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Renal Dimensions at Ultrasound in Adult Saudi Population

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Abstract. The aim of this study is to determine the normal range of renal measurements in healthy Saudi adults, and its correlation with their age, body mass index, height, side and gender by means of ultrasonography. Knowledge of the normal range of renal size is useful in appreciating variations that occur due to morbidities. Ultrasonography is an effective, easy and non invasive method to determine renal measurements. Ultrasonographic renal measurements were performed on 100 adult Saudi patients at the Radiology Department, King Abdulaziz University Hospital, Jeddah. The effect of age, gender, side, height and BMI were analyzed using Statistical Package for the Social Sciences. The average right renal length was 9.91 cm ± 0.85 and the left side was 10.17 cm ± 0.89, with the left renal length was significantly greater than right, and both renal lengths were greater in males than in females. Both kidneys' length correlated negatively with age and positively with BMI. No significant correlation between the renal length and personal height in either sex. The only significant factor affecting kidney width was BMI. Measurement of cortical thickness is less feasible. Expanded population- based studies are needed to establish normal renal values for Saudi population.

Keywords: Kidney, Size, Gender, Age, Height, Race, BMI, Ultrasound, Measurements.

Introduction

Renal size depends on different factors, which include side, age, and gender. However, race has particular connotations, which directly determines all the previous variables. The change in renal size can be

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very suggestive evidence of disease, whose interpretation requires specific parameters for the population to study. It is therefore necessary to have benchmark parameters in each population group[1].

The most accurate measurement of renal size is the total renal volume, which is correlated with height, weight and total body area. This measurement requires expensive, highly complex studies with specific protocols, such as axial tomography and magnetic resonance. However, renal length has also been shown to be a reliable parameter with a high level of inter and intra-observer reproducibility in comparison to volumetric renal estimation, which correlates appropriately with function and different anthropometric variables[2].

Renal length estimation by ultrasound is an important parameter in clinical evaluation of kidney disease and healthy donor. Changes in renal measurement may be a sign of the kidney[3].

Renal size is also affected by height. The eventual height of an adult human depends on combination of health, hereditary and environmental factors[4]. The average height for each sex within a population is significantly different, with adult males being (on average) taller than adult females. Women ordinarily reach their greatest height at a younger age than men[4]. Renal size also varies according to the body mass index (BMI), which is a measure of body fat based on height and weight that applies to both, adult men and women[5].

Aim of Work

The aim of this study was to establish the normal range of renal measurements in healthy Saudi adults and to verify possible correlation with age, BMI, height, side and gender by means of ultrasonography.

Material and Methods

This study was performed in Diagnostic Radiology Department, King Abdulaziz University Hospital (KAUH) in Jeddah, Saudi Arabia on March and April, 2010. Utrasonographic renal measurements were performed on 100 healthy Saudi volunteers after oral consent; 34 males and 66 females. Their ages varied from 18 to 65 years with the following criteria for inclusion: No history of hypertension or *diabetes mellitus* (DM), no existence of acute or chronic disease and no personal or family history of renal disease.

The study included only Saudi participants. Immigrants from other countries were excluded.

The exclusion criteria also included: Pregnant females, in addition to renal cysts or masses, single kidney, ectopic kidney, hydronephrosis discovered during ultrasound.

Height of participants was measured from the bottom of the feet to the top of the head, when standing erect without shoes or hat.

Calculation of BMI was done based on the following formula (Table 1).

Table 1. Formula and calculation of BMI[6].

Measurement Units	Formula and Calculation
Kilograms and meters (or centimeters)	Formula: weight (kg) / [height (m)]2

Participants were classified into four groups according to the following (Table 2).

Table 2. BMI Categories(5].

Categories	BMI
Underweight	Below 18.5
Normal	18.5 - 24.9
Overweight	25.0 - 29.9
Obesity	30.0 and Above

Renal measurements were performed using "HDL5000ATL Philips Ultra-Sound machine" with convex array transducer of (2-5 MHz) frequency. All participants were asked to empty the urinary bladder prior to the examination to avoid pelvicalyceal fullness caused by oral hydration. All examinations were done while the participants were in the supine position.

The major distance between the renal poles (superior and inferior) was taken as the length; kidney length (KL) at the long axis of the kidney. Consequently, the major distance between the lateral and medial borders perpendicular to the length was taken as the width; kidney width (KW). Renal cortical thickness was measured usually at the mid-renal zone in sagittal images (Fig. 1).

All participants were asked to empty their bladders prior to the examination, to avoid an increase in renal length or pelvicalyceal fullness caused by oral hydration.

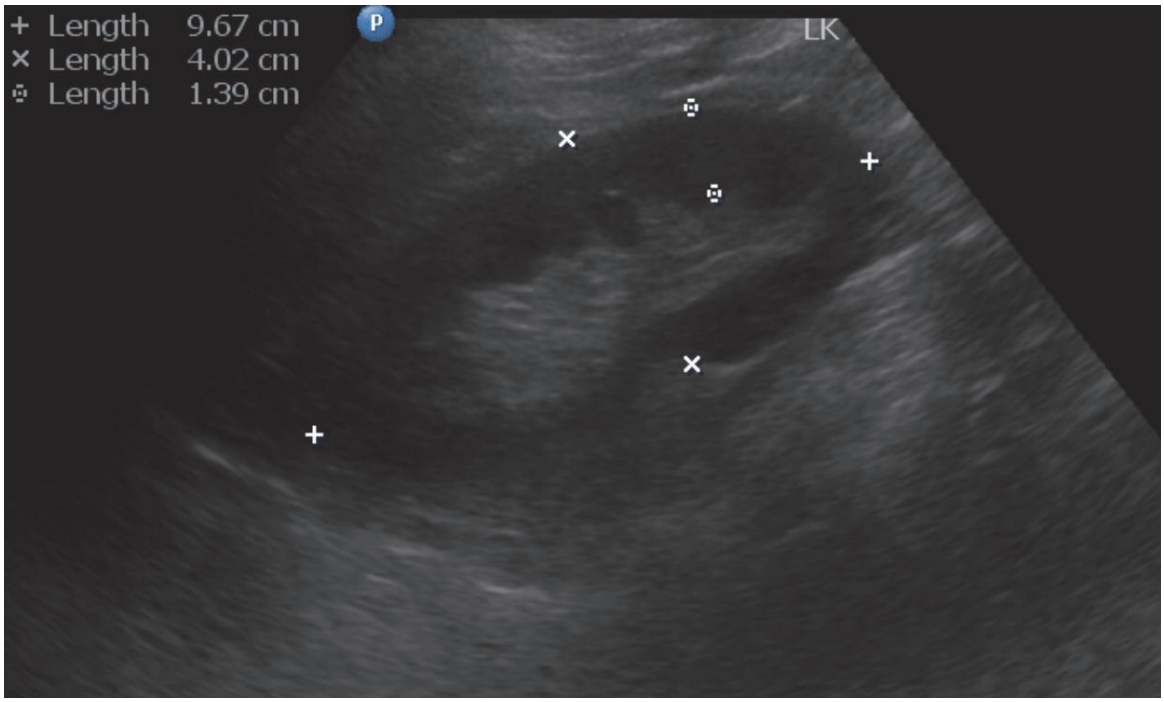

Fig. 1. Renal length, width and cortical thickness by ultrasound.

Results are expressed as mean ± standard deviation (X ± SD). The effect of age, gender; side, individual height and BMI were statistically analyzed using SPSS program, v. 16.

Results

Kidney Length

The mean right kidney length in the total group was (9.91 cm ± 0.85) while the mean left kidney length was (10.17 cm ± 0.89). With that result the left kidney length is significantly longer than the right side ($p = 0.000$).

Comparing the renal lengths between both genders revealed that, the mean right and left kidney lengths in male were found to be significantly longer than that in female; (10.36 cm ± 0.73 *vs.* 9.67 cm ± 0.82 with $p = 0.000$) for the right side (Fig. 2) and (10.47 ± 0.88 cm *vs.* 10.01 ± 0.86 cm with $p = 0.008$) for the left side (Fig. 3).

The relation between the age and renal size was also studied in details. The participants were classified into 2 age groups for simplicity; Group 1 from 18 to 30 years and Group 2 from 31 to 65 years.

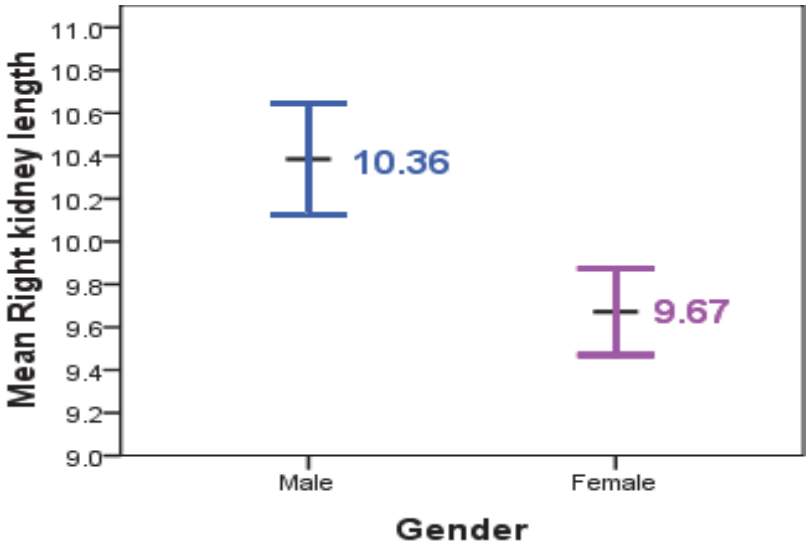

Fig. 2. Right kidney length according to gender.

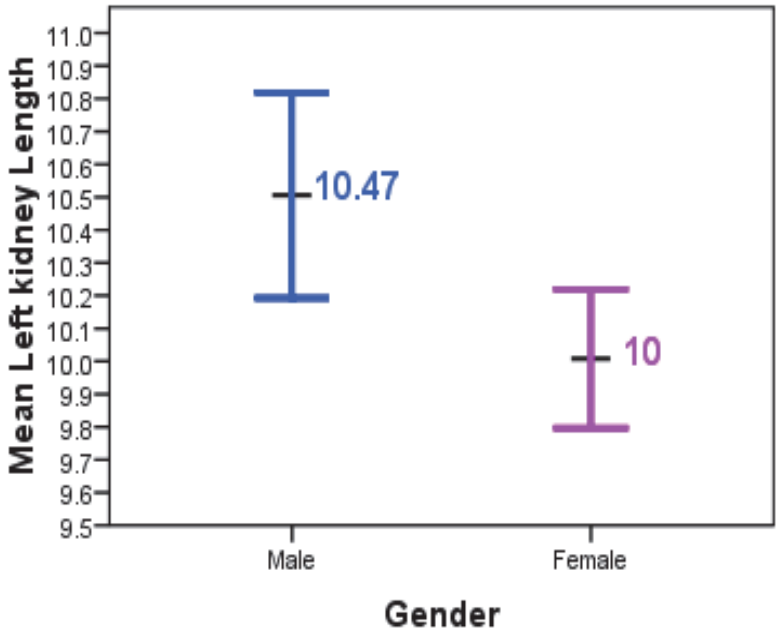

Fig. 3. Left kidney length according to gender.

In Group 1, the mean right and left kidney lengths were significantly shorter than that of Group 2 (9.72 cm ± 0.80 *vs.* 10.34 cm ± 0.82 with p = 0.001) for the right side and (9.94 cm ± 0.81 *vs.* 10.69 cm ± 0.86 with p = 0.000) for the left side.

Participants were classified into four groups according to their BMI: less than 18.5, 18.5 – 24.9, 25 - 29.9 and more than 30. As shown in Table 3[6], it was found that there was significant increase of the right and left renal lengths with increased BMI with (p = 0.000).

Table 3. Renal size according to different BMI in the study group.

	Right Kidney	Left Kidney
Group 1 (less than 18.5)	9.63cm ± 0.70	9.61 cm ± 0.75
Group 2 (18.5 – 24.9)	9.68 cm ± 0.76	9.92 cm ± 0.76
Group 3 (25 -29.9)	9.97cm ± 0.62	10.37 cm ± 0.62
Group 4 more than 30	10.621 cm ± 0.87	10.97 cm ± 1.01

The average adult height in Saudi Arabia is 174 cm in males and 164 cm in females[7]. To correlate kidney length to individual height, the male participants was classified into two groups; 174 cm and below, and 175 cm and above with the ideal height is 175 cm. There was no significant increase in the mean right or left kidney length with increased height (10.33 cm ± 0.71 *vs.* 10.45 cm ± 0.82 with p = 0.724) for the right side and (10.462 cm ± .087 *vs.* 10.469 cm ± 0.93 with p = 0.971) for the left side. Female participants' height was classified into two groups; 164 cm and below, and 165 cm & above. There was also no significant increase in the mean right or left kidney length with increased female height (9.64 cm ± 0.87 *vs.* 9.85 cm ± 0.41 with p = 0.169) for the right kidney and (10.02 cm ± 0.84 *vs.* 9.91 cm ± 1.05 with p = 0.961) for the left kidney.

Kidney Width

The mean right kidney width in the total group was 3.77 cm ± 0.59, while the mean left kidney width was 4.62 cm ± 0.71 (significantly more than right side, p = 0.000). According to the gender, the mean right and left kidney width in male was found to be slightly more than that in female for the right side, and for the left side there was no significant difference as shown on Table 4. This table also shows that in age group 18-30, the mean right and left kidney widths were slightly shorter than that of age group 31-65 years.

Table 4. Renal width according to gender and age in the study group.

Participants	Right Renal Width	P Value	Left Renal Width	P Value
Male	3.93 cm ± 0.63	p = .087	4.78 cm ± 0.84	0.151
Female	3.71 cm ± 0.56		4.55 cm ± 0.64	
Age group 1	3.70 cm ± 0.57	0.062	4.66 cm ± 0.69	p = 0.412
Age group 2	3.943 cm ± 0.60		4.53 cm ± 0.77	

Table 5. The relation between the renal width and BMI in the study group.

	Right Kidney	Left Kidney
Group 1 (less than 18.5)	3.52 cm ± 0.49	4.39 cm ± 0.64
Group 2 (18.5 – 24.9)	3.59 cm ± 0.48	4.56 cm ± 0.67
Group 3 (25 -29.9)	3.88 cm ± 0.59	4.63 cm ± 0.70
Group 4 (> 30)	4.31 cm ± 0.59	4.94 cm ± 0.85

There was significant increase in the means of right and left kidney width with increased BMI ($p = 0.000$ and $p = 0.025$, respectively, as shown in Table 5).

In correlation between kidney width and individual height, there was no significant increase in the mean right or left kidney width in males with an increased height (3.88 cm ± 0.69 in first group *vs.* 4.16 cm ± 0.50 in second group with $p = 0.322$) on the right side and on the left side (4.75 cm ± 0.92 in first group *vs.* 4.8 cm ± 0.31 in second group with $p = 0.888$). Those findings were also the same for the female group.

Renal Cortical Thickness

The mean right renal cortical thickness in the total group was 1.23 cm ± 0.95, while the mean left renal cortical thickness was 1.36 cm ± 0.79. There was no significant difference between both sides ($p = 0.96$).

The mean right renal cortical thickness in male was found to be slightly more than that in female (1.49 cm ± 1.61 *vs.*1.11 cm ± 0.26). This was insignificant ($p = 0.06$). The mean left renal cortical thickness in males was found (1.33 cm ± 0.29) and less than that of in females (1.37 cm ± 0.95). There was also insignificant differences ($p = 0.082$).

Discussion

Renal size is one of the most important assessed parameters during renal ultrasonography. Renal size can change in a number of morbidities and therefore, its assessment can aid in diagnosis of many diseases. However, this requires establishment of normal dimensions of the kidneys in various age groups, gender and races in order to appreciate deviations from normal[3]. Ultrasound is an ideal imaging modality to measure renal size as it uses non ionizing radiation, and is free of the radiographic magnification or contrast induced increases in renal size.

Renal length and volume are important parameters in the clinical scenario. Specifically, renal length measurement is more valuable in adults due to its reproducibility and accuracy[3].

In this study, it was found that the mean renal length in the total group was (10.17 cm ± 0.89) on the left side and (9.91 cm ± 0.85) on the right side with the left side longer. In this aspect, our study was compatible with the study done by Carrasco *et al*.[3] where they found a significant difference between right and left kidney length in Mexican adults with the p value < 0.05[3]. But our results didn't match with the studies done by Bircan *et al*.[8], and Ablett *et al*.[9], on Turkish population, and the study of Buchholz *et al*.[10] on Pakistani population where all of them mentioned that "there was no significant difference between the right and left kidney length"[8-10].

Comparing the renal length between both genders revealed that, the mean right and left kidney length in male was found to be significantly longer than that in female with p value < 0.05 for both. Those results were also proved by other studies *e.g.,* as Carrasco *et al*.[3] studying renal size on Mexican adults, Bircan and Oner[8] who conducted their study on Turkish population and, Buchholz *et al.*[10] applying their study on Pakistani population. All of them agreed that the kidney length of males was found to be longer than those of female counterparts"[3,8,10].

Regarding the relation between the age and renal size, the mean right and left kidney length was significantly shorter in the younger age group than that of the older one with p = 0.001 and 0.000 for the right and left sides respectively. Our study was compatible with the study done by Bircan and Oner[8] on Turkish population, where they mention that "there was significant positive correlation between age and kidney length of men and women"[8]. But our results didn't match with the studies conducted by Carrasco *et al*.[3], Emamian *et al*.[11], Damir *et al*.[12] and on Mexican adults where they mentioned that renal length decreases considerably with age and that the rate of decrease accelerates with age, especially after 60 years, but above all after 70 years[3,11,12].

Similarly, studies of Fernandes *et al*.[13] have established a correlation between renal dimensions and age, since it was shown that a reduction of up to 40% in renal weight occurs over the years[13].

It is also known that aging leads to a progressive reduction of renal size. From the 5th decade on, kidney length decreases approximately 0.5 cm per decade[14], especially due to a reduction of about 1% per year in blood flow after the third decade[10]. This discrepancy was referred in our results due to the limited participants aging 60 and above.

In the Saudi society, there is a difference in body weight, which could affect the renal size. Participants were classified into four groups according to their BMI. There was significant increase in renal length with increased BMI (p = 0.000 for both the right and left sides). Carrasco *et al*.[3] in Mexico, Bircan *et al*.[8] in Turkey and Buchholz *et al*.[10] in Pakistan agreed with our study that "The two renal length correlate in a significant positive manner with BMI"[3,8,10].

There was no significant increase in the mean right or left kidney length with increased personal height in both male and female participants. Those results were surprisingly opposite from the studies done by Carrasco *et al*.[3] in Mexico, Bircan *et al*.[8] in Turkey and Emamian *et al*.[11] in Mexico who also agreed that "Renal length correlated best with body height"[3,8,11]. Racial background may be a contributing factor.

The possible variation in renal width according to the previous factors was also highlighted in this study where it was found that the right kidney width is significant less than the left side (p = 0.000). This result matched with the study of Buchholz *et al*.[10] in Pakistan who stated that "right renal width was smaller than the left renal width"[10].

The mean right and left kidney width in male was slightly more than that in female p = .087 and 0.151 for the right and left sides, respectively. Younger age group showed shorter renal width than that of older group on both the right and left sides with p value of 0.062 on the right side and 0.412 on the left side.

There was significant increase in the mean right and left kidney width with increased BMI (p = 0.000 and 0.025, respectively). In this aspect our study was compatible with the study conducted by Buchholz *et al*.[10] in Pakistan where they mention that "there was significant increase in renal width with increased BMI"[10].

There was no significant increase in the mean right or left kidney width in males with increased height (p = 0.322 and 0.888, respectively).

While in female, it was found a slight increase in the means of right and left kidney width with increased height (p = 0.360) (p = 0.582), respectively, but also of no significance.

These results inferred that the renal width is not a strong parameter to depend on in estimating the renal size owing to its non significant correlation between it and gender, height or different age groups. Supporting our opinion is the lack of studies –to our knowledge- of the correlation between the renal width and different population parameters.

The renal cortical thickness was also correlated with different parameters in our study group. No significant difference between the renal cortical thickness of the right and left sides (p = 0.96). The mean right renal cortical thickness in male was found to be slightly more than that in female (p = 0.06). And on the left side it was less in male than in female with no significance (p = 0.082). Measurement of cortical thickness is less feasible due to the built-in calibers on US machine allows measurement in increments of 1mm only. However, measurements of cortical thickness may be useful in pathologic condition.

Although, it is known to sonographers that the normal kidney size of an adult human is about 10 to 13 cm long as mentioned by most studies *e.g.*, Thakur *et al.*[15]. But there is a significant variation of the renal dimensions among different races as noticed from our study, compared with other studies results.

Renal dimensions, especially the renal length are very important parameters during Ultrasound examination. Deviation from the normal values of renal length is a very important indication of renal pathology. Renal size is susceptible to variations according to the different races.

In a study of Moëll[16], the absolute values obtained for the dimensions of both kidneys were below those found in European studies[16]. The present renal length values for their Brazilian subjects show that the normal pattern defined by other studies from other countries is not adequate for their population. Data adjusted by height showed that gender and BW did not influence RD, but height showed a direct correlation with renal length[16].

In another study of Fernandes *et al.*[13], it showed that the Brazilian population has a mean height between that of Asian[17] and European[16]

population. One study in Pakistan[10] also highlights the necessity of investigating renal dimensions for each population, strengthening that European and American populations' data cannot be used as universal patterns[13].

For that reason, all our participants were Saudi. Hence, excluded immigrants trying to put a standard for the renal size in our population and to study if it is different from other races or not.

In our study, the average right renal length was 9.91 cm ± 0.85 and on the left side was 10.17 cm ± 0.89. In the study of Carrasco *et al*.[3] on Mexican population left renal length (LRL) in the whole group was 10.58 ± 7.56 cm and right renal length (RRL) was 10.43 ± 6.45 cm ($p = 0.000$)[3]. Renal size and height were shorter in this population in comparison with figures published in European populations[3]. In another study on Pakistani population, the mean kidney length was 10.4 ± 0.8 cm, mean width 4.5 ± 0.6 cm and mean cortical thickness 1.6 ± 0.2 cm. Kidney length did not significantly differ between right and left. Right kidneys were smaller than the left ones[10].

Conclusion and Recommendation

From this research, it was found that the average right renal length was 9.91 cm ± 0.85 and on the left side was 10.17 cm ± 0.89. And the left renal length was greater than right kidney length in Saudi population, and both renal lengths were greater in males than in females. Both kidneys' length correlated negatively with age and positively with BMI. No significant correlation between the renal length and personal height in either males or females.

The left kidney width was significantly greater than right kidney width in all study groups; otherwise, no significant difference in kidney widths in relation to gender, age or height. Kidney width correlates positively with BMI.

Measurement of cortical thickness was less feasible.

Some of our results matched with similar studies done for different races while other results differed from that of the same population groups. This means that every race has its own renal measurements which should be followed.

Therefore, it is recommended further population based studies are necessary to establish the normal renal size values for Saudi population according to their age, gender, height and BMI, and to expand this study all over the Kingdom of Saudi Arabia.

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قياس أبعاد الكلى بواسطة الموجات فوق الصوتية فى مجال السكان السعوديين

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المستخلص. معرفة المعدل الطبيعي لحجم الكلى مفيد لتقدير التغيرات التي تحدث لأسباب مرضية. التصوير بالموجات فوق الصوتية وسيلة فعالة وآمنة لتحديد قياسات للكلى كالطول، العرض، سمك القشرة. لمعرفة قياسات الكلية الصحيحة لابد من معرفة قياساتها في الأصحاء البالغين لأنها تتأثر بعوامل مختلفة. الهدف من الدراسة هو تحديد المعدل الطبيعي لقياسات الكلى في السعوديين وعلاقته مع العمر، مؤشر كتلة الجسم، الجنس، جهة الكلية والطول بالموجات فوق الصوتية. أقيمت الدراسة على مائة متطوع سعودي (من ١٨:٦٥ سنة، ٣٤ رجال، ٦٦ نساء) خالين من أمراض الكلى، ارتفاع ضغط الدم أو السكري. أجريت الدراسة في قسم الأشعة بمستشفى جامعة الملك عبدالعزيز بجدة. تم قياس الطول، العرض والسماكة القشرية للكليتين. تم التحليل الإحصائي باستخدام البرنامج الإحصائي للعلوم الاجتماعية. وجد أن طول الكلية اليسري ١٠,١٧ سم واليمنى ٩,٩١ سم. لوحظ أن طول الكلى في الرجال أطول من النساء وازداد طول الكلى طرديا مع العمر ومؤشر كتلة الجسم. لم يكن هناك زياده مع زياده الطول الفردي في الجنسين. ووجد أن

عرض الكلية اليسري أكبر من عرض اليمنى. العامل الوحيد المؤثر على ازدياد عرض الكلية هو مؤشر الكتلة الجسمية. هناك حاجة لدراسة القيم الطبيعية لحجم الكلى للسعوديين ونوصي لتوسيع نطاق هذه الدراسة في جميع أنحاء المملكة العربية السعودية.