

Assessing the hydration status of children with chronic kidney disease and on dialysis: a comparison of techniques

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Background. Fluid balance is pivotal in the management of children with chronic kidney disease (CKD) and on dialysis. Optimal weight or “dry weight” has been traditionally determined by clinical assessment, taking into consideration the presence of clinical signs of volume overload, blood pressure trends and changes in weight. Clinical assessment of optimal weight is subjective, requiring experience and careful assessment. Although many techniques are available to assess fluid status, there are few studies in children, and none of the techniques have been compared against each other or against cardiovascular outcome measures.

Objectives. In this study we evaluated:

- the correlation between optimal weight by clinical assessment (Wt-CA) and weight derived from BIS (Wt-BIS);
- the accuracy of Rel-OH against other indicators of fluid status including peripheral blood pressure, central blood pressure, N-terminal pro-brain natriuretic peptide (NT-proBNP) levels and serum sodium (se Na); and
- the association between Rel-OH with cardiovascular outcome indicators, including pulse wave velocity (PWV) Z-score adjusted for age and increased left ventricular mass index (LVMI).

Methods. We performed a longitudinal study in 30 CKD children and 13 age-matched healthy controls (71 measurements) to determine a correlation between optimal weight by bioimpedance spectroscopy (Wt-BIS) and clinical assessment (Wt-CA). The accuracy of Wt-BIS (relative overhydration [Rel-OH]) was compared against indicators of fluid status and cardiovascular measures.

Results.

	HD	PD	CKD5	CONTROL	p [*]
Total	10	10	10	13	
Male gender	7 (70.0%)	5 (50.0%)	6 (60.0%)	5 (38.5%)	0.81
Mean age (years)	12.7±3.71	12.3±3.96	11.4±3.79	11.4±4.49	
Median Z score of weight for age -sex	-1.61(-2.26,-0.01)	-1.57(-2.30,-0.69)	-0.14(-0.80,0.11)	-0.05(-0.72,0.80)	0.03
Median Z score of height for age -sex	-1.7(-2.7,-0.8)	-1.1(-1.9,-0.5)	-0.9(-1.9,-0.5)	0.1(-0.7,1.0)	0.21
Median Z score BMI	-1.3(-2.3,0.8)	-0.8(-1.5,0.7)	0.1(-0.1,1.0)	0.1(-0.7,0.7)	0.47
Median duration of renal replacement therapy (months)	27.8(2,7,65.0)	6.0(3,18.5)	NA	NA	NA
Number on antihypertensive treatment	3(30%)	5(50%)	4 (40%)	0	NA
Median number of antihypertensive agents	0	1	0	0	NA
Number of patients on ACEI/ARB	2 (20%)	1(10%)	0	NA	NA
Number of patients with arteriovenous fistula	4(40%)	0	1(10%)	NA	NA
Aetiology of underlying chronic kidney disease					
1. Congenital anomalies of the kidneys and urinary tract	2	6	7		
2. Cystic kidney disease	1	1	-		
3. Primary glomerular disease	3	-	1		
4. Lupus nephritis	1	-	-	NA	NA
5. Others (HIVAN, Wilms' tumour, metabolic disease, undefined genetic syndrome)	3	3	2		

Data expressed as n(%) or median and interquartile range
p^{*} Comparison between groups
ACEI: Angiotensin converting enzyme inhibitor, ARB: Angiotensin receptor blocker, SBP: systolic blood pressure, DBP: diastolic blood pressure, IQR: interquartile range, BMI: body mass index, HIVAN: Human immunodeficiency virus associated nephropathy

Table 1| Clinical characteristics of study and control groups.

➤ There was poor agreement between Wt-CA and Wt-BIS in children on dialysis when compared to CKD5 or control subjects (p=0.01) (Figure 1).

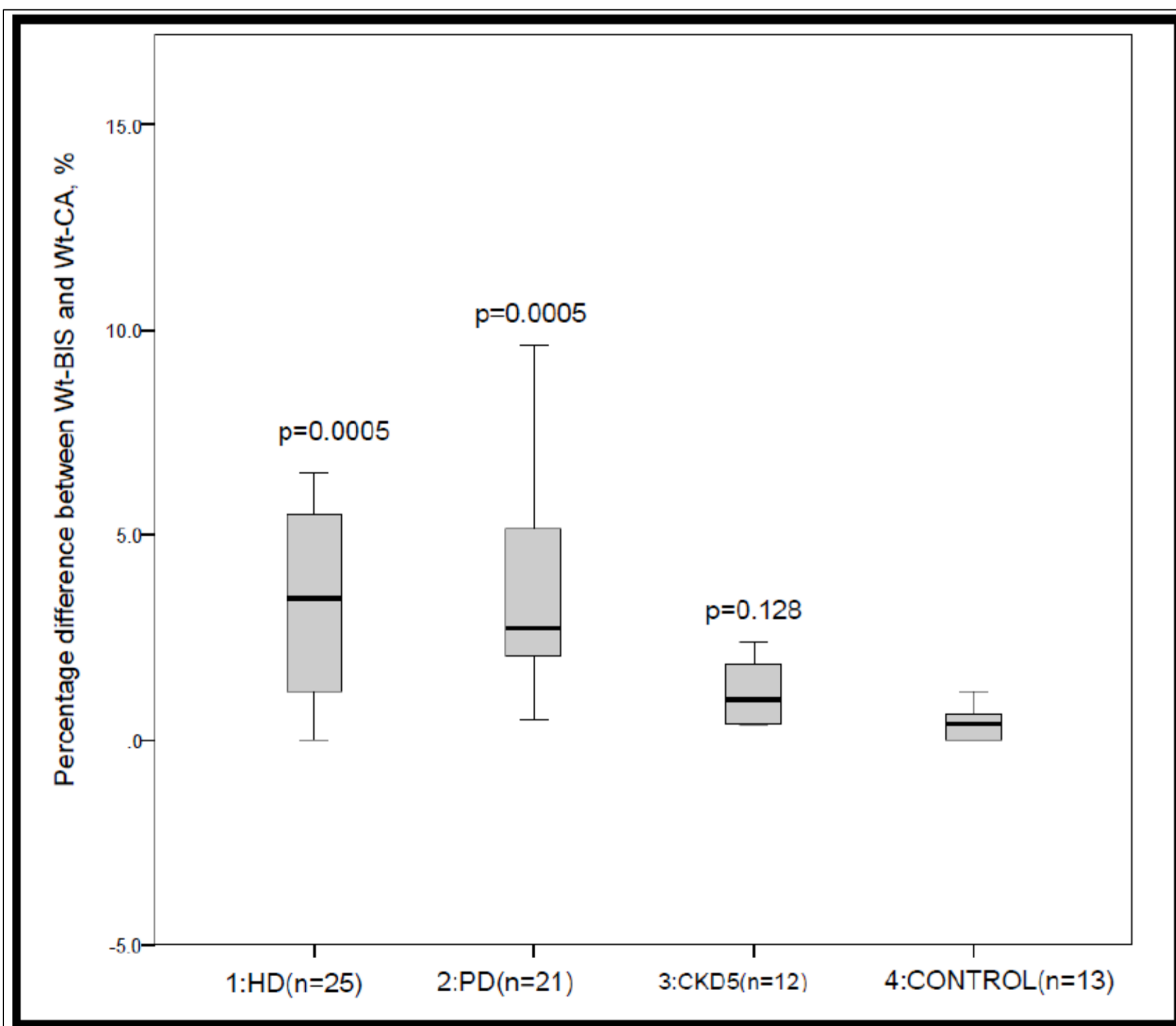


Figure 1| Percentage difference between Wt-BIS and Wt-CA
A one-way Welch ANOVA was conducted to identify if the percentage difference was different for the various groups. The percentage difference was significantly different between the groups. Welch's F (3, 32.64) = 18.53, p=0.0005. Games-Howell post hoc analysis revealed that the higher percentage difference in HD compared to control group was statistically significant (2.72, 95%CI 1.48 to 3.97; p=0.0005). Similar observation noted for the PD group (3.93, 95%CI 1.73 to 6.12; p=0.0005).

- We developed a modified chart to plot Rel-OH against systolic BP z-score for the appropriate representation of volume status and BP in children.
- We believe that expressing the SBP as a z-score will represent the paediatric cohort better as blood pressure limits in children are closely related to gender, age and height.
- 25% of measurements showed systolic BP >90th percentile but not with concurrent overhydration (Figure 2). The original plot is shown in Figure 3.
- Rel-OH correlated with peripheral pulse pressure (p=0.03; R=0.3), left ventricular end-diastolic diameter (p=0.05; R=0.38) and higher NT-proBNP (p=0.02; R=0.33) but not with central aortic BP (Figure 4).

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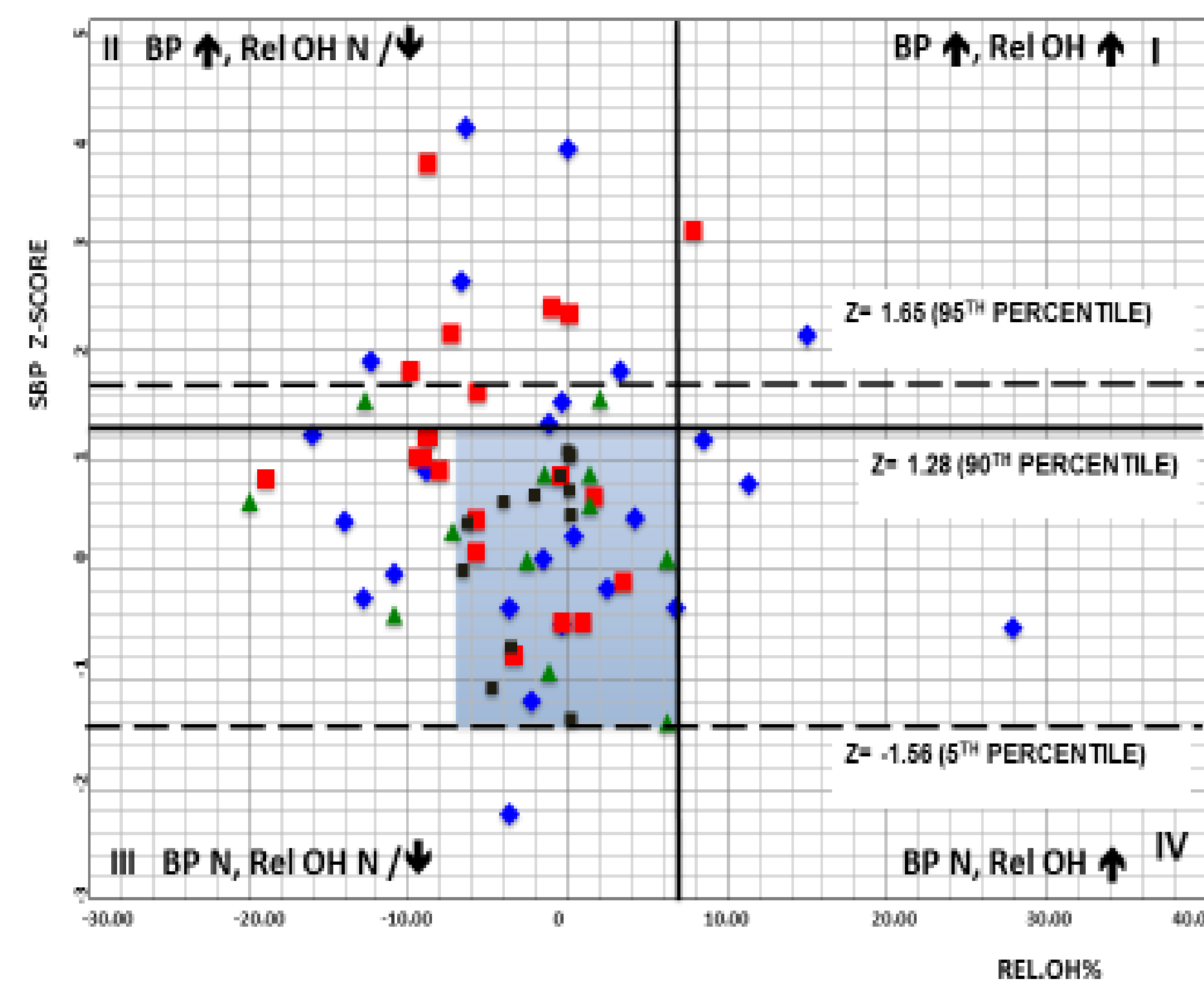


Figure 2| Relative overhydration (Rel-OH) against systolic blood pressure (SBP) Z-score. The four respective quadrants represent the hydration status in relation to the systolic blood pressure z-score for age, gender and height. The blue plot represents normal i.e. SBP Z score -1.56 (5th percentile) to 1.28 (90th percentile) and Rel-OH from -7% to 7%. Solid black line across the y axis represents the 90th percentile or z score = 1.28. Dotted black line represents z score = 1.96 corresponding with the 95th percentile, threshold for defining hypertension.

- Systolic BP was positively associated with PWV z-score (p=0.04). 40% of children on HD and 30% on PD had increased LVMI. Systolic BP was positively associated with PWV z-score (p=0.04). 40% of children on HD and 30% on PD had increased LVMI.

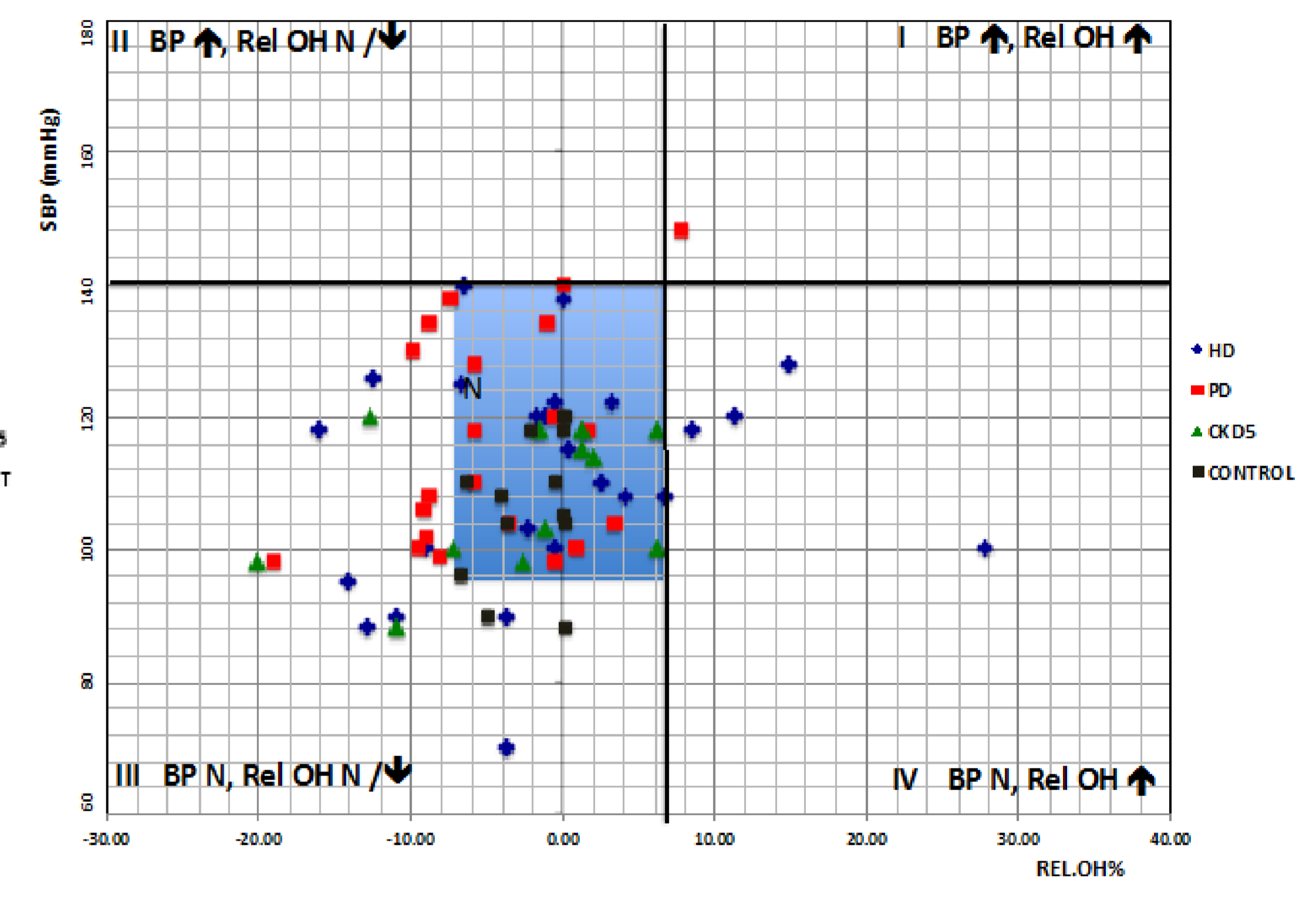


Figure 3 | This Hydration Reference Plot provided with the BCM[®]. In the original work described by Wabel and team, 140mmHg was taken as the upper limit reference for systolic blood pressure. Plotting paediatric data on this, only 1 measurement noted with Rel-OH >7% and elevated blood pressure.

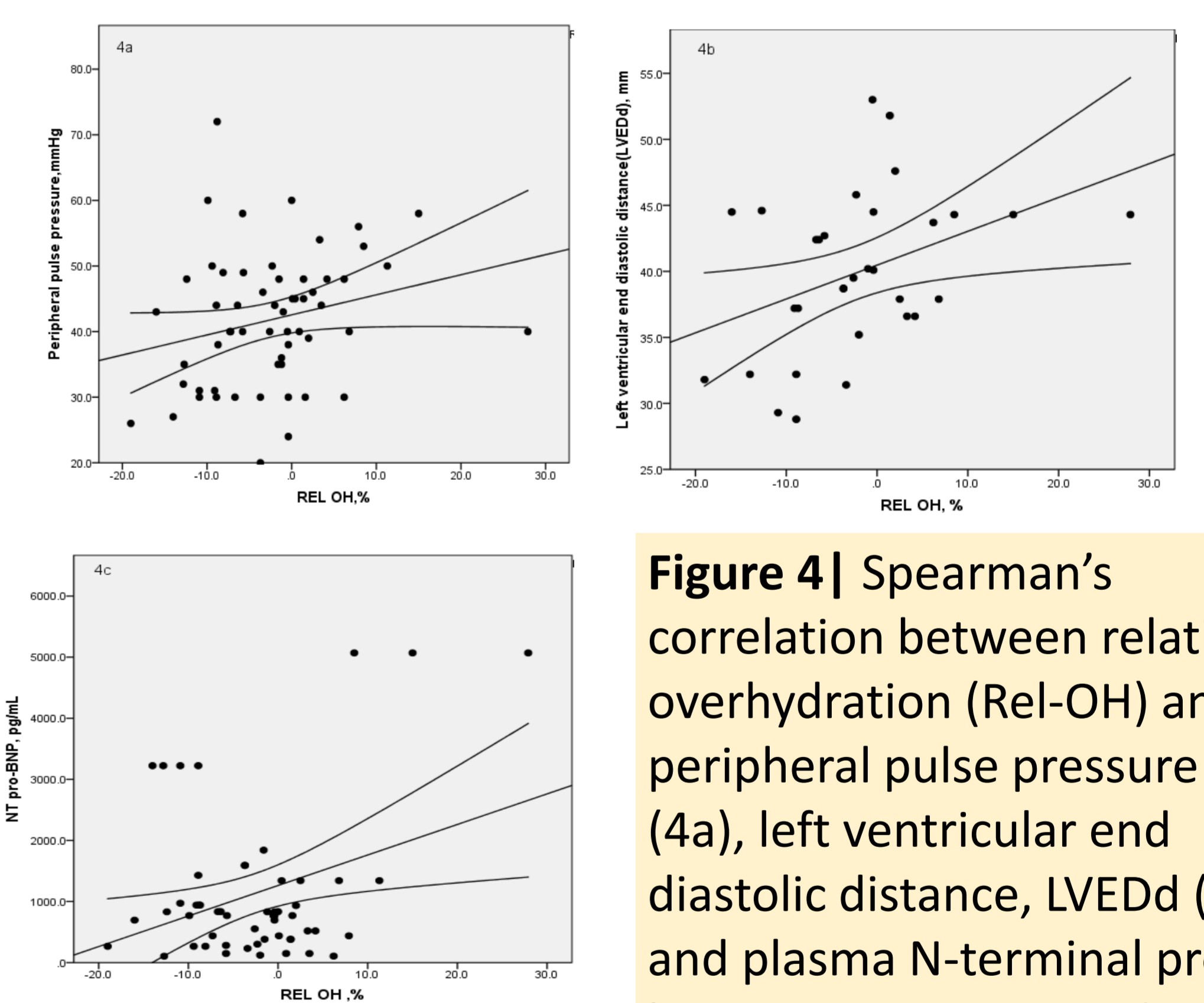


Figure 4| Spearman's correlation between relative overhydration (Rel-OH) and peripheral pulse pressure (4a), left ventricular end-diastolic distance, LVEDd (4b) and plasma N-terminal pro-brain natriuretic peptide levels, NT pro-BNP (4c).

Conclusions. BIS provides an objective method for the assessment of hydration status in children on dialysis. We noted a marked discrepancy between BP and hydration status in children on dialysis that warrants further investigation.

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CONFLICT OF INTEREST STATEMENT
None declared.

