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Original article

# Upper body subcutaneous adipose as a potential predictor for type 2 diabetes mellitus

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**Summary.** *Background/Aim:* Upper body skinfold measurements show association with type 2 diabetes mellitus (DM2). Precise predictive potential of the various points of the subcutaneous adipose tissue thickness in the upper body is not completely defined. The aim of this study was to examine the predictive potential of 4 subcutaneous fatty tissue spots (i.e., biceps, triceps, abdominal and subcapsular) regarding DM2 subjects diagnosed with disease before 60 years of age. *Methods:* Subcutaneous fatty tissue points were measured by a caliper in 108 subjects with DM2 who were diagnosed with the disease before the 60 years of age and compared with the same points of subcutaneous adipose tissue thickness of 112 control group subjects. *Results:* Skinfold measurments parameters were higher in DM2 subjects compared to controls (p <0,05). Female subjects with DM2 had significantly higher skinfold measurements (19,85±0,99 mm compared to 14,90 ± 0,61 mm, p <0,001 for Biceps and 29,09 ± 1,20 mm compared to controls, 22,00 ± 1,00 mm for Triceps). Abdominal and subscapular SAT measurements were higher in female DM2 group compared to controls 34,53 ± 0,99 mm compared to 27,72 ±1,08 mm and 33,53 ± 1,07 mm compared to 26,00 ± 1,18 mm with p <0,001, respectively, while no significant difference was found in male subjects (p >0,05). Upper body skinfold measurement values were found to be predictors for DM2 and they more significant in female subjects with OR values of 1,139 for biceps, 1,091 for triceps, 1,099 for abdominal and 1,088 for subscapular spot, while they were found to be less significant in male subjects (p >0,05). Body mass index and waist circumference were also shown to be significant predictors for DM2 in female subjects (p <0,05). *Conclusion:* Subcutaneous fatty tissue of the upper body has a great predictive potential when it comes to DM2, especially in women.

**Key words**: type 2 diabetes mellitus, subcutaneous fatty tissue, biceps, triceps, abdominal, subscapular

## Introduction

It is estimated that over 500 million people globally have type 2 diabetes mellitus (DM2), of which about 50% are undiagnosed (1). According to the data from 2017, the prevalence of diabetes in Montenegro is 57,900 people (12.9%) with a tendency to increase to 62.700 people (14.6%) - according to predictions for 2045 (2).

DM2 is a disease characterized by genetic, biochemical and anthropometric parameters (3, 4).

It has been proven subcutaneous fatty tissue has a separate effect on insulin resistance in this disease (5). A particular part of the pathogenic effect for the development of this disease is the exceeding of the maximum storage capacity of subcutaneous adipose in a variety of upper body spots, being one of the most important factors in the inflammatory effect of the adipocytes on insulin resistance (6). Studies have shown that increased thickness of the abdominal subcutaneous fat tissue, represent a very significant risk for the development of DM2 (7). Also, the waist circumference, subcapsular subcutaneous fatty tissue and total tree fat were also identified as risk factors for the development of this disease (8-9). Subscapular subcutaneous fatty tissue is often more pronounced, as opposed to subcutaneous fatty tissue of biceps and triceps that are often degraded in diabetics with a duration of more than 10 years, identifying these points as potential predictors of DM2 (8).

It has been established that there are differences in men and women in the metabolic function of fatty tissue (10). A study by Meisinger (2006) and the authors suggests that total and abdominal adiposity is strongly associated with the development of type 2 diabetes. Since there is a additive effect of total and abdominal obesity on risk prediction, researchers suggest that the waist circumference should be measured in addition to BMI to assess the risk of type 2 diabetes in both sexes. (11)

The aim of this study was to examine the predictive potential of 4 subcutaneous fatty tissue spots (i.e., biceps, triceps, abdominal and subcapsular) regarding the type 2 diabetes in subjects diagnosed with disease before 60 years of age.

## Materials and Methods

*Location and sampling*

Subjects were admitted to the Biochemical Department of the Primary Health Care Center in Podgorica (Montenegro) from December 2016 to April 2017 with consent to participate in the study and to complete the medical anamnesis. During the same day, anthropometric measurements and biochemical analyses were performed. The study was conducted according to the principle of case-control study. DM2 group (with a diagnosis of 60 years of age) was formed from 108 subjects (67 males and 41 females) and a control group of 112 subjects (30 males and 82 females).

The study was done with the approval of the Ethical Committee of the Primary Health Care Center and the Department of the Faculty of Natural Sciences and Mathematics in Podgorica. Each participant voluntarily provided written informed consent before participating.

*Criteria for inclusion and exclusion*

Criteria for the inclusion in the study were as follows: patients with DM2 diagnosed before 60 years of age. The American Diabetes Association standards ware used for the diagnosis of DM2 (12). Diabetes can be reported in its own way or defined after at least two elevated plasma glucose levels (glucose up to ≥7.0 mmol / L, random plasma glucose level ≥11.1 mmol / L, or plasma glucose level ≥11.1 mmol / L), 2 h after an oral glucose tolerance test), or glycated hemoglobin (HbA1c) ≥6.5%.

Exclusion criteria were: patients with type 1 diabetes mellitus, acute inflammatory diseases and elevated C-reactive protein (CRP) above 10 mg/L. Subjects with primary dyslipidemias were also excluded from the study.

In the control group there are patients with the same inclusion approach, except that they did not have DM2.

The anthropometric parameters in the study were waist circumference (cm), body height (cm), and body weight (kg) were obtained, and body mass index (BMI) was calculated (kg/m$^2$) and skinfold thicknesses were measured on four sites with a John Bull calliper (i.e., at biceps, triceps, iliac, and subscapular sites). Skinfold measurements were taken at the central part of the biceps brachii (biceps brachii subcutaneous adipose tissue - SAT), central part of triceps brachii (triceps brachii SAT), 5 cm to the left of the level of the abdomen (abdominal SAT) and lowest spot at the lower angle of scapula (subscapular SAT). Skinfold parameters at the measurement points are shown as the thickness of the subcutaneous adipose tissue (mm).

*Statistical analysis*

Student t-test was used for the comparison of the mean values of the parameters. The values are shown as the mean value ± standard error with the corresponding p values. Risk factors were analyzed through logistic regression models where the DM2 presence was taken as an independent variable in the subjects, while the dependent variables were incorporated into an adjusted model. The results are adjusted for age, sex and the percentage of smokers. Patients were additionally divided into male and female groups and further separate sex analysis performed. Potential predictors (biceps SAT, triceps SAT, abdominal

SAT, subscapular SAT, BMI and waist circumference) were analyzed through the obtained odds ratio, regression coefficients and Wald statistics with corresponding p values. The upper limit of statistical significance for p values was taken as 0.05. Statistical analysis was done in the IBM SPSS software package 21 for Windows 10.

## Results

Table 1. shows the results of descriptive statistics.

DM2 group had 56.32 ± 0.93 years compared to 53.12 ± 1.45 years in control group. Diabetes duration was 6.98 ± 0.68 years while diagnosis age was 49.3426 ± 0.74 set before the age of 60. Smoking percentages in control and DM2 groups were 27.70% and 30.60%. BMI and waist circumference were higher in DM2 group 30.3529 ± 0.52 cm (p=0.02*) and 107.3519 ± 1.27 cm (p<0.001*) compared to the 28.0049 ± 0.51 cm and 98.0536 ± 1.40 cm in the control group, respectively.

The results of skinfold measurments are shown in Table 2.

Female subjects were shown to have higher skinfold measurements compared to males in both DM2 and control groups. Biceps brachii SAT did not differ statistically between the groups even though it had higher mean in DM2 group compared to the controls (15.59 ± 0.64 mm and 14.58 ± 0.53 mm, p = 0.23). Triceps brachii SAT was very similar in both groups (20.60 ± 0.87 mm and 20.50 ± 1.11 mm with p value of 0.93). However, female subjects with DM2 had significantly higher parameters of skinfold measurements (19,85±0,99 mm compared to 14,90 ± 0,61 mm, p <0,001 for Biceps and 29,09 ± 1,20 mm compared to controls, 22,00 ± 1,00 mm for Triceps, p <0,001).

Abdominal SAT had much higher mean skinfold thickness in DM2 group compared to its controls (31.92 ± 0.80 mm and 28.85 ± 0.80 mm, p <0.01) which is also found in Subscapular SAT (30.44 ± 0.81 mm and 27.87 ± 0.93 mm, p <0.05), regarding the total sample. Separate analysis of the female and male subjects have shown that Subcutaneous adipose thickness measurements were statistically significant predictors only in females similary to previous analysis. Abdominal SAT was 34,53 ± 0,99 mm in female DM2 group compared to 27,72 ±1,08 mm, while Subscapular sat was 33,53 ± 1,07 mm compared to 26,00 ± 1,18 mm with o values p <0,001, showing statistically higher measurements compared to female controls.

Table 3. presents the results of the predictive analysis.

Logistic regression analysis revealed that all analyzed parameters we shown to be potential predictors

**Table 1.** Group descriptive statistics of control and diabetics group

| | | N | Mean | P |
|---|---|---|---|---|
| Years | Control | 112 | 53.12 ± 1.45 | 0.68 |
| | DM2 | 108 | 56.32 ± 0.93 | |
| Sex (m/f) | Control | 112 | 30/82 | / |
| | DM2 | 108 | 67/41 | |
| Diabetes duration (years) | Control | 112 | / | / |
| | DM2 | 108 | 6.98 ± 0.68 | |
| Diagnosis period (age) | Control | 112 | / | / |
| | DM2 | 108 | 49.3426 ± 0.74 | |
| Smoking (%) | Control | 112 | 27.70 | |
| | DM2 | 108 | 30.60 | |
| Body mass index (kg/m2) | Control | 112 | 28.0049 ± 0.51 | 0.02* |
| | DM2 | 108 | 30.3529 ± 0.52 | |
| Waist circumference (cm) | Control | 112 | 98.0536 ± 1.40 | <0.001* |
| | DM2 | 108 | 107.3519 ± 1.27 | |

Values are presented as means ± standard error or numbers/percentages. DM2-type 2 diabetes mellitus, N-number, statistically stignificant (*)*p<0,05, ** p<0,01,*** p<0,001

**Table 2.** Skinfold measurements of control and diabetics group

| | Mean Control (n=112) | SE | Mean DM2 (n=108) | SE | p |
|---|---|---|---|---|---|
| Biceps branchii SAT (mm) | 14,58 | 0,53 | 15,59 | 0,64 | 0,230 |
| Male | 11,93 | 1,06 | 12,86 | 0,66 | 0,445 |
| Female | 14,90 | 0,61 | 19,85 | 0,99 | <0,001*** |
| Triceps branchii SAT (mm) | 20,60 | 0,87 | 20,50 | 1,11 | 0,930 |
| Male | 14,90 | 1,40 | 15,15 | 0,83 | 0,873 |
| Female | 22,00 | 1,00 | 29,09 | 1,20 | <0,001*** |
| Abdominal SAT (mm) | 28,85 | 0,80 | 31,92 | 0,80 | <0,01** |
| Male | 28,00 | 1,46 | 30,37 | 1,11 | 0,221 |
| Female | 27,72 | 1,08 | 34,53 | 0,99 | <0,001*** |
| Subscapular SAT (mm) | 27,87 | 0,93 | 30,44 | 0,81 | <0,05* |
| Male | 29,56 | 1,73 | 28,56 | 1,07 | 0,611 |
| Female | 26,00 | 1,18 | 33,53 | 1,07 | <0,001*** |

Values are presented as means and standard errors of the mean. DM2 diabetes mellitus, N-number, statistically stignificant (*), SE-standard error, *p<0,05, ** p<0,01,*** p<0,001

**Table 3.** Logistic regression analysis of DM2 predictors

| N=220 | OR | 95% C.I.for OR | | |
|---|---|---|---|---|
| | | Lower | Upper | p |
| Biceps branchii SAT (mm) | $1{,}080_a$ | 1,025 | 1,138 | 0,004** |
| Male | $1{,}032_b$ | 0,950 | 1,120 | 0,456 |
| Female | $1{,}139_b$ | 1,057 | 1,227 | 0,001** |
| Triceps branchii SAT (mm) | $1{,}055_a$ | 1,016 | 1,096 | 0,006* |
| Male | $1{,}004_b$ | 0,944 | 1,069 | 0,892 |
| Female | $1{,}091_b$ | 1,037 | 1,149 | 0,001** |
| Abdominal SAT (mm) | $1{,}058_a$ | 1,020 | 1,098 | 0,002* |
| Male | $1{,}029_b$ | 0,979 | 1,082 | 0,254 |
| Female | $1{,}099_b$ | 1,038 | 1,164 | 0,001** |
| Subscapular SAT (mm) | $1{,}034_a$ | 1,001 | 1,068 | 0,040* |
| Male | $0{,}987_b$ | 0,939 | 1,036 | 0,591 |
| Female | $1{,}088_b$ | 1,035 | 1,145 | 0,001** |
| Body mass index (kg/m2) | $1{,}085_a$ | 1,027 | 1,148 | 0,004* |
| Male | $1{,}017_b$ | 0,926 | 1,116 | 0,725 |
| Female | $1{,}139_b$ | 1,057 | 1,228 | 0,001** |
| Waist circumference (cm) | $1{,}041_a$ | 1,017 | 1,064 | 0,001* |
| Male | $1{,}011_b$ | 0,977 | 1,045 | 0,528 |
| Female | $1{,}075_b$ | 1,038 | 1,113 | <0,001** |

Values are presented as Wald statistic, odds ratio and confidence interval. DM2-type 2 diabetes mellitus, N-number, statistically significant (*), SAT – subcutaneous adipose tissue, OR-odds ratio, C.I.-confidence interval, *p<0,05, ** p<0,01,*** p<0,001, a –adjusted for age, sex and percentage of smokers, b-adjusted for age

for DM2. Higher subcutaneous fat tissue measurement predicted increased probabilities the disease in all 4 spots showing probability increase per milimeter increase in the regression, OR=1,08 (biceps), 1,055 (triceps), 1,058 (abdominal), and 1,034 (subscapular) regarding the total sample adjusted for age, sex and percentage of smokers. Similar results were attained regarding the body mass index that predicted higher probability for DM2 with OR of 1,085 per kg/m$^2$ unit increase as was the OR related to waist circumference (OR=1,041 per 1 cm increase). When male and female subjects were analysed separately analysis have shown that there is a difference regarding these potential risk factors for DM2. Odds ratios values show that the OR values are insignificant in men showing less predictive potential ($p > 0,05$). In female subjects OR values were significant and higher than those in total sample OR=1,139 (biceps), 1,091 (triceps), 1,099 (abdominal), and 1,088 (subscapular), ($p < 0,001$). Results were similar regarding the predictor potential of body mass index and waist circumference with significant ($p < 0,001$) OR values of 1,139 and 1,075 showing higher probability for DM2 regarding the unit increase in females, respectively, while no significant predictor potential was found in men ($p > 0,05$).

## Discussion

This study demonstrates a highly diversified predictive potential of skinfold measures of subcutaneous adipose tissue for DM2. The concept of association of subcutaneous adipose tissue with diabetes has already been found in various studies (5,13-17), which is in agreement with the results of this study, especially in line with the fact that the results have shown stronger predictive potential in female subjects. The results of previous study (18) have shown that the accumulation of fat in the deposits of the subcutaneous fatty tissue of the lower body is associated with a lower likelihood of IR and DM2 than when deposited at centrally located locations. Lower peripheral fat in the body can be used to alleviate the effect of excess energy intake, and central body fat can be involved in the pathogenesis of insulin resistance and DM2. This effect was independent of the overall adiposity in men and women and regardless of the volume of waist in men.

However, the great influence of age on distribution of adipose tissue, as well as the progression of the disease itself, has a significant effect on quite ambiguous results, especially when the predictive potentials of the subcutaneous adipose tissue at the level of Biceps brachii and Triceps brachii for DM2 are questionable. Studies have shown that the subcutaneous adipose tissue in the peripheral parts of the body actually decreases in diabetic patients with high temporal progression of the disease, which is under the great influence of age (8, 19). The current study was performed in regards of reducing the impact of age on results, according to which the pattern is limited to diabetics whose illness was diagnosed prior to the age of 60.

All 4 spots of the analyzed subcutaneous adipose tissue in the study have been shown to be significant potential predictors for DM2, which in particular derives its significance by taking into account analyses that have shown that the intervention of reducing subcutaneous adipose in those places on the body has a significant effect on morning glucose and glycated hemoglobin in patients who were not on therapy (20).

The extent of the waist and abdominal subcutaneous adipose tissue were strong predictors of disease, which is in accordance with previous studies that have a particularly important role in the development of DM2 especially when it comes to abdominal adipose tissue (6, 9). Although the thickness of the subcutaneous adipose tissue was only higher in the abdominal and subscapular levels, after adjusting for age, sex and percentage of smokers, the subcutaneous adipose tissue of biceps and triceps were also singled out as potential predictors. The study showed a strong predictor potential of subcutaneous adipose tissue at the biceps brachii spot which is in agreement with the earlier generalized study (21). A special aspect of the importance of the current result is highlighted by Wald statistics for the predictor potential of biceps subcutaneous fatty tissue thickness that is greater than the predictor potential BMI.

Subcutaneous fatty tissue thickness at Triceps brachii and Subscapular levels also showed a predictor potential that is consistent with a number of earlier studies (9), but lower in relation to the subcutaneous fatty tissue at the level of the abdomen and biceps and more significant in female subjects. Subcutaneous fatty tissue thickness at the levels of biceps, triceps, subscapular and abdominal level showed strong predictor potential for DM2 (22), as was shown in the current study. Since the abdominal adipose tissue with the waist circumference is clearly a predictor through almost all studies (7), the special significance of the results implies a large predictor potential of the subcutaneous fatty tissue at the level of biceps, which is not always circulating in other studies depending on the degree development of the disease. Subcutaneous fatty tissue thickness at the level of Biceps brachii but also Triceps brachii could thus be identified as a predictor of disease progression and age of diabetics, which could give them even greater predictive potential.

The limitations of the current study were reflected in the number of subjects, the inability to form larger groups of diabetics with a characteristic duration of diabetes and years of diagnosis.

The increasing knowledge about body fat distribution and its modifiers may lead to the development of more effective treatment strategies for people with/or at high risk for DM2 and coronary artery disease. These accumulating observations also urge our need for a new definition of obesity based on the anatomical location of fat rather than on its volume, especially when cardiometabolic risk is considered (23,24).

More structured studies are needed on a larger number of subjects to further investigate the predictor potential of the various skinfold points when it comes to subcutaneous adipose tissue and its relation to DM2.

## Conclusion

Subcutaneous fatty tissue of the upper body has a large prediction potential when it comes to DM2, where abdominal, biceps, triceps and subscapular spots have shown a strong predictive value. Centralization of fatty tissue in the region of abdomen is the most important risk factor for DM2, while subcutaneous fatty tissue thickness (skinfold caliper measurements) of biceps and triceps remain statistically significant predictors. Subcutaneous fat tissue measurements of the upper body are stronger predictors of DM2 in female subjects.

## Statement on conflict of interests

The authors of the paper claim that the manuscript has not been published elsewhere as a whole or partly. We agree with the content of the manuscript and approve about its publication in Progress in Nutrition. Researching has been approved by institutional ethics committee. These are no financial problems that might lead to a conflict of interest. The authors declare no conflicts of interest.

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