ORIGINAL ARTICLE

Sonographic Assessment of Renal Size and Its Correlation With Anthropometric Measures Among Indigenous Population in Peninsular Malaysia

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ABSTRACT

Introduction: Renal size measurement using ultrasound is a valuable parameter in the diagnosis of renal function and its diseases. This study is aimed to determine the differences of mean and correlation between the renal length (RL), renal width (RW) and renal parenchymal thickness (RPT) with age, gender and anthropometric measurements among indigenous population in Malaysia. **Methods:** A prospective cross-sectional study was carried out in this survey. Abdominal sonography was performed on 240 subjects. Sonography of the renal size included measurements of RL, RW and RPT. A portable ultrasound machine (Mindray DP-50, Shenzen, China) with a 3.5 MHz convex probe was used in this study. An independent-samples t-test, one-way ANOVA and Pearson's correlation coefficient test were performed in statistical analysis. Data were analyzed using SPSS program version 22.0. A P-value of <0.05 was considered significant. **Results:** The mean left RL was significantly decreased after the age of 54 years. RL of both kidneys was positively significant correlated with height (P<0.001), weight (P<0.001), waist circumference (WC) (P<0.001) and hip circumference (HC)(P<0.001). Similarly, a significant positive correlation was found between right RW and right RPT with weight (P=0.007 and P=0.003, respectively). Left RPT was significant correlated with height (P=0.006), weight (P<0.001) and HC (P=0.035). There was a significant positive correlation between left RW and height (P=0.048). A significant difference was also reported between right RL (P<0.001), left RL (P<0.001) and left RPT (P=0.040) with BMI. **Conclusion:** The normal values of renal size measurements are related to age, gender, height, weight, BMI, WC, and HC.

Keywords: Sonography, Renal size measurements, Indigenous population, Peninsula Malaysia

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INTRODUCTION

Renal size measurements reflect the health of the kidney (1). Variety in the renal dimensions is a diagnostic feature of kidney disease where renal size is strongly affected by renal vascular disease, neoplasm, chronic kidney disease (CKD) and urinary tract disease (2). The renal size measurements can be evaluated by different diagnostic modalities, however, there is no single tool highly recommended by radiologists for the measurement of the renal size (3) as all radiological tools are correlated with prediction errors (4). Currently, ultrasound is widely used to assess the renal size as it is a non-invasive tool, available, safe, lower cost compared to the other radiological modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) (5). In addition, it demonstrates optimal anatomical details for kidneys such as location and dimensions including length, width, thickness, as well as detection of focal lesions (6). An underestimation of renal ultrasound measurements is noted as compared with measurements obtained by CT (4, 7) and MRI (8). In the case of the donor kidney, however, ultrasound measurements were more accurate than measurements obtained by plain radiography, urography and renal angiography (9).

The renal size can be determined by measuring renal length (RL), renal width (RW) and renal parenchymal thickness (RPT) (4). Renal measurements by ultrasound were observed to associate with somatic parameters in several previous literatures in which right RL and left RL were significantly associated with BMI, weight and body surface area (10, 11). A study has been suggested that RL is correlated with renal function and anthropometric measures (12). The strong correlation between renal dimensions measurements and anthropometric parameters is attributed to somatic growth (13). In addition, the renal dimensions are variable with body habits (14). As the renal dimensions increase with BMI increases (15), physicians suggest an idea in which renal dimensions with anthropometric measures can consider a guide for the detection of renal pathology, as a result, assistant to modern technologies. Interestingly, the previous study stated that RL and RPT have been revealed to be significantly decreased with CKD. Moreover, RPT is one of the renal dimensions which can be a guide for diagnosis end-stage kidneys (16). More important, improvement is potential if RPT is between 10 mm to 15 mm and it is irreversible change if it is less than 10 mm (17). Meanwhile, the same study showed that improvement of the renal diseases was potential if the RPT was between 10 to 15 mm and that irreversible alteration was closely related with RPT of less than 10 mm (17). Moreover, RPT measurement provides a more accurate estimation of renal function than measurement obtained by RL (18). All these indicate that abnormalities of renal dimensions are reflective of several kidney diseases. Thus, renal dimensions measurements are considered as valuable to include when the patient is examined.

There was no previous study about sonographic measurements of renal size carried out among indigenous population in different rural villages in Malaysia. Such a population has a different lifestyle compared to urban or suburban populations. Currently, sonographic measurements of renal dimensions of any age are compared with those that are determined by standard values which are derived from western or urban populations. This is could result in a misdiagnosis of renal diseases (11). As the renal size is mainly affected by many renal diseases, it is important to have measuring during the ultrasound examination. In practice, therefore, it is necessary to knowledge normative renal values in this population. Thus, this study was designed to determine the differences of mean and correlation between the RL, RW and RPT with age, gender and anthropometric measurements among the indigenous population in peninsular Malaysia.

MATERIALS AND METHODS

Study design and population

A prospective cross-sectional study was carried out in this survey. This survey included visiting twelve states in the south, middle, and north of Malaysia. The data were collected for the period of three years' from December 2012 to December 2015. The target population was the indigenous population in peninsular Malaysia. Randomly, a total of 270 consecutive subjects attended to our community service. There were 30 subjects (11 males vs 19 females) out of 270 subjects met the exclusion criteria. The sample size of 240 subjects (85 males vs 155 females) met the inclusion criteria and have included in the statistical analysis. Ethical approval was obtained from the Ethics Committee for Research Involving Human Subject at University Putra Malaysia. The participants who included in this survey were Malaysian from both genders aged 16 years and above. Informed consent was obtained from all participants before the commencement of this study. The data collection were mainly based on interview and guided by a structure self-administered questionnaire. The questionnaire included questions about socio-demographic, education level, occupation, medical history of diseases (i.e: diabetes mellitus (DM), hypertension, renal diseases, renal surgery) and medication intake. Moreover, the anthropometric measurements such as height, weight, body mass index (BMI), waist circumference (WC) and hip circumference (HC), waist to hip ratio (WHR) were also recorded in the questionnaire. If the participant was illiterate, he/she was orally asked about each question in the questionnaire and their answer was written – down by the researchers themselves. The subjects who had abnormal renal function test, small kidney, removal one kidney, renal stone, renal simple or complex cyst, renal tumor, DM and hypertension were excluded from this study. The biochemical parameters were also analyzed to exclude patients with non-communicable diseases (NCDs) such as CKD, rheumatoid arthritis, cardiovascular diseases and cancers.

Anthropometric and blood data acquisition

Weighing scale (Tanita BF-310 GS, Tanita Corporation, Tokyo, Japan) was used to measure body weight, whereas a body meter (SECA 206, Tanita Corporation, Tokyo, Japan) was used to measure body height, and then a BMI (kg/m2) was calculated. BMI was classified based on a global database on BMI in adults as follows: BMI of less than 18.5 kg/m^2 was classified as underweight, 18.5 – 24.9 kg/m^2 was classified as normal, 25.0 – 29.9 0 kg/m^2 was classified as overweight, 30.0 0 kg/m^2 and above was classified as obese (19). Moreover, an elastic tape measure was used to measure WC and HC. WC was measured at the midpoint between the lower costal border and the iliac crest while HC was measured as a circumference around the buttocks. Then, WHR was also calculated. A standardized sphygmomanometer was used to measure blood pressure with the subjects in a sitting position. According to the National Cholesterol Education Program (NCEP), Adult Treatment Panel III, 2002, (20) considerations of subjects to have hypertension if they had systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg, taking antihypertensive medication(s), had a self-reported history of hypertension. Likewise, the blood specimen was taken from all subjects by two physicians who were supervisors of this survey. Then, the specimens were sent to the nearest lab to measure fasting blood glucose (FBG) and glycosylated hemoglobin (HbA1c). After that, the subjects were considered to have DM if they had FBG ≥126 mg/dL, had HbA1c ≥ 6.5 %, taking antidiabetic medication (s), or had a self – reported a history of DM.

Ultrasound

A portable digital ultrasound machine (Mindray DP-50, MINDRAY Medical International Co., Ltd., Shenzen, China) equipped with a convex probe (3.5 MHz) was used for abdominal scanning in this study. Ultrasound examination was carried out by radiologists with work experience of more than 10 years. In this study, the renal size included measurements of length, width and parenchymal thickness. The patient was scanned with both supine and lateral positions. Longitudinal and transverse scans were applied for both kidneys to measure their lengths and widths, respectively. The RL was measured bipolar from the superior pole to the inferior pole (Fig. 1). The RW was measured from the right to the left side of the ipsilateral kidney (Fig. 2). Furthermore, the RPT was also measured on the longitudinal scan and assessed as the distance between the renal capsule and outer renal echo sinus (Fig. 1).

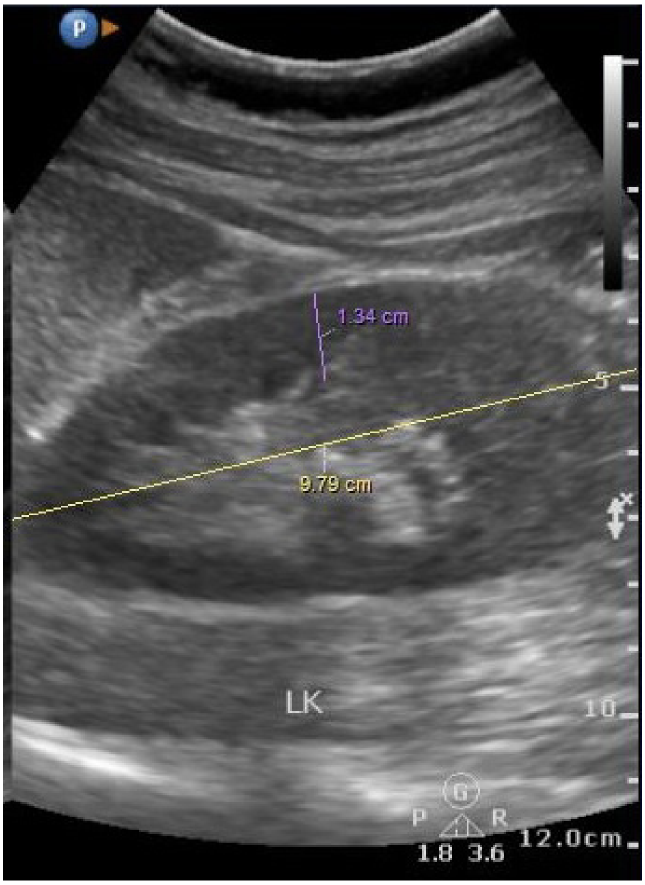

Figure 1: Sonography longitudinal scan of the left kidney shows renal bipolar length measurement (yellow line) and also shows renal parenchymal thickness measurement (purple line).

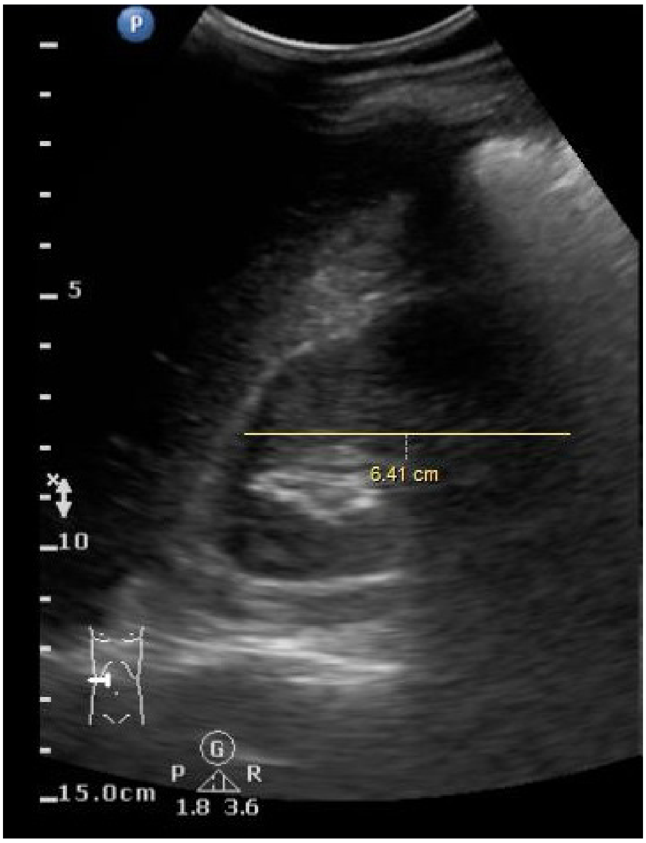

Figure 2: Sonography transverse scan of the right kidney shows renal width measurement

Statistical analysis

Data were analyzed by using Statistical Package for Social Science (SPSS) program version 22.0. The descriptive statistic was used to find the percentages and frequencies for categorical variables' and mean ± standard deviation (SD) for the continuous variables. As our data was normally distributed, an independent - samples t-test was used to compare the mean of the measurements of the renal dimensions among gender. In addition, one way - ANOVA was used to compare the mean of the measurements of the renal dimensions among age groups and BMI categories. Furthermore, Pearson's correlation coefficient was used to determine the linear correlation between renal dimensions measurements and other continuous variables (height, weight, WC, HC, WHR). A P-value of less than 0.05 was considered statistically significant.

RESULTS

Of the 240 total number of consecutive subjects were recruited over three years from 2012 to 2015. The mean age of the subjects was 42.3 ± 13.2 years. The distribution of the study population is as shown in Table I. The females were predominance in our study population (64.6%) as compared with males (35.4%). The mean height was 1.5 ± 0.1 m and weight was 63.4 ± 14.6 Kg. Otherwise, the majority of the subjects had normal BMI (35.4%). The mean of right RL was 9.4 ± 0.6 cm and the left RL was 9.6 ± 1.0 cm. The mean right RW was 4.4 ±0.6 cm and the left RW was 4.8 ± 2.4 cm. The

Table I: Demographic characteristics, BMI and renal size measurements of the study population (n*=240)

Variables	Mean ±SD	n (%)
Age (years)	42.3 ±13.2	
Gender		
Male		85 (35.4)
Female		155 (64.6)
Height (m)	1.5 ±0.1	
Weight (Kg)	63.4 ±14.6	
BMI categories		
Underweight (Kg/m²)		17 (7.1)
Normal (Kg/m²)		85 (35.4)
Overweight (Kg/m²)		81 (33.7)
Obese (Kg/m²)		57 (23.8)
WC (cm)	87.7 ±12.1	
HC (cm)	100.0 ±11.8	
WHR	0.88 ±0.07	
Renal size measurements		
Right RL(cm)	9.4 ±1.0	
Right RW (cm)	4.4 ±0.6	
Right RPT (cm)	1.3 ±0.3	
Left RL (cm)	9.6 ±1.0	
Left RW (cm)	4.8 ±2.4	
Left RPT (cm)	1.3 ±0.3	

n- sample size, m-meter, Kg- Kilogram, Kg/m²- Kilogram/square meter, cm-centimeter.

means right RPT and left RPT were equal in thickness (1.3 ± 0.3 cm).

Our results revealed that mean of left RL was decreased after age 54 years even reach 7.9 cm after the age of 67 years. When the subanalysis of the age group was done, we found that the percentage of this reduction was 9.2%. Thus, the differences between left RL and age groups were noted to be statistically significant (< 0.001) as shown in Table II. Nevertheless, there was no significant difference between other renal size measurements and age. Similarly, the mean differences between right RL, right RW, right RPT, left RL, left RW and left RPT and gender were not found to be significant (P- values < 0.05) (Table III).

Table II: Association between age groups and renal size measurements

Variables	Age Groups in years					
	16 - 28	29 - 41	42 - 54	55 - 67	68 - 80	*P*-value
Right RL (cm)	9.4±1.1	9.4±1.1	9.4± 0.9	9.4± 0.8	8.7±1.6	0.467
Right RW (cm)	4.4±0.5	4.3±0.5	4.5± 0.6	4.2±0.7	4.4±0.8	0.125
Right RPT (cm)	1.4±0.4	1.3±0.3	1.4±0.4	1.3±0.2	1.1±1.3	0.085
Left RL (cm)	9.6±1.1	9.6±1.1	9.7±0.9	9.5±0.8	7.9±1.4	< 0.001
Left RW (cm)	4.7±0.6	5.2±4.4	4.7±0.5	4.6±0.5	4.2±0.6	0.541
Left RPT (cm)	1.4±0.3	1.3±0.3	1.4±0.3	1.3±0.2	1.2±0.2	0.068

cm-centimeter

Table III: Differences between gender and renal size measurements

Variables	Male	Range	Female	Range	*P*-value
Right RL (cm)	9.5±0.8	6.7 – 11.7	9.3±1.1	6.0 – 12.0	0.385
Right RW (cm)	4.5 ±0.5	3.5 – 5.9	4.3 ±0.6	2.0 – 5.9	0.168
Right RPT (cm)	1.3 ± 0.3	0.7 – 2.2	1.3 ±0.3	0.5 – 2.2	0.668
Left RL (cm)	9.6 ±1.1	5.5 – 11.8	9.6 ±1.0	6.9 – 12.0	0.910
Left RW (cm)	5.1±3.4	3.5 – 8.8	4.7 ±0.6	3.6 – 5.9	0.198
Left RPT (cm)	1.4±0.3	0.9 – 2.4	1.3 ±0.3	0.5 – 2.0	0.575

cm-centimeter

On correlation coefficients test, our results demonstrated that right RL was positively significant correlated with height (r = 0.280, P < 0.001), weight (r = 0.345, P< 0.001), WC (r = 0.217, P < 0.001) and HC (r = 0.234, < 0.001) whereas there was no significant correlation between right RL and WHR (r = 0.039, P = 0.549) (Table IV). Likewise, a positive significant correlation was found between right RW (r = 0.173, P = 0.007) and right RPT (r = 0.193, P = 0.003) with weight. There was, however, no significant correlation between right RW and height (r = 0.101, P = 0.118), WC (r = 0.110, P = 0.089), HC (r = 0.122, P = 0.060) and WHR (r = 0.006, P = 0.923). In the same line, there was no significant correlation between the right RPT and height (r = 0.068, P=0.293), WC (r = 0.116, P = 0.073), HC (r = 0.126, P = 0.052) and WHR (r = 0.025, P = 0.701). Nevertheless, left RL was significantly and positively correlated with height (r = 0.254, P < 0.001), weight (r = 0.477, P< 0.001), WC (r = 0.324, P < 0.001) and HC (r = 0.360, P < 0.001), while the correlation between left RL and WHR was no significant (r = 0.033, P=0.608). The correlation between left RW and height was found to be positive and significant (r = 0.128, P = 0.048). Unexpected, there was no significant correlation found between left RW and weight (r = 0.109, P = 0.092), WC (r = 0.025, P = 0.704), HC (r = 0.031, P = 0.636) and WHR (r = 0.003, P = 0.986). Furthermore, left RPT was significant correlated with height (r = 0.178, P = 0.006), weight (r = 0.251, P< 0.001) and HC (r = 0.136, P = 0.035) whereas no significant correlation was observed between left RPT with WC (r = 0.110, P = 0.088) and WHR (r = -0.005, P = 0.944).

According to BMI categories, the differences of mean right RL, left RL and left RPT among BMI categories were noted to be significant (P < 0.001, < 0.001 and 0.040, respectively) (Table V). Interestingly, the left RL was gradually increased with BMI increases. In contrast, there was no significant difference between BMI and right RW (P = 0.078), right RPT (P = 0.221) and left RW (P = 0.547).

DISCUSSION

This is the first study carried out among the entire

Table IV: Correlation coefficients between anthropometric measures and renal size measurements

Variables	Height(m)	*P*-value	Weight (Kg)	*P*-value	WC (cm)	*P*-value	HC (cm)	*P*-value	WHR	*P*-value
Right RL (cm)	0.280	< 0.001	0.345	< 0.001	0.217	< 0.001	0.234	< 0.001	0.039	0.549
Right RW (cm)	0.101	0.118	0.173	0.007	0.110	0.089	0.122	0.060	0.006	0.923
Right RPT(cm)	0.068	0.293	0.193	0.003	0.116	0.073	0.126	0.052	0.025	0.701
Left RL (cm)	0.254	< 0.001	0.477	< 0.001	0.324	< 0.001	0.360	< 0.001	0.033	0.608
Left RW (cm)	0.128	0.048	0.109	0.092	0.025	0.704	0.031	0.636	0.003	0.986
Left RPT (cm)	0.178	0.006	0.251	< 0.001	0.110	0.088	0.136	0.035	-0.005	0.944

m-meter, Kg- Kilogram, cm-centimeter

Table V: Differences between BMI categories and renal size measurements

Variables	BMI categories (Kg/m²)				
	Underweight	Normal	Overweight	Obese	*P*-value
Right RL (cm)	8.5 ± 1.1	9.4±0.9	9.3 ± 1.1	9.7±1.0	< 0.001
Right RW (cm)	4.1±0.7	4.4±0.6	4.4±0.6	4.5±0.6	0.078
Right RPT (cm)	1.2±0.4	1.3±0.3	1.4±0.4	1.4±0.3	0.221
Left RL (cm)	8.5±1.2	9.4±0.9	9.6±0.9	10.1±1.0	< 0.001
Left RW (cm)	4.5±0.6	4.6±0.5	5.1±4.1	4.9±0.5	0.547
Left RPT (cm)	1.2±0.3	1.3±0.3	1.3±0.3	1.4±0.3	0.040

Kg/m^2- Kilogram/square meter, cm-centimeter

indigenous population in peninsular Malaysia. The total number of sample size who included in this study is 240 subjects. This sample size was recruited over three years from December 2012 to December 2015. The recruitment included the indigenous subjects in twelve states in the south, middle, and north of Malaysia. This number was randomly selected based on our inclusion criteria. Renal size is one of the most important parameters that should be measured during abdominal sonography. As the renal size can be changed by several renal conditions, its measurement can assist to diagnose many kidney diseases. However, it requires determining the normal renal dimensions in various age group, gender and BMI to estimate the standard deviation from normal (21, 22). Reduction in renal size is closely associated with renal vascular obstruction and chronic renal failure. Surprisingly, although the renal size was seen to be associated with vascular diseases, there was no correlation with blood pressure (22).

Our study found that mean RL and RW were smaller on the right side than those on the left side. The same finding was reported by previous studies (9, 23-27). This may due to the fact that the left renal artery is shorter than right leading to increase blood flow on the left side and subsequently the left kidney receives a larger amount of blood and oxygen than the right kidney. Moreover, the spleen is relatively smaller than the liver so that the left kidney has more space to grow. The mean RL in our study is slightly lower than RL in the Pakistani population and the Denmark population (25, 28), respectively. This discrepancy may be associated with genetic, nutrition and environmental factors as well as differences in ethnicities. Also, the body organ size is closely correlated with whole-body size; thus, the small renal length of our study population is relatively reflected a small body size because of the reduction of blood and oxygen reaching the kidney compared to the normoxic population (29). For the same reason, another study from South-East Nigeria demonstrated that RPT on both sides was thicker than RPT in our study population (30). The same study also showed that the mean right RPT was noted to be thinner 1.85 ± 0.20 cm than left RPT 1.95 ± 0.19 cm. On the contrary, the present study did not find a difference between right RPT and left RPT (1.3 ± 0.3 cm for both sides) among our study population.

Previous studies found that the renal length was physiologically reduced by 10 mm for every 10 years after middle age (22, 31). A recent study from Saudi Arabia recorded that renal volume was rapidly reduced after 50 years old (22). These findings were partially agreed with our finding where the latter showed that the right RL was reduced after age 67 years; however, this reduction was not found to be statistically significant. In the same context, left RL was gradually reduced after age 54 years. The explanation is that number of renal nephrons is decreased with advanced age. Furthermore, postmortem study revealed that renal weight is lower in aged people by 19% than young adults (32). Reduction in the renal weight and volume with aging may be caused by glomerulosclerosis, tubulointerstitial fibrosis, oxidative stress, cellular senescence, cytokines alterations, vascular collapse and thickening (33). However, we did not observe a significant difference in mean right RW and left RW among our age groups. Our study was compatible with a study from Malaysia in which renal size was slightly larger in males than in females but these differences were not found to be significant (34). In contrast, other studies reported that RL and RW were significantly larger in men than women (22, 24, 35). Regarding RPT, our study was consistent with the study done by Eze Charles et al. (30) where both stated that mean RPT in males was no significantly higher than that in females on both sides.

In terms of the anthropometric measurements, our study showed a significant positive correlation of right RL and left RL with body height, weight, WC and HC. Mustafa J. Musa &Ahmed Abukonna also found that correlation between RL of both sides and body height was found to be significant and positive (22). Furthermore, a significant positive correlation between RL and body weight was documented by the number of previous studies (34, 36, 37). This may be attributed to high body weight has a greater number of nephrons and glomeruli than small body weight (38-40). The present results documented that left RPT increased with body height, weight and HC increases whereas right RPT increased with only body weight increases. These findings were partially agreed with other results done by Emmanian et al. (28) and Weisenbach et al. (2), which showed a strong positive correlation of RPT with body height and weight. On the other hand, our study revealed a significant positive correlation was found between right RW and weight. In the light of that, a correlation between right RW with height, WC and HC was not observed to be significant and positive. Similarly, this study showed a significant positive correlation between left RW and height where left RW was not significantly correlated with weight, WC and HC. Some others partially agreed with the present findings where they believed that RW was not associated with height in both genders (23). These unexpected results return to unknown causes. A correlation between renal dimensions and WHR was lacked to address by previous studies where it was tested in this study but it was not statistically significant.

When BMI was calculated and categorized, our study showed that RL on both sides was significantly increased with BMI increases. Previous studies also confirmed a significant positive correlation between BMI and RL (25, 36, 41). This is attributed to the fact that human organs are closely associated with body size in which organs with high body BMI receives more blood and oxygen than those with normative or underweight (29). The present study also exhibited a significant increase of the left RPT with BMI increases where right RPT was not significantly associated with BMI categories. In this regard, Eze Charles et al. (30) partly agreed with us where they stated a strong positive correlation between RPT and BMI. Also, they showed that left RPT had slightly increased with BMI compare to right RPT.

The limitations of this study included a relatively small sample size for the determination of the normative values. The interobserver and intraobserver variations in the renal size measurements were not assessed in this study. Hopefully, future related work should address these limitations.

The strength of this study was population based study that included visits to many states in north, middle and south parts of Malaysia. It is not easy to get data from the indigenous population due to cost, effort and time to reach and collect data from these communities.

CONCLUSION

The RL, RW and RPT of the Malaysian indigenous population are found to be lower as comparison with other populations such as Pakistani, Denmark and Nigerian population. This may be attributed to that renal size is positively correlated with the whole body size. Although the difference is not significant, the RL in males is relatively longer than in females. Interestingly, left RL is reduced after middle age even reaches the lowest length after 80 years old. The RL on both sides and left RPT are significantly increased with BMI increases. RL on both sides is significantly correlated with height, weight, WC, and HC. This study also showed that right RW is significantly correlated with weight whereas left RW is significantly correlated with height. A significant and positive correlation was observed between RPT on both sides and weight. In addition, the correlation between left RPT with height and HC was significant and positive.

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