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UFA AND FI - ANTHROPOMETRIC INDEXES OF PERIPHERAL OBESITY

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Cushing syndrome (CS) is characterized with extremely visceral obesity. The degree of obesity and body fat distribution in CS and non-CS were determined, as well as the upper arm fat area (UFA) and fat index (FI) by Frisancho AR, and their relationship with body fat compartments determined by the method of Mateigka, total fat mass (TFM), peripheral fat mass (PFM), the rest visceral mass (VM) and their percentages from the total body mass, TFM%, PFM% and VM%. Control group (C) with BMI (22.41±1.81 kg/m^2) was examined as well as 33 female CS with BMI (29.66±4.82kg/m^2) which were individually matched with 66 obese women (O) by their BMI (29.56±4.76 kg/m^2).

UFA was not significantly different between C (20.93±7.46 cm^2) and CS (23.94±8.69 cm^2), but it was significantly higher in O (34.1±10.65 cm^2). FI was not different between C (0.37±0.07) and CS (0.35±0.09), but it was significantly higher in O (0.42±0.05). UFA and FI correlated highly significantly with BMI in nonCS ($p<0.0001$). UFA correlated significantly positively with TFM, PFM and PFM% in CS and non-CS ($p<0.0001$), but significantly negatively with VM% in CS. FI correlated with TFM in O ($p<0.0001$), also significantly positively with PFM in CS ($p<0.001$), and in O ($p<0.0001$). FI correlated significantly positively with PFM% in CS and in O ($p<0.0001$). FI correlated significantly negatively with VM ($p<0.04$) and %VM in CS ($p<0.0001$). Conclusion: UFA and FI were significantly increased in obese, but not in Cushings, and correlated with the TFM, PFM and BMI confirming them as an indexes of the peripheral obesity, and indicators of the degree of obesity, but not as an indexes of body fat distribution.

Key words: Cushing, obese, upper-arm fat area, body adiposity

Determination of the lean and adipose tissue components of the upper arm is particularly useful in evaluation of the nutritional status of children and adults. The upper arm muscle area (UMA) is considered a good indicator of body muscle and hence of protein-energy reserves, and UFA is a good indicator of adiposity and thus of energy reserves (Frisancho, 1974; Sanna et al. 2001). UMA and UFA are good indicators of the nutritional, and thus health status, and are useful to evaluate the state of nutrition and possible situations of overweight and obesity (Buonomo et al. 1991; Kerruish et al. 1997). Matiegka J. in 1921, for the first time developed a series of formulas for prediction of the corporal composition from anthropometric measurements (Jović I sur. 1982; Perunović i sur 1982; Radivojević i sur. 1982).

Body Mass Index (BMI) is a reliable indicator of body fatness for people, and can be considered an alternative for direct measures of body fat. BMI is highly correlated with body weight (BW) independent of height as well as with body fat mass and its percentage of BW and is, therefore, a reasonably good index of the body energy stores as fat. Overweight and especially obesity are characterized by an excess of fat, and by using the BMI their nutritional status can be assessed.

The aim of this study was to calculate UFA and fat index (FI) using the formulae of Frisancho AR, and to determine their relationship to BMI and to the body fat compartments determined by the method of Mateigka, TFM, PFM, VM, and their percentages from the total body mass, in CS, O and C.

MATERIALS AND METHODS

Anthropometric measurements were performed in 33 consecutive patients with recently diagnosed CS, before surgical treatment, with BMI (29.66±4.82 kg/m^2), mean age (38.48±10 yr), and where compared to 33 nonobese healthy controls (C) with normal BMI (22.41±1.81 kg/m^2) and mean age (30.7±8.96 yr), as well as with 66 individually BMI and age-matched healthy obese controls (O), with a mean age (35.43±10 yr), and BMI (29.56±4.76 kg/m^2). The diagnosis of CS was clinically obvious in all cases, and was confirmed by objective tests. O and C had a stable weight for at least several months before performing the study. All subjects were weighed in the morning after an overnight fast. Measurements were performed by the author, in the Clinic of Endocrinology from 1990 to 2006 yr.

The following indices were assessed: body weight and height, BMI, body circumferences (C), diameters (D) and skinfolds thicknesses (SF). Body C were measured by plastic tape – Hoffmann La Roche. Small bone calliper, based on the sliding branch principle, was used for bone diameter measurements. The SF (mm) were measured to the nearest mm with a Lange skinfold calliper having a pressure of 10 g/mm^2 of contact surface area. Readings were made in triplicate and the results were averaged. Equipment was manufactured in California, USA. BMI was calculated as a ratio of BW and height (kg)/(m^2).

Anthropometric measurements taken according to the method of Mateigka were several skinfold thicknesses (biceps, forearm, thigh, leg, chest, and abdomen), body C (arm, forearm, thigh and leg) and joint diameters (elbow, knee, wrist, and ankle), body height (cm), body mass (kg). The measurements were used in Mateigka's equations. Absolute and relative muscular (M,M%), osseous (OS,OS%), total fat (TFM,TFM%) and peripheral fat mass (PFM,PFM%) components of the total corporal, body mass (BM) in all women were calculated by Mateigka's equations as an indirect anthropometric method (Perunović i sur. 1982; Jović i sur. 1982; Radivojević i sur. 1982). Each relative mass M%, OS%, TFM%, PFM% is a % of their absolute mass from the total BM. The rest mass, visceral mass (VM) was determined indirectly, as a difference of all these components M, OS and PFM from the total corporal mass. The rest mass, visceral mass is mainly dependent on the visceral fat mass, because visceral organ mass is almost constant for each BMI. Lean body mass (LBM) was a sum of M and OS. TFM was calculated by subtracting LBM from the total BM.

Anthropometric measurements taken according to the method of Frisancho equations were upper arm C (Ci) and right triceps SF (T), which were used for fat and muscle areas calculation. Ci was measured to the nearest cm, with the right arm hanging relaxed. T measurement was taken midway between the tip of the acromion and olecranon process, with the SF parallel to the longitudinal axis of the upper arm. UFA and FI were calculated from anthropometric measures according to Frisancho (Frisancho, 1981). Total upper arm area (TUA), UMA, and UFA were derived from measures of Ci converted to mm (c) and T also in mm according to Frisancho equation. TUA was calculated by the computation: TUA (mm^2) = $\pi/4 \times d^2$, where d= c/π. When d value was calculated TUA=$c^2/4\ \pi$. UMA was calculated by the computation as follows: UMA (mm^2) = $(c- \pi T)^2/4\ \pi$. UFA was derived as follows: UFA (mm^2) = TUA-UMA. In this study Ci and T were expressed in cm, and TUA, UMA and UFA in cm^2. FI was calculated as a ratio between UFA and TUA, FI=UFA/TUA.

Statistical analysis was performed with statistical program SPSS 11.0, by a linear correlation Pearson and Spearman's rang correlation, and for comparison of the mean values was used analysis of variance ANOVA, and nonparametric tests Kruskal Wallis and Mann Whitney – U test of inversion.

RESULTS

Absolute M was (26.61±5.05 kg) in CS, (31.5±6.57 kg) in O and (26.1±4.13 kg) in C. Absolute OS was (8.43±0.98 kg) in CS, (8.78±0.93 kg) in O and (8.38±0.99 kg) in C. LBM is a sum of M and OS mass. TFM was calculated by subtracting LBM from the total BM. BM was (72.26±10.7 kg) in CS, (76.07±11.62 kg) in O and (58.83±6.58 kg) in C. Absolute and relative TFM was (36.86±7.76 kg; 51±4.46 %) in CS, (35.59±7.03 kg; 46.41.±6.06 %) in O and (24.89±5.73 kg; 40±5.2 %) in C.

PFM and PFM% determined by Mateigka's equation were (19.27±6.04 kg; 26.19±6.09%) in CS, (27.32±5.86 kg; 35.45±5.43%) in O, and (17.86±5.89 kg; 28.93±6.39%) in C. VM was calculated by subtracting M, OS and PFM from BM. It was (18.06±4.89 kg; 25.05±6.04%) in CS, (8.27±3.45 kg; 10.96±4.24%) in O and (7.03±2.69kg; 11.83±4.39%) in C.

TUA values were (66.68±13.06 cm^2) in CS, (80.85±24 cm^2) in O and (56.09±15.55 cm^2) in C. UMA values were (42.75±13.41 cm^2) in CS, (46.75±14.92 cm^2) in O, and (35.17±10.26 cm^2) in C. UFA values were (23.94±8.69 cm^2) in CS, (34.1±10.65 cm^2) in O and (20.93±7.46 cm^2) in C. UFA was not significantly different between C and CS, but it was significantly higher in O compared to C and CS ($p<0.0001$). FI values (0.37±0.07) in C and (0.35±0.09) in CS were not significantly different between themselves, but FI was significantly higher in O (0.42±0.05) compared to C and CS ($p<0.0001$).

UFA and FI correlated highly significantly with BMI in non-CS ($p<0.0001$). UFA correlated significantly positively with BMI in CS ($p<0.012$), but FI didn't correlate with BMI in CS ($P>0.05$).

UFA correlated highly significantly positively with TFM, PFM and PFM% in non-CS ($p<0.0001$), and TFM% ($p<0.001$). UFA correlated with TFM ($p<0.008$) also with PFM and PFM% ($p<0.0001$) in CS, but it didn't correlate with TFM% ($p>0.05$). UFA didn't correlate with VM in CS and non-CS ($p>0.05$), but correlated negatively with %VM in non-CS ($p<0.001$), and in CS ($p<0.0001$).

FI correlated highly significantly positively with TFM, TFM%, PFM and PFM% in non-CS ($p<0.0001$), also with PFM and PFM% in CS ($p<0.001$), but not with TFM and TFM%. FI didn't correlate with VM in non-CS ($p>0.05$), and correlated negatively with VM in CS ($p<0.004$). FI correlated significantly negatively with VM% in non-CS ($p<0.017$), and in CS ($p<0.0001$). UMA and FI correlated highly significantly positively between themselves ($p<0.0001$).

DISCUSION

Arm muscular tissue and fat ring areas can be evaluated by anthropometric measures, estimate body adiposity and the maximal strength of upper limbs and trunk (Pompeu, 2004). Since the degree of outer fatness and the size of the muscle mass are indirect indicators of calorie and protein reserves, anthropometric evaluations of the upper limb, measurements of SF thickness and limb muscle size have become valuable in the assessment of the nutritional status of children and adults (Frisancho, 1971; Frisancho, 1981; Hernandez et al. 1994).

SF measurements are used to assess thickness of subcutaneous tissues, but used independently, however, they are of limited value because they fail to take into account change in muscle mass. But such measurements become more useful in combination with some other measurements like Ci to estimate total body fat, UMA and UFA. Use of SF, especially of T and arm fat area in assessment of nutritional status is based on the assumption that increased subcutaneous fat is resulting from either high calorie intake or low energy expenditure or reflect a greater calorie reserve (Kumar, 2004), which is important in obese (Reid et al. 1992).

Himes et al, in 1980 stressed how fat areas can help to understand change with age or with sex difference in adiposity. They have shown that fat areas may increase with age, and that the mean value of arm fat area ranges from 16.33 cm2 to 17.75 cm2 in females. The mean value of arm fat area is more in females than in males.

A number of techniques have been used to measure limb fat and muscle. The most widely adopted anthropometric method involves the measurement of SF thickness using callipers (Kerruish et al. 1997; Ohzeki et al. 1998). Measurements of UMA and UFA by computerized tomography (CT) correlated well with the composition of the upper arms measured by anthropometry and ultrasonography (Chiba et al. 1989). Also, impedance and anthropometric measurement of limb fat and muscle correlate well with CT cross-sections. CT of the limb can certainly provide the desired information on fat and muscle (Heymsfield et al. 1982), but the availability is limited, radiation dose must be considered and the cost is high, so that serial measurements to follow nutritional changes cannot usually be justified. Correlations between magnetic resonance imaging and UFA were significant in the control group and in the obese group (Rolland-Cachera et al. 1997).

In this study UFA correlated highly significantly positively with PFM and PFM% in non-CS, and in CS, but it didn't correlate with VM in non-CS and CS, that confirmes it as an indicator of the peripheral fat mass. UFA correlated significantly positively with TFM and TFM% in non-CS which is characterized with preponderant peripheral fat mass increase compared to CS. It didn't correlate with TFM% in CS, because TFM% increase is a result of visceral mass increase in CS, not peripheral fat mass increase. UFA correlated negatively with VM% in both groups, especially in CS. This also confirmes UFA as an indicator of peripheral not visceral fat.

FI correlated significantly positively with TFM, TFM%, PFM and PFM%, because they are dependent on the preponderant peripheral paf mass increase in non-CS. It didn't correlate with VM and correlated significantly negatively with VM% in non-CS, confirming that it is an index of peripheral, not visceral fat mass. It is well known fact that in obese there is a preponderant fat mass increase, but also there is an increase of the muscular and osseal mass. FI correlated significantly negatively with VM and VM% in CS, because it is not an indicator of the visceral fat mass. These data confirmed FI as an index of peripheral fat mass. UMA and FI correlated highly significantly positively between themselves that also confirmed them as an indexes of the peripheral fat mass. These results confirmed equations of Mateigka and Frisancho as a very useful alternative of direct measurements of body composition, and fat mass distribution.

Overweight and obese individuals are at increased risk for many diseases and health conditions. BMI is only one factor related to risk for disease. It is used as a screening tool to identify possible weight problems for adults that may lead to health problems. BMI has also been used as a simple anthropometric index that reflects the body's fat content and hence the body's energy stores. It has been proposed as a simple and valid measure for monitoring fatness. BMI is not a direct measure of body fatness, and it correlates to direct measures of body fat stores, obtained through reliable methods such as densitometry and underwater weighing. It is relatively inexpensive, easy to collect and to analyse. Anthropometric measurements especially BMI, provide simple, non-invasive methods to assess the nutritional status of populations.

UFA and FI correlated highly significantly positively with BMI in nonCS. UFA correlated less positively ($p<0.012$) with BMI in CS than in non-CS, but FI didn't correlate with BMI in CS, because BMI and TFM% increase in CS is result of visceral mass increase, not a result of PFM increase, that happens in O. These results confirmed UFA and FI as well as BMI as indexes of overall obesity.

The relationship between BMI and anthropometric measurements was evaluated by Gugelmin et al. in 2006, and high correlations were found between BMI and body mass, waist and Ci for both sexes. For women, fat arm area and total arm area were also highly correlated with BMI, while for men hip circumference and total arm area showed a high correlation with BMI. The results suggest that high BMI values are related to excess fat.

It can be concluded that UFA and FI were significantly increased in obese, but not in Cushings, and correlated with the TFM, PFM and BMI, confirming them as an indexes of the peripheral obesity, and indicators of the degree of obesity, but not as an indexes of visceral obesity and body fat distribution. UFA and FI were also an indicators only of the peripheral fat in CS. They can be useful in nutritional status assessment in simple peripheral obesity, but not in visceral obesity.

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UFA I FI – ANTROPOMETRIJSKI INDEKSI PERIFERNE GOJAZNOSTI

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Kušingov sindrom (engl.CS) se karakteriše ekstremnom visceralnom gojaznošću. U ovom radu su utvrđeni stepen gojaznosti i i distribucija masti kod osoba sa sindromom CS i kod osoba bez ovog sindroma bez-CS. Takođe je utvrđena masna komponenta nadlaktice (engl.UFA) i masni indeks (engl.FI) po Frisanku AR, i njihova veza sa delovima masne komponente koji su određeni metodom po Mateigki, totalna masna komponenta (engl.TFM), periferna masna komponenta (engl.PFM), ostatak visceralne masti (engl.VM) i njihovi procenti u totalnoj masi tela, TFM%, PFM% i VM%. Analizirana je kontrolna grupa (C) sa prosečnim BMI 22.41±1.81kg/m^2, kao i 33 žene sa sindromom (CS) (29.66±4.82 kg/m^2) i 66 gojaznih žena (O) čiji je BMI 29.56±4.76 kg/m^2. UFA se nije signifikantno razlikovao kod C (20.93±7.46cm^2) i CS (23.94±8.69cm^2), ali je značajno viši kod O (34.1±10.65cm^2). FI se nije razlikovao između C (0.37±0.07) i CS (0.35±0.09), ali je značajno viši kod O (0.42±0.05). UFA i FI su u značajnoj korelaciji sa BMI kod osoba bez sindroma bez-CS ($p < 0.0001$). UFA je u značajnoj pozitivnoj korelaciji sa TFM, PFM i PFM% kod CS i bez-CS ($p < 0.0001$), ali u značajnoj negativnoj korelaciji sa VM% kod CS. FI je u korelaciji sa TFM kod O ($p < 0.0001$), a takođe je u pozitivnoj korelaciji i sa PFM kod CS ($p < 0.001$), i kod O ($p < 0.0001$). FI značajno pozitivno korelira sa PFM% kod CS i kod O ($p < 0.0001$). FI je u značajnoj negativnoj korelaciji sa VM ($p < 0.04$) i %VM kod CS ($p < 0.0001$).

Zaključak: UFA i FI su značajno viši kod gojaznih, ali ne i kod osoba sa Kušing sindromom, i u korelaciji su sa TFM, PFM i BMI što ukazuje da oni predstavljaju indekse periferne gojaznosti, i indikatori su stepena gojaznosti, ali ne ukazuju na distribuciju masnog tkiva.

Ključne reči: Kušing, gojaznost, masna komponenta nadlaktice, telesna gojaznost.