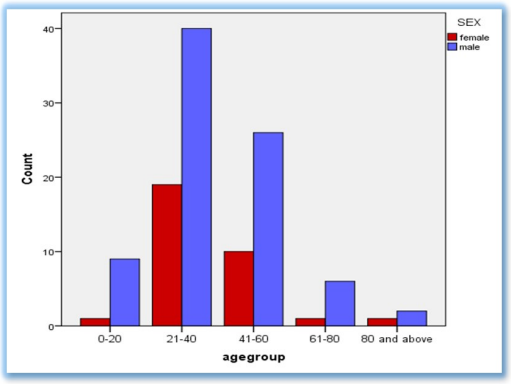
and table 2 for the average weight of internal organs.

Fig. 1: Proportion of male to female subjects in the study.



Total number of the study subjects was 115, there were 83 male subjects representing 72.17% and 32 female subjects representing 27.83%

Fig. 2: Age distribution of Male and Female subjects.



The majority of both male and female subjects in this study were aged between the age of 21 years and 60 years with few subjects being below the age of 20 years or above the age of 60 years

Table 1: Descriptive statistics for study population.

	Male N=83		Female N=32	
	Min -Max	Mean	Min-Max	Mean
Age	16-85 years	38.1 years	18-85 years	39.9 years
Weight	33Kg-87Kg	58.5 Kg	36-77Kg	57.5 Kg
Height	149-187cm	169.0 cm	151-176cm	163.4 cm

Key: Age = age of the subject. Weight =weight of the subject and Height = the height of the subject.

Note: *Height and Weight of ICRP male=* ***176cm and 73kg*** *respectively while height and weight of the female ICRP is* ***163.0cm and 60Kg*** *respectively* (ICRP publication 89, 2003).

Table 2: Descriptive statistics for the average weight of internal organs of subjects at Ndola Teaching Hospital.

	Male subjects		Female subjects	
Heart	169-379g	279.2g	180-451g	268.4g
Liver	649-1894g	1285.3g	828-2154g	1367.9g
Spleen	44-468g	169.9g	28-515g	161.7g
Left kidney	70-175g	117.9g	75-180g	108.3g
Right Kidney	71-193g	110.0g	61-152g	101.2g
Brain	1054-1630	1335.0g	1064-1400g	1228.3g
Left Lung	144-922	442.0g	216-691g	365.7g
Right Lung	230-1053	504.6g	235-795g	405.0g

Table 3: Table showing weight of ICRP internal organ weights and values collected from Ndola Teaching Hospital internal organ weights

ORGAN	ICRP 89		NTH Organ Weights	
	Male	Female	Male	Female
Heart	330g	278g	279.2g	268.4g
Spleen	180g	154g	169.9g	161.7g
Liver	1800g	1575g	1285.3g	1367.9g
Right Kidney	310g	271g	110.0g	101.2g
Left Kidney			117.9g	108.3g
Brain	1430g	1335g	1335.0g	1228.3g
Right Lung	100g	758g	504.6g	405.0g
Left Lung			442.0g	365.7g

Key: ICRP 89= International commission on radiological protection reference man: publication 89. NTH= Ndola Teaching Hospital.

Note: The weight of the organs that exist as pairs has been summed up in the ICRP 89. So that for both left and right lung is 1000g in male and 758 in the female, while the weight of the kidneys is 310g in male and 271g in the female population.

Table 4: One sample t-test comparing the weight of internal organ between ICRP Publication 89 and Ndola Teaching Hospital Data.

Organ	Female		Male	
	t-value	p-value	t-value	p-value
Heart	-0.845	0.404	-10.314	<0.001
Spleen	0.467	0.643	-0.856	0.395
Liver	-3.28	0.003	-17.36	<0.001
Kidney	-9.583	<0.001	-12.346	<0.001
Brain	-7.902	<0.001	-6.896	<0.001

The weight of internal organs in the subjects at Ndola central hospital is smaller if the t-value is negative and also statistically significant smaller if the p-value is $p<0.05$.

DISCUSSION

Description of study subjects: The sample

population for this study was composed of subjects who had died in road traffic accidents and homicide cases that were brought to Ndola Teaching Hospital for autopsy in forensic investigations. 115 cases were selected for the study 32 subjects were female representing 27.83% and 83 subjects were male representing 72.17% as can be seen in figure 1.0. The majority of both male and female subjects in this study were aged between the age of 21 years and 60 years with few subjects being below the age of 20 years or above the age of 60 years (figure 2). The age of the female subjects ranged from 18 years to 85 years with an average age of 39.9 years (Table 1). The average weight and height for the female subjects was 57.5 Kg and 163.4cm respectively and that of the male population was 58.5 Kg and 169.2 cm as can be seen in table 1.0.

Comparison Between weight of ICRP internal organ weights and Values collected from Ndola Teaching Hospital.

Heart: The average weight of the heart was 268.4g in female subjects and 279.2g in the male subjects (table 2). When the weight of the heart in the female subjects was compared to the average weight of the female subjects in the ICRP 89, the ICRP 89 values were greater than those of the female subjects at Ndola Teaching Hospital (table 3). The average weight of the female heart in the ICRP 89 was 278g compared to 268.4g at Ndola Teaching Hospital, never the less the difference was not statistically significantly different with t = -0.845 and p = 0.404 as can be seen from table 4.

The average weight of the heart in the male subjects was significantly smaller when compared to ICRP 89 values of 330g at $p<0.05$. The t-test value for comparing with the ICRP 89 was t = -10.314 and $p < 0.001$ (table 4.0). The ICRP 89 reference man and women weight of the heart is 330g and 278g respectively. Taking into account that the average weight and height of the ICRP 89 reference man of 73 kg and 176 cm respectively and the male study population had an average body weight of 58.5 Kg and average height of 169.0 (see note in table 1 and table 2). The observed differences with the weight of the heart in this study could be attributed to the difference in body weight between the male subjects, since the weight of the heart has a positive correlation with the weight of the subject [9,10]. Further, the average weight and height of the subjects in the female population was not significantly different from that of the population under study. The female study population had an average body weight of 57.5 Kg and average height of 163.4 cm, (see table 1 and table 2) while the average body weight of the ICRP reference woman was 60.0 Kg and average body height of 163.0 cm (see note in table 1), this would explain why there was no significant difference in the weight of the heart between the female subjects in the study and ICRP 89 reference woman at $p<0.05$. From the findings of this study on the weight of the heart, it can be said that the average weight of the heart in adult Zambian males is smaller compared to ICRP 89 values, while in females, though the heart was smaller, the difference in weight of the heart was not significant.

The spleen: The average weight of the spleen was found to be 169.9g in males and 161.7g in females respectively.

The ICRP 89 reference man for the value of the spleen was 178g, making the spleen of the ICRP 89 reference man bigger than 169.9g (see Table 3) in male population in the study with a t-value of -0.856 and p-value of 0.395 (Table 4). The difference however between the male subjects in the study and ICRP 89 for the weight of the spleen is not significant at $p < 0.05$ as can be seen in table 4. The ICRP 89 reference woman however had a smaller size of spleen of 154 g compared to the size of the spleen of the female subjects of 161g in this study (Table 3), the size of the spleen was not however statistically different as well between ICRP reference woman and the female subjects in the study.

The liver: The average weight of the liver in the male subjects was 1285g while that of the female subjects was 1367.9g (table 2). The ICRP 89 reference man for the weight of liver was greater than the subjects at NTH. The ICRP 89 average weight of the liver was 1800g while that of the subjects at NTH was 1285.g for the male subjects as can be seen in table 3. The difference between the average weight of the liver in male subjects at NTH and the average weight of the liver recorded in ICRP 89, was significant

with the t-value at t = -17.36 and p-value at p < 0.001. Studies have shown that there is a positive correlation between the weight of the body and the weight of the liver [10,11]. As such, it was postulated that the difference in the size of the liver with values in table 3.0 of the male subjects could be attributed to the small body stature for the male subjects that were studied who averaged 58.5 Kg at NTH compared to the ICRP 89 of the male averaging 73.0 Kg (see table 1 and the Note).

The weight of the liver in the female population in this study was compared to the ICRP weight, it was found that the weight of the liver for the female population was significantly smaller at with a t-value of t = -3.28 and p-value of p = 0.003, as can be seen from table 4.0. The differences in weight of the liver in the female subjects can also be attributed to the differences in the weight and height of the subjects [9,11].

The Kidneys:

The average weight of the left kidney was 117.9g and 108.3g in male subjects and female subjects respectively, while the average weight of the right kidneys was 110.0g and 101.2g in male and female subjects respectively see tables 2.0.

The average weight of the kidneys in ICRP 89 was added to together such that for the organs that are in pairs, the average weight was that of the both left and right paired organs. The average weight of the paired kidneys for the reference man was 310g while the average weight of the paired kidneys for the study male subjects at NTH was 227.9g. The average weight of the Kidneys for the male subjects at NTH was lower when compared to the standard reference man ICRP 89. For the female population, the reference woman recorded in ICRP 89 was 270g while for the female subjects under study was 209.5g indicating that the average weight of the reference woman is greater than the average weight of the of the female subject in this study.

Mathuramon et al [9] showed that the weight of the kidneys is positively correlated to body weight, consequently the differences observed in the weights of the kidneys between ICRP 89 and NTH values could be explained by the differences in body size.

The Brain: The average weight of the brain was 1335.0g for the male subjects and 1228.3g for the female subjects see table 2. The weight of the brain of reference man and woman at 1430g and 1335g respectively was heavier compared to the study subjects at NTH. The weight of the brain for the subjects at NTH was significantly smaller compared to the compared ICRP 89 reference man and woman with a t-value of t = -6.896 and p-value of p < 0.001 for the male subjects and t = -7.902 and p < 0.001 for the female subjects. See table 4 and table 2. The difference in weight of the brain between the ICRP 89 and the subjects at NTH can be attributed to the differences in the weights and heights. Gray's Anatomy by Standring S [12], shows that the weight of the brain is 2% of body weight in an adult. Furthermore studies by Chirachariyavej et al [11] and Hartmann et al [13] show that the weight of the brain is positively correlated to the weight of the body.

The lungs: The weight of the lungs was 442.0g left lung and 504.6g right lung representing in the male subjects, while in the female subjects, the weight of the left Lung was 365.7g and the right lung 405.0g. The average weight of the lungs as indicated in the ICRP 89 is 1000g for the male and 758g for the female population. It should be noted that in the ICRP 89, the average weight of the lungs is recorded added together for both lungs as paired organs and not as left and right. For the purposes of comparison, the average weight for the paired organs in the population under study was used. The male average weight for the paired lungs was 946.6g and that for the female was 770.7g. The average weight of the lungs recorded in ICRP 89 was greater than the average weight for the weight of the lungs in the population under study the t-test to test how significant this difference was not done. In the female subjects, when the weight of the lungs was compared to ICRP 89 reference woman, the weight of the lungs in the female subjects under study was greater than that which was recorded in the ICRP 89 and for this comparison a t-test was no done as well to test how statistically significant the difference was (see table 2). Further work is required to ascertain this outcome where, the average weight of the lungs in the female population

under study were heavier than those of the ICRP 89 while the average weight of the lungs in the male population was lower than the ICRP 89. The average weight of the paired lungs was computed by adding the average weight of the left lung and the right lung in Table 2.

Strengths of the study: It should be noted that this study differs from other studies because the data was collected prospectively. By so doing the researchers were able to see the subjects which gave the researchers more information on the rejection and inclusion criteria. The same pathologist and anatomist collected the data which means that the methods of cutting and weighing of the organs were consistent there by reducing errors which would arise from having many people collection data.

Limitation and weaknesses of the study: There was no information about the kind of life the subjects in the study lived and the medical condition of the subjects at the time of death was not known. The answers about the medical condition of the subjects would have helped a great deal in refining the weight of internal organs. Histological studies could have helped in removing weights of internal organs that may have looked normal on gross appearance and yet pathological. It was no easy to get a large sample size, especially with female subjects which were only 32 in number, in which case the interpretation of the data for the female population should be done with a lot of caution. The study may not be suitable in interpreting data of people from other provinces of Zambia.

Recommendation: More work with increased number of study subjects in multiple centers in different provinces is required to establish the standard weights for the population of Zambia.

CONCLUSION

The weight of internal organs for the subjects at Ndola Teaching hospital was smaller compared to the ICRP reference man and woman in publication 89, except for the Spleen which was not statistically the same in both male and female subjects and the Heart which was statistically the same in the female subjects.

Conflicts of Interests: **None**

REFERENCES

[1]. International Commission on Radiological Protection. Basic anatomical and physiological data for use in radiological protection: reference values. ICRP Publication 89. Oxford: Pergamon Press; 2003.
[2]. Gharpure P.V and Jhala H.I Normal standard for body weight and organ weights in India. IMG 1958;92(93):445-47.
[3]. McParland BJ. Nuclear Medicine Radiation Dosimetry, Advanced Theoretical Principles. Springer Verlag London Limited 2010.
[4]. Stabin MG. Uncertainties in internal dose calculations for radiopharmaceuticals. J Nuc Med 2008;49:853-860.
[5]. Singh D, Bansal YS, Sreenivas M, Pandey AN, Tyagi S. Weights of human organs at autopsy in Chandigarh zone of north-west India. JIAFM 2004;26(3):0971-3.
[6]. Prakash C, Deopa D and Thakkar H. Study of Internal Organ Weight and its Correlation to Body Wight in Kumaon Region. Of Uttarakhand, J. Indian Acad Forensic Med 2013;35(1).
[7]. Tanaka, G., Kawamura. Reference Man Models Based on Normal Data from Human Populations. Nippon Press Center Bldg. Tokyo.2000. No. 00602, Poster No.P-3a 195.
[8]. Pearl and Bacon. Biometrical studies in pathology. John Hopkins hospital Rep1924; 21:351.
[9]. Mathuramon P, Chirachariyavej T, Peonim V and Rochanawutanon M. Correlation of internal organ weight with body weight and body length in normal Thai adults. J.Med Asso Thai 2009;92(2):250-258.
[10]. Mubbunu L, Bowa K, Petrenko V and Silitongo M. Correlation of internal organ weights with body weight and Body Height in Normal adult Zambians: A case study of Ndola Teaching Hospital. Anatomy Research International. 2018. Doi.org/10.1155/2018/4687538.
[11]. Chirachariyavej T, Ouyswat K, Sanggarjanavanic S, Tiensuwan M, Poenim V and Sirikulchayanonta V. Normal internal organ weight of Thai adults correlated to body length and body weight. J Med Assoc Thai 2006;89(10):1702-12.
[12]. Standring Susan. Grays' anatomy, anatomical basis of clinical practice, 41st edition. Churchill Livingstone- Elsevier, UK. 2016.
[13]. Hartmann P, Ramseier A, Gudat F, Mihatsch MJ, Polasek W. Normal weight of the brain in adults in relation to age, sex, body height and weight. Pathology 1994;15:165-70.

How to cite this article: Lumamba Mubbunu, Kasonde Bowa, Moono Silitongo, Volodymyer Petrenko. A PROSPECTIVE STUDY TO COMPARE THE ADULT WEIGHTS OF INTERNAL ORGANS FROM THE COPPERBELT PROVINCE OF ZAMBIA WITH THE REFERENCE INTERNAL ORGAN WEIGHTS LISTED IN THE INTERNATIONAL COMMISSION ON RADIO-LOGICAL PROTECTION PUBLICATION 89 (ICRP 89). Int J Anat Res 2019;7(2.2):6521-6526. **DOI:** 10.16965/ijar.2019.157