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Associations of MRI-derived kidney volume, kidney function, body composition, and physical performance in ~38,000 UK Biobank participants: A population-based observational study

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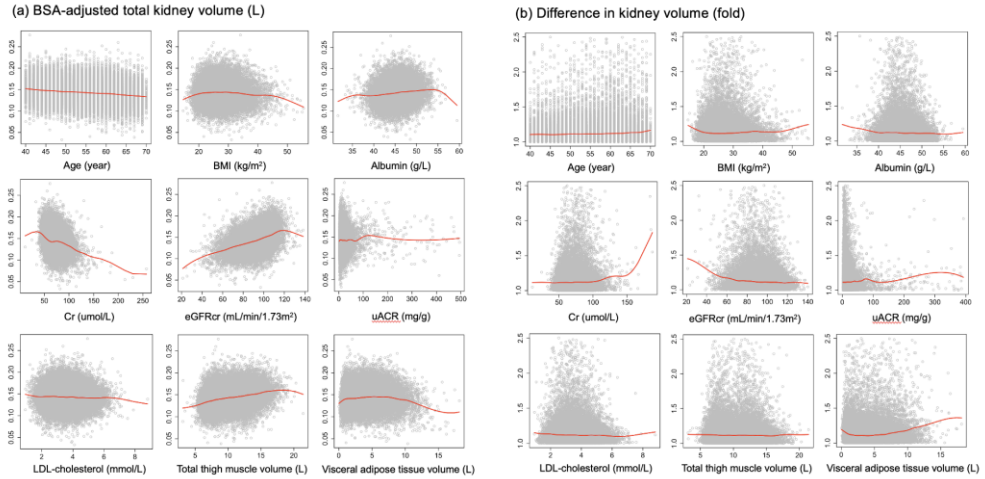
Objectives : Kidney volume is used as predictive and therapeutic marker for several clinical conditions. However, there is a lack of large-scale studies examining the relationship between kidney volume and various clinicodemographic factors, including kidney function, body composition, and physical performance.
Methods : In this observational study, MRI-derived kidney volume measurements from 38,526 UK Biobank participants were analyzed. Major kidney volume-related measures included body surface area (BSA)-adjusted total kidney volume (TKV) and the difference of bilateral kidneys. Multivariable-adjusted linear regression and cubic spline analyses were used to explore the association between kidney volume-related measures and clinicodemographic factors. Cox or logistic regression was used to identify the risks of death, non-kidney cancer, myocardial infarction, ischemic stroke, and chronic kidney disease (CKD).
Results : The median of BSA-adjusted TKV and difference in kidney volume were 141.9 (128.1–156.9) mL/m^2 and 1.08 (1.04–1.15) fold, respectively. Higher BSA-adjusted TKV was significantly associated with higher eGFR (beta [95% CIs], 0.43 [0.42–0.44]; $P < 0.001$), higher composition of muscle volume (beta [95% CIs], 0.50 [0.48–0.51]; $P < 0.001$), and higher mean handgrip strength (beta [95% CIs], 0.15 [0.13–0.16]; $P < 0.001$), while associated with lower visceral adipose tissue volume (VAT, beta [95% CIs], -0.09 [-0.11 – -0.07]; $P < 0.001$) in adjusted models. Higher difference in bilateral kidney volumes was associated with lower eGFR, muscle volume, and physical performance, while associated with higher proteinuria and VAT. Higher BSA-adjusted TKV was significantly associated with the reduced risk of CKD (odds ratio [OR], 0.7 [0.63–0.77]; $P < 0.001$), while higher difference in kidney volume was significantly associated with increased risk of CKD (OR, 1.13 [1.07–1.20]; $P < 0.001$).
Conclusions : Higher BSA-adjusted TKV and lower discrepancies in bilateral kidney volumes are associated with higher kidney function, muscle volume, physical performance, and reduced risk of CKD.

Table.png

Outcome	BSA-adjusted TKV, SD scale		Difference in kidney volume, SD scale	
Exposures, SD scale	Multivariable model Beta (95% CIs)	P value	Multivariable model Beta (95% CIs)	P value
Age	-0.004 (-0.01, -0.002)	<0.001	-0.06 (-0.10, -0.03)	<0.001
Male	0.45 (0.42, 0.48)	<0.001	0.004 (0.003, 0.01)	<0.001
Current smoking	0.09 (0.08, 0.11)	<0.001	0.003 (-0.02, 0.02)	0.73
Alcohol use	-0.05 (-0.06, -0.04)	<0.001	0.02 (0.01, 0.03)	<0.001
BMI	0.01 (-0.01, 0.03)	0.29	-0.03 (-0.06, -0.01)	0.003
BSA	0.16 (0.14, 0.18)	<0.001	-0.02 (-0.04, 0.002)	0.07
Systolic BP	0.03 (0.01, 0.04)	<0.001	-0.02 (-0.03, 0.01)	0.07
eGFR				
CKD-EPIcr	0.43 (0.42, 0.44)	<0.001	-0.04 (-0.05, -0.03)	<0.001
CKD-EPIcr-cys	0.57 (0.56, 0.58)	<0.001	-0.06 (-0.08, -0.05)	<0.001
CKD-EPIcys	0.50 (0.49, 0.51)	<0.001	-0.06 (-0.07, -0.04)	<0.001
EKFCcr	0.48 (0.47, 0.49)	<0.001	-0.04 (-0.06, -0.03)	<0.001
EKFCcys	0.54 (0.53, 0.55)	<0.001	-0.06 (-0.07, -0.04)	<0.001
MRI-derived measures				
Total thigh fat-free muscle volume	0.50 (0.48, 0.51)	<0.001	-0.05 (-0.07, -0.03)	<0.001
Visceral adipose tissue volume	-0.09 (-0.11, -0.07)	<0.001	0.09 (0.08, 0.11)	<0.001
Abdominal subcutaneous adipose tissue volume	-0.12 (-0.13, -0.10)	<0.001	-0.03 (-0.05, -0.01)	0.003
Physical performance-related measures				
Mean handgrip strength	0.15 (0.13, 0.16)	<0.001	-0.03 (-0.04, -0.01)	0.01
Walking pace	0.05 (0.04, 0.06)	<0.001	-0.001 (-0.01, 0.01)	0.84
Laboratory values				
Hemoglobin	-0.02 (-0.03, -0.01)	0.001	0.001 (-0.01, 0.02)	0.84
Creatinine	-0.52 (-0.57, -0.48)	<0.001	0.11 (0.05, 0.16)	<0.001
Cystatin C	-0.35 (-0.36, -0.34)	<0.001	0.06 (0.05, 0.08)	<0.001
Glucose	0.03 (0.02, 0.04)	<0.001	-0.01 (-0.02, 0.01)	0.34
Albumin	0.08 (0.07, 0.10)	<0.001	-0.02 (-0.04, -0.01)	<0.001
Uric acid	-0.05 (-0.06, -0.04)	<0.001	0.01 (-0.01, 0.02)	0.35
LDL-c	-0.02 (-0.03, -0.01)	<0.001	-0.02 (-0.03, -0.01)	<0.001
Urine albumin-creatinine ratio	-0.01 (-0.02, 0.002)	0.139	0.03 (0.02, 0.04)	<0.001
Comorbidities				
Hypertension	0.10 (0.07, 0.13)	<0.001	0.16 (0.13, 0.19)	<0.001
Dyslipidemia	0.02 (-0.01, 0.06)	0.17	-0.002 (-0.04, 0.04)	0.94
Diabetes mellitus	0.05 (-0.01, 0.11)	0.11	0.07 (-0.01, 0.14)	0.07

Table.png


(a) BSA-adjusted total kidney volume (L)
(b) Difference in kidney volume (fold)
Age (year)
BMI (kg/m²)
Albumin (g/L)
Cr (umol/L)
eGFRcr (mL/min/1.73m²)
uACR (mg/g)
LDL-cholesterol (mmol/L)
Total thigh muscle volume (L)
Visceral adipose tissue volume (L)