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In patients we trust. Reliability of self-reported weight and size in patients attending a nuclear medicine department.

Short running title: Is measuring weight and size mandatory for nuclear medicine imaging?

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Abstract

Purpose: The aim of the study was to assess the reliability of self-reported weight and size of nuclear medicine patients in view of recommendation for the weight-dependent tracer application for imaging and therapy.

Methods: A total of 824 patients (334m, 490f) were asked to report their weight and size prior imaging or therapy and their level of confidence. Subsequently, weight and size of each patient was measured and body mass index (BMI), body surface area (BSA) and lean body mass (LBM) were calculated. Differences between reported and true values were compared for statistically significant differences.

Results: The average patient age was (60+/-14) years ((17-91) years). An over-or underestimation of weight of ≥10% was observed in 3% of patients, size was overestimated by 1% by the patients. The BMI-calculation was affected by incorrect self-reported values.

Conclusions: Most self-reported weights and sizes of nuclear medicine patients are accurate. However since over- and underestimation of weight and size leads to incorrect BMI, BSA and LBM values patient weights should be measured at least for patients receiving a weight-adapted therapy or if quantification in PET/CT is needed.

Keywords: Self-reported weight and size; nuclear medicine imaging and therapy; BMI; BSA; LBM

Abbreviations: BMI-body mass index, BSA-body surface area, CT-computed tomography, LBM-lean body mass, PET-Positron-emitted tomography, SPECT-single photon emitted computed tomography, SUV-standardized uptake values,

Introduction

Patient-specific measures, such as body weight and body size and parameters calculated thereof, e.g., body mass index (BMI), lean body mass (LBM) and body surface area (BSA), are important information in nuclear medicine. In diagnostic imaging procedures, body weight is frequently used to determine the injected activity (*1*). Further, quantitative evaluations based on standardized uptake values (SUV) rely on the normalization of the injected tracer to body weight, BSA or LBM (*2-4*). Also for therapeutic application, such as targeted radionuclide therapy, these body specific measures are often used for the dosage of the therapeutic compound. For example, the dosage of 223Ra-radium-dicloride for the treatment of bone metastases is based on patient weight (*5*) while the dose prescription for radioembolization of hepatic malignancies using 90Y mircrospheres is based on the BSA (*6*). Therefore, the knowledge of patient's body weight and size is a prerequisite both, to avoid over- or underdosage in nuclear medicine (*7,8*) and for employing SUVs for staging of malignancies and to monitor therapy response (*9*).

However, weight assessment is often based on information provided by the patient rather than on objective measurements (*10*). Upon first examination, this approach may seem appropriate as former studies have shown a relatively good conformity of patient reported values with the actual measurements of weight (*11,12*) and BMI (*13-15*). However, the investigated patient populations in these studies were considerably small or restricted to a single professional group, gender or age range. Thus, these results may not be transferable to the breadth of nuclear medicine patients, which is typically relatively old and mixed. Therefore, the aim of the present study was to evaluate if weighting and size measurements of patients are necessary prior to nuclear medicine procedures, to gain reliable values for body weight, BMI, BSA and LBM.

Methods

Between October 2017 and February 2018 all patients referred to the Nuclear medicine department ZRN Rheinland and the Radiology Center Vienna were asked to participate in this study. This included patients undergoing diagnostic nuclear medicine imaging as well as pre-therapy imaging. The local ethics committee approved this prospective study, which was performed in accordance with the Declaration of Helsinki. Written consent of all patients was obtained prior to enrolment in this study.

Patients were asked to report their weight and size together with their level of confidence in the reported values using an individualized form. Levels of confidence were broken down into three classifications: “confident”, “less confident”, and “not confident”. Prior to the imaging examination and after completing the form all patients were asked to take off their outerwear and shoes and weighting was performed on a standard electronic bathroom scale (My Weight XL-550, My Weight Europe, Erkelenz, Germany) in an upright position. The size was measured in an upright position without shoes, with a flexible ruler tape measure (Uxcell, 300cm Flexible ruler tape measure, Hong Kong, China).

Descriptive statistics was reported. A Student t-test was used to test for significant differences ($p<0.05$) in self-reported weight and size differences between men and women and in different age groups (age <65 y, age=/>65 y). A potential relationship between confidence and accuracy of self-reported weight and size was analyzed using an ANOVA followed by a Tukey`s HSD test.

In addition, differences in BMI, BSA and LBM calculated from the reported weight and size and calculated from the measured data were assessed. For this, BMI, BSA and LBM was calculated for all patients according to the following formulas:

BMI = $\frac{weight}{size^2}$ (*16*) eqn 1

BSA = $0.007184 * \mathrm{size}^{0.725} * \mathrm{weight}^{0.425}$ (*17*) eqn 2

LBM (male) = $1.1 * \mathrm{weight} - 128 * \left(\frac{\mathrm{weight}}{\mathrm{size}}\right)^2$ eqn 3

LBM (female) = $1.07 * \mathrm{weight} - 148 * \left(\frac{\mathrm{weight}}{\mathrm{size}}\right)^2$ (*18*) eqn 4

All data were statistically analyzed with the software R (The R project for statistical computing).

Results

In total, 857 patients were examined during this study. Of these, 824 patients (96%), 334 male and 490 female, agreed to participate and were included in the assessment of the reported weights. Average age was (60±14) years (range: 17 y - 91 y). For the assessment of the reported sizes 713 patients (300 male and 413 female) with an average age of (54±14 years (range: 17 y - 91 y) were included. The values of 111 patients had to be excluded from the body size assessment, because they were not able to stand in an upright position.

Self-reported versus measured weight

As summarized in Table 1 the mean estimated weight of all patients was (79±18) kg (range: 37kg -162 kg). The mean measured weight was slightly higher at (80±18) kg (range: 34kg-161 kg), thus, indicating an underestimation of weight of 1.6 kg across all participants (range: -18.6kg-14.7 kg). A histogram of the differences between self-reported and measured weight is shown in Figure 1a, indicating that the majority of values ranged from -6% to 2% between self-reported and measured values, with a slight tendency of underestimation of self-reported weight. Of note, the weight was over-/underestimated by more than 10% by 2.9% of the patients (n= 18, 10 female and 8 male). However, no significant difference in the accuracy of self-reported weight was found between females and males, or between different age groups. The ANOVA and Tukey`s test showed no significant difference in accuracy of the reported weight between patients being “confident” and “less confident”. However, a significant difference in the accuracy of the reported weight was found between patient’s being “confident” or “less confident” and patients being “not confident” (Figure 2).

Self-reported vs measured size

The mean self-reported size was (171±9) cm (range: 146cm-196 cm), the mean measured value was with (170±10) cm slightly smaller (range: 146cm-196 cm; Table 1). The majority of differences between self-reported and measured size ranged from -1% to 2% in all participants (Figure 1b). Gender and age had no significant impact on the accuracy of self-reported size. No statistical difference in the grade of confidence and accuracy of the reported values was found for the reported size.

BMI, BSA and LBM

The average deviation of the body specific parameters calculated from reported data was -2%, 2% and 0% for BMI, BSA and LBM, respectively. However, these deviations ranged from -22% to 13% (BMI), -9% to 8% (BSA) and -11% to 12% (LBM). In 4% of all patients deviations of 10%, or more were found for the BMI, while for BSA and LBM, similar deviations where present in only <1% patients (Figure 3, Table 2).

Discussion

Our results show that self-reported weight and size in most adult patients in routine nuclear medicine departments is reliable although a slight tendency of underestimation of patient weight and overestimation of patient size was observed. Neither gender nor age had a significant impact of the validity of reported values. The validity of the state of confidence was questionable only for the “not confident” category, and, thus, not clinically significant.

In the majority of our patients the difference between estimated and measured weight (average underestimation of 2%) had no significant clinical impact. This is in line with previous reports for different patient groups (*11-15*). Similar to these studies the percentage of under- and overestimation of weight and size was small. However, in 3% of patients deviations of self-reported and measured weight of more than 10% were found.

The clinical significance of this order of deviations can be manifold. For example, incorrect weight directly translates linearly into incorrect SUV calculations. Such deviations add to the bias of SUV arising from other sources and, therefore, may contribute to a bias of therapy response assessment. For therapeutic approaches, inaccuracies of body specific measures, which are used to determine the dosage like patient weight, BMI etc. may cause significant errors in individual cases. For example, in our study, the maximum deviation between declared and measured weight was 19%. This would lead to a deviation of 19% from the prescribed dose if a patient was treated for metastatic castration-resistant prostate cancer using 233Ra-radium-dicloride (*5*). Thus, this case would be regarded a mal- or misadministration incident, which, depending on the country, would require reporting to the competent authority (e.g., in

Australia the threshold for a required reporting is 15% deviation from the prescribed dose in therapeutic applications, while in the Nuclear Regulatory Commission in the United States sets a threshold of 20% deviation from the prescribed dose) (*19,20*).

As any incidence should be omitted, a reliable assessment of body specific measures used for dose calculations needs to be ensured. This holds true for values, which are derived from weight and size, such as the BMI. Here, an underestimation of weight and an overestimation of size, as seen in our study, causes an accumulation of the errors and, thus, may contribute to incorrect diagnostic or therapeutic decisions. For example, a 5% underestimation of weight and a 5% overestimation of size results in a 14% underestimation of the BMI. Therefore, we suggest that the measurement of all relevant parameters should be mandatory prior to therapy and included into the guidelines.

In general, we suggest at least to measure weight and size of the patients for any procedure where these values are used. The time needed to perform the weighting and size assessment is minor, and, therefore, is not expected to influence the clinical workflow. Further, the time during these measurements can be used to interact with the patient, for understanding the clinical history and to get informed consent. In nuclear medicine departments where pre-drawn doses are used, it is necessary to ask for actual weight and size prior the appointment.

A limitation of our study is, that the results might be reported more accurate in the study setting than under normal circumstances. Further, it was not possible to collect size information in all patients. However, given the large sample size, adequate statistical power is expected also with the limitations mentioned above.

Conclusion

Our study demonstrates, that although the self-reported weight and size of patients in Nuclear medicine departments appears reliable for most patients, a small percentage of incorrect self-reported values would have relevance for therapeutic dosing. Therefore we suggest actual measurement of all relevant parameters at least in patients receiving a weight-adapted therapy, in patients who undergo a quantitative imaging procedure and in pediatric patients.

Disclosure:

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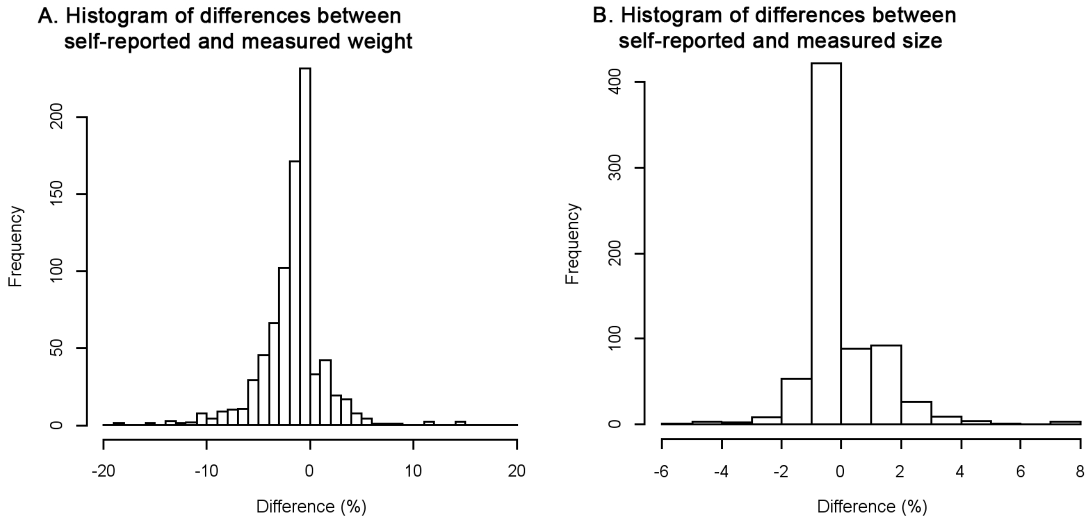

Figure 1: Accuracy of self-reported weight (A) and size (B) compared to measured weight (A) and size (B).

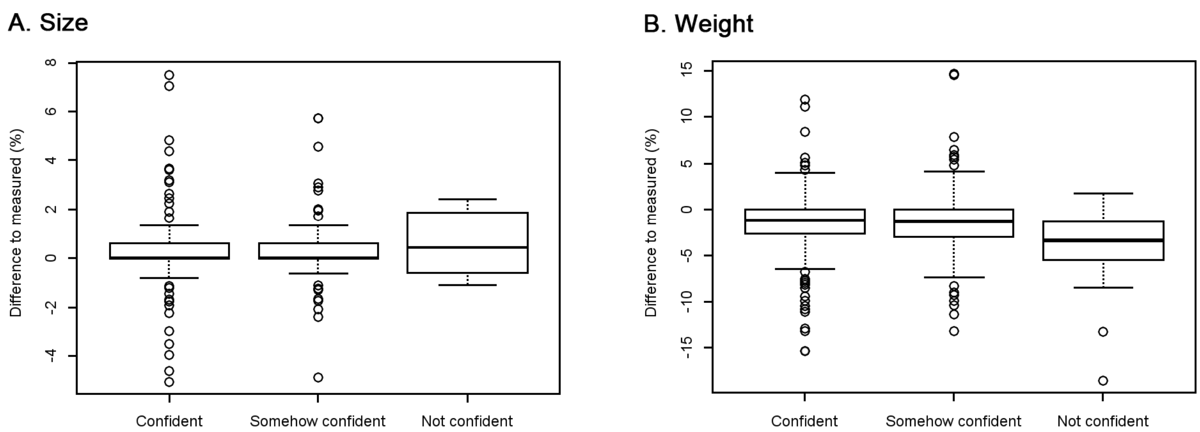

Figure 2: Grade of confidence in self reported size (A) and weight (B) compared to the difference of measured values (%).

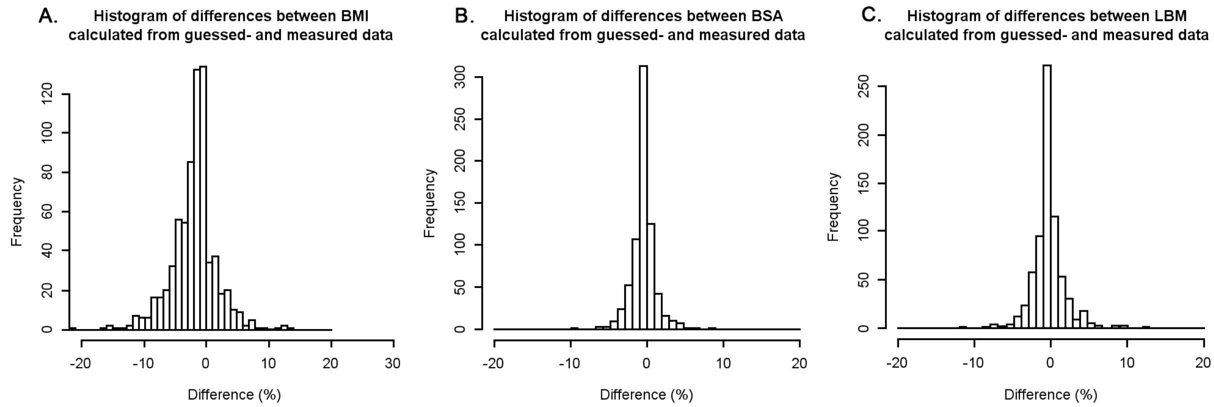

Figure 3: Histograms of differences between (A) BMI, (B) BSA and (C) LBM calculated from self-reported and measured values.

Table 1: Number of participants with self-reported weight and size, measured weight and size and the difference between both values, added by mean values and standard deviation. BMI, BSA and LBM calculated from self-reported and measured values, with mean values (M), standard deviation (SD) and difference between values.

	Number of participants	**Self-reported values (M;SD)**	**Measured values (M;SD)**	**Difference (%) (M;SD)**
Weight [kg]	Total (n=824)	78.9±17.7 (37.0-161.5)	80.3±18.3 (34.0-161.0)	-1.6±3.0 (-18.6-14.7)
	Female (n=490)	73.0±16.9 (37.0-135.0)	74.3±17.5 (34.0-135.0)	-1.6±2.9 (-15.4-14.7)
	Male (n=334)	87.5±15.2 (54.5-161.5)	88.9±15.9 (56.0-161.0)	-1.5±3.3 (-18.6-4.5)
Size [cm]	Total (n=713)	170.5±9.4 (146.0-196.0)	170.1±9.5 (146.0-196.0)	0.2±1.2 (-5.0-7.5)
	Female (n=413)	164.9±6.2 (146.0-186.0)	164.5±6.5 (146.0-186.0)	0.2±1.1 (-5.0-7.5)
	Male (n=300)	178.1±7.2 (158.0-196.0)	177.7±7.5 (156.0-196.0)	0.2±1.2 (-2.3-7.5)
BMI [kg/m^2]	n=713	27.1±5.4 (14.5-50.7)	27.6±5.7 (14.8-52.1)	-1.9±3.7 (-22.0-13.2)
BSA [m^2]	n=713	1.9±0.2 (1.3-2.7)	1.9±0.2 (1.2-2.7)	-0.5±1.6 (-9.1-8.3)
LBM [kg]	n=713	54.6±10.2 (31.7-82.7)	54.9±10.4 (28.9-84.0)	-0.3±2.2 (-11.2-12.3)

kg= kilograms, cm=centimetre, M=mean value, SD=standard deviation, BMI-body mass index, BSA-body surface area, LBM-lean body mass

Table 2: Differences between self-reported and measured weight and size of participants

	Differences of self-reported versus measured values in percentage (n/total)	
	≥5%	≥10%
Weight	11% (91/824)	2% (18/824)
Size	1% (5/713)	0% (0/713)
BMI	19% (132/713)	4% (25/713)
BSA	1% (10/713)	0% (0/713)
LBM	4% (28/713)	<1% (2/713)

BMI-body mass index, BSA-body surface area, LBM-lean body mass