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Discussion

Data of the current study including body composition (%fat and %SMM) has been obtained from 302 male adults (age range 19-63 years) using two different methods (DXA and Omron BF-511). The main aim of the present study was to examine the accuracy of Omron (BF-511) as one of the commercial body composition scale using DXA instrument as a criterion standard measure for measuring body composition. Omron manufactory has claimed that Omron scale model BF-511 is accurate to assess body composition including percentage of body fat and percentage of skeletal muscle mass (%fat and %SMM) (Omron-Healthcare 2018). The result of the present study indicated that for clinical and research purposes, Omron BF-511 was not accurate enough to measure neither %fat nor %SMM in our sample. Several studies have shown that DXA provided accurate assessment of body composition consistently (Jensen, Kanaley et al. 1993, Pritchard, Nowson et al. 1993, Albanese, Diessel et al. 2003). Although the mean values for both examined measures (%fat and %SMM) were close to the criterion method (DXA), the observed data from Omron BF-511 significantly underestimated both %fat and %SMM comparing to DXA data (%Fat, Omron=29.02 ±7.68 vs. DXA=31.93 ±8.01, P=0.000; %SMM, Omron=34.42 ±4.83 vs. DXA=35.70 ±4.66, P=0.002). These results concurrent with the previous studies(Gibson, Heyward et al. 2000, Lazzer, Boirie et al. 2003, Both, Matheus et al. 2015, Kutac and Kopecky 2015). In a previous study, Lazzer and colleagues found that the agreement between DXA and hand-foot BIA relativly closer comparing to the other BIA instruments (foot-foot method) (–7.7 and +4.3, –12.0 and +10.6 vs. –2.1 and +6.7). They concluded that hand-to-foot BIA could be acceptable to estimate body composition in large scale of sample. However, they alerted from using such devices (hand-foot BIA) for body composition assessment in individuals due to the large errors in estimates (Lazzer, Boirie et al. 2003). There are some studies considered Omron BF511 as valid instrument to assess body composition (%fat & %SMM). Moreover, a recent study concluded that some the bioelectrical impedance analysis instruments such as Omron have limited potential to accurately assess %fat when DXA is used as the criterion measure (Rockamann, Dalton et al. 2017). Although the results of the current study showed high correlation between the examined instruments (Omron BF-511 and DXA) in estimating %fat and %SMM, the high correlation does not necessarily mean high level of agreement between the two instruments in measuring %fat and %SMM (figures 2 &3). Particularly, when Bland and Altman Plots applied, the differences between means were significant biased (Altman 1990). It has been recommended that for clinical and crucial estimating of body composition (%fat & %SMM) high level of accuracy is recommended (Pribyl, Smith et al. 2011). On the other hand, manufacturers should to account for some the important characterization (e.g. age, BMI, gender, physical activity level, and ethnicity) in order to create a population-specific equation for BIA devices such as Omron BF-511. The results of a recent study concluded that more studies are needed to develop more accurate algorithm for BIA devices taking in account the key factors such as specific parameters of the examined participants (Chețan 2015).

In summary, the current study concluded that although Omron BF-511 could provide close estimation of body fat percentage (%fat) and skeletal muscle mass (%SMM) comparing to DXA method, the result of the study found it invalid in measuring %fat and %SMM especially when an accurate estimate of %fat and %SMM is crucial. Thus, using more accurate methods such as DXA is recommended. However, for non-crucial estimating of body composition (%fat and %SMM), using Omron BF-511 could provide close assessment. Therefore, more investigation is recommended to develop the accuracy of the commercial BIA (e.g. Omron BF-511) in order to be able to estimate body composition parameters.

Acknowledgment

Author would like to express his appreciation to the Research Center at the College of Sports Sciences and Physical Activity and the Deanship of Scientific Research at King Saud University for supporting the present study.

Ethics approval and consent to participate

The current study protocol has been approved by the Internal Review Board (IRB) at King Saud University (IRB No. E-16-1785). Written informed consent was provided by all participants.

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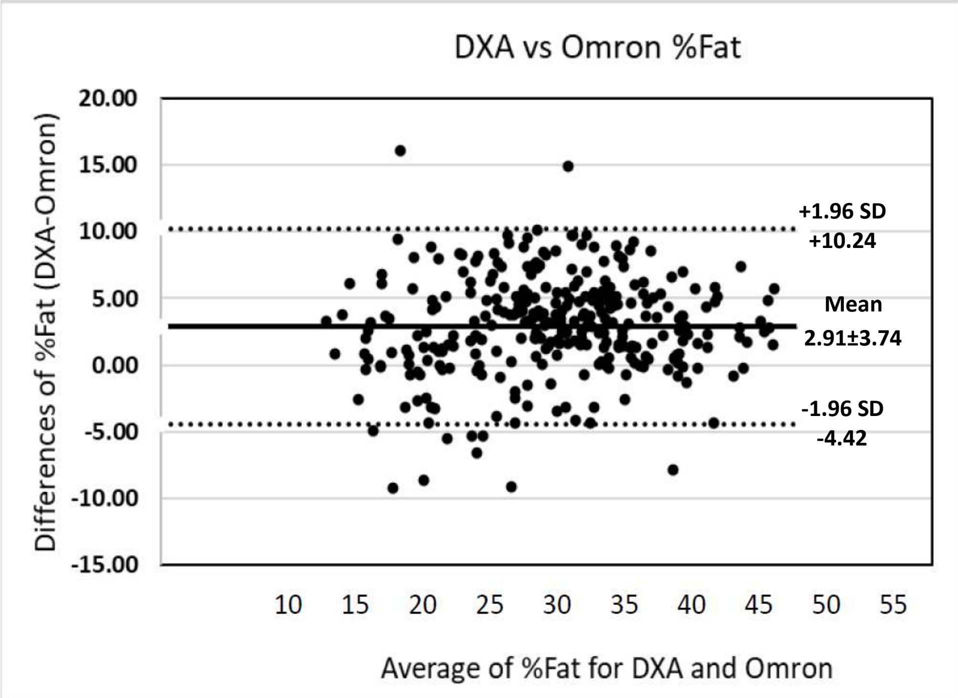

Fig.2 Bland Altman plots of body fat percentage (%fat) assessed by DXA and Omron (BF-511), with mean differences (straight line) and 95% limits of agreement (dots line).

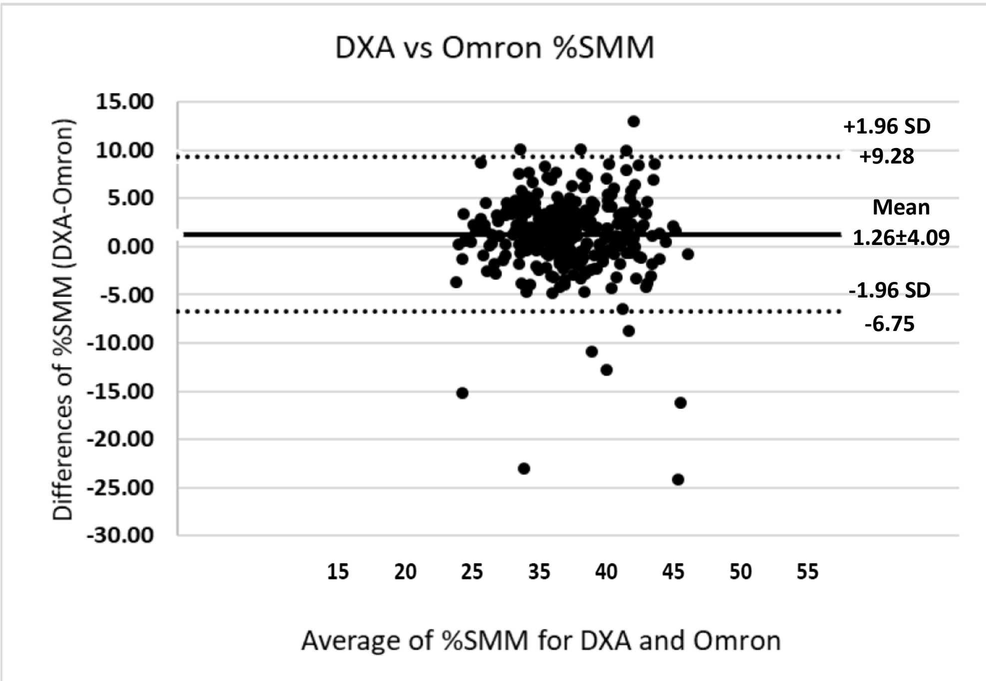

Fig. 3 Bland Altman plots of skeletal muscle mass percentage (%SMM) assessed by DXA and Omron (BF-511), with mean differences (straight line) and 95% limits of agreement (dots line).

Table2. comparison of body composition percentage (SMM, Fat) measured by DXA and Omron, represented as mean ±SD; including percent error within ±3.5 for both instruments, (n=302).

Body composition parameters	DXA	Omron	Percent Error for Omron within ±3.5	*P* value
Skeletal muscle mass (SMM) (%)	35.70 ±4.66	34.42 ±4.83	29.14	0,002
Fat (%)	31.93 ±8.01	29.02 ±7.68	26.16	0,000

Correlation

On the other hand, Pearson correlation between parameters including body composition (%SMM & %Fat) measured by both instruments (Omron & DXA) were strong in most occasions (table 3). Interesting findings were observed in the strong negative association between waist circumference (WC) and body composition parameters (%SMM & %Fat). The present study found a significant strong association between skeletal muscle mass percentage measured by DXA and WC (WC vs SMM-DXA r= -0.565; P=0.000). Similar level of association was found in Omron (WC vs SMM-Omron r= - 0.662, P=0.000). Moreover, a significant strong negative correlations were found between fat percentage versus skeletal muscle mass percentage in both instruments (%fat vs %SMM in DXA r= - 0.821, %fat vs %SMM in Omron r= - 0.851; both P=0.000). The association between %Fat data obtained from the two instruments (DXA & Omron) showed very strong positive correlation significantly (r=0.888, P=0.000). Furthermore, a significant strong correlation between the two instruments in measuring skeletal muscle mass percentage was reported (r=0.630, P=0.000).

Table3: Pearson correlation coefficient between body anthropometric parameters including body composition (%SMM & %Fat) assessed by BIA (Omron BF-511) and DXA instruments.

	Age	Body mass	WC	BMI	Omr_MMS	DEXA_MMS	Omr_Fat
Weight	-.037-						
	.523						
WC	.153**	.817**					
	.008	.000					
BMI	.059	.922**	.836**				
	.308	.000	.000				
Omr_MMS	-.263-**	-.721-**	-.662-**	-.761-**			
	.000	.000	.000	.000			
DEXA_MMS	-.273-**	-.449-**	-.565-**	-.550-**	.630**		
	.000	.000	.000	.000	.000		
Omr_Fat	.042	.822**	.824**	.882**	-.851-**	-.664-**	
	.463	.000	.000	.000	.000	.000	
DEXA_Fat	.171**	.685**	.768**	.767**	-.795-**	-.821-**	.888**
	.003	.000	.000	.000	.000	.000	.000

** Significant correlation between parameters (P<0.01)

Bland Altman plots showed that the examined BIA (Omron, BF-511) underestimated body fat percentage (%fat) and skeletal muscle mass percentage (%SMM) significantly comparing to DXA's values (%fat & %SMM). Specifically, figure 2 showed that Omron (BF-511) underestimated body fat percentage (%fat) comparing to %fat measured by DXA by a mean of 2.91% (±3.74). (limits of agreement –4.42 and 10.24%). Moreover, Omron (BF-511) also, underestimated skeletal muscle mass percentage (%SMM) comparing to %SMM measured by DXA, by a mean of 1.26% ±4.09 (limits of agreement –6.75 and 9.28%).

Follow Table 1.

Physical characteristics	Mean	Std. Deviation	Max	Min
Height (H) (cm)	171.4	6.51	193.00	149.00
Body Mass (BM) (Kg)	83.72	17.61	145.00	45.50
BMI (BM(kg)/H^2(m))	28.93	5.43	47.03	17.44
WC (cm)	93.41	14.14	117.00	60.00
SBP (mmgh)	117.12	14.94	91.00	178.00
DBP (mmgh)	74.83	11.22	53.00	109.00
RHR (bpm)	69.22	10.51	48.00	104.00

The results of the current study showed that although BIA (Omron BF-511) provide close assessment in skeletal muscle mass percentage and fat percentage comparing to DXA (Lunar iDXA, GE Healthcare, USA), the values (%SMM & %Fat) between the two devices (Omron & DXA) where significantly differences. An independent t-test of the difference values (%SMM & %Fat) between the two instruments indicated that Omron BF-511 significantly underestimated both %SMM and %BF (%Fat, Omron=29.02 ±7.68 vs. DXA=31.93 ±8.01, P=0.000; %SMM, Omron=34.42 ±4.83 vs. DXA=35.70 ±4.66, P=0.002) (Figure 1 a&b).

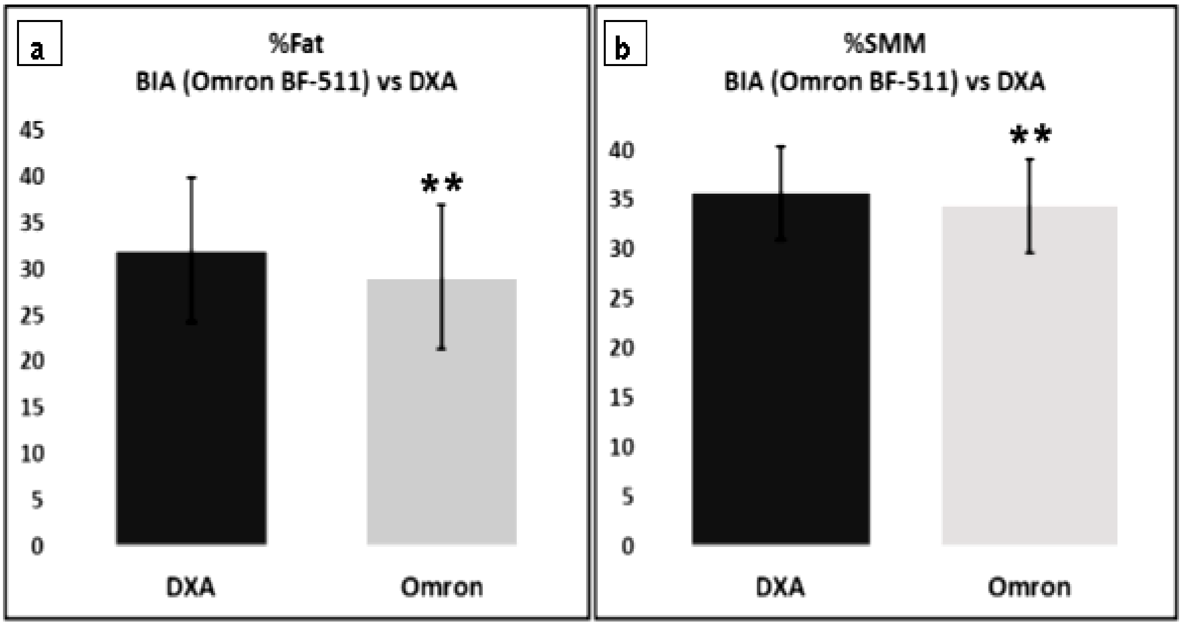

Figure 1:Figure (1-a) Data indicated that there is a significant difference between the two instruments (Omron vs DXA) (P=0.000), in assessing Fat percentage (%Fat) for adults.

Figure (1-b) Data indicated that there is a significant difference between the two instruments (Omron vs DXA) (P=0.002), in assessing skeletal muscle mass percentage (%SMM) for adults.

** Significant differences between parameters (P<0.01)

Furthermore, table 2 shows that Omron device (model BF-511) did not assess %SMM and %Fat accurately. The results indicated that less than third of the total sample were within the acceptable percent error limit (±3.5).

Introduction

Accurate assessment of the body composition is very important because it is one of the key indicators that reflects the health status of the population. Bioelectrical impedance analysis (BIA) is widely used to assess body composition in adults. However, the accuracy of some models may need to be evaluated in order to determine the purpose of use. Dual energy X-ray absorptiometry (DXA) is an accepted method of measurement of body composition. Omron BF 511 is one of the commercial scale that could help people to monitor their body composition and it is not expensive compare to the medical BIA. Moreover, the studies that examine the validity and accuracy of this model (Omron BF 511) is limited. The main aim of this study was to investigate the accuracy of Omron BF 511 model to assessing body composition in male adults.

Methods

Subjects and study design

In the current study, 302 apparently healthy men aged between 19-63 years old. Participants were recruited via notice board in public places and through social media. The sample size included a wide range age and body composition from different areas in Riyadh city. Consent form has been signed by each participant before engaging in the study. The current study was a cross-sectional descriptive study conducted at the Laboratory of Body Composition in the Department of Exercise Physiology, College of Sport Sciences and Physical Activity, King Saudi University, Riyadh, Saudi Arabia 2016.

Anthropometry

Body mass was measured to the nearest 0.1 kg using portable digital scale (Seca model 899), height was measured to the nearest 0.5 cm. Waist circumference (WC) was measured to the nearest 0.1 cm at the umbilicus using measuring tape. Body mass index (BMI) was calculated (BMI=body mass (Kg)/height (meter)2).

Body composition

Body composition including body fat percentage, skeletal muscle mass percentage, has been measured by two instruments. The first was Dual-energy X-ray absorptiometry (DXA) (Lunar iDXA, GE Healthcare, USA) as a gold standard. Quality assurance calibration was performed for DXA automatically; and the system should confirm that the test is passed. The second instrument was a commercial bioelectrical impedance analysis Omron (model BF-511). Omron BF-511 has eight electrodes and the manufacturer recommends use it in standing position on metal footpads' bare feet. Based on the recommendation of the manufacturer, body composition were assessed during the morning and participants were asked not exercise, eat, drink or take shower before assessing their body composition (Omron-Healthcare 2018).

Since DXA do not provide direct measurement for skeletal muscle mass, prediction formula was applied in order to obtain a predicted skeletal muscle mass (SMM). The validity of the prediction formula was evaluated in previous study (Kim, Heshka et al. 2004).

skeletal muscle mass (SMM) (Kg)= 1.19* appendicular lean soft tissue (ALST) – 1.65

where ALST measured by DXA. Then, SMM percentage was calculated and presented as mean and standard deviation. Participants who had radiation exposure such as X-rays in the prior two weeks, or had frequent exposure to radiation in the prior year have been excluded for their health safety. Full and clear procedure has been presented to each participant period to take part in the study.

Statistical analysis

Data stored in excel files and were analyzed using SPSS software (version 21 Chicago, IL, USA). Results were presented as mean and standard deviation (±SD). Data set were checked for normality using the Kolmogorov-Smirnov test. Independent *t* tests (two-tail), which examined mean differences in both %BF and %SMM between the two devices (DXA and Omron). Wilcoxon signed ranks tests were used as appropriate. The Limits of Agreement (LoA) was examined for both devices (DXA and Omron) using the Bland-Altman plots method (Bland and Altman, 1986). Pearson's correlation coefficients were applied to assess the association between the two devices in measuring %BF and %SMM. Acceptable percent error limit (±3.5) was calculated for the examined device (Omron BF-511) using a developed equation %error = [(Omron – DXA)/DXA x 100] (Gibson, Heyward et al. 2000). Statistical significance was set at $P<0.05$ for all the analyses.

Results

Physical characteristics and anthropometry parameters of the participants presented in table 1 as mean (±SD) and the maximum and minimum values.

Table 1. physical characteristics of participants (n=302)

Physical characteristics	Mean	Std. Deviation	Max	Min
Age 19-29yrs (%52.0) 30-39yrs (%31.1) 40-63yrs (%16.9)	31.73	10.32	63	19

مصداقية جهاز تحليل المعاوقة الكهروحيوية التجاري مقارنة بجهاز قياس امتصاص الأشعة السينية المزدوج الطاقة في تقدير التكوين الجسمي للبالغين الذكور

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(قدم للنشر في ١٤/ ٢/ ٢٠١٨م ؛ وقبل للنشر في ١٢/ ٣/ ٢٠١٨م)

الكلمات المفتاحية: التكوين الجسمي، جهاز التحليل الكهروحيوي، الصدق، Omron BF-511، DXA.

ملخص البحث: الخلفية: يستخدم تحليل المعاوقة الكهروحيوية على نطاق واسع لتقييم تكوين الجسم. ولا يزال هناك شح في الدراسات التي اختبرات مصداقية هذا النوع من الأجهزة التي يقدر التكوين الجسمي خاصة التاجري منها مثل (Omron BF-511). الهدف: هدفت هذه الدراسة إلى تقييم مدى دقة جهاز Omron BF-511 في تقدير نسبة الشحوم ونسبة العضلات الهيكلية لدى البالغين الذكور. الإجراءات: شارك في هذه الدراسة ٣٠٢ مشارك من الذكور (متوسط العمر= ٣١,٧ ± ١٠,٣ سنة)، وقد تم قياس بعض عناصر التكوين الجسمي (٪ الشحوم و٪ العضلات الهيكلية) لجميع المشاركين في نفس الظروف باستخدام Omron BF-511 و جهاز قياس امتصاص الأشعة السينية المزدوج الطاقة DXA كمقياس معياري. النتائج: رغم أن النتائج أظهرت قيم قريبة نسبيا (٪ الشحوم و٪ العضلات الهيكلية) بين الجهازين (Omron BF-511 & DXA)، ورغم وجود علاقة ارتباطية قوية بينهما في تقدير المتغيرين قيد الدراسة؛ إلا أن الفروق الاحصائية بين الجهازين في كلا المتغيرين (٪الشحوم و٪ العضلات الهيكلية) كان دالة (٪الشحوم، Omron= 29.02+7.68 vs DXA= P=0.000, 31.93+8.01 و٪ العضلات الهيكلية، Omron= 35.70+4.66 DXA vs = ,34.42+4.83 P=0.002)، الاستنتاج: خلصت هذه الدراسة إلى أن جهاز Omron BF-511 يمكن أن يوفر تقدير مقبول لنسبة الشحوم والعضلات الهيكلية في الجسم، إلا أنه ينبغي توخي الحذر عندما تكون الدقة في قياس هذه المتغيرات (٪ الشحوم و٪ العضلات الهيكلية) أمر بالغ الأهمية، لذا توصى هذه الدراسة بإجراء مزيد من الأبحاث لتطوير مثل هذه الأجهزة (مثل Omron BF-511) لتوفر تقييم أدق لعناصر التكوين الجسمي.

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Validity of a commercial bioelectrical impedance analysis against the dual energy X-ray absorptiometry in assessing body composition of adult males

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Keywords: Body composition, bioelectrical impedance analysis, validity, Omron BF-511, DXA.

Abstract: Bioelectrical impedance analysis (BIA) is widely used to assess body composition. However, there is lack of studies that evaluated the validity of BIA especially the commercial models such as Omron BF-511. Aim: The main aim of the present study was to examine the accuracy of Omron BF-511 model in assessing body composition in male adults. Method: Apparently healthy men (n=302, mean age=31.7±10.3 years) participated in this cross-sectional study. Body composition (%fat and %SMM) has been assessed for all participants under the same conditions using Omron BF-511 and DXA as a criterion measure. Results: Although the results showed relatively close values (%fat &%SMM) between the examined instruments (Omron BF-511 & DXA), and the correlation between Omron BF-511 and DXA were high in both %fat and %SMM, the differences existed in both measures were significant (%Fat, Omron=29.02+7.68 vs. DXA=31.93+8.01, P=0.000; %SMM, Omron=34.42+4.83 vs. DXA=35.70+4.66, P=0.002). Conclusion: The current study concluded that Omron BF-511 could provide close estimation of %fat and %SMM. However, caution should be taken when an accurate estimate of %fat and %SMM is crucial. Therefore, more investigations are recommended to develop the accuracy of the commercial BIA (e.g. Omron BF-511) in order to provide accurate body composition assessment.