# Renal Doppler Indices of Normal Adult Individuals and their Correlation with Anthropometric Variables in Kano, Nigeria

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## Summary

**INTRIDUCTION**

**Doppler ultrasound has been extensively used in renal diseases. Data of the normal renal resistive index (RI) and pulsatility index (PI) of normal adult individuals in a population is critical in the diagnosis, prognostics and therapeutic assessments of patients with kidney disease. The study aimed at evaluating the renal Doppler indices of normal adult individuals and their correlation with demographic variables in Kano, Nigeria.**

**MATERIALS AND METHODS**

**This study design was a prospective cross-sectional conducted in normal adult individuals from July 2019 to April 2020 in the Radiology Department, Aminu of Kano Teaching Hospital, Kano, Nigeria. Stratified and simple random sampling methods were employed in the study and a sample size of 384 participants; 192 males and 192 females were recruited. The Doppler ultrasound was performed on all the participants. An RI value above 0.70 was considered abnormal while PI value above 1.56 was also considered abnormal. The data was analyzed using SPSS Version 22.0. Preset ρ-value (0.05).**

**RESULTS**

**The mean and the standard deviation of the right and left RI and PI for the males' participants were 0.60±0.02, 0.59±0.02, 1.26±0.15 and 1.25±0.14. For females' participants it was 0.59±0.25, 0.59±0.03, 1.17±0.16 and 1.16±0.16. There was statistically significant strong positive correlation between RI and PI with age (r>6, p=0), there was also statistically significant moderate positive correlation with weight, BMI and BSA (r>4, p=0).**

**CONCLUSION**

**This study has established normative values of RI and PI for adult individuals in Kano, Nigeria. There was a strong positive correlation between RI and PI with age and moderate positive correlation with weight, BMI and BSA.**

***Keywords:*** *RI, PI, Normal, Adult Individuals*

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# Introduction

The evaluation of renal Doppler indices; resistive index (RI) and pulsatility index offer data on renal arterial impedance. The RI is the difference between peak systolic velocity (PSV) and end diastolic velocity (EDV) divided by end diastolic velocity, whereas PI is the difference between peak systolic velocity (PSV) and end diastolic velocity (EDV) divided by mean velocity.[1] A RI value of 0.60 ± 0.01 (mean ± SD) is usually taken as normal in adult individuals with a value of 0.70 being considered the upper normal threshold.[2] The normal value of PI is 1.36–1.56 in apparently normal adult individuals.[3]

Several factors can influence RI independent of renal disease, including heart rate, vessel wall compliance, and systemic vascular resistance. Bradycardia increases the RI because there is more time for the diastolic flow to decrease; on the other hand, tachycardia does not allow the diastolic flow to fully decrease, thus lowering the RI. In patients with widespread atherosclerosis or reduced vascular compliance in general (as in elderly patients), the renal RI may be increased even with normal kidney function.[4]

Doppler ultrasound has been extensively used in renal diseases, both in diagnostic, prognostic and therapeutic assessments due to the non-invasive, safe and low cost method for the evaluation of the renal blood flow.[5] The advantage of using Doppler ultrasound (DUS) lies in its ability in detecting not only renal morphological abnormalities, but also functional ones; colour Doppler, DUS and spectral analysis provide qualitative and quantitative haemodynamic information about the intrarenal and extrarenal vasculature highlighting changes in the renal blood flow.[6]

Doppler examination has been used in the diagnosis of renal artery stenosis, renal vein thrombosis, complications secondary to biopsy, assessment of renal inflammation, obstructive collecting system dilatation and in the evaluation of renal vascular resistance in various renal parenchymal diseases such as diabetic nephropathy, systemic lupus erythomatosus, autosomal-dominant polycystic kidney disease, hepatorenal syndrome, haemolytic uremic syndrome, or interstitial nephritis.[1]

Having data of the normal renal RI and PI of apparently healthy adult individuals in a population is critical in the diagnosis, prognostics and therapeutic assessments of patients with kidney disease. A study was conducted by Isma'il *et al*[7]in the same study area with the current study having a sample size of 80 subjects in a population of about 12 million and might not be the correct representation of the population. Pulsatility index was not evaluated and since PI involves mean velocity, it can reflect flow better than RI.[8] Furthermore; the previous study did not screen the subjects for human immunodeficiency virus (HIV) infection. Studies conducted by[9, 10, 11] showed HIV-associated nephropathy (HIVAN)

in some patients with HIV/AIDS and HIVAN influence RI and PI values. Urine protein was not also evaluated by the previous study and the test remains vital for excluding subjects with abnormal renal function. This study fills the missing gap in the previous study. The study is aimed at evaluating the renal Doppler indices of normal adult individuals and their correlation with demographic variables in Kano, Nigeria.

# Materials and Methods

This study design was a prospective cross-sectional conducted in normal adult individuals from July 2019 to April 2020 in the Radiology Department of Aminu Kano Teaching Hospital, Kano, Nigeria. Stratified and simple random sampling methods were employed in the study and a sample size of 384 participants; 192 males and 192 females recruited. Excluded from the study were diabetic and hypertensive patients[12], pregnant women, pediatric patients, geriatric patients[7], patients that were unable to hold their breath during the scan and HIV sero-positive individuals. Participants with abnormal renal parenchymal echogenicity and or abnormal renal volume during the scan were also excluded. All the participants were screened for high blood pressure, diabetes and HIV; those found abnormal were excluded.

An ethical approval to conduct the study was obtained from the Human Research and Ethics Committee of Aminu Kano Teaching Hospital, and an informed consent was obtained from the participants after they had agreed to the objectives and significance of the study.

A SONOSCAPE SSI–8000, 2014 digital colour Doppler ultrasound system, Schenzhen China machine, equipped with a 3.5MHz curvilinear transducer and electronic calipers were used as instruments for data collection. The patients were examined in the prone position. The resistance to blood flow increased from the renal hilar vessels towards the peripheral parenchymal vessels.[7] Therefore, sampling for the renal resistive index was performed at the level of the interlobar arteries in-between the medullary pyramids. The target vessel was then insonated using a 2–4 mm Doppler gate[7]. The waveforms were obtained from the upper pole, the middle part and the lower pole of the kidney. The wave form was traced and the machine displayed the RI and PI automatically in each case as shown in Figure 1.

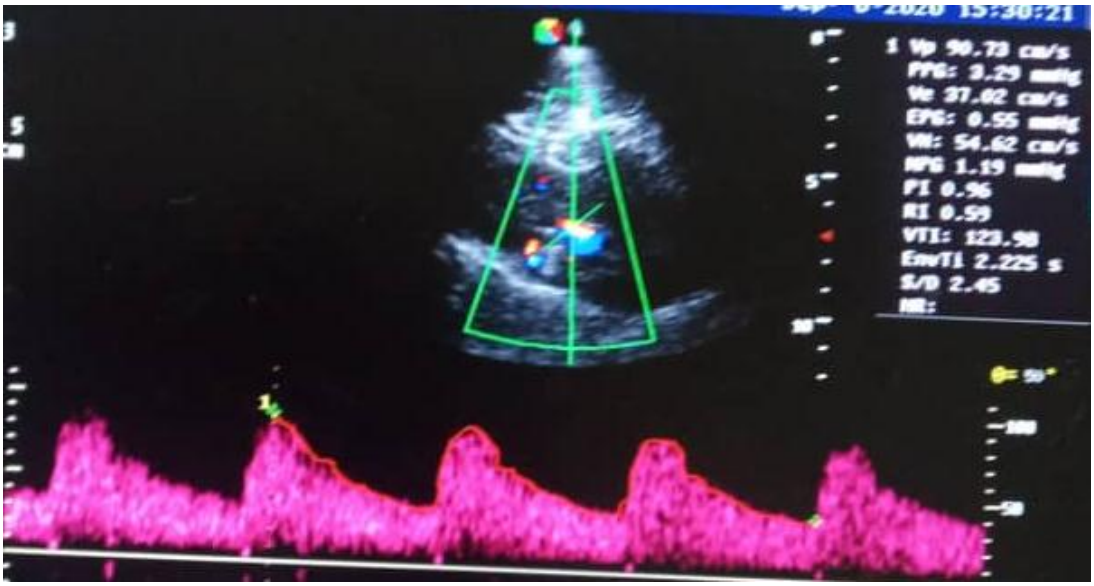


***Figure 1: Technique for Measurement of RI and PI of the Interlober Artery for 29 Year old Normal Adult. Sample Volume = 3mm; the wave was Acquired as Shown Above. PI Value = 0.96. RI = 0.59. Both Values are within normal limit.***

The average of the RI and PI of the three regions of the kidney was recorded as the RI and PI of the kidney. On completion of the renal Doppler scan, the patient was accompanied to the laboratory where a sample of blood and urine was collected for CD4 count, serum creatinine, urea determinations and proteinuria. The participants found with abnormal values of the serum creatinine and or urea, or proteinuria were excluded from the study.

The means, standard deviations (SD) and range of the RI, PI, serum creatinine and urea were obtained using descriptive statistics. The difference in mean of the RI and PI between males and females was obtained using Mann-Whitney u test. Correlation of the RI and PI with demographic variables was obtained using Spearman correlation method. The data was analyzed using SPSS Version 22.0. Preset ρ-value (0.05).

# Results

Table 1 shows the mean and standard deviation values of systolic and diastolic blood pressure, serum urea and creatinine, fasting blood sugar and CD4+ cells count for the males participants to be 120.06±11.82 mmHg, 66.71±5.74 mmHg, 2.98±1.20 mmol/L, 64.66±10.51 mmol/L, 4.15±0.45 mmol/L, and 817.06±241.19 cells/mm$^3$. For the females participants was found to be 110.13±14.33 mmHg, 62.19±7.18 mmHg, 2.71±0.83 mmol/L, 58.01±6.40 mmol/L, 3.90±0.32 mmol/L, and 796.87±248.51 cells/mm$^3$. The participants were HIV sero-negative and negative to urine protein test.

*Table 1: Mean Values of Systolic and Diastolic Blood Pressure, Serum Urea and Creatinine, Fasting Blood Sugar and CD4+ Cells Count; HIV Status and Proteinuria of the Participants.*

| Variables | Male (n=192) | Female (n=192) | Total (n=384) |
|---|---|---|---|
| Systolic (mmHg) | 120.06±11.82 (100-140) | 110.13±14.33 (95-140) | 115.10±13.08 (95-140) |
| Diastolic (mmHg) | 66.71±5.74 (60-90) | 62.19±7.18 (58-92) | 64.45±6.46 (58-92) |
| Urea (mmol/L) | 2.98±1.20 (1-6.4) | 2.71±0.83 (1.8-5.8) | 2.85±1.04 (1-6.4) |
| Creatinine (umol/L) | 64.66±10.51 (44-102) | 58.01±6.40 (35-80) | 61.3±9.30 (35-102) |
| FBS (mmol/L) | 4.15±0.45 (3-5.3) | 3.90±0.32 (3-5.2) | 4.03±0.0.39 (3-5.3) |
| CD4+ (cells/$mm^3$) | 817.06±241.19 (404-1667) | 796.87±248.51 (291-1851) | 806.97±244.77 (291-1851) |
| HIV Status | Non-reactive | Non-reactive | Non-reactive |
| Protein | Negative | Negative | Negative |

Data presented as mean ±SD (range). SD= standard deviation, FBS=fasting blood sugar

Table 2 shows the mean and standard deviation of the age, weight, height, body mass index (BMI) and body surface area (BSA) for the males participants to be 42.97±11.62 years, 1.69±0.07 m, 65.13±10.36 Kg, 22.85±3.41 $Kg/m^2$ and 1.76±0.14 $m^2$. While that of the females participants was 40.22±12.50 years, 1.64±0.07 m, 59±12.29 Kg 21.99±4.25 $Kg/m^2$ and 1.65±0.17 $m^2$.

*Table 2: Demographic characteristics of the participants*

| Variables | Male (n=192) | Female (n=192) | Total (n=384) |
|---|---|---|---|
| Age (years) | 42.97±11.62 (18-65) | 40.22±12.50 (18-65) | 41.60±12.06 (18-65) |
| Height (m) | 1.69±0.07 (1.55-1.86) | 1.64±0.07 (1.45-1.86) | 1.66±0.07 (1.45-1.86) |
| Weight (Kg) | 65.13±10.36 (40-100) | 59.09±12.29 (38-105) | 62.11±11.33 (38-105) |
| BMI ($Kg/m^2$) | 22.85±3.41 (14.86-37.11) | 21.99±4.25 (13.01-38.10) | 22.42±3.83 (13.01-38.10) |
| BSA ($m^2$) | 1.76±0.14 (1.40-2.27) | 1.65±0.17 (1.27-2.14) | 1.71±0.16 (1.27-2.27) |

Data presented as mean ±SD (range). SD= standard deviation, BMI= body mass index, BSA= body surface area

Table 3 shows the mean and the standard deviation of the right and left RI and PI for the males' participants to be 0.62±0.02, 0.61±0.02, 1.26±0.15 and 1.25±0.14. For females' participants it was 0.61±0.02, 0.60±0.03, 1.17±0.16 and 1.16±0.16.

*Table 3: Renal Doppler Indices of Right and Left Kidneys of the Participants*

| Variables | Male (n=192) | Female (n=192) | Total (n=384) |
|---|---|---|---|
| RRI | 0.62±0.02 (0.53-0.63) | 0.61±0.02 (0.52-0.63) | 0.62±0.02 (0.52-0.63) |
| LRI | 0.61±0.02 (0.5-0.62) | 0.60±0.03 (0.52-0.62) | 0.61±0.03 (0.5-0.62) |
| RPI | 1.26±0.15 (0.9-1.54) | 1.17±0.16 (0.87-1.49) | 1.22±0.16 (0.87-1.54) |
| LPI | 1.25±0.14 (0.91-1.53) | 1.16±0.16 (0.86-1.48) | 1.21±0.15 (0.86-1.53) |

Data presented as mean ±SD (range). SD= standard deviation, RRI= right renal resistive index, LRI= left renal resistive index, RPI= right renal pulsatility index, LPI= left renal pulsatility index

Table 4 shows statistically significant difference between the RI and PI of the male participants with that of female participants (p=0.000).

*Table 4: Comparison of Right and Left Renal Doppler Indices between the Male and Female Subjects*

| Variables | Male (N=192) | Female (N=192) | p-Value |
|---|---|---|---|
| RRI | 0.62±0.02 | 0.61±0.02 | .000 |
| LRI | 0.61±0.02 | 0.60±0.03 | .000 |
| RPI | 1.26±0.15 | 1.17±0.16 | .000 |
| LPI | 1.25±0.14 | 1.16±0.16 | .000 |

Data presented as mean ±SD. SD= standard deviation, RRI= right renal resistive index, LRI= left renal resistive index, RPI= right renal pulsatility index, LPI= left renal pulsatility index

Table 5 shows statistical significant strong positive correlation between RI and PI with age, there was also statistically significant moderate positive correlation with weight, BMI and BSA. However, there was weak positive no significant correlation with height.

*Table 5: Correlation of Right and Left Renal Doppler Indices with the Anthropologic Parameters (age, Height, Weight, BMI and BSA) for the Male subjects*

| Variables | RRI | | RPI | | LRI | | LPI | |
|---|---|---|---|---|---|---|---|---|
| | r | p | r | p | r | p | r | p |
| Age (years) | .844** | .000 | .636** | .000 | .804** | .000 | .632** | .000 |
| Height (m) | .079 | .273 | -.041 | .573 | .036 | .625 | -.032 | .662 |
| Weight (Kg) | .425** | .000 | .360** | .000 | .447** | .000 | .364** | .000 |
| BMI ($Kg/m^2$) | .420** | .000 | .361** | .000 | .437** | .000 | .359** | .000 |
| BSA ($m^2$) | .412** | .000 | .293** | .000 | .389** | .000 | .300** | .000 |

**: correlation of significance at the 0.01 level (2-tailed)

Table 6 shows statistical significant strong positive correlation between RI and PI with age. There was also statistical significant moderate positive correlation with weight, BMI and BSA in female subjects. However, there was weak positive no significant correlation with height.

***Table 6: Correlation of Right and Left RI and PI with the Anthropometric Parameters for the Female Control Adults***

| **Anthropometric Variables** | **Renal Doppler Indices** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **RRI** | | **RPI** | | **LRI** | | **LPI** | |
| | ***r*** | **ρ** | ***r*** | **ρ** | ***r*** | **ρ** | ***r*** | **ρ** |
| Age (years) | 0.778** | 0.000 | 0.750** | 0.000 | 0.733** | 0.000 | 0.749** | 0.000 |
| Height (m) | 0.038 | 0.600 | 0.055 | 0.450 | 0.008 | 0.911 | 0.032 | 0.662 |
| Weight (Kg) | 0.405** | 0.000 | 0.316** | 0.000 | 0.417** | 0.000 | 0.324** | 0.000 |
| BMI ($Kg/m^2$) | 0.392** | 0.000 | 0.321** | 0.000 | 0.409** | 0.000 | 0.338** | 0.000 |
| BSA ($m^2$) | 0.390** | 0.000 | 0.282** | 0.000 | 0.367** | 0.000 | 0.320** | 0.000 |

Key: RRI=right resistive index, RPI= right pulsatility index,
LRI=left resistive index, LPI= left pulsatility index.

**: correlation of significance at the 0.01 level (2-tailed)

# Discussion

The findings of this study as shown in Table 1 show that all the studied participants had normal blood pressure, serum urea and creatinine, fasting blood, HIV sero-negative and negative urine protein test. It is critical to evaluate the above mentioned variables because of their influence on RI and PI.

In this study shown in Table 2, the findings are contrary to what was reported by the studies conducted by Pekkafalı *et al.*[1] Isma'il *et al.*[7] and Ansarin *et al.*[12] that reported age ranges of 27-56 years, 18-84 years and 23-39 years respectively. The possible reason of the disagreement is based on objectives of the studies, to obtained normative values the age range has to be 18-65 years to avoid underdevelopment of the organ or physiological hypertrophy. The studies conducted by Pekkafalı *et al.*[1] and [1] Isma'il *et al.*[7] reported BMI that are similar to that of the current studies. However, studies conducted by Pekkafalı *et al*[1], Isma'il *et al.*[7] and Ansarin *et al.*[12] did not report height, weight and BSA of the participants studied.

As shown in Table 3, the findings of the current study are contrary to the findings of the studies conducted by Pekkafalı *et al.*[1] Isma'il *et al.*[7] and Ansarin *et al.*[12] that reported mean and standard deviation RI values of 0.63 ± 0.05, 0.64 ± 0.13 and 0.60 ± 0.08 for males and females respectively and 0.59. The possible reasons of the disagreement between this study and former studies might be the small sample size used by the previous studies and the age range of the participants. In the previous studies participants were not screened for HIV infection and HIVAN has proven to have an influence on RI.[13.14] Furthermore, in the case of the study conducted by Isma'il *et al.*[7], proteinuria was not performed on the participants and is a critical test in ascertaining normal renal function. The findings of this study as also shown in Table 3 are also not in accordance with the findings of the studies conducted by Pekkafalı *et al.*[1] and Ansarin *et al.*[12] who reported mean and standard

deviation PI values of 1.10 ± 0.14 and 1.02 ± 0.14, respectively. The possible reasons of the non-accordance might be the same reasons of the disagreement of the RI values. Furthermore, the study conducted by Isma'il *et al.*[7] did not report the PI values. Additionally, the findings of this study as also shown in Table 3 is in keeping with the findings of the study conducted by Isma'il *et al.*[7] that reported the mean RI values for males to be higher than females, however, the difference in the mean of the RI value is higher in the previous study than the current study.

The findings of this study as shown in table 3 are not in accordance with what was reported by Isma'il *et al.*[7] and Ansarin *et al*.[12] that showed RI value of the left kidney to be higher than the right. However, it is in accordance with Ansarin *et al*.[12] that reported right PI values to be than the left.

In this study as shown in Table 4, there was statistically significant difference between the RI and PI of the males participants with their females' counterparts. The findings of this study are in agreement with the study conducted by Isma'il *et al.*[7] that reported statistical significant difference between males and female RI values. The possible reason of the similarity might be because the two studies were conducted in the same location. However, the findings of this study are contrary to the findings of the study conducted by Pekkafalı *et al.*[1] that reported gender had no effect RI and PI values. The possible reason of the disagreement might be because the two studies were conducted in different locations.

Furthermore, as shown in Table 5, the findings of this reported statistical significant strong positive correlation with age, the findings are in accordance with what was reported by Isma'il *et al.*[7] that reported statistical significant correlation between RI and age. The possible reason of the agreement might be because the two studies were conducted in the same location. These findings are not in agreement with the findings of the study conducted by Pekkafalı *et al.*[1] that reported age had no correlation with age. The possible reason of the disagreement might be because the two studies were conducted in different locations.

This study also demonstrates a statistically significant moderate positive correlation between RI and PI with weight, BMI and BSA. The study conducted by Isma'il *et al.*[7] also reported statistically significant correlation between BMI and RI, however, Pekkafalı *et al.*[1] reported no correlation between RI and PI with BMI.

Similarly, this study demonstrates no significant correlation between the RI and PI with the height of the participants (table 6). The previous studies did not correlate the RI and PI weight, height and BSA.

# Conclusion

This study has established normative values of RI and PI for adult individuals in Kano, Nigeria. There was strong positive correlation between RI and PI with age and moderate positive correlation with weight, BMI and BSA. There was no significant correlation between the RI and PI with height.

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