DOI: 10.12957/demetra.2016.15564

Association between anthropometric measurements and body composition with components of the metabolic syndrome and diet quality index in overweight adult individuals

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Abstract

Introduction: Adiposity excess, especially in the abdominal region, is associated with cardiovascular risk factors, such as dyslipidemia, diabetes mellitus type 2 and systemic arterial hypertension, among other clinical complications that affect quality of life. *Aim:* To evaluate the association between anthropometric measurements and body composition with components of metabolic syndrome (MS) and the diet quality index (DQI) in overweight subjects. *Methods:* A cross-sectional study conducted with patients treated at the UFOP Health Center. After the initial interview and anthropometric assessment, biochemical exams were requested. Dietary intake was assessed by dietary instruments used to calculate DQI. Statistical analyses were performed in SPSS 18.0 software. The Kolmogorov-Smirnov test (to evaluate the normality of the data) and the Pearson correlation were used. *Results:* The prevalence of MS was 15.7%. There was an association between the DQI score with serum total cholesterol (r=0.320; p=0.041), and an inverse association between serum levels of HDL-c with body mass index (r=-0.434; p=0.002). The average consumption of the DQI components was within the recommendations of the *Dietary Reference Intakes*, except for sodium, which was above, and calcium, which was below the recommended values. There was no difference in the DQI items between individuals with and without MS ($p > 0.05$). *Conclusion:* The results shows an accumulation of body fat, changes in anthropometric and biochemical parameters, an inadequate intake of calcium and sodium, demonstrating the importance of nutritional counseling to prevent the occurrence of new morbidities.

Keywords: Diet Quality Index. Metabolic Syndrome. Anthropometric Parameters. Biochemical Parameters. Body Mass Index. Body Composition.

Introduction

The prevalence of chronic noncommunicable diseases has been increasing in the last decades, becoming a global public health problem, responsible for approximately two out of three deaths worldwide.[1] Among these diseases, overweight and obesity has been a major concern, since they are risk factors for the development of other chronic morbidities.[1, 2]

According to the World Health Organization (WHO), in 2014 more than 1.9 billion people aged 18 years or over were overweight (39%). Of these, 600 million were already considered obese (13%).[3] In Brazil, in 2013, 50.8% of the adult population was overweight and 17.5% were considered obese.[4]

Thus, it is crucial to understand the risk factors involved in the genesis of this disease, which encompasses biological, behavioral, environmental and genetic determinants.[3] In this perspective, a sedentary lifestyle and changes in eating habits with increasing consumption of foods of high energy density have been considered the most incisive modifiable risk factors of the increasing incidence of obesity.[5]

Therefore, Brazilian government, together with the Ministry of Health, has sought to implement important political strategies to address these diseases.[6] In order to incorporate changes in eating habits, nutritional intervention strategies are used and also instruments that value and encourage healthy eating practices.[7]

For an effective nutritional evaluation, in addition to anthropometry, body composition and biochemical analysis, verifying the standard of food consumption of a population becomes essential.[8] Also, due to easiness to apply and low operational cost, the Body Mass Index (BMI) has been used as indicating overweight (BMI $\geq$ 25 kg/m^2) and obesity (BMI $\geq$ 30 kg/m^2) in several epidemiological studies involving adults.[9]

When we want to establish the amount of calories, macronutrients and micronutrients ingested, in order to relate diets to individuals' nutritional status, we use instruments such as the 24-hour Reminder, the Food Intake Record and the Food Frequency Questionnaire.[10] In addition, several indices have been proposed to quantify diets quality standard, such as the Diet Quality Index (DQI), which evaluates the adequate intake of nutrients, number of carbohydrates, fruits and vegetables servings consumed, the amount of total fat, saturated fat, cholesterol, protein, calcium and sodium ingested by the individual.[11] Thus, it is possible to assess diets adequacy and health through DQI[11] based on the recommendations at *Diet and Health*.[12]

The biochemical evaluation is extremely important because it allows to complement the evaluation of the physical examination, anthropometric data and food intake, contributing to a better diagnosis.[13] The most commonly used tests are lipidic profile (total cholesterol, HDL-c, LDL-c and triacylglycerols) and glycemia, since these parameters tend to be altered in overweight and characterize the presence of metabolic syndrome.[14]

In view of the above, the objective of this study was to evaluate nutritional status through anthropometric, body composition and biochemical measurements, as well as to verify the association of these parameters with DQI and the metabolic syndrome components in overweight individuals.

Materials and Methods

The cross-sectional study, with a non-probabilistic sample for convenience, was performed at a Nutrition Outpatient Clinic located at the Health Center of Brazilian Universidade Federal de Ouro Preto (Ouro Preto Federal University), between 2011 and 2013. Patients searching for dietary-therapeutic assistance would be informed about the research and selected after signing an Informed Consent Form.

To be included, volunteers, regardless of gender, should be older than 18 years and having a nutritional diagnosis of overweight or obesity by BMI. Children, adolescents and individuals with a nutritional diagnosis of eutrophy or low weight would be excluded.

Volunteers were submitted to an anthropometric evaluation (weight, height, circumferences and skinfolds), dietetics (food registry) and biochemistry (complete blood count, lipidic profile and glucose). Body weight would be measured using a WELMY® brand electronic scale with a capacity for 150 kg. Height would be measured through a metal stadiometer coupled to the electronic scale, with an accuracy of 0.1 mm. For both measures, volunteers would be barefoot, wearing light clothing, and standing erect in the center of the equipment.

The measurement of tricipital skinfolds (TSF-mm), bicipital skinfolds (BSF-mm), subscapular skinfolds (SSSF-mm) and suprailiac skinfolds (PCSI-mm) was performed using a Cescorf brand adipometer skinfold caliper which has a pressure of 10 g/mm^2, sensitivity of 0.1 mm and reading scope of 85 mm. The value recorded was the average of the 3 consecutive measurements.[10]

Measurement of abdominal (AC-cm), brachial (BC-Cm), waist (WC-cm) and hip (HC-cm) circumferences was performed with an inelastic tape measure, with a 0.1-cm precision. AC was collected at the midpoint above the umbilical scar. As for WC, it was collected at the midpoint between the last rib and the iliac crest (in the natural curvature). BC was measured between the midpoint of the acromion and the olecranon with the individual with the arm extended along the body. For HC, the flexible measuring tape circled the hip in the area of greater perimeter between the waist and thigh, with the individual wearing thin and light clothing.[15]

Anthropometric data were used in the calculation of BMI (Kg/m^2), waist-to-hip ratio (WHR-cm), (mid-)upper arm circumference ((M)UAC-cm), body fat percentage (%BFP) and atherogenic index (AI). WHR was the most commonly used indicator to identify body fat distribution and it was determined using the equation: WHR = WC/HC. As for (M)UAC-cm, which evaluates the reserve of muscle tissue, it was obtained by the values of BC and TSF by the formula: (M)UAC (cm) = BC (cm) – π x [TSF (mm) / 10]. The %BFP was obtained by the sum of the 4 skinfolds and the atherogenic index by dividing SSSF by TSF.[15]

Overweight individuals' nutritional status classification was carried out according to the cutoff points which considers BMI 25.0-29.9 kg/m^2 (overweight or pre-obesity), BMI 30.0-34.9 kg/m^2 (class I obesity), BMI 35.0-39.9 kg/m^2 (class II obesity), and BMI ≥ 40.0 kg/m^2 (class III obesity).[10]

The following laboratory tests were requested: complete blood count, lipidic profile (total cholesterol, LDL-c, HDL-c and triacylglycerols) and glucose. These tests were determined at Brazilian Laboratório Piloto de Análises Clínicas (Pilot Laboratory for Clinical Analyses) at Universidade Federal de Ouro Preto (LAPAC/UFOP). For the biochemical examination, volunteers were instructed to fast for 8 hours.

Dietary intake was then evaluated through a 24-hour recall, where the volunteer reported the food and drinks ingested the previous day. And a 72-hour food record in which the individual was instructed to record, at the time of consumption, foods and beverages consumed on alternate days, including two days of the week (typical days) and one day of the weekend (atypical day).[10]

Ingestion data was entered into software *Dietwin* for the quantification of macronutrients (carbohydrates, proteins and lipids). The diet quality was assessed using the DQI score, where the consumption of fruits and vegetables, carbohydrates, proteins, total lipids, saturated fats, cholesterol, sodium and calcium was evaluated through a score ranging from 0 to 2[11], according to recommendations in *Diet and Health*.[12] From these parameters, the individual could present a score 0 indicating a diet of excellent quality or attaining a maximum of 16 points, when their intake was considered very bad.[11]

From the anthropometric and biochemical data collected, the individuals were classified according to the presence of metabolic syndrome, adopting the criterion of associating at least 3 risk factors: abdominal obesity, atherogenic dyslipidemia (decreased HDL-c and increased LDL-c), hypertriglyceridemia, systemic arterial hypertension, hyperglycemia.[16] After all evaluations, individuals received individual nutritional guidance by trained nutritionists.

The statistical analyseswere performed using software *Predictive Analytics Software (PASW) Statistics 18* considering a 5% significance level.[17] The Kolmogorov-Smirnov test was used to test the data normality. The variables of normal distribution were presented in mean and standard deviation, while those of non-normal distribution were in median and interquartile range. Pearson correlation was used to verify the association between the metabolic syndrome components with anthropometric, biochemical and body composition data, as well as the association of the DQI components with the volunteers' anthropometric, body composition, clinical and biochemical measurements. Fisher's exact test was performed to analyze the DQI components with the presence or absence of metabolic syndrome.

This study was approved by the Research Ethics Committee of Universidade Federal de Ouro Preto in official letter CEP Nº073/2011.

Results and Discussion

The study had the participation of 68 volunteers, 27.94% (n = 19) males and 72% (n = 49) females, aged between 20 and 57 years. This population's metabolic syndrome (MS) frequency was analyzed, since obesity and overweight have been considered as critical in this syndrome genesis.[16, 18] Of the individuals followed 16.17% (n = 11) had MS, that is, they had factors usually related to central fat deposition and insulin resistance. Similar data were found by Pimenta et al.,[19] who evaluated the prevalence of MS and its associated factors in a rural area of Brazilian state Minas Gerais, observing a 14.9% prevalence.

It should be emphasized that MS has been considered from the epidemiological point of view as responsible for the increase in cardiovascular mortality estimated at 2.5 times. In this aspect, it is important to highlight that several studies have investigated the association between obesity and MS. However, the non-establishment of the risk factors considered and the divergence among diagnostic criteria have made it impossible to compare them. In Brazil no representative data were found on the prevalence of MS. However, studies in different populations, such as in Mexico, North America and Asia, show high prevalences, depending on the criteria used and the characteristics of the population, rates varying from 12% to 28.5% in men and from 10.7% to 40.5% in women.[16]

Table 1 shows the anthropometric, body composition, biochemical and dietary measures. Individuals monitored showed excess adiposity, confirmed by the mean of the BMI, WC, WHR, %BFP and by the 4 skinfolds, which was already expected, due to the criterion of inclusion of the volunteers, who should be overweight. In our study, mean BMI was 31.38 ± 4.44, similar to a study performed at a Basic Health Unit in the Brazilian city of Nova Prata, RS, where this figure was 32.83 kg/m[20]. It is possible to emphasize that WC has been considered an excellent indicator of corporal distribution and risk of developing other morbidities.[21] In addition, body distribution, depending on its location, predisposes the individual to a higher risk of metabolic complications, with WHR being the most commonly used indicator for this classification.[15]

Table 1. Anthropometric, body composition, clinical, biochemical and dietary data of the sample of volunteers (n = 68). Ouro Preto, MG, 2011-2013.

Anthropometric data (average ± SD)

BMI (Kg/m²)	WC (cm)	HC (cm)	WHR (cm)	BFP (%)	UBAI (%)	(M)UAC (cm)	TSF (mm)	BSF (mm)	SSSF (mm)	SISF (mm)
31.38 ± 4.44	99.52 ± 11.63	113.47 ± 1.10	0.87 ± 0.11	37.34 ± 7.22	1.06 (0.05)*	26.76 ± 5.55	29.19 ± 8.02	22.89 ± 8.06	29.25 ± 8.11	32.42 ± 7.89

Biochemical data (average ± SD)

Hm (10⁶/mm³)	Ht (%)	Hb (g/dL)	Leuc (mm³)	Glucose (mg/dL)	Cholesterol (mg/dL)	TG (mg/dL)	HDL-c (mg/dL)	LDL-c (mg/dL)
5.13 ± 1.56	41.22 ± 4.87	13.65 ± 1.91	7.49 ± 1.31	89.36 ± 15.65	197.05 ± 40.00	143.63 ± 81.19	51.38 ± 13.48	112.79 ± 35.79

Dietetic data (average ± SD)

Calories (Kcal)	Protein (%)	Carbohydrate (%)	Fat (%)	Saturated fat (%)	Cholesterol (mg)	Sodium (mg)	Calcium (mg)	Total DQI
2147.95 ± 815.74	15.19 ± 4.17	54.00 ± 9.83	30.81 ± 8.30	24.77 ± 8.44	214.44 ± 107.01	2999.51 ± 935.6	649.41 ± 393.07	6.36 ± 1.95

AC: Abdominal circumference; WC: Waist circumference; HC: Hip circumference; (M)UAC: (Mid-)upper arm circumference; SD: Standard deviation; BF: Body fat; HDL-c: High density lipoprotein; Hm: Blood cells; Ht: Hematocrit, Hb: Hemoglobin; UBAI: Upper body adiposity index; BMI: Body mass index; IQR: Interquartile range; LDL-c: Low density lipoprotein; Leuc: Leukocytes TG: Triacylglycerols, DBP: Diastolic blood pressure; SBP: Systolic blood pressure; BSF: Bicipital skinfolds; SSSF: Subscapular skinfolds; SISF: Suprailiac skinfolds; TSF: Tricipital skinfolds, WHR: Waist-to-hip ratio. Kolmogorov–Smirnov test, data presented in average ± SD ($p > 0.05$).* Data presented in median ± IQR ($p < 0.05$)

Obesity is associated with the emergence of several comorbidities, such as insulin resistance, diabetes mellitus type 2, dyslipidemias and hypertension.[10, 15] In relation to the biochemical data, glucose and total cholesterol averages remained within the reference values. However, LDL-c was in the range considered borderline (< 129 mg/dL) and HDL-c below the recommendation (≥ 60 mg/dL).[22] This biochemical profile in overweight individuals is found in the literature, as in Ramos et al.,[23] who have evaluated the socioeconomic, anthropometric, biochemical and lifestyle profiles of patients seen in the "weight control" program, demonstrating that LDL-c was above the recommendation and HDL-c below the reference value.

Regarding the DQI score, the mean value found was 6.36 ± 1.98 for men and 5.59 ± 2.24 for women, inferring diet quality closest to the ideal. The consumption of macronutrients (lipids, proteins and carbohydrates) was within the range recommended by the DRIs (Dietary Reference Intakes),[24] which is very important, since an inadequate consumption is related to the genesis of obesity.[5] Contrary to the data found, evidence suggests an inadequate consumption of macronutrients in obesity, such as for the patients seen at a clinic in the Brazilian city of Porto Alegre, RS, which had high consumption of carbohydrates, lipids and proteins.[25] As for a research that evaluated the diet quality of employees at a public university through the healthy eating index, a high consumption of lipids was observed.[26]

It is noted that sodium intake is above recommended levels and calcium below recommended levels. The increase of sodium consumption along with obesity are predisposing factors for the emergence of hypertension,[27] However, the individuals evaluated presented blood pressure mean values within normal (SBP: 116.70 ± 2.15 mmHg; DBP: 75.21 ± 1.33 mmHg). Unlike our results, Manfroi et al.,[28] evaluating sodium consumption by patients with metabolic syndrome, have found that 81.8% of the individuals analyzed presented at least one of the blood pressures elevated and sodium consumption mean values below the recommended level (1483 ± 777.9 mg). As for Sarno et al.,[29] they have demonstrated that the amount of Brazilian sodium consumption exceeds by more than twice the recommended intake limit, corroborating our data. Excessive sodium consumption also occurs in developed countries, as demonstrated by the study carried out by Cook[30] in the United States, which shows an average consumption of 3600 mg per day.

Regarding calcium, its participation in the pathophysiology of obesity is evidenced, because when ingested below the recommendation it induces increased lipogenesis, decreased lipolysis and lipidic oxidation. Another relevant fact is that calcium can associate with free fatty acids in the gastrointestinal tract, decreasing its absorption.[31] Therefore, achieving an adequate calcium intake is a key goal for the individuals monitored.

When analyzing the correlation of the metabolic syndrome components with the anthropometric, biochemical and body composition data, we found a negative correlation between BMI and HDL-c ($p = 0.002$) and a positive correlation between %BFP and triglycerides ($p = 0.001$) (Table 2). Rezende et al.[32] have also observed a reduction of HDL-c as a result of increased BMI and abdominal fat. On the other hand, triglycerides increased due to elevated body fat, BMI and AC. Overweight along with the reduction of HDL-c and increased triglycerides, are important risk factors for the development of cardiovascular complications, and nutritional monitoring is essential in order to reduce BMI and %BFP.[16]

Table 2. Significant correlations of the metabolic syndrome components with anthropometric parameters of the sample of volunteers (n = 68), Ouro Preto, MG, 2011-2013.

Variables	Components of the metabolic syndrome						
	Glucose	SBP (mmHg)	DBP (mmHg)	AC (cm)	Triglycerides (mg/dL)	LDL-c (mg/dL)	HDL-c (mg/dL)
BMI (kg/m²)	r = 0.052	r = 0.073	r = 0.430	r = 0.011	r = 0.026	r = 0.003	r = -0.434**
	p = 0.065	p = 0.227	p = 0.455	p = 0.227	p = 0.878	p = 0.959	p = 0.002
UBAI (%)	r = 0.118	r = 0.124	r = 0.457	r = 0.714	r = 0.133	r = 0.313	r = 0.174
	p = 0.150	p = 0.570	p = 0.679	p = 0.172	p = 0.127	p = 0.089	p = 0.087
BFP (%)	r = 0.674	r = 0.284	r = 0.382	r = 0.340	r = 0.561**	r = 0.332	r = 0.139
	p = 0.312	p = 0.122	p = 0.654	p = 0.567	p = 0.001	p = 0.701	p = 0.141

AC: Abdominal circumference; BF: Body fat; UBAI: Upper body adiposity index; BMI: Body mass index; LDL-c: Low density lipoprotein; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; r: Pearson correlation coefficient. * $p < 0.05$, ** $p < 0.01$.

There was no positive correlation between glycemia and anthropometric parameters, which was not expected, since overweight is often associated with the emergence of insulin resistance, hyperglycemia and diabetes mellitus type 2.[14, 22]

It is observed that there was a positive correlation between HC with calcium and cholesterol with DQI (Table 3). The inverse association between calcium consumption and body weight gain has been reported and it has been proposed that calcium alters fat absorption by the body and affects the metabolism of adipocytes.[31] Esteves et al.[33] have not found a significant correlation between the adiposity variables analyzed (BMI, %BFP, WC and WHR) and calcium intake. Contrary to this finding, Zemel[34] has shown that women with an intake of 1300 mg/day of calcium have a lower risk of accumulating body fat.

Table 3. Correlations of DQI components with anthropometric and biochemical measures of the sample of volunteers (n = 68), Ouro Preto, MG, 2011-2013.

Variables	DQI components (food standard)							
	CHO%	PTN%	LIP%	SAT%	Cholesterol (mg)	Calcium (mg)	Sodium (mg)	Total DQI
BMI (kg/m²)	r = 0.111	r = -0.157	r = 0.008	r = 0.075	r = 0.212	r = 0.048	r = 0.107	r = 0.207
	p = 0.624	p = 0.485	p = 0.951	p = 0.567	p = 0.104	p = 0.708	p = 0.410	p = 0.106
WC (cm)	r = 0.078	r = -0.121	r = 0.023	r = 0.130	r = 0.129	r = -0.170	r = 0.201	r = 0.174
	p = 0.729	p = 0.593	p = 0.863	p = 0.340	p = 0.345	p = 0.206	p = 0.134	p = 0.196
HC (cm)	r = -0.135	r = 0.082	r = -0.172	r = -0.086	r = 0.108	**r = 0.295***	r = 0.231	r = 0.075
	p = 0.571	p = 0.730	p = 0.200	p = 0.537	p = 0.438	**p = 0.027**	p = 0.086	p = 0.581
Glucose (mg/dL)	r = -0.171	r = 0.054	r = 0.029	r = -0.240	r = 0.150	r = -0.272	r = 0.048	r = -0.021
	p = 0.513	p = 0.836	p = 0.858	p = 0.136	p = 0.355	p = 0.086	p = 0.766	p = 0.895
Cholesterol (mg/dL)	r = 0.266	r = 0.002	r = 0.250	r = 0.169	r = 0.264	r = -0.052	r = 0.231	**r = 0.320***
	p = 0.286	p = 0.993	p = 0.115	p = 0.304	p = 0.105	p = 0.746	p = 0.146	**p = 0.041**
TG (mg/dL)	r = -0.184	r = 0.287	r = 0.018	r = 0.101	r = 0.067	r = -0.230	r = 0.193	r = 0.157
	p = 0.464	p = 0.249	p = 0.912	p = 0.547	p = 0.690	p = 0.154	p = 0.232	p = 0.333

WC: Waist circumference; HC: Hip circumference; BMI: Body mass index; DQI: Diet quality index; BF: Body fat; CHO: Carbohydrates; PTN: Proteins; LIP: Lipids; TG: Triacylglycerols; SAT: Saturated fat; r: Pearson correlation coefficient. * $p < 0.05$.

Regarding cholesterol, no data have been found to date that correlate cholesterol with DQI. Probably the correlation found can be explained by the fact that the increase in cholesterol is associated with inadequate dietary habits[10], which in turn is related to the increase in the DQI.[11]

Finally, Table 4 shows that there was no association between the DQI components and presence or absence of MS, contrary to what has been found in the literature, as in the review article by Steemburgo et al.[35], which points out several research studies demonstrating the importance of diet components in the genesis and protection of MS.

Table 4. Analysis of the DQI components with presence and absence of metabolic syndrome, Ouro Preto, MG, 2011-2013.

DQI components	Individuals				
	Absence of metabolic syndrome		Presence of metabolic syndrome		
	N	%	N	%	p-value
Total lipids					
≤ 30%	28	49.10	5	45.50	
30-40%	19	33.33	5	45.50	0.260
> 40%	7	12.30	0	0.00	
Saturated fatty acids					
≤ 10%	32	56.10	6	54.50	
10-13%	14	24.60	2	18.20	0.403
> 13%	6	10.50	1	9.10	
Cholesterol					
≤ 300 mg	38	66.70	6	54.50	
300-400 mg	8	14.00	2	18.20	0.344
> 400 mg	6	10.50	1	9.10	

to be continued

DQI components	Individuals				
	Absence of metabolic syndrome		Presence of metabolic syndrome		
	N	%	N	%	p-value
Potherbs/vegetables/fruits					
5 or + servings	7	12.30	0	0.00	
3-4 servings	9	15.80	5	45.50	0.137
0-2 servings	24	42.10	2	18.20	
Breads, grains and cereals					
6 or + servings	24	42.10	3	27.30	
4-5 servings	11	19.30	4	36.40	0.556
0-3 servings	5	8.80	0	0.00	
Protein					
≤ 100% RDA	21	36.80	3	27.30	
100-150% RDA	23	40.40	5	45.50	0.440
> 150% RDA	9	15.80	2	18.20	
Sodium					
≤ 2400 mg	23	40.40	2	18.20	
2400-3400 mg	17	29.80	7	63.60	0.120
> 3400 mg	13	22.80	1	9.10	
Calcium					
≥ RDA	8	14.00	2	18.20	
2/3 RDA	17	29.80	2	18.20	0.540
< 2/3 RDA	28	49.10	6	54.50	

DQI: Diet Quality Index. $p > 0.05$ for all variables analyzed – Fisher's exact test. RDA: *Recommended Dietary Allowances*[24]

Conclusion

The results demonstrate that individuals with excess body weight have a higher risk of developing morbidities, since they presented anthropometric and biochemical alterations and an inadequate intake of calcium and sodium. Thus, the importance of nutritional monitoring is noted in order to avoid health problems and to make these patients aware of the importance of healthy eating, acting in the control and prevention of the complications found, and avoiding new occurrences of metabolic syndrome.

Acknowledgments

To Brazilian Universidade Federal de Ouro Preto (Ouro Preto Federal University) and Escola de Nutrição (Nutrition School) for making possible and supporting the research. And to all the volunteers who kindly participated in the study.

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Received: March 14, 2015
Revised: September 22, 2015
Accepted: February 4, 2016