PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 13 (7): 415-421, 2014
ISSN 1680-5194

Effect of Crispy Arrowroot Flake on Waist Circumference, Fasting Glucose and Free Fatty Acid in Type 2 Diabetes Patients

Sunarti[1], Rio Jati Kusuma[2], Dianandha Septiana Rubi[2] and Hemi Sinorita[3]
[1]Department of Biochemistry, Faculty of Medicine, Universitas Gadjah Mada, Yogyakarta, Indonesia
[2]Department of Health and Nutrition, Faculty of Medicine, Universitas Gadjah Mada, Yogyakarta, Indonesia
[3]Department of Internal Medicine, Dr. Sardjito Hospital, Division of Endocrinology, Yogyakarta, Indonesia

Abstract: In type 2 diabetes mellitus, waist circumference was associated with increase of plasma free fatty acid and improvement in insulin resistance. Crispy arrowroot flake contain high fiber content and has a low glycemic index value which is expected to lower waist circumference through lipolysis. This study was conducted to determine the effect of the crispy arrowroot flake on waist circumference and plasma free fatty acid in type 2 diabetes mellitus. A quasi-experimental study was conducted on 30 type 2 diabetic patients who regularly visited endocrine clinic of RSUP Dr. Sardjito Yogyakarta. The criteria's participants are age 35-60 years, fasting blood glucose $\geq$ 126 mg / dL and they aren't smoking, pregnant, lactating and hypertension. The 7 grams of flake was given 3 times per day for 8 weeks. Waist circumference and blood free fatty acid were measured before and after 8 weeks intervention. Consuming of the flake can reduce waist circumference and increase free fatty acid. Waist circumference was lower in men (86.35±6.78 vs 85.30±6.38, p = 0.453) than in women (84.74±8.92 vs 83.76±7.81, p = 0.176). Free fatty acid was found increase in men (0.29±0.512 vs 0.633±0.26, p = 0.231), whereas no change was observed in women (0.837±0.26 vs 0.834±0.32, p = 0.962). Consumption of the crispy arrowroot flake can reduce waist circumference that is more amount in men than in women type 2 diabetes. Increased of free fatty acid only found in men.

Key words: Crispy arrowroot flake, waist circumference, free fatty acids, type 2 diabetes

INTRODUCTION

Type 2 diabetes mellitus is a metabolic disorder that is characterized by the presence of chronic hyperglycemia due to interference in the metabolism of carbohydrates, fats and proteins in which cause a disturbance in insulin secretion, insulin activity or both (WHO, 1999; ADA, 2005; Mullugeta *et al*., 2012). Insulin resistance is found in the majority of type 2 diabetes mellitus patients (Reaven, 2005). Bonora *et al*. (1998) reported that 84% of patients with diabetes mellitus type 2 were insulin resistance. Kumar *et al*. (2005) reported that 37% type 2 diabetes mellitus patients were insulin resistance.

Insulin resistance is an important factor which trigger lipolysis in adipocyte tissue, cause an increase in blood free fatty acid of type 2 diabetes mellitus patients (Hennes *et al*., 1996; Barker *et al*., 1993). Lipolysis is the breakdown of triglyceride intramyocellular that lead to increased free fatty acid and diacylglycerol levels in intracellular due to decreased glucose utilization in skeletal muscle (Lim *et al*., 2011). Increased lipolysis in type 2 diabetes mellitus is caused by an increase in the activity of the triglyceride lipase enzyme in adipocyte tissue due to chronic hyperglycemia (Krentz, 2003; Schoenborn *et al*., 2006). Increased activity of the enzyme is affected by fasting or starvation conditions and weakening of insulin activity in adipocyte tissue (Kershaw *et al*., 2006; Chakrabarti and Kandror, 2011).

Centralization of body fat is one of the major caused of insulin resistance (Goedecke *et al*., 2013), especially excess in visceral adipose tissue (VAT) (Fox *et al*., 2007; Sandeep *et al*., 2010; Preis *et al*. 2010). The plausible mechanism linking insulin resistance and VAT is released of non esterified fatty acid (NEFA) from VAT depots (Frayn, 2000). Based on portal vein hypothesis, free fatty acid, as a product of lipolysis will enter into liver through portal vein and cause increased lipid synthesis, gluconeogenesis and insulin resistance (Patel and Abate, 2013). The excessive amount of free fatty acids may lead to peripheral insulin resistance through inhibition of muscle glucose uptake (Garg, 2004).

The waist circumference is a better predictor to measurement intra abdominal adipose tissue (visceral fat) and also a good predictor insulin sensitivity. The waist circumference will provide information about body shape and also reflect both subcutaneous abdominal adipose tissue and intra abdominal adipose tissue volumes (Klein *et al*., 2007; Wahrenberg *et al*., 2005). Increased the waist size has been identified as an important risk factor in the development of insulin resistance in obese individuals (Gautier *et al*., 2010; Gill *et al*., 2011; Zadeh-Vakili *et al*., 2011). According to Despres *et al*. (2008), Frayn (2000), Donohoe (2011)

Corresponding Author: Sunarti, Department of Biochemistry, Faculty of Medicine, Universitas Gadjah Mada, Yogyakarta, Indonesia

excessive intra abdominal fat (visceral fat) is as predictor of insulin resistance, thus individuals who have marked increased in visceral fat are at higher risk of insulin resistance. Visceral fat is a metabolically active organ compared to periperhal subcutaneous organ (Nesto, 2005; Donohoe, 2011). The higher rates of lipolysis in visceral fat can be caused by the action of dysregulating lipolysis hormones, insulin and catecholamines. The lipolytic effect of catecholamines are demonstrated clearly, whereas antilipolytic insulin effect is weaker in visceral compared subcutaneous adipose tissue (Wajchenberg, 2000). Thus, there are risk of developing to insulin resistance related to visceral fat deposit in the body (Donohoe, 2011).

Several studies showed that consumption of foods with low glycemic index and high in fiber can lower the waist circumference, improve glycemic control, reduce blood pressure, improve insulin control, prevent the formation of free fatty acids in the blood as a result of lipolysis and prevent dyslipidemia in patients with type 2 diabetes mellitus (Opperman *et al*., 2004; Radulian *et al*., 2009; Du *et al*., 2010; Du *et al*., 2011; Kirpitch and Maryniuk, 2011; Brooking *et al*., 2012; Kaczmarczyk *et al*., 2012). The crispy arrowroot flake is food with a low glycemic index values with dietary fiber content of 80%. Therefore, the purpose of this study was to determine the effect of the crispy arrowroot flake on the waist circumference and plasma free fatty acids in patients with type 2 diabetes.

MATERIALS AND METHODS

Research design and subjects: Quasi experimental study was used in this study. We studied 10 men and 20 women with type 2 diabetes who come for routine check up at endocrinology clinic, general hospital Dr. Sardjito, Yogyakarta. The protocol study was approved by medical and health research ethics committee Faculty of Medicine Universitas Gadjah Mada and each patient signed informed consent. The Inclusion criterias were, men and women patients who have fasting blood glucose level $\geq$ 126 mg/dL and the age between 35-60 years of age. While the exclusion criterias are patients with blood pressure >160 mmHg, smoking, pregnant and breast-feeding.

Protocol of study: Subject who had signed informed consent and agreed to follow this study, then given education from nutritionist, so that they could estimate their daily food consumption of approximately 1500 Kcal of energy. The body weight, height and the waist circumference were measured before and after administration of the crispy arrowroot flake. The body weight was measured using digital scales (Camry) with accuracy of 0.00. The height was measured using microtoise at Frankurt position. While the waist circumference was measured using a tape measure. Anthropometric measurement was carried out by trained technicians according to standard procedures.

Blood sampling for measurement of fatty acid level was done after subject fasted at least 8 h. After blood sampling, subjects started consuming the crispy arrowroot flake as much as 21 g/day. The consumption of the crispy arrowroot flake were divided into 3 times, each consumption consist of 7 grams for 8 weeks. Level of subject compliances were measured using questionnaire. If subjects suffered gastrointestinal disorders due to consuming the crispy arrowroot flake, the consumption were stopped and subjects were stated as dropped out. Analysis of the plasma free fatty acids level was performed using enzymatic method (ELISA) kits (Randox, UK).

Statistical analysis: Free fatty acids level and the waist circumference were analyzed using paired t test. Correlation analysis was used to determine relationship between variables. Values were given as means±SE. Differences at $p<0.05$ were considered significant.

RESULTS

This study was followed by 30 subjects which consist of 10 men and 20 women. Most of subjects were obese. General characteristics of the subject are given in Table 1.

After consuming the crispy arrowroot flake three times a day as much as 7 grams for 8 weeks, we found increased the plasma free fatty acid, while the body weight and the waist circumference were found to be decreased though changes in the three variables were not statistically different (Table 2).

This study showed that the decreased in the body weight in women's group was higher compared to men's group although not significantly different ($p = 0.825$). Decreased in the waist circumference in men's group was higher compared to women's group although not significantly different ($p = 0.453$). Before treatment of the crispy arrowroot flake, women's group have higher the plasma free fatty acid level than men's group. However, after

Table 1: Characteristics of the subject

Variables	Mean±SE
Gender	
Male (n = 10; 33%)	-
Female (n = 20;67%)	-
Old (year)	56.00±9.40
BMI	
Normal (n = 7; 23%)	25.96±3.98
Overweight (n = 6; 20%)	-
Obese (n = 17;57%)	-
Food Intake	
Energy	1395.07±79.88
Protein	47.04±3.18
Lipid	47.26±3.78
Carbohydrate	194.68±11.02
Fiber	10.99±0.83

Table 2: Effect of consuming the crispy arrowroot flake for 8 weeks on blood free fatty acids level, the body weight and the waist circumference of type 2 diabetes patients

Variables	Pre test	Post test	95% CI	p
Free fatty acid	0.76±0.05	0.77±0.06	-0.09-0.11	0.819
Body Weight	62.55±1.95	62.23±1.90	-0.50-0.96	0.531
Waist circumference	84.35±1.35	83.52±1.27	-0.34-2.34	0.139

*Data shown in mean±SE, p<0.05

Table 3: Effect of consumption of the crispy arrowroot flake on the body weight, the waist circumference and plasma free fatty acids in subject based on gender

	Women			Men		
Variables	Pre test	Post test	p	Pre test	Post test	p
Body weight	62.38±10.44	61.74±10.11	0.488	66.19±8.45	66.00±9.10	0.825
Waist circumference	84.74±8.92	83.76±7.81	0.176	86.35±6.78	85.30±6.38	0.453
Plasma free fatty acids	0.837±0.26	0.834±0.32	0.962	0.512±0.29	0.633±0.26	0.231

Table 4: Correlation and changes between variable after 8 weeks consuming the crispy arrowroot flake (post test)

Variables	Coefficient	p
Body weigh-waist circumference (post test)	0.769	0.000*
Body weight-free fatty acids (post test)	-0.069	0.719
Waist circumference-free fatty acids (post test)	0.131	0.500
Body weight-waist circumference (delta)	0.440	0.015*
Body weight-free fatty acids (delta)	0.144	0.448
Waist circumference-free fatty acids (delta)	-0.013	0.947

Based on spearman correlation test

*Significant at p<0.05

consuming the crispy arrowroot flake, the plasma free fatty acid level in men's group was increased but in women's group was relatively stable (Table 3).

Spearman correlation test suggested that after consuming the crispy arrowroot flake, the plasma free fatty acids level weakly correlated to the body weight and the waist circumference, while the body weight and the waist circumference are strongly correlated. Furthermore, the result of correlation by considering changes of the body weight, the waist circumference and the plasma free fatty acid level showed that the body weight positively correlated with the plasma free fatty acids level, but this correlation was weak. The waist circumference negatively and weakly correlated to the plasma free fatty acids level, however the body weight positively and strongly correlated to the waist circumference (Table 4).

DISCUSSION

Visceral adipose tissue (VAT) may increase metabolic activity, both lipolysis and lipogenesis. Based on portal vein hypothesis, increased the plasma free fatty acid, as a product of lipolysis will enter into liver through portal vein and cause increased in lipid synthesis and gluconeogenesis. Moreover, increased the plasma free fatty acid flux also lead to insulin resistance through decreased insulin-stimulated glucose uptake (primarily in skeletal muscle) (Patel and Abate, 2013; Wajchenberg, 2000; Garg, 2004). According to Lebovitz and Banereji (2005), VAT is related to insulin resistance in type 2 diabetes. Fox *et al.* (2007) has reported that higher amount of hepatic free fatty acids produced from VAT lipolysis in women presumed to correlated in fat distribution between women and men. In addition, Fox *et al.* (2007) also reported that VAT remain more strongly correlated with metabolic risk factor than subcutaneous adipose tissue (SAT).

Body fat distribution is also important risk factor for diseases related to obesity. Excess of abdominal fat can increase risk of cardiometabolic disease, including type 2 diabetes, stroke, hypertension and cardiovascular diseases. The waist circumference usually used as a fat abdominal mass marker, because the waist circumference has a correlation with abdominal fat mass (subcutaneous and intra abdominal) and cardiometabolic disease risk (Ali and Crowther, 2005; Klein *et al.*, 2007). In addition, the waist circumference is a good predictor of insulin sensitivity, both women and men with the waist circumference <100 cm were not included in group of insulin resistance (Wahrenberg *et al.*, 2005).

Gender affects body fat distribution, women commonly have greater percentage of body fat compared to men (Blaak, 2001). In healthy subjects, average range of percentage body fat was 10-15% in men and 20-30% in women (Veilleux and Tchernof, 2012). A greater amounts of subcutaneous fat was found in women, whereas a greater amount of visceral fat was found in men (Nedungadi and Clegg, 2009). The cause of differences of body fat distribution is uncertain, though differences in concentration of enzymes, hormones and hormone receptors between women and men play a role (Vella and Kravitz, 2002).

In recent study, consuming the crispy arrowroot flake three times a day for 8 weeks can reduce the body weight and the waist circumference although not

statistically different (p_{BW} = 0.521 and p_{WC} = 0.134). This reduction may be caused by fiber content in the crispy arrowroot flake that is about 80%. Reducing the body weight in women more than in men, the average of the weight reduction in all subjects were 0.51%, whereas in women were 1.03% and in men were 0.29%. Although it was not statistically different, however, according to Williamson *et al.* (2000), Fujioka (2010), The Look Ahead Research Group (2010) and Wing *et al.* (2011), reduction of the body weight in the diabetes mellitus patients who are overweight or obesity as much as 0.4-5% may decrease 0.5% HbA1c level, systolic and diastolic blood pressure (both about 5 mmHg), triglycerides level 40 mg/dL and reduce mortality. The reduction of the body weight also increase HDL level about 5 mg/dL.

The differences in the body weight reduction between women and men, in this study is accordance with Romaguera *et al.* (2011) who reported that increase in fiber consumption may reduce the body weight significantly in women but not in men. Du *et al.* (2010) also reported that fiber consumption in women are more beneficial in the weight reduction compared to men. The weight reduction in men are more influenced by physical activity, whereas in women physical activity had no effect (Mozafarian *et al.*, 2011). Increased in dietary fiber consumption has been known to slow down digestion and maintain stability of glucose level, give longer satiety effect and also lower energy intake (Chandalia *et al.*, 2000; Isaksson *et al.*, 2009).

Consuming the crispy arrowroot flake may reduce the waist circumference as much as 0.98% but not statistically different. The average reduction of the waist circumference in men (1.22%) is more higher than in women (1.16%). This finding is accordance with Evans *et al.* (2012) who reported that men is more effective decreasing abdominal fat mass than women. Another study has shown that men tend to loss abdominal fat mass than women, while in women tend to loss femoral fat mass (Mauriege *et al.*, 1999; Janssen *et al.*, 2002). Weyers *et al.* (2002) reported that men will loss their fat mass 2.7 more times than women. Volek *et al.* (2004) and Evans *et al.* (2012) also reported that men tend to loss abdominal fat than women, when got low-carbohydrate and low-lipid diet or high-protein diet. This difference is related to energy metabolism and steroid hormone between women and men (Wu and O'Sullivan, 2011; Karastergiou *et al.*, 2012).

In this study, we found that the body weight positively and significantly correlated with the waist circumference (p = 0.000). This result indicate that reduction of the body weight will be followed by reduction of the waist circumference (Brenner *et al.*, 2010). Miyatake *et al.* (2007a) reported that reduction of the body weight as much as 3 kg will be followed by decreased the waist circumference as much as 3.45 cm in men and 2.83 cm in women. The decreased the waist circumference as much as 3 cm in men with obesity has been known to reduce the blood pressure and triglycerides level, and also increase HDL level in subject with central obesity (Miyatake *et al.*, 2007 b).

After consuming the crispy arrowroot flake, level of the plasma free fatty acid was found increased as much as 1.32% though not statistically different. Increased the plasma free fatty acid level only observed in men (23.63%), while in women the plasma free fatty acids level were relatively similar before and after consuming the crispy arrowroot flake (Table 3). Increased the plasma free fatty acid level in men is caused by oxidation of triglycerides, which occur more frequent in men than in women. Santosa *et al.* (2008) has reported that oxidation of triglyceride occur more frequent in obese men than in women after treatment for the body weight reduction though it's not statistically different. Moreover, this study found that the body weight and the waist circumference were negatively correlated with the plasma free fatty acids level. These result are consistent with the findings of Nestel and Whyte (1968), Mittendorfer *et al.* (2009) and McQuaid *et al.* (2011), who reported that negatively correlation between the blood free fatty acid level with body fat mass. This result indicated that reduction of the body weight and the waist circumference, or the body fat mass will increase the blood fatty acid level.

Conclusion: We conclude that type 2 diabetes mellitus patients who consume the crispy arrowroot flake can reduce the waist circumference more amount in men than in women. The plasma free fatty acid was found increased in men, whereas no change in women.

REFERENCES

Ali, A.T. and N.J. Crowther, 2005. Body fat distribution and insulin resistance. South Afr. Med. J., 95: 1-3.

American Diabetes Association, 2005. Diagnosis and Classification of Diabetes Mellitus. Diabetes Care, 28: 37-42.

Keswell, D., 2013. The Role of Adipose Tissue in Insulin Resistance in Women of African Ancestry. J. Obesity, 2013: 1-9.

Barker, D.J., C.N. Hales, C.H. Fall, C. Osmond, K. Phipps and P.M. Clark, 1993. Type 2 (non-insulin-dependent) diabetes mellitus, hypertension and hyperlipidaemia (syndrome X): relation to reduced fetal growth. Diabetologia, 36: 62-67.

Blaak, E., 2001. Gender differences in fat metabolism. Curr. Opin. Clin. Nutr. Metab. Care, 4: 499-502.

Bonora, E., S. Kiechl, J. Willeit, F. Oberhollenzer, G. Egger, G. Targher, M. Alberiche, R.C. Bonadonna and M. Muggeo, 1998. Prevalence of insulin resistance in metabolic disoreders: the Bruneck Study, Diabetes, 47: 1643-1649.

Brenner, D.R., K. Tepylo, K.M. Eny, L.E. Cahill and El-A. Sohemy, 2010. Comparison of body mass index and waist circumference as predictors of cardiometabolic health in a population of young Canadian adults. Diabetol Metab. Syndr, 2: 28.

Brooking, L.A., S.M. Williams and J.I. Mann, 2012. Effects of macronutrient composition of the diet on body fat in indigenous people at high risk of type 2 diabetes. Diabetes Res. Clin. Pract., 96: 40-46.

Chakrabarti, P. and K.V. Kandror, 2011. Adipose triglyceride lipase: a new target in the regulation of lipolysis by insulin. Curr. Diabetes Rev., 7: 270-277.

Chandalia, M., A. Garg, D. Lutjohann, von K. Bergmann, S.M. Grundy and L.J. Brinkley, 2000. Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. N. Engl. J. Med., 342: 1392-1398.

Despres, J.P., I. Lemieux, J. Bergeron, P. Pibarot, P. Mathieu, E. Larose, J. Rodes-Cabau, O.F. Bertrand and P. Poirier. 2008. Abdominal obesity and the metabolic syndrome: contribution to global cardiometabolic risk. Arterioscler Thromb. Vasc. Biol., 28: 1039-1049.

Donohoe, C.L., S.L. Doyle and J.V. Reynolds, 2011. Visceral adiposity, insulin resistance and cancer risk. Diabetol. Metab. Syndr, 3: 1-13.

Du, H., van A.D.L. der, van M.M. Bakel, N. Slimani, N.G. Forouhi, N.J. Wareham, J. Halkjaer, A. Tjonneland, M.U. Jakobsen, K. Overvad, M.B. Schulze, B. Buijsse, H. Boeing, D. Palli, G. Masala, T.I. Sorensen, W.H. Saris and E.J. Feskens, 2010. Dietary glycaemic index, glycaemic load and subsequent changes of weight and waist circumference in European men and women. Int. J. Obes., 33: 1280-1288.

Du, H.W., J.Y. Li and Y. He, 2011. Glycemic and blood pressure control in older patients with hypertension and diabetes: association with carotid atherosclerosis. J. Geriatr Cardiol., 8: 24-30.

Evans, E.M., M.C. Mojtahedi, M.P. Thorpe, R.J. Valentine, P.M. Kris-Etherton and D.K. Layman, 2012. Effects of protein intake and gender on body composition changes: a randomized clinical weight loss trial. Nutr. Metab., 9: 1-9.

Fox, C.S., J.M. Massaro, U. Hoffmann, K.M. Pou, P. Maurovich-Horvat, C.Y. Liu, R.S. Vasan, J.M. Murabito, J.B. Meigs, L.A. Cupples, R.B. D'Agostino Sr and C.J. O'Donnell, 2007. Abdominal visceral and subcutaneous adipose tissue compartments: association with metabolic risk factors in the Framingham Heart Study. Circulation, 116: 39-48.

Frayn, K.N., 2000. Visceral fat and insulin resistance-causative or correlative. Br. J. Nutr., 83: 71-77.

Fujioka, K., 2010. Benefits of moderate weight loss in patients with type 2 diabetes. Diabetes Obes. Metab., 12: 186-194.

Garg, A., 2004. Regional Adiposity and Insulin Resistance. J. Clin. Endocrinol. Metab., 89: 4206-4210.

Gautier, A., R. Roussel, P.H. Ducluzeau, C. Lange, S. Vol, B. Balkau and F. Bonnet, 2010. The DESIR Study Group. Increases in Waist Circumference and Weight as Predictors of Type 2 Diabetes in Individuals With Impaired Fasting Glucose: Influence of Baseline BMI. Diabetes Care, 33: 1850-1852.

Gill, J.M.R., R. Bhopal, A. Douglas, S. Wallia, R. Bhopal, A. Sheikh, J.F. Forbes, J. McKnight, N. Sattar, G. Murray, M.E.J. Lean and S.H. Wild, 2011. Sitting Time and Waist Circumference Are Associated With Glycemia in U.K. South Asians. Diabetes Care, 34: 1214-1218.

Goedecke , J.H., N.S. Levitt, J. Evans, N. Ellman, D.J. Hume, L. Kotze, M. Tootla, H. Victor and D. Keswell, 2013. The Role of Adipose Tissue in Insulin Resistance in Women of African Ancestry. J. Obes., 1-10

Hennes, M.M., I.M. O'Shaughnessy, T.M. Kelly, P. LaBelle, B.M. Egan and A.H. Kissebah, 1996. Insulin-resistant lipolysis in abdominally obese hypertensive individuals. Role of the renin-angiotensin system. Hypertension, 28: 120-126.

Isaksson, H., H. Fredriksson, R. Andersson, J. Olsson and P. Aman, 2009. Effect of rye bread breakfasts on subjective hunger and satiety: a randomized controlled trial. Nutr. J., 8: 1-8.

Janssen, I., A. Fortier, R. Hudson and R. Ross, 2002. Effects of an energy-restrictive diet with or without exercise on abdominal fat, intermuscular fat and metabolic risk factors in obese women. Diabetes Care, 25: 431-438.

Kaczmarczyk, M.M., M.J. Miller and G.G. Freund, 2012. The health benefits of dietary fiber: beyond the usual suspects of type 2 diabetes mellitus, cardiovascular disease and colon cancer. Metab., 61: 1058-1066.

Karastergiou, K., S.R. Smith, A.S. Greenberg and S.K. Fried, 2012. Sex differences in human adipose tissues - the biology of pear shape. Biol. Sex Differ, 3: 13.

Kershaw, E.E., J.K. Hamm, L.A. Verhagen, O. Peroni, M. Katic and J.S. Flier, 2006. Adipose triglyceride lipase: function, regulation by insulin and comparison with adiponutrin. Diabetes, 55:148-157.

Kirpitch, A.R. and M.D. Maryniuk, 2011. The 3 R's of Glycemic Index: Recommendations, Research and the Real World. Clin. Diabet, 29: 155-159.

Klein, S., D.B. Allison, S.B. Heymsfield, D.E. Kelley, R.L. Leibel, C. Nonas and R. Kahn, 2007. Association for Weight Management and Obesity Prevention; NAASO. The Obesity Society; American Society for Nutrition; American Diabetes Association. Waist circumference and cardiometabolic risk: a consensus statement from Shaping America's Health: Association for Weight Management and Obesity Prevention; NAASO, The Obesity Society; the American Society for Nutrition and the American Diabetes Association. Am. J. Clin. Nutr., 85: 1197-1202.

Krentz, A.J., 2003. Lipoprotein Abnormalities and Their Consequences for Patients with Type 2 Diabetes. Diabetes Obes. Metab., 5: 19-27.

Kumar, A., P. Tewari, S.S. Sahoo and A.K. Srivastava, 2005. Prevalence of insulin resistance in first degree relatives of type-2 diabetes mellitus patients: A prospective study in north Indian population. Ind. J. Clin. Biochem., 20: 10-17.

Lebovitz, H.E. and M.A. Banereji, 2005. Point: visceral adiposity is causally related to insulin resistance. Diabetes Care, 28: 2322-2325.

Lim, E.L., K.G. Hollingsworth, F.E. Smith, P.E. Thelwall and R. Taylor, 2011. Inhibition of Lipolisis in Type 2 Diabetes Normalizes Glucose Disposal Without Change in Muscle Glycogen Synthesis Rate. Clin. Sci., 121: 169-177.

Mauriège, P., P. Imbeault, D. Langin, M. Lacaille, N. Alméras, A. Tremblay and J.P. Després, 1999. Regional and gender variations in adipose tissue lipolysis in response to weight loss. J. Lipid Res., 40: 1559-1571.

McQuaid, S.E., L. Hodson, M.J. Neville, A.L. Dennis, J. Cheeseman, S.M. Humphreys, T. Ruge, M. Gilbert, B.A. Fielding, K.N. Frayn and F. Karpe, 2011. Downregulation of adipose tissue fatty acid trafficking in obesity: a driver for ectopic fat deposition? Diabetes, 60: 47-55.

Mittendorfer, B., F. Magkos, E. Fabbrini, B.S. Mohammed and S. Klein, 2009. Relationship between body fat mass and free fatty acid kinetics in men and women. Obesity (Silver Spring), 17: 1872-1877.

Miyatake, N., S. Matsumoto, M. Fujii and T. Numata, 2007a. Reducing waist circumference by at least 3 cm is recommended for improving metabolic syndrome in obese Japanese men. Diabetes Res. Clin. Pract., 79: 191-5.

Miyatake, N., S. Matsumoto, M. Miyachi, M. Fujii and T. Numata, 2007b. Relationship between Changes in Body Weight and Waist Circumference in Japanese. Environ. Health Prev. Med., 12: 220-223.

Mozaffarian, D., T. Hao, E.B. Rimm, W.C. Willett and F.B. Hu, 2011. Changes in diet and lifestyle and long-term weight gain in women and men. N. Engl. J. Med., 364: 2392-2404.

Mullugeta, Y., R. Chawla, T. Kebede and Y. Worku, 2012. Dyslipidemia Associated with Poor Glycemic Control in Type 2 Diabetes Mellitus and the Protective Effect of Metformin Supplementation. Ind. J. Clin. Biochem., 27: 363-369.

Nedungadi, T.P. and D.J. Clegg, 2009. Sexual dimorphism in body fat distribution and risk for cardiovascular diseases. J Cardiovasc Transl. Res., 2: 321-327.

Nestel, P.J. and H.M. Whyte, 1968. Plasma free fatty acid and triglyceride turnover in obesity. Metab., 17: 1122-1128.

Nesto, R.W., 2005. Obesity : A Major Component of the Metabolic Syndrome. Tex Heart Inst. J., 32: 387-389.

Opperman, A.M., C.S. Venter, W. Oosthuizen, R.L. Thompson and H.H. Vorster, 2004. Meta-analysis of the health effects of using the glycaemic index in meal-planning. Br. J. Nutr., 92: 367-381.

Patel, P. and N. Abate, 2013. Body Fat Distribution and Insulin Resistance. Nutr., 5: 2019-2027.

Preis, S.R., J.M. Massaro, S.J. Robins, U. Hoffmann, R.S. Vasan, T. Irlbeck, J.B. Meigs, P. Sutherland, R.B. D'Agostino Sr, C.J. O'Donnell and C.S. Fox, 2010. Abdominal subcutaneous and visceral adipose tissue and insulin resistance in the Framingham heart study. Obesity (Silver Spring), 18: 2191-2198.

Radulian, G., E. Rusu, A. Dragomir, M. Posea, 2009. Metabolic effects of low glycaemic index diets. Nutr. J., 8: 1-8.

Reaven, G., 2005. Insulin Resistance, Type 2 Diabetes and Cardiovascular Disease. Circulation, 112: 3030-3032.

Romaguera, D, L. Angquist, H. Du, M.U. Jakobsen, N.G. Forouhi, J. Halkjær, E.J. Feskens, van A.D.L. der, G. Masala, A. Steffen, D. Palli, N.J. Wareham, K. Overvad, A. Tjønneland, H. Boeing, E. Riboli and T.I. Sørensen, 2011. Food composition of the diet in relation to changes in waist circumference adjusted for body mass index. PLoS One, 6: 23384.

Sandeep, S., K. Gokulakrishnan, K. Velmurugan, M. Deepa and V. Mohan., 2010. Visceral and subcutaneous abdominal fat in relation to insulin resistance and metabolic syndrome in non-diabetic south Indians. Ind. J. Med. Res., 131: 629-635.

Santosa, S., D.D. Hensrud, S.B. Votruba and M.D. Jensen, 2008. The influence of sex and obesity phenotype on meal fatty acid metabolism before and after weight loss. Am. J. Clin. Nutr., 88: 1134-41.

Schoenborn, V., I.M. Heid, C. Vollmert, A. Lingenhel, T.D. Adams, P.N. Hopkins, T. Illig, R. Zimmermann, R. Zechner, S.C. Hunt and F. Kronenberg, 2006. The ATGL gene is associated with free fatty acids, triglycerides and type 2 diabetes. Diabetes, 55: 1270-1275.

Look Ahead Research Group, 2010. Long Term Effects of a Lifestyle Intervention on Weight and Cardiovascular Risk Factors in Individuals with Type 2 Diabetes: Four Year Results of the Look Ahead Trial. Arch. Int. Med., 170: 1566-1575.

Veilleux, A. and A. Tchernof, 2012. Sex Differences in Body Fat Distribution. In: Symonds ME ed. Adipose Tissue Biol. New York: Springer.

Vella, C.A. and L. Kravitz, 2002. Gender Differences in Fat Metabolism. Idea Health and Fitness Sour., 20: 36-46.

Volek, J., M. Sharman, A. Gómez, D. Judelson, M. Rubin, G. Watson, B. Sokmen, R. Silvestre, D. French and W. Kraemer, 2004. Comparison of energy-restricted very low-carbohydrate and low-fat diets on weight loss and body composition in overweight men and women. Nutr. Metab., 1: 13.

Wahrenberg, H., K. Hertel, B.M. Leijonhufvud, L.G. Persson, E. Toft and P. Arner, 2005. Use of waist circumference to predict insulin resistance: retrospective study. BMJ, 30: 1363-1364.

Wajchenberg, B.L., 2000. Subcutaneous and visceral adipose tissue: their relation to the metabolic syndrome. Endocr. Rev., 21: 697-738.

Weyers, A.M., S.A. Mazzetti, D.M. Love, A.L. Gómez, W.J. Kraemer and J.S. Volek, 2002. Comparison of methods for assessing body composition changes during weight loss. Med. Sci. Sports Exerc., 34: 497-502.

Williamson, D.F., T.J. Thompson, M. Thun, D. Flanders, E. Pamuk and T. Byers, 2000. Intentional weight loss and mortality among overweight individuals with diabetes. Diabetes Care, 23: 1499-1504.

Wing, R.R., W. Lang, T.A. Wadden, M. Safford, W.C. Knowler, A.G. Bertoni, J.O. Hill, F.L. Brancati, A. Peters, L. Wagenknecht and Look Ahead Research Group, 2011. Benefits of modest weight loss in improving cardiovascular risk factors in overweight and obese individuals with type 2 diabetes. Diabetes Care, 34: 1481-1486.

World Health Organization, 1999. Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications: Report of WHO Consultation. Geneva: Department of Noncomunicable Disease Surveillance.

Wu, B.N. and A.J. O'Sullivan, 2011. Sex differences in energy metabolism need to be considered with lifestyle modifications in humans. J. Nutr. Metab., 2011: 391809.

Zadeh-Vakili, A., F.R. Tehrani and F. Hosseinpanah, 2011. Waist Circumference and Insulin Resistance: a Community Based Cross Sectional Study on Reproductive Aged Iranian Women. Diabetol. and Metab. Syndr., 3: 1-6.