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1 **Effects of procedure, upright equilibrium time, sex and BMI on the precision of body**
2 **fluid measurements using bioelectrical impedance analysis.**

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16 **Conflict of Interest:** SECA provided monetary compensation to subjects for their time
17 participating in the study programme. None of the researchers received direct funding from
18 the company.

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20

21 **Abstract**

22 **Background/Objectives:** Extensive work has addressed the validity of bioimpedance (BIA)
23 measurements and the effect of posture on fluid homeostasis. However, limited research has
24 investigated effects of subject preparation. This study aimed to determine the precision of
25 total body water (TBW) and extracellular water (ECW) measurements using a stand-on
26 multifrequency BIA (MFBIA seca mBCA 514/515), in three pre-test procedures: supine,
27 sitting, and following walking, with specific reference to the influence of sex and BMI.

28 **Subjects/Methods:** Fifty three healthy, ambulatory men (n=26, age:32.5±9.4yrs) and women
29 (n=27, age:35.2±10.3yrs) received repeat MFBIA measurements (six measurements from 0 to
30 15 min). Agreement and precision were evaluated for each condition and time point.

31 **Results:** Significant TBW sex differences from supine posture were observed for walking
32 (females) and sitting (males) postures. For BMI ($\leq 24.9 \text{ kg.m}^{-2}$) significant TBW differences
33 from supine were observed for both sitting and walking and significant ECW differences
34 from sitting were also observed with both supine and walking. There was no significant effect
35 of sex or BMI ($\geq 25.0 \text{ kg.m}^{-2}$) on ECW measures. Irrespective of sex or BMI, there was close
36 agreement in TBW and ECW precision over the three protocols.

37 **Conclusions:** Practitioners can have confidence in the precision of TBW and ECW
38 measurements within a 15 minute time period and pre-testing conditions (supine, sitting or
39 walking) in healthy subjects, though must be cautious in assessments when pre-test postures
40 change. Further research to examine the impact of pre-testing procedures on stand-on MFBIA
41 BIA measurements, including subjects with fluid disturbance, is warranted.

42

43 **Key words:** BIA; body water; fluid status; subject posture; clinical; equilibrium.

44

45 **Introduction**

46 The accurate assessment of fluid status in subjects is important for the clinical management
47 of many diseases including renal disease, obesity and cystic fibrosis. Knowledge of total
48 body water (TBW) and its compartments extracellular water (ECW) and intracellular water
49 (ICW) has critical importance in particular for parenteral fluid therapy in acute care and for
50 conditions such as peritoneal dialysis and for clinical decision-making on dialysis dose (1-3).
51 In addition, water retention is a common outcome of response to injury and trauma or critical
52 illness (4). A commonly-used method for the estimation of fluid status is bioelectrical
53 impedance analysis (BIA). This method is particularly suited for use in routine clinical
54 practice given its speed of measurement and low cost in comparison to other available
55 methods.

56 Single frequency bioelectrical impedance analysers (SFBIA) utilizes an alternating
57 electrical current at 50kHz which passes through TBW, and fat being anhydrous, the
58 measured impedance index (Ht^2/R) at 50kHz is proportional to TBW (5,6). Over the last
59 decade, technological advances have led to the introduction of multi-frequency bioelectrical
60 impedance analysers (MFBIA) and bioimpedance spectroscopy (BIS) with segmental
61 analysis to derive body fluid compartments of the arms, legs and trunk. MFBIA has a small
62 number of frequencies (normally four) over the range 1 kHz to 1 MHz. The use of low and
63 high frequencies enable the estimation of ECW, TBW and by subtraction ICW (Maltron
64 Bioscan 920-25 /Bodystat Quadscan 4000). These analysers utilize frequencies 5, 50, 100,
65 200 kHz. At low frequency (5 kHz) the current passes predominantly through ECW and the
66 impedance at this frequency is used to predict ECW. The impedance at the higher frequencies
67 is used to predict TBW. BIS uses a larger number of frequencies, 50 to 256, over the
68 frequency range 1 kHz to 1 MHz (Fresenius BCM / ImpediMed SFB7). Mathematical
69 modelling then estimates the theoretical impedance at zero frequency, where passage of the

70 current would be entirely through the ECW space, and at infinite frequency, where the
71 electrical current would pass freely through the complete TBW space, including ICW as well
72 as ECW. This allows estimation of ECW, ICW, and TBW volumes (3,7).

73 Stand-on BIA devices such as the seca mBCA 514/515 have also been developed.
74 Predictive equations are used to estimate the fluid compartments and these have been
75 validated for fluid status and body composition measurements against gold standard reference
76 ranges in an adult multi-ethnic population (8), and normative adult body composition ranges
77 have recently been published (9). The stand-on device has several reported practical
78 advantages, including permanently incorporated electrodes standardising anatomical
79 positioning, built in weighing scales and reduced total measurement time (~17 seconds per
80 measurement) (8), all potential critical factors in obtaining accurate and precise
81 measurements (10,11).

82 The effect of body posture on BIA measurements is based on the redistribution of
83 body fluids. A change from standing to supine position produces a fluid shift from arms/legs
84 to the trunk. The trunk only contributes about 5% to the total body impedance this results in
85 an increase in total body impedance. A change from supine to standing will produce the
86 opposite effect. To minimise the effect of body posture changes, the recommended
87 equilibrium time before initiating the BIA measurement in the supine position is
88 approximately 10 min. (12). There have been a number of studies investigating the effect of
89 posture differences on equilibrium time, and comparisons of supine / standing modes on body
90 fluid estimates. (13-18). These results have been used to determine the measurement
91 stabilisation time and the effect of postural change on body fluid compartments. However,
92 there is limited data available on upright equilibrium time and variability of the stand-on BIA
93 position. One recent study monitored fluid shifts, taking 6 measurements over a 30min
94 period in both the supine and standing positions. The authors conclude that 5min is sufficient

95 for TBW measurements in either posture, but ECW stabilization required 30min (19). An
96 earlier study of impedance changes of the total body, arms and legs, measured four times in
97 the standing position over 9 hours, concluded that whole body impedance did not change
98 significantly but arms, legs impedance changed significantly in opposite directions,
99 suggesting that impedance should be measured at scheduled times during the day (20).

100 In clinical practice, BIA testing is performed with varying subject preparations:
101 following the supine position in bed rest-hospitalisation, sitting by the bed side or in
102 outpatients, or immediately following periods of walking to the outpatient clinic. However, to
103 date, there are no standard protocols for subject preparation prior to BIA testing, which can
104 vary within subject when their condition changes, for example, on discharge from inpatients.
105 Further, during stand on BIA testing, subjects are required to remain in upright equilibrium
106 during testing. To date, the optimal time course of subject equilibrium in the upright position
107 pre-measurement remains unknown. Without this knowledge, there is a risk for reaching
108 erroneous conclusions in practice. This may be particularly the case when serial
109 measurements are relied on for monitoring the progression or recovery of a given condition,
110 or the effects of treatment. It is known that BMI can affect the body composition results from
111 BIA (21,22) therefore the effect of BMI on the results of the study require evaluation.

112

113 The aims of this study were:

114 1) To determine *in-vivo* precision of TBW and ECW measurements in three different pre-test
115 procedures designed to replicate clinical practice: supine (bed rest/hospitalisation), sitting
116 (bed side or outpatients), and following a period of walking (out-patients).

117 2) To determine the influence of sex and BMI ($\leq 24.9 \text{kg.m}^{-2}$ and $\geq 25.0 \text{kg.m}^{-2}$) on precision.

118 3) To substantiate the impact of equilibrium time, up to 15 minutes, on the variance of
119 measurement.

120 4) Provide from an evidence-base, a proposed standardisation procedure on adult subject
121 preparation and equilibrium time for MFBIA measurements on a seca 514/515 stand-on
122 bioimpedance analyser.

123

124

125 **Materials and Methods**

126

127 *Study design and subjects*

128 A controlled, cross-over experimental design was utilised for the study, which was reviewed
129 and approved by the Institution's Research Ethics Committee in accordance to the clauses of
130 the Declaration of Helsinki. All subjects provided their signed informed consent prior to
131 receiving any tests or experimental procedures.

132 The only inclusion criteria for participation in the study were age over 20 years, being
133 ambulatory and capable of standing continuously for 15 minutes. A health screening
134 questionnaire was administered, which included a self-report of current injury, Exclusion
135 criteria included acute and chronic diseases (hypertension, hypotension, renal and cardiac),
136 metallic or electrical implants and any history of fainting episodes. Volunteers were recruited
137 from academic, non-academic and retired staff from two local Universities. Fifty three
138 subjects, men (n= 26) and women (n= 27) took part, and received each of the three pre-test
139 procedures and 18 MFBIA evaluations in total to initially determine effect of sex on
140 precision. Additional analysis was then performed to study the effect of BMI on precision
141 with subjects grouped using WHO classification into normal BMI $\leq 24.9\text{kg.m}^{-2}$ (n=34) and
142 overweight / obese BMI $\geq 25\text{kg.m}^{-2}$ (n=19, 4 were obese). Bio impedance measurements were
143 performed using the MFBIA, at 6 time periods within each experimental condition: 0, 3, 6, 9,

144 12 and 15 min. Estimates of precision were made from paired values between 0 and 3, 6 and
145 9, 12 and 15 min.

146

147 *MFBIA: Seca medical Body Composition Analyzer 514/515.*

148 The seca mBCA 514/515 used in this study, is an eight electrode segmental multi frequency
149 analyser that measures impedance at 19 frequencies ranging from 1 kHz to 1 MHz. It is a
150 'stand-on' MFBIA device where subjects place their feet on top of the electrodes so that the
151 heel is central to the smaller posterior electrode and the forefoot is central to the larger
152 anterior electrode (Fig. 1). Each side of the handrail has six electrodes, two are chosen
153 dependant on the height of the subject with the angle between arms and the body about 30°.
154 The hands touch the electrodes so that the electrode separator is positioned between the
155 middle and ring finger. Each measurement takes approximately 20 seconds. BIA values
156 obtained at 5 and 50 kHz are used in the predictive equations, and it is recommended that
157 subjects should stand for a minimum of 10 minutes before the initial measurement (8). The
158 RMSE for this device has been reported to be 1.34 kg (TBW) and 0.79 kg (ECW) (8).

159

160 *Experimental conditions*

161 Subjects were asked to refrain from exercise and alcohol consumption in the 24 hours prior to
162 the testing session. They were also asked to consume 500mL of water the evening before the
163 day of testing, and on the morning of testing. Thereafter, the condition was *ad libitum*. On
164 arrival to the Research Unit, each subject was asked to void their bladder. Subjects were also
165 asked not to consume food from 2 hours prior to testing. Testing started at 15 minutes from
166 arrival, and began with height and weight measurements. No food was consumed once testing
167 had started, and although small amounts of water were permitted, no participants requested
168 this.

169 Three different procedures, before MFBIA measurements, were designed and
170 implemented to replicate clinical practice: supine (bed rest/hospitalisation), sitting (bedside or
171 outpatients), and following a period of walking (out-patients).

172 Room temperature was monitored throughout each testing session, and remained constant at
173 23.6 ± 1.6 °C. The first experimental condition involved the subject assuming a supine
174 position with one pillow under the head for support, for the duration of 15 minutes. This
175 condition was designed to replicate bed rest inpatients preparation. Immediately post 15
176 minutes, the subject received repeat MFBIA assessments, at 0 and 3min dismounting the
177 MFBIA platform in between each measurement. The subject remained standing and
178 measurements were repeated at 6, 9, 12 and 15 minutes. The second condition involved the
179 subject assuming a sitting position on a generic waiting room chair. This condition was
180 designed to replicate waiting in an Outpatients clinic or for an inpatient at the bedside.
181 MFBIA assessments were then conducted from 0 to 15min. The third condition involved the
182 subject walking continuously for 15 minutes, both outside on tarmac surface and inside the
183 building. Walk speed was self-selected based on each subject's individual walking pace. This
184 condition was designed to replicate walking to an Outpatients clinic. MFBIA assessments
185 were then conducted from 0 to 15min. A heart rate monitor was worn to monitor exertion
186 during the walk.

187
188 *Physical measurements*

189 For all physical measurements, subjects removed all jewellery and wore light-weight clothing
190 that did not contain buckles or catches. Height was measured to the nearest mm using a free-
191 standing stadiometer (seca, Birmingham, UK), and body weight was measured to the nearest
192 kg using the MFBIA device (seca mBCA 514/515, Hamburg, Germany).

193

194 *Statistical analysis*

195 Data analysis was computed using Microsoft Excel 2007 and SPSS Version 21.0 (LEAD
196 Technologies Inc©). Prior to analysis, normality and equality of variance was assessed using
197 Kolmogorov-Smirnov test. The study group descriptive data were derived as the mean and
198 standard deviation (SD). Sex specific ANOVA was used to determine if any significant
199 differences in the estimates of TBW and ECW, inter and between measurements modes, were
200 observed in the study. Significant main effects were assessed with paired t-tests using a
201 Bonferroni adjustment, with statistical significance set at $p < 0.05$. The ANOVA analysis was
202 repeated for the BMI subgroups.

203 *In-vivo* precision of the seca mBCA 514/515 device was derived from paired
204 measurements for each of the procedures and equilibrium time points. Precision is reported as
205 the root-mean-square standard deviation RMS-SD and %CV.

206 %CV was derived from the equation: $\%CV = (SD/mean\ value) * 100$.

207

208

209 **Results**

210 The study group were heterogeneous in age (range: 21.4 to 59.4 years) and included 27
211 females and 26 males. Descriptive characteristics of the study group sub-divided by BMI
212 classification into two groups: normal BMI ($<25\text{kg.m}^{-2}$) group and an overweight + obese
213 BMI ($>25\text{kg.m}^{-2}$) group, are given in Table 1.

214

215 **INSERT --Table 1 Descriptive characteristics of study groups --**

216

217 Mean (SD) baseline blood pressure and resting heart rates were 110/70 mmHg: 62.9 ± 9.0
218 bpm, and 122/75 mmHg: 62 ± 12 bpm, in women and men respectively.

219

220 In females, the mean (SD) TBW ranged from 31.80 ± 3.93 kg (0:3 min post walking) to
221 32.07 ± 3.83 kg (0:3 min post supine). In males, TBW ranged from 46.53 ± 5.10 kg (6:9 min
222 post sitting) to 46.76 ± 5.08 kg (12:15 min post supine). For all procedures and equilibrium
223 times, TBW RMS-SD precision ranged from 0.10 to 0.24kg (0.33%CV to 0.74%CV) in
224 females and in males 0.12 to 0.26kg (0.26%CV to 0.55%CV) (Table 2).

225 Anova indicated a significant effect of posture with supine TBW significantly higher
226 than TBW walking ($p=0.03$) in females and supine TBW significantly higher than TBW
227 sitting ($p=0.003$) in males (Fig 2). There was no significant effect of time on the
228 measurements and only a small significant effect of posture x time in females ($p=0.02$).

229

230 **INSERT --Table 2 Seca mBCA 514/515 derived TBW precision for study groups**
231 **over three pre-test postures and varying equilibrium time --**

232

233 In females ECW ranged from 13.76 ± 1.55 kg (12:15 min post sitting) to 13.85 ± 1.51
234 kg (6:9 min post supine). With males, ECW ranged from 18.39 ± 2.29 kg (0:3 min post
235 walking) to 18.54 ± 2.30 kg (12:15 min post supine). ECW RMS-SD precision ranged from
236 0.04 to 0.12kg (0.31%CV to 0.90%CV) in females and 0.06 to 0.11kg (0.30%CV to
237 0.61%CV) in males (Table 3).

238 There were no significant effects of posture, time or interaction of *posture x time* on
239 ECW for both females and males (Fig 3).

240 **INSERT --Table 3 Seca mBCA 514/515 derived ECW precision for study groups over**
241 **three pre-testing postures and varying equilibrium time**

242

243 With BMI <25kg.m⁻², the mean (SD) TBW ranged from 36.86 ± 7.32 kg (0:3 min post
244 walking) to 37.20 ± 7.25kg (0:3 min post supine). With BMI >25kg.m⁻² TBW ranged from
245 42.92 ± 9.74kg (0:3 min post sitting) to 43.08 ± 9.80kg (12:15 min post supine) TBW RMS-
246 SD precision ranged from 0.14 to 0.24kg (0.41%CV to 0.58%CV) in BMI <25kg.m⁻² group
247 and 0.13 to 0.23kg (0.34%CV to 0.51%CV) in the BMI >25kg.m⁻² group (Table 2).

248

249 For BMI <25kg.m⁻² TBW supine was significantly higher than TBW sitting ($p=0.001$) and
250 TBW walking ($p=0.004$) (Fig 2). There was no significant effect of time on measurements
251 but there was a small significant interaction of *posture x time* ($p=0.02$). There was no
252 significant effects of posture, time or interactions of *posture x time* with TBW for BMI
253 >25kg.m⁻².

254

255 ECW ranged from 15.06 ± 2.39kg (0:3 min post sitting) to 15.15 ± 2.40 kg (6:9 min post
256 supine) in the BMI <25kg.m⁻² group and 17.86 ±3.30kg (0:3 min post sitting) to 17.99
257 ±3.38kg (6:9 min post walking) in the BMI > 25kg.m⁻² group. ECW RMS-SD precision
258 ranged from 0.06 to 0.10kg (0.41%CV to 0.67%CV) and in the BMI>25kg.m⁻² group 0.05 to
259 0.11kg (0.32%CV to 0.58 %CV) (Table 3). There was a significant effect of posture in the
260 ECW BMI <25kg.m⁻² group with supine and walking greater than sitting ($p=0.003$ and 0.05).
261 There were no significant effects of posture, time or *posture x time* in the BMI >25kg.m⁻²
262 group (Fig 3).

263 TBW and ECW in the post supine procedure had the highest measured values and
264 significant differences were observed with both the sitting and walking procedures. The only
265 significant differences between sitting and walking procedures occurred with ECW in the
266 BMI<25kg.m⁻² group (Fig 3). There was no effect of time in any of the study groups. Similar

267 posture and equilibrium time measurements were observed between females and the
268 BMI<25kg.m⁻² groups: body mass 63.5± 8.9kg and 65.7± 9.0kg respectively and between the
269 males and BMI >25kg.m⁻² groups: body mass 81.6±13.4kg and 84.4±14.8kg respectively for
270 both TBW and ECW this may be due to the similar body masses. TBW post supine in
271 females and BMI <25kg.m⁻² tended to reduce with time whilst TBW males and BMI
272 >25kg.m⁻² remained constant.

273 There was close agreement between all four groups for the RMS-SD precision
274 estimates of TBW and ECW over the three procedures. The TBW precision range for all
275 groups was 0.10 to 0.26kg (%CV = 0.33 to 0.55) and for ECW the precision range was 0.04
276 to 0.12kg (%CV = 0.31 to 0.91).

277 **Discussion**

278 BIA measurements of body water are frequently used in clinical practice due to their ease of
279 use, portability, rapid measurement acquisition, and cost-effectiveness. In this study we have
280 determined the *in-vivo* precision of a stand on MFBIA (seca mBCA 514/515) for the
281 measurement of TBW and ECW, following three different preparation conditions, and over
282 various upright equilibrium timings. We have demonstrated excellent reproducibility of
283 measurements using MFBIA, regardless of pre-testing condition (supine, sitting or walking)
284 and with no effect of subject upright equilibrium time on precision.

285 Fluid shifts based on postural changes have been previously investigated using various
286 combinations of supine, seated or standing with the duration of stay in each posture varying
287 from minutes to hours (13,15,19,20,23–25). Our samples with different prior preparation
288 conditions showed effects on both TBW and ECW measurements. Most notably that supine is
289 significantly higher: in TBW in females (compared to walking): in males (compared to
290 sitting): in the BMI<25kg.m⁻² group (compared to sitting and walking). For ECW

291 measurements, both the supine and walking presented greater values than sitting in the
292 BMI<25kg.m⁻² group. The difference in measurements is the result of body water
293 redistribution as a consequence of gravity and changes in contributions to whole body
294 resistance (19). Direct comparison with other results (13,15,19,20,23–25) is limited as none
295 have used the stand on MFBIA with its unique electrode arrangement and similar prior
296 preparation conditions. Though, we emphasise the importance that clinicians should adopt the
297 same prior preparation (posture and time) for assessments and lack of interchangeability and
298 agreement between horizontal and vertical measurements up to 30 minutes (16,19).

299 The results of our study should be of interest and value to health professionals and
300 clinics utilising MFBIA in practice. It is well established that the overriding benefit of
301 MFBIA is the superior precision of the techniques and therefore ability to detect changes in
302 response to nutrition interventions, disease trajectory or treatments. The strength of this
303 advantage is viewed to overcome the limitations of accuracy when compared to outcomes
304 derived from methods such as isotope dilution (3). Previous studies have reported excellent
305 precision for MFBIA in particular, with 1.2%CV for TBW and 0.2%CV for ECW, exceeding
306 precision of SFBIA (26). However, to date, whether or not pre-testing conditions affect the
307 reliability of such fluid status measurements has been hypothetical. In clinical practice, the
308 preparation of subjects can vary from testing immediately from supine position, from sitting
309 in a waiting room or ward, or following walking to an outpatient's department. Prior to this
310 study it was also unclear whether or not a longer duration in equilibrium would provide more
311 reliable results in terms of MFBIA measurements. We have demonstrated no effect of time in
312 upright equilibrium on the reproducibility of MFBIA body water measurements, with
313 application over durations of 0 to 15 minutes. Our results should provide reassurance to
314 health professionals that the high precision of body water measurements using MFBIA is not
315 adversely affected by varying pre-testing positioning conditions or equilibrium time, and thus

316 application of the technique in different scenarios as they arise will not lead to erroneous
317 conclusions during monitoring.

318 Following most pre-test conditions our findings show no sex-specific effects on
319 MFBIA body water measurement precision, as reported recently elsewhere (26). It was
320 however noticeable that the device performed somewhat better for total body water and
321 extracellular water precision measurements post sitting in males 0.16kg (%CV = 0.34) and
322 0.08kg (%CV = 0.41) respectively than in females 0.24kg (%CV= 0.74) and 0.12kg (%CV =
323 0.90%). Although all precision errors were highly acceptable, in females the precision of the
324 immediate TBW measurements post-sitting was poorer than for subsequent measures taken at
325 6 and 12 minutes post-sitting, where precision improved 2-fold. The reason for this
326 discrepancy appears due to three outliers in the women group. When the three outliers were
327 removed the mean TBW = 32.4 ± 3.4 kg and RMS-SD = 0.14kg with %CV = 0.42%.

328 However, on re-examination, no reason could be found for removing the data.

329 Our study group comprised of 53 healthy men and women, ranging widely in age and BMI.

330 Therefore, the high precision values are not a reflection of a homogeneous group. All subjects
331 were hydrated from the outset of the study. These results therefore should not be generalised
332 to all adults undergoing MFBIA measurements in practice. It is possible that precision may
333 vary according to hydration and/or disease status, hence it is recommended that further
334 studies are completed in clinical populations. Never-the-less, our findings provide confidence
335 that environmental variables such as subject positioning and time in upright equilibrium up to
336 15 minutes, do not impact negatively on precision of body water measurements using MFBIA
337 in adults. Further work is warranted to determine if a greater equilibrium time is required for
338 post supine measurements or if a combination of pre-preparation postures ie moving a subject
339 from a supine position to sitting position prior to measurement resolves the observation that
340 TBW post supine in females and in subjects with a BMI $<25\text{kg.m}^{-2}$ tended to reduce with

341 time, whilst TBW in males and subjects with a BMI $>25\text{kg.m}^{-2}$ remained constant. In
342 addition, studies on subjects with fluid imbalance are required.

343 To conclude, caution should be taken in testing subjects under differing preparation
344 procedures. The post supine procedure had the highest measured TBW and ECW values with
345 significant differences observed with both the sitting and walking procedures. There was
346 close agreement for precision estimates for both TBW and ECW between the three
347 procedures. Neither sex nor BMI affected the precision measurements of TBW and ECW,
348 regardless of the pre-test procedures. Therefore, clinicians can have confidence in the
349 precision of TBW and ECW measurements within a 15 minute time period, though must be
350 cautious in assessments when pre-test procedures change.

351

352

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356 Oldroyd, S Thurlow, G Taylor-Covil and P Sahota drafting or revision of the manuscript and
357 approval of the final version of the manuscript.

358

359

360 **Conflict of Interest:** SECA provided monetary compensation to subjects for their time
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362 the company.

363

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445 Figure Legends:

446 Fig 1 Illustration of electrode configuration and patient positioning for the MFBIA Seca

447 mBCA 514/515.

448 Fig 2 Effect of posture, equilibrium time and gender (A) and BMI (B) on Seca BIA estimates

449 of TBW.

450 Fig 3 Effect of posture, equilibrium times and gender (A) and BMI (B) on Seca BIA

451 estimates of ECW.



Table 1 Descriptive characteristics of study groups

	Females (n = 27)		Males(n = 26)		BMI <25kg.m ⁻² (Females = 19:Males = 15)		BMI >25kg.m ⁻² (Females = 8:Males = 11)	
	Mean ± sd	Range	Mean ± sd	Range	Mean ± sd	Range	Mean ± sd	Range
Age (y)	35.2 ± 10.3	24.9 to 59.4	32.5 ± 9.4	21.4 to 55.3	31.8 ± 8.9	22.8 to 59.4	37.5 ± 10.7	21.4 to 55.3
Height (m)	1.639 ± 0.070	1.480 to 1.750	1.779 ± 0.049	1.701 to 1.904	1.703 ± .089	1.524 to 1.850	1.716 ± 0.060	1.480 to 1.904
Weight (kg)	63.5 ± 8.9	48.9 to 82.5	81.6 ± 13.4	61.7 to 125.7	65.7 ± 9.0	48.9 to 82.5	84.4 ± 14.8	60.4 to 125.7
BMI (kg/m²)	23.6 ± 3.1	19.7 to 31.3	25.7 ± 3.8	20.2 to 35.6	22.5 ± 1.5	19.7 to 24.95	28.5 ± 3.0	25.2 to 35.6

Mean ± sd

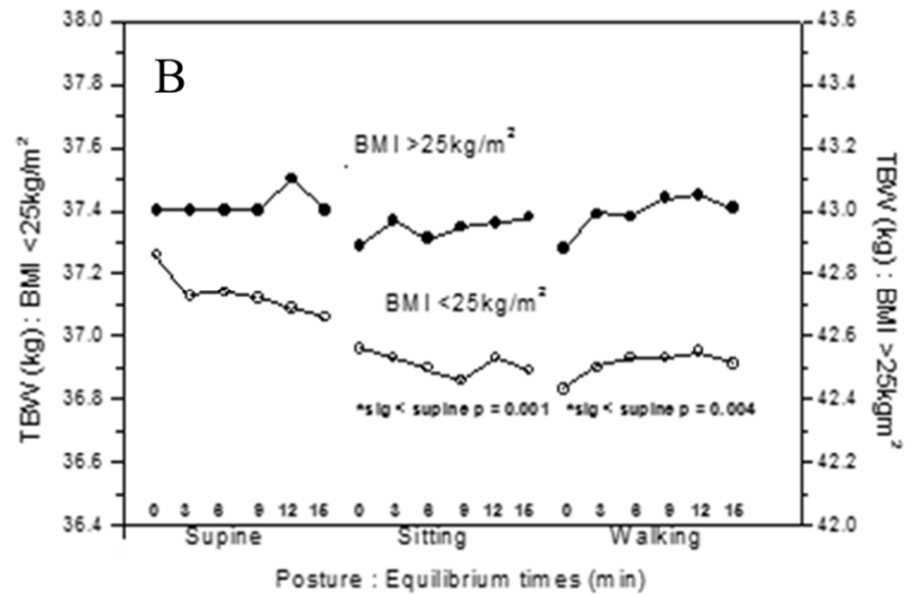
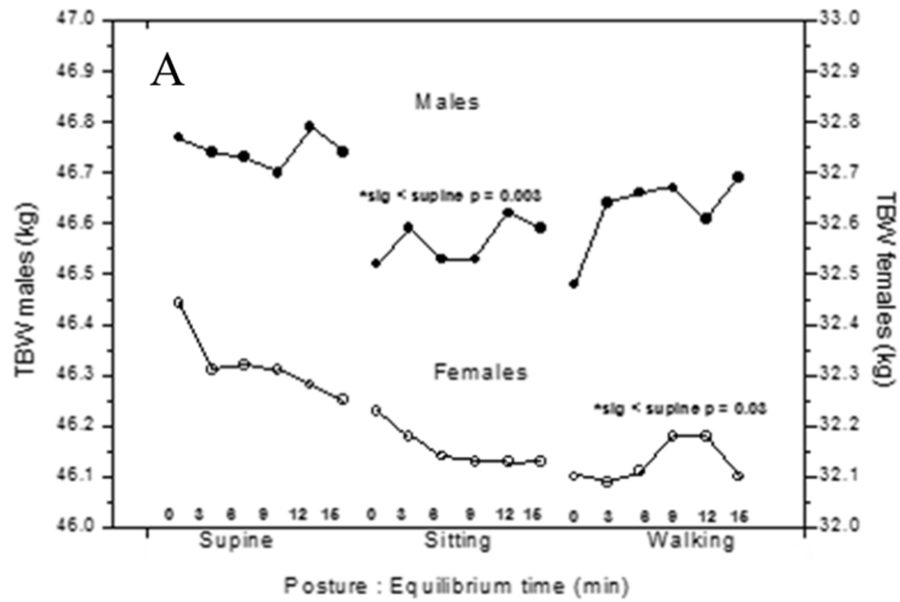


Fig 2 Effect of posture, equilibrium time and gender (A) and BMI (B) on Seca BIA estimates of TBW.

Table 2. Seca mBCA 514/515 derived TBW precision for study groups over three pre-test postures and varying equilibrium time

		Females		Males		BMI<25kg.m ⁻²		BMI>25kg.m ⁻²	
Posture	Time (min)	*TBW(kg) (±sd)	RMS-SD (kg) (%CV)	*TBW (kg) (±sd)	RMS-SD (kg) (%CV)	*TBW(kg) (±sd)	RMS-SD (kg) (%CV)	*TBW (kg) (±sd)	RMS-SD (kg) (%CV)
Supine	0-3	32.07 ±3.83	0.20 (0.60)	46.75 ±4.96	0.19 (0.41)	37.20 ± 7.25	0.21 (0.60)	43.00 ± 9.74	0.16 (0.37)
	6-9	32.02 ±3.84	0.15 (0.47)	46.71 ±5.03	0.12 (0.26)	37.13 ± 7.28	0.14 (0.41)	43.00 ± 9.75	0.13 (0.34)
	12-15	31.97 ±3.83	0.17 (0.52)	46.76 ±5.08	0.13 (0.28)	37.07 ± 7.29	0.14 (0.39)	43.08 ± 9.80	0.16 (0.41)
Sitting	0-3	31.89 ±3.96	0.24 (0.74)	46.55 ±5.08	0.16 (0.34)	36.94 ± 7.29	0.22 (0.73)	42.92 ± 9.74	0.16 (0.36)
	6-9	31.84 ±3.97	0.10 (0.33)	46.53 ±5.10	0.18 (0.38)	36.88 ± 7.31	0.14 (0.38)	42.93 ± 9.73	0.15 (0.32)
	12-15	31.84 ±3.96	0.11 (0.35)	46.60 ±5.00	0.24 (0.50)	36.90 ± 7.34	0.17 (0.42)	42.98 ± 9.70	0.20 (0.43)
Walking	0-3	31.80 ±3.93	0.18 (0.57)	46.55 ±5.08	0.23 (0.49)	36.86 ± 7.32	0.19 (0.56)	42.93 ± 9.76	0.23 (0.51)
	6-9	31.85 ±3.93	0.15 (0.48)	46.66 ±5.20	0.26 (0.55)	36.94 ± 7.33	0.24 (0.58)	42.99 ± 9.87	0.14 (0.37)
	12-15	31.85 ±3.98	0.20 (0.62)	46.64 ±5.22	0.22 (0.46)	36.91 ± 7.37	0.22 (0.61)	43.03 ± 9.85	0.18 (0.43)

Mean ± sd

*TBW: mean of paired measurements at 0 and 3 min : 6 and 9 min : 12 and 15 min

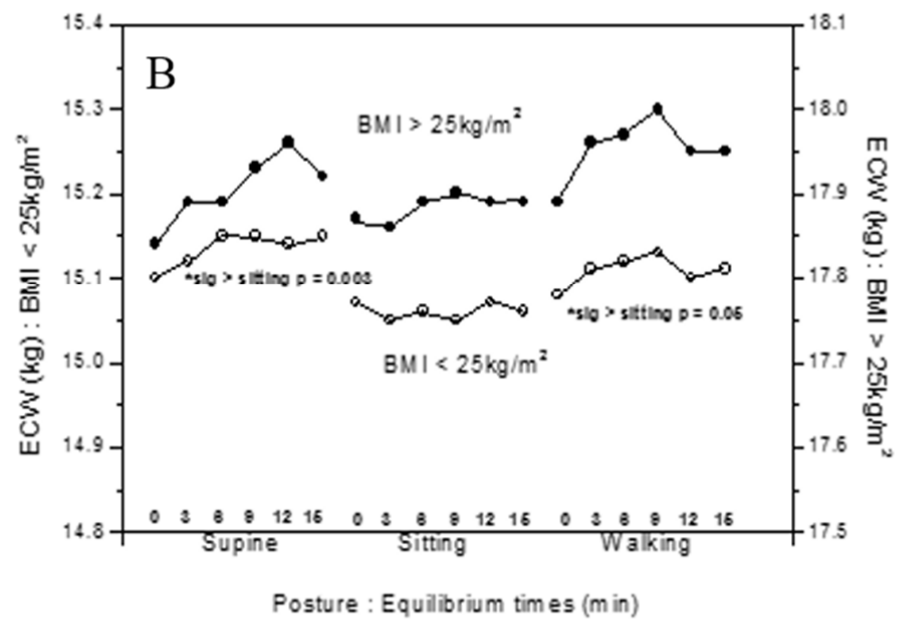
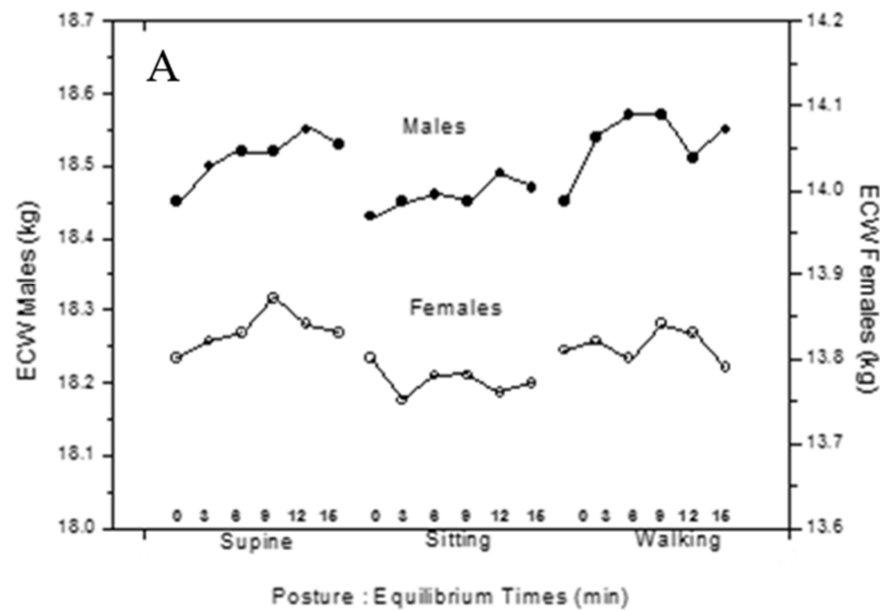


Fig 3 Effect of posture, equilibrium time and gender (A) and BMI (B) on Seca BIA estimates of ECW.

Table 3. Seca mBCA 514/515 derived ECW precision for study groups over three pre-testing postures and varying equilibrium time

		Females		Males		BMI<25kg.m ⁻²		BMI>25kg.m ⁻²	
Posture	Time (min)	*ECW (kg) (sd)	RMS-SD(kg) (%CV)	*ECW (kg) (sd)	RMS-SD(kg) (%CV)	*ECW (kg) (sd)	RMS-SD(kg) (%CV)	*ECW (kg) (sd)	RMS-SD (kg) (%CV)
Supine	0-3	13.81 ±1.51	0.09 (0.68)	18.47 ±2.27	0.11 (0.57)	15.11 ± 2.38	0.10 (0.64)	17.87 ± 3.29	0.09 (0.51)
	6-9	13.85 ±1.51	0.07 (0.48)	18.52 ±2.28	0.06 (0.32)	15.15 ± 2.40	0.06 (0.41)	17.91 ± 3.31	0.07 (0.40)
	12-15	13.84 ±1.50	0.07 (0.48)	18.54 ±2.30	0.06 (0.30)	15.14 ± 2.41	0.07 (0.43)	17.94 ± 3.32	0.05 (0.32)
Sitting	0-3	13.77 ±1.52	0.12 (0.90)	18.44 ±2.31	0.08 (0.41)	15.06 ± 2.39	0.10 (0.67)	17.86 ± 3.30	0.11 (0.67)
	6-9	13.78 ±1.55	0.06 (0.42)	18.46 ±2.33	0.07 (0.39)	15.06 ± 2.41	0.07 (0.46)	17.90 ± 3.31	0.06 (0.27)
	12-15	13.76 ±1.55	0.04 (0.31)	18.48 ±2.27	0.09 (0.51)	15.07 ± 2.42	0.06 (0.38)	17.89 ± 3.29	0.08 (0.44)
Walking	0-3	13.82 ±1.53	0.08 (0.58)	18.39 ±2.29	0.11 (0.61)	15.09 ± 2.41	0.09 (0.60)	17.93 ± 3.28	0.11 (0.58)
	6-9	13.82 ±1.54	0.06 (0.46)	18.48 ±2.36	0.11 (0.56)	15.12 ± 2.43	0.10 (0.56)	17.99 ± 3.38	0.06 (0.38)
	12-15	13.81 ±1.56	0.08 (0.56)	18.44 ±2.34	0.11 (0.57)	15.11 ± 2.45	0.10 (0.61)	17.95 ± 3.33	0.09 (0.48)

Mean ± sd *ECW mean: mean of paired measurements at 0 and 3min: 6 and 9min: 12 and 15 min