REPRODUCIBILITY OF BIOIMPEDANCE SPECTROSCOPY (BIS) IN HEALTH AND DISEASE

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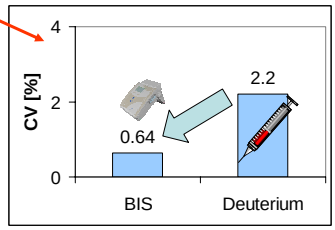
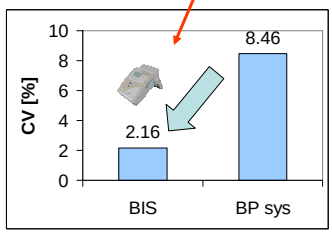
Parameter	Healthy Subjects								Patients
	Intraelectr..	Interelec.	Inter-observer	Food Intake	3 day period	48 hours	31 days	1 year	30 days
n	34	12	10	24	34	3	3	4	127
Standard deviation (SD)									
SD_{RE} [Ω]	± 1.54	± 9.9	± 13.4	± 10.9	± 13.13	± 18.22	± 29.54	± 25.04	± 22.9
SD_{RI} [Ω]	± 4.04	± 16.9	± 25.3	± 21.5	± 25.06	± 37.64	± 46.2	± 48.35	± 79.2
SD_{ECW} [L]	±0.028	**± 0.134**	± 0.16	± 0.16	± 0.26	± 0.31	± 0.43	± 0.44	**± 0.36**
SD_{ICW} [L]	±0.071	± 0.245	± 0.25	± 0.37	± 0.45	± 0.33	± 0.48	± 0.63	± 0.57
SD_{TBW} [L]	±0.063	**± 0.28**	± 0.31	± 0.36	± 0.45	± 0.44	± 0.62	± 0.7	**± 0.71**
SD_{weight} [kg]	-	-	-	± 0.44	± 0.38	± 0.47	± 0.5	± 0.67	± 0.48
Coefficient of variation (CV)									
CV_{RE}	0.21 %	1.29 %	1.81 %	1.66%	1.82 %	2.62 %	4.03 %	3.76 %	3.5 %
CV_{RI}	0.32 %	1.24 %	1.70 %	1.48%	1.8 %	2.57 %	2.94 %	3.45 %	4.4%
CV_{ECW}	0.16 %	**0.75 %**	1.21 %	1 %	1.27 %	1.85 %	2.88 %	2.67 %	**2.16 %**
CV_{ICW}	0.3 %	1.04 %	1.41 %	1.85%	1.53 %	1.61 %	2.47 %	2.96 %	3.71 %
CV_{TBW}	0.15 %	**0.64 %**	1.01 %	1 %	0.87 %	1.27 %	1.84 %	2.1 %	**2.16%**
CV_{weight}	-	-	-	0.63 %	0.51 %	0.67 %	0.75 %	1 %	0.68 %

- Biompedance Spectroscopy (BIS) measured with the BCM – Body Composition Monitor has a very high reproducibility that is superior to reference methods
- With limited training a very high precision can be achieved by the clinical staff



Comparison of BIS reproducibility with deuterium dilution for the assessment of TBW.



Comparison of BIS reproducibility (ECW) to systolic blood pressure measurements.

1.AIM OF THE STUDY

The aim of the study was to ascertain the reproducibility of bioimpedance spectroscopy (BIS). We investigated:

- **The influence of electrode placement**
- **The influence of physiological changes**
- **The performance of this technology in the clinical setting**

2. SETUP OF REPRODUCIBILITY TRIALS

Intraelectrode reproducibility: 3 measurements were performed in succession in 34 healthy subjects, without electrode replacement

Interelectrode reproducibility: The purpose was to assess reproducibility of electrode replacement using only anatomical features of wrist and ankle. 3 new electrode sets were applied on 12 subjects by the same trained observer

Interobserver: 10 students received brief training before performing measurements on the same healthy subject. Each observer applied new electrodes.

Food intake: 24 subjects were measured after 8 hour fasting and standardised breakfast of 600g

3 day reproducibility: 34 healthy subjects were measured on 3 consecutive days

48 hour reproducibility: 3 healthy subjects were measured every 2 hrs (day & night)

31 day period: 3 healthy subjects were measured on 31 consecutive days at the same time of day by the same observer

1 year period: 4 healthy subjects were measured over 1 year

Clinical reproducibility: 127 stable patients were measured predialysis on same day of week. 3 measurements were taken within 3 days by the same observer.

The following parameters were analysed:
- RE – extracellular resistance
- RI – intracellular resistance
- ECW – extracellular water
- ICW – intracellular water
- TBW – total body water

3. RESULTS AND DISCUSSION

- The results of all trials are summarised in the table.
- 3 subgroups may be identified that influence reproducibility
  - BIS measurement precision (best case intraelectrode reproducibility),
  - electrode positioning
  - physiological changes.
- The interelectode trial gives the most realistic impression of the reproducibility to be expected in clinical practice.
- Slight fluctuations in the orientation of the electrode by the observer cannot be avoided which leads to errors several times greater than BIS measurement precision.
- We found that RE was 0.9 ohm/cm change in proximal electrode position. The position of the distal electrode was found to have negligible effect when separated from the proximal electrode by at least 4 cm.
- Electrode positioning appears to be the dominant factor governing reproducibility. When comparing the effects of different observers with food intake no significant difference was found between these trials.
- When the period of observation extends beyond 3 days, physiological factors come into play (such as changes in body composition), that are responsible for increased scatter.
- It was interesting to find that the CV_{ECW} in dialysis patients was lower than that of healthy subjects and could have been attributed to the enrollment of stable patients with tight control of room temperature and fluid status.

4. CONCLUSIONS

Excellent reproducibility can be achieved with BIS measurements if the observer receives limited training regarding electrode positioning

- The precision of BIS is superior to the available reference methods such as deuterium dilution and clinical observations such as blood pressure
- BIS is highly suited for identification of physiological variations in fluid and nutrition status

5. REFERENCES

1. Ellis KJ, Shypailo RJ, Wong W: Measurement of body water by multifrequency bioelectrical impedance spectroscopy in a multiethnic pediatric population. Am J Clin Nutr 1999:847-853, 2003
2. Kushner RF, Gudivaka R, Schoeller DA: Clinical Characteristics influencing Bioelectrical Impedance Analysis Measurements. Am J Clin Nutr 64:423S-427S, 1996
3. Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P, Elia M, Gomez JM, Heitmann BL, Kent-Smith L, Melchior JC, Pirlich M: Bioelectrical impedance analysis--part I: review of principles and methods. Clinical Nutrition 23:1226-1243, 2004