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Determination of Body Fat Percentage by Body State Devices and Dual Energy X-Ray Absorptiometry

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Authors' contributions

This work was carried out in collaboration among all authors. Author RAM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors DRN and NAES managed the analyses of the study. Author NAES managed the literature searches. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Background: Dual energy X-ray absorptiometry (DEXA) is the most accurate technique in determining fat percentage but it is unpotable, expensive, unavailable for general applicability.
Objective: This study aimed to find the most accurate and easiest technique as alternative to DEXA for quick determination of body fat%. This study examined the accuracy of three models of Bioelectrical impedance analysis (BIA) technique (Fat Loss Monitor- Body Composition -Body Fat Analyzer) in determining the body fat percentage with using DEXA as a reference standard.
Subject and Methods: A cross sectional study was carried out during the period from (28-9-2017) to (5-4-2018) among a random sample of (53) volunteers female student in Umm Al Qura University from Faculty of Applied Medical Science aged between (20-39 years) from different level of education. All subjects were generally healthy, data was collected through a structured questionnaire compose of three section. Demographic data was collected and anthropometric

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measurements were evaluated as well as body composition (Only body fat%) using DEXA, body composition monitor, fat loss monitor and body fat analyzer.

Results: BMI classification of the total 53 subjects was including 8 healthy females, 17 overfat, 25 obese and 3 underweight. The fat% result from DEXA and body fat analyzer was significant difference at ($P < 0.05$). Fat percent result from DEXA and Body Composition device was non-significant difference at ($P>0.05$). The fat% result from DEXA and Fat Loss Monitor device was significant at difference ($P<0.05$).

Conclusion: The most accurate of BIA technique was the Body Composition device compering to DEXA.

Keywords: BIA technique; body composition; body fat analyzer; body fat percentage; DEXA; fat loss monitor.

1. INTRODUCTION

The prediction of changes in body composition is unimportant when compare with providing the data by multiple investigation, from this point DEXA has a good role when comparing actual fat-free mass and fat mass [1].

When compare BIA to DEXA BIA-derived equations may not provide sufficient accuracy to track changes in fat-free mass after 12 weeks of resistance training in older women [2].

It has been wide accepted that excess body fat and fatness represent risk factors for future disorder also as different chronic diseases [3]. Some people who are overweight are not over fat (body-builders). Whereas others have BMIs among the traditional vary and nevertheless have a high proportion of their weight as fat [4].

Body composition assessment is being progressively recognized, as a vital tool within the analysis of nutritionary standing in a very type of clinical conditions [5]. Is a vital indicator of health and good shape [6,7].

Dual energy X-ray absorptiometry (DEXA) and bioimpedance analysis (BIA) are two frequently used methods for the quantification of body composition. DEXA estimates of body composition are wide compared to alternative techniques for assessing body composition [8].

DEXA is associate degree correct and dependableness, and provides for the assessment of regional body composition [9]. Moreover it provides completely different results like: Bone mineral content, fat mass, Lean soft tissue mass, fat free mass and Percent fat mass [10].

Bioelectrical impedance analysis (BIA) has been adopted by some wrestling governing bodies as an alternate to DEXA attributable to its larger accessibility due to lower cost, accumulated immovableness, simple, and smaller risk of user error compared to alternative tools [11].

BIA gives a dependable appraises of add up to body water underneath most conditions. It can be a helpful method for body composition analysis in healthy people and in those with a variety of chronic conditions like mild-to-moderate fatness, DM, and alternative medical conditions. BIA values are full of various variables together with body position, association standing, consumption of food and beverages, recent physical activity. Reliable needs standardization and management of those variables [12].

With the advances in technology and variations within the style (frequency, electrodes, points of contact, etc.) and proprietary body composition prediction algorithms between makers [13]. The purpose of this study is to match the body fat percent (BF%) results from 3 BIA devices vs. that from DEXA in Umm Al-Qura University students.

2. MATERIALS AND METHODS

2.1 Subject

Across sectional study was carried out during the period from (28-9-2017) to (5-4-2018) among a random sample of (53) volunteer female student in UQU from Faculty of Applied Medical Science aged between (20-39 years) from different level of education. All subjects were generally healthy.

2.2 Methods

2.2.1 Study design

Data was collected through a structured questionnaire compose of three section.

Section A: Demographic data
Section B: Anthropometric measurements
Section C: Body composition (only body fat percentage)

2.2.2 Anthropometric measurements

2.2.2.1 Height

Each subject height was measured in metric linear unit whereas the participant stood while not shoes [12], the topic was asked to square straight with the pinnacle Frankfort set up, feet along, knee straight, and heels, buttocks, and shoulder blades involved with the surface of the stadiometer and wall [14].

2.2.2.2 Body weight

Weight was measured in kilograms to the nearest 0.1 kg with electronic weight scale with a digital read-out [12].

2.2.2.3 Body Mass Index (BMI)

BMI was calculated the BMI formula (weight / Height^2); (Kg/m^2) category of BMI [15].

2.2.3 Body composition assessment

2.2.3.1 Dual –energy X-ray absorptiometry (DXA) / (DEXA)

A total body dual energy X-ray beams (DEXA) scan, serial No 60825-1 (Fig. 2.1.) A trained technologist performed measurements [16]. Subjects wore a standard light cotton shirt to minimize clothing absorption and were asked to remove any metal such as jewelry, body piercings and hair accessories. Make certain the individuals are within the center of the table with relevance the middle lines at the pinnacle and foot of the pad (Dual Energy X-ray Absorptiometry (DEXA) Procedures Manual).

2.2.3.2 Bioelectrical Impedance Analysis (BIA)

BIA is based on the principle that lean tissue (Muscles, blood vessels and bones are body tissues), that contains massive amounts of water and electrolytes, could be a sensible electrical conductor, and Body fat is tissue, that is anhydrous, could be a poor conductor [17]. Researchers used three different model using BIA devices (Body fat analyzer, body composition monitor, fat loose monitor) [18]. All devices BIA used Whole-body electrical resistance or resistance is measured by using Ohm's law, that states that the R of a substance is proportional to the drop of associate degree applied current because it passes through the resistive substance: R = E(volts) / I(amperes), the category of body fat percentage of subjects showed in Table 2.1.

Table 2.1. Category of body-fat percentage for female

Under fat	≤ 20
Healthy	21 - 32
Over fat	33-38
Obese	≥ 39

Used Analyzer is the BT-905 skylark model a right-sided tetra polar surface electrode technique (Fig. 2.2) [19]. 4 electrodes are placed over metacarpus (the group of five bones of the hand between the wrists) and metatarsus (the group of bones in the foot, between the ankle and the toes) where a 50 kHz current is introduced.

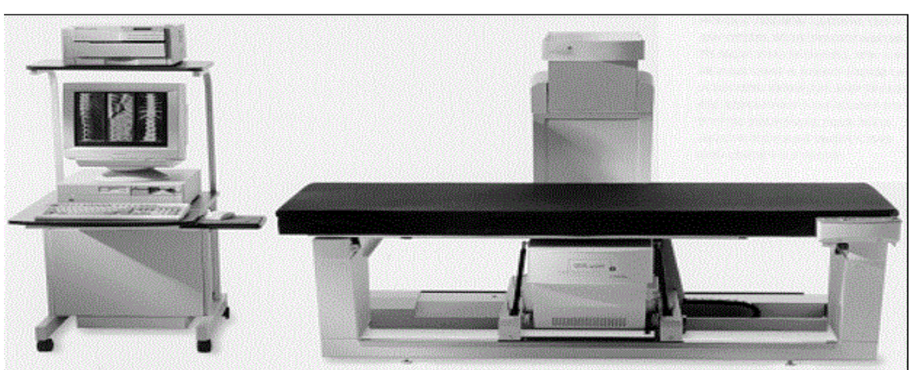

Fig. 2.1. Dual energy X-ray beams (DEXA)

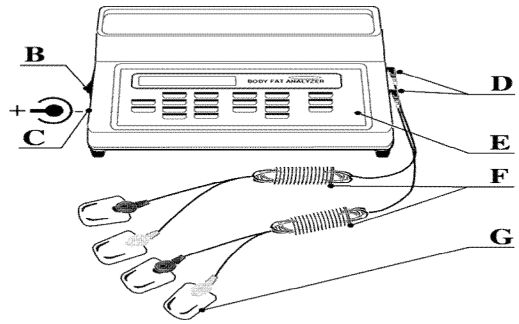

Fig. 2.2. Body fat analyzer

OMRON body composition monitor, Model: BF511 (Fig. 2.4). The person stood upright, positioning their clean feet on the footpads and their hands on the handles. Each footpads and handles every contain 2 electrodes, providing eight points of contact. As a result of the magnitude relation of water within the higher body and lower body is completely different in the morning and evening, and this suggests that the electrical resistance of the body additionally varies. Than device sends a particularly weak electrical current of fifty kilohertz and fewer than five hundred µA through Subjects body This weak electrical current isn't felt, resistance is measured and total body water and also the corresponding proportion of fat mass are calculated by the integral package. Specific knowledge for body composition calculations enclosed age, sex and body build (athletic and normal) (body composition monitor Manual).

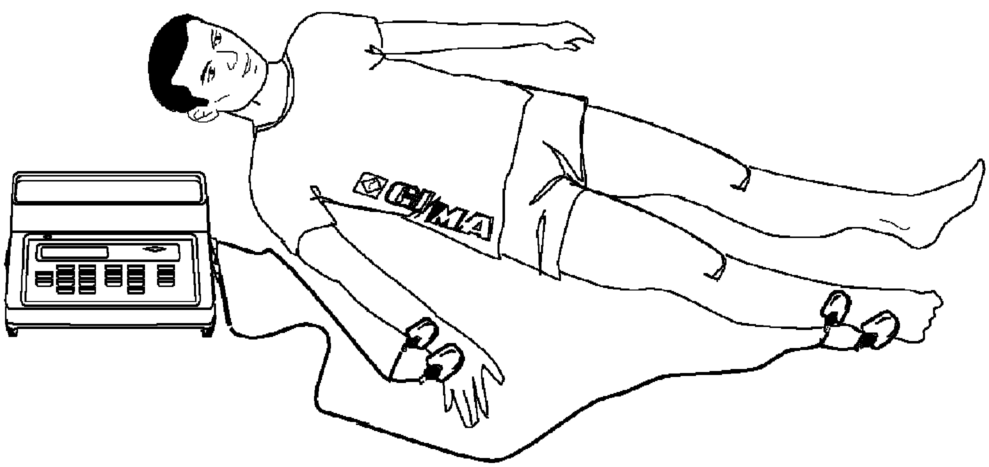

Fig. 2.3a. A place 4 electrodes

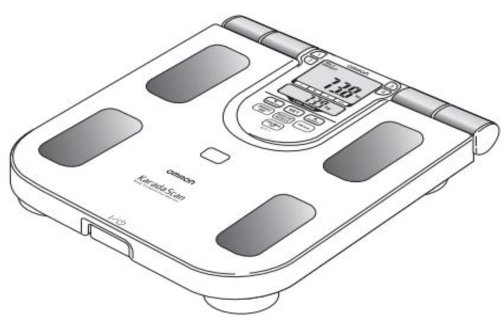

Fig. 2.3b. Body composition monitor

Fig. 2.4. Fat loos monitor

2.2.3.3 Fat lose monitor

OMRON Fat Loss Monitor, Model: HBF-306C, Weight: Approx. 8 oz. (230 g) (not including batteries) Subjects were asked to square with each feet slightly apart, each hands on the monitor by holding the grip electrodes, Hold your arms straight out at a 90° angle to your body. Press the beginning button. The Fat Loss Monitor sends a particularly low-level electrical current of fifty kilohertz and five hundred μA through your body to work out the number of fat tissue. This weak electrical current is safe (Fat Loss Monitor Manual).

2.3 Statistical Analysis

Statistical analysis of data were performed by victimization bug statistical package for science (SPSS) version sixteen and compared with one another using the acceptable tests. All obtained results were tabulated as mean ± SD) of mean values. Chi-square and ANOVA test were used. Significant differences expressed ($p \le 0.05$).

3. RESULTS

According to Table 3.1 data obtained about the mean values of body fat percentage by using DEXA, Body fat analyzer, Body Composition device and Fat Loss Monitor were (38.74 ± 4.86, 31.12 ± 5.78, 36.84 ± 7.1 and 32.76 ± 6.92) respectively which were significantly differences ($P < 0.05$).

Data in Table 3.2 shows the fat percent result from DEXA and body fat analyzer, the result was significant difference ($P < 0.05$). The total subjects were 53 including 8 healthy females, 17 overfat, 25 obese and 3 underweight (Figs. from 2.5 to 2.19).

According to Table 3.3 shows, the fat percent result from DEXA and Body Composition device was no significant difference ($P > 0.05$). The total subjects were 53 including 8 healthy females, 17 overfat, 25 obese and 3 underweight (Figs. from 2.5 to 2.19).

Data shown in Table 3.4 shows the fat percent result from DEXA and fat loss monitor device was highly significant difference ($P < 0.05$). The total volunteers were 53 including 8 healthy, 17 overfat, 25 obese and 3 underweight (Figs. from 2.5 to 2.19).

Table 3.1. Mean ± SD of body fat % measured by DEXA, body fat analyzer, body composition device and fat loss monitor

Devices	Means	P. value
DEXA	$38.74^{a} \pm 4.86$	**0.037**
Body fat analyzer	$31.12^{b} \pm 5.78$	
Body Composition device	$36.84^{a} \pm 7.1$	
Fat Loss Monitor	$32.76^{b} \pm 6.92$	

**The same letter in the same column show insignificant difference*

Table 3.2. Frequency distribution of subjects according to their boy fat percentage by using DEXA and body fat analyzer

Body fat percentage category	DEXA	Body fat analyzer	P. value
Under fat (≤21)	4	9	0.009
Healthy (21.1-33)	7	19	
Over (33.1 - 39.5)	17	12	
Obese (≥39.6)	25	13	
Total	53	53	

Table 3.3. Frequency distribution of subjects according to their boy fat percentage by using DEXA and body composition

Body fat percentage category	DEXA	Body composition	P. value
Under fat (≤21)	4	10	0.064
Healthy (21.1-33)	7	16	
Over (33.1 - 39.5)	17	13	
Obese (≥39.6)	25	14	
Total	53	53	

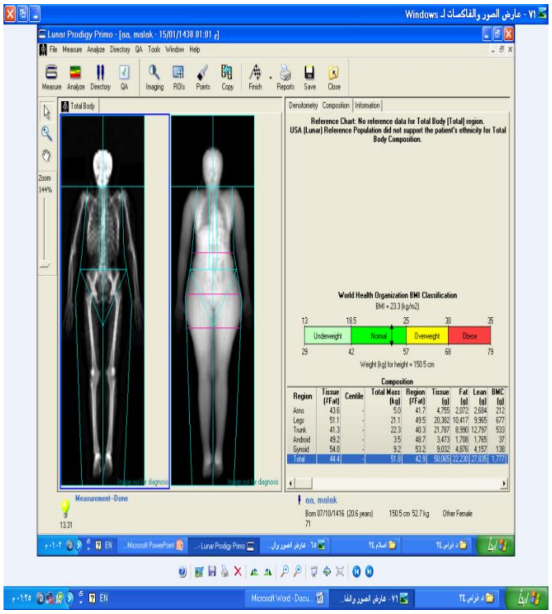

Fig. 2.5. Samples from normal evaluated cases using DEXA scan

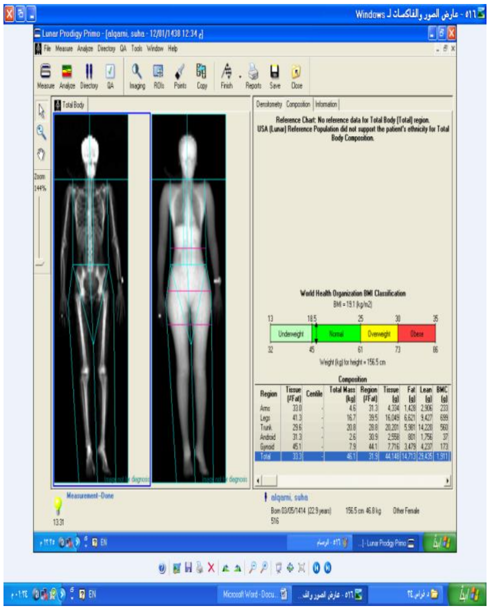

Fig. 2.6. Samples from normal evaluated cases using DEXA scan

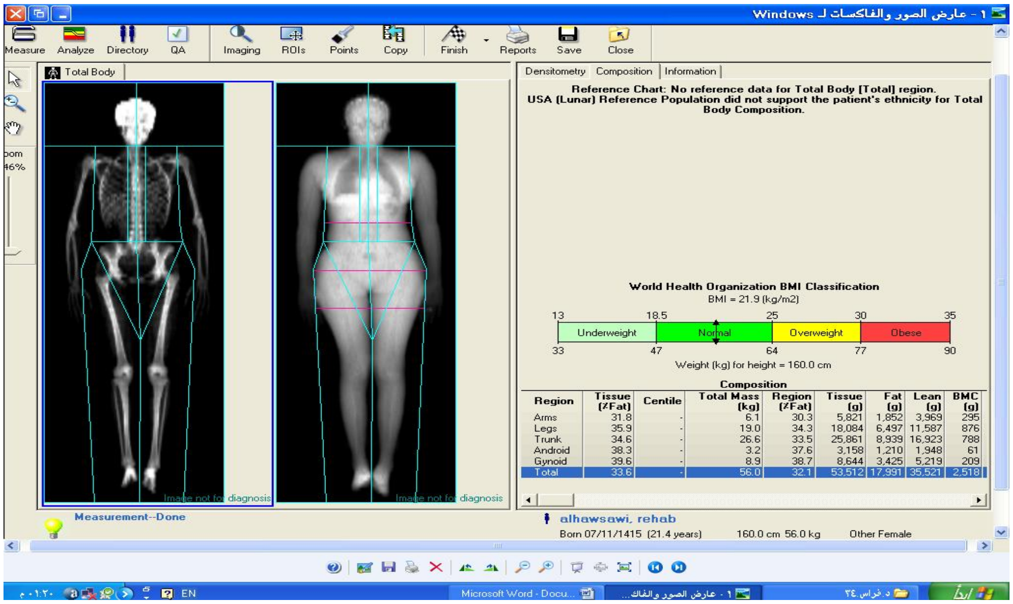

Fig. 2.7. Samples from normal evaluated cases using DEXA scan

Table 3.4. Frequency distribution of subjects according to their boy fat percentage by using DEXA and fat loss monitor

Body fat percentage category	DEXA	Fat loss monitor	P. value
Under fat (≤21)	4	3	0.000
Healthy (21.1-33)	7	37	
Over (33.1 - 39.5)	17	7	
Obese (≥39.6)	25	6	
Total	53	53	

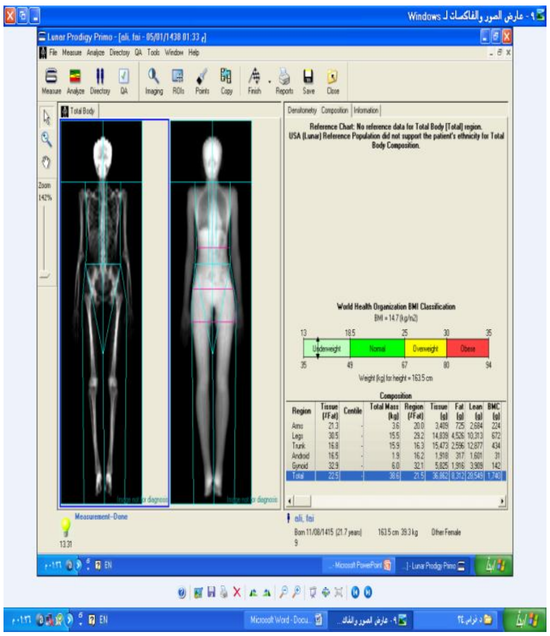

Fig. 2.8. Samples from underweight evaluated cases using DEXA scan

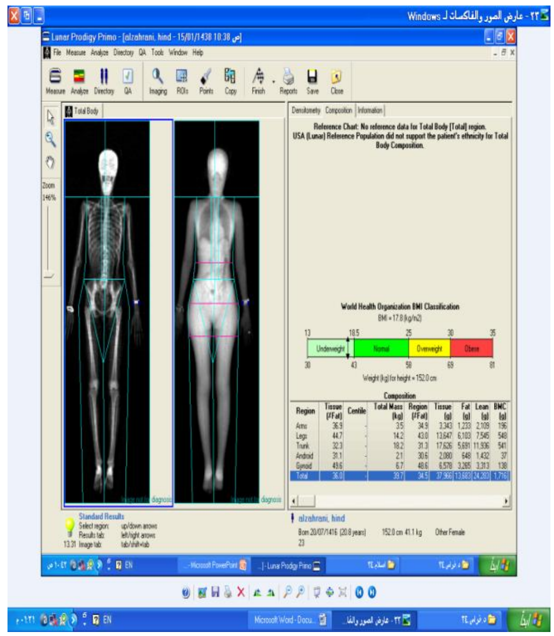

Fig. 2.9. Samples from underweight evaluated cases using DEXA scan

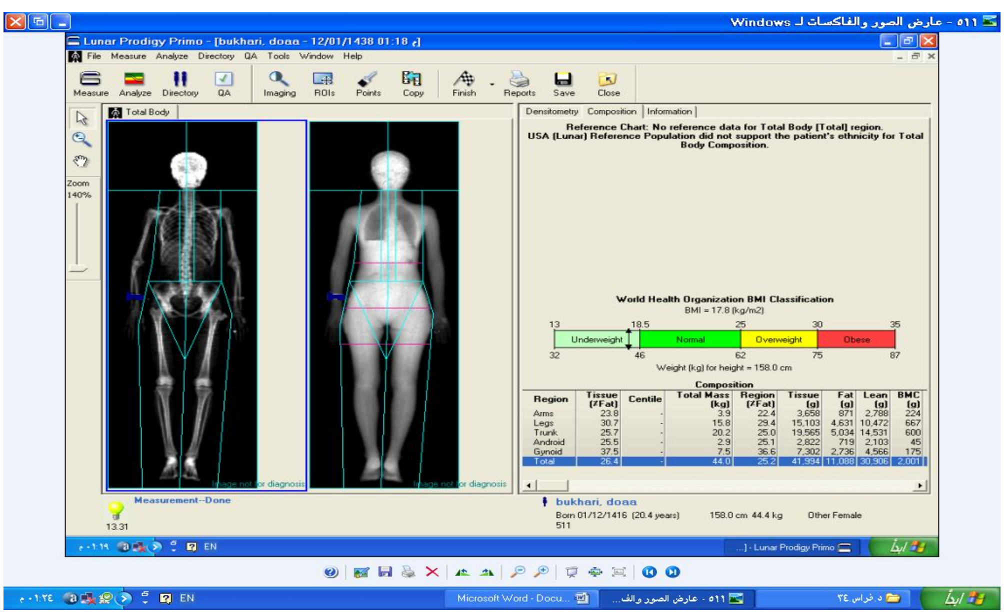

Fig. 2.10. Samples from underweight evaluated cases using DEXA scan

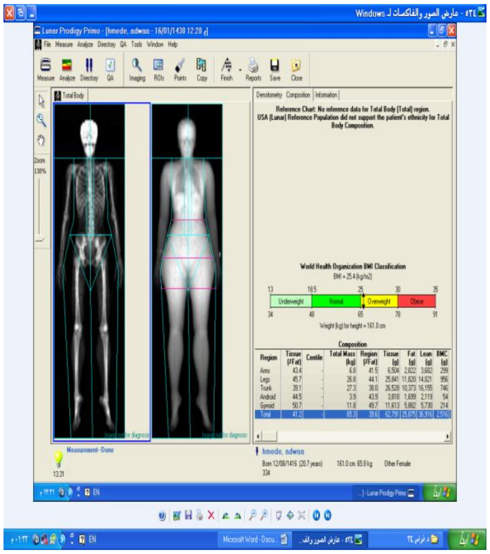

Fig. 2.11. Samples from overweight evaluated cases using DEXA scan

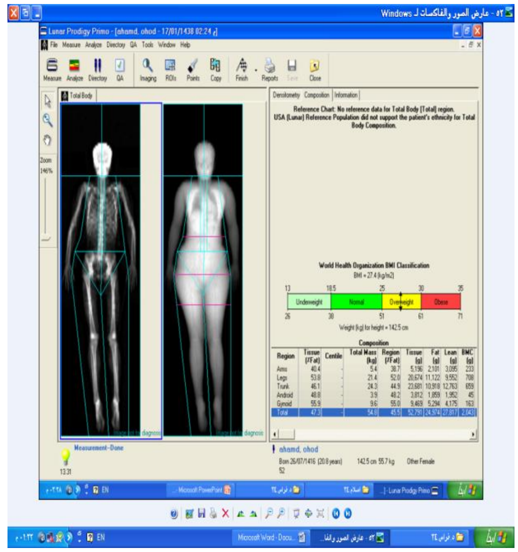

Fig. 2.12. Samples from overweight evaluated cases using DEXA scan

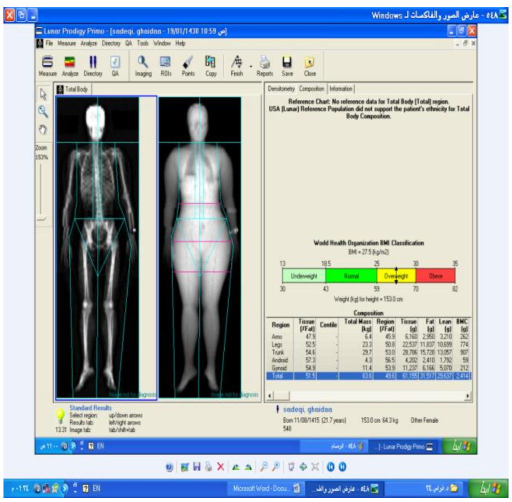

Fig. 2.13. Samples from overweight evaluated cases using DEXA scan

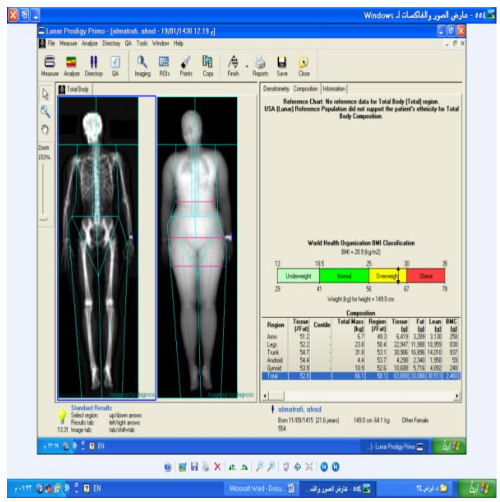

Fig. 2.14. Samples from overweight evaluated cases using DEXA scan

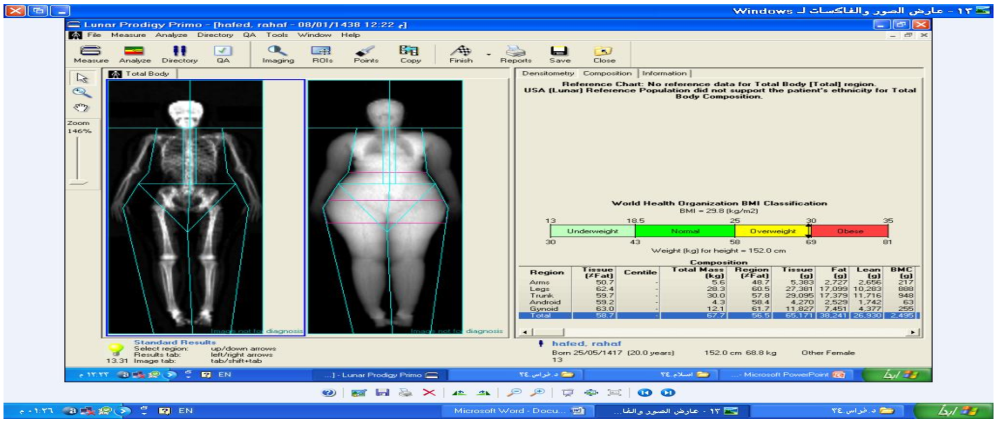

Fig. 2.15. Samples from overweight evaluated cases using DEXA scan

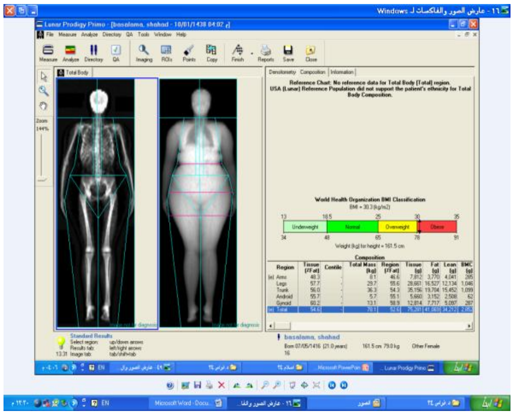

Fig. 2.16. Samples from obese evaluated cases using DEXA scan

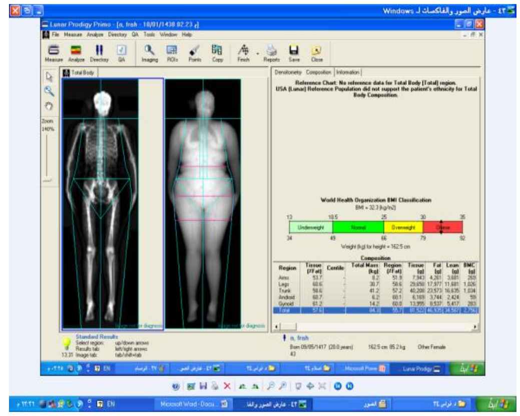

Fig. 2.17. Samples from obese evaluated cases using DEXA scan

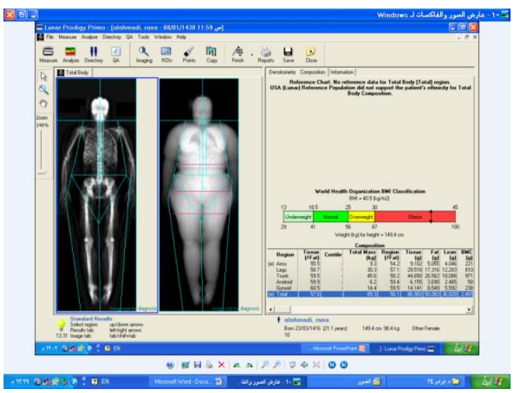

Fig. 2.18. Samples from obese evaluated cases using DEXA scan

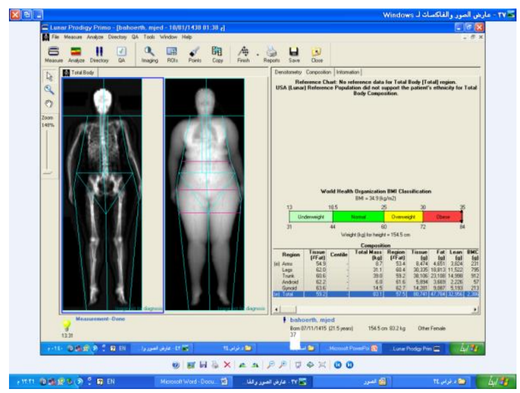

Fig. 2.19. Samples from obese evaluated cases using DEXA scan

4. DISCUSSION

It is very important to know that there's no single activity technique that provides a measurement of all tissues and organs and additionally there is no method is error free. Moreover, if a activity technique makes assumptions associated with body composition proportions and characteristics that are inaccurate bias will be introduced [9]. Additionally, body composition can influences by training, disease, or diet and that the reason of the particular interest to nutrition professionals [20].

Both DEXA and BIA methods are suitable for body composition studies [21]. What is more, regression equations for the BIA-derived body composition estimates were generated to grant an excellent additional comparable knowledge to DEXA [22]. The BIA was significantly related to DEXA body composition parameters [23].

The DEXA technique is generally accepted as being an accurate and precise technique in assessing body composition. Additionally to its increasing role as a gold normal, DEXA might doubtless be accustomed live body fat % for the aim of assessing fatness in a very clinical sitting [8]. The utilization of DEXA is proscribed by the comparatively high value of the instrumentation. What is more, subjects should stay still throughout the procedure that can be dull and uncomfortable for a few patients [21]. In most things, BIA and alternative field ways are the sole techniques accessible for body-composition measurements. A large-scale genetic study recruited 591 subjects to work out the results of sex and adiposeness on the distinction in proportion body fat % (BF%) foretold by BIA compared with dual-energy X-ray absorptiometry (DXA), the study all over that BIA could be a sensible different for estimating BF% once subjects are among a standard body fat vary [24].

Body composition was studied in one hundred consecutive subjects, fifty nine ladies and forty one men. The lean body mass (LBM), fat body mass (FBM), and % body fat (BF%) were measured by the DEXA and BIA techniques, the study results show that there have been extremely statistically important linear relationships between LBM, FBM and BF% assessed by DEXA and BIA in each sexes. No influence of age or BMI on the connection between DEXA and BIA results was determined [21]. Twelve subjects with tetraplegia were studied for absolute weight as fat and % fat by the subsequent methods; bioelectrical electrical resistance (BIA), twin energy X-ray absorptiometry (DEXA), total body potassium (TBK), total body water (TBW), and 4 measurement ways. last, BIA, DEXA, TBW are equally valuable for estimating fat in those with tetraplegia. A study aimed to assess the validity of BIA against ADP and DXA to measure BF%, and to check the dependability of every technique showed that BIA could also be a legitimate method in analysis and population samples. what is more all 3 ways showed excellent dependability [25].

The bioelectrical impedance analysis (BIA) has shown a great use in estimating body composition (Donald et al. 1996).The utilization of BIA system standardization was supported in subjects with severe fatness. While not using of a complex, pricey instrumentation and invasive procedures, BIA measurements will simply be obtained in clinical follow to observe patient responses to treatment [26]. What is more, BIA approach for estimating adiposeness and body fat relies on empirical relations established by several investigators. Properly used, this noninvasive body-composition assessment approach will quickly, easily, give correct and reliable estimates of fat-free mass [27]. In addition, The BIA has a lot of other advantages stripped-down participant participation needed and safety (not counseled for participants with a pacemaker), so creating it engaging for large-scale studies [28]. Also it is fast, practical, and frequently used method for fat-free mass estimation [29]. Furthermore it is readily available tool for estimation of body composition in a general population [30]. In estimating %BF in specific population, there is similar result between BIA and DEXA. However, this agreement between BIA and DEXA is within the body fat percentage [31]. In a very previous study, routine ways of BIA were analyzed for the estimating of body fat in patients undergoing blood transfusion using DEXA as a reference technique found that the body state devise (BIA) showed additional similar ends up in comparison to DEXA [30].

All BIA ways provided sensible correlation with DXA .SF-BIA (i.e., Imp-SF and Tanita) showed a good absolute relationship, whereas MF-BIA showed poor absolute relationship. Therefore, SF-BIA methods may be useful for group comparisons [31]. BIA could be easy, comparatively cheap technique for estimating body composition, that not like DXA, emits no radiation to the topic. As a result of it needs stripped-down technical coaching for assessment, and solely some minutes for participant activity and analysis, it's potential to be used in a very type of settings with massive numbers of people. BIA could be a helpful and acceptable technique for assessing body composition in adolescent ladies attributable to its low value and reduced coaching necessities compared to DXA [32]. In In general, our results are consistent with those reported in several other studies [33,34].

5. CONCLUSION

In conclusion, this study examined the accuracy of three models of BIA devices (Fat Loss Monitor - Body Composition -Body Fat Analyzer) in determining the body fat percentage with using DEXA as a reference standard. The results showed that the most accurate of BIA devices was the Body Composition device as compared to DEXA.

CONSENT AND ETHICAL APPROVAL

As per university standard guideline participant consent and ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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