International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 05, 2020
ISSN: 1475-7192

Obesity in Children: Frequency of Occurrence and Features of Thickness of Epicardial Fat Depending on Indicators of Body Weight Index and Lipid Spectrum

Agzamova Shoira Abdusalamovna and Hasanova Guzaliya Marsovna

Abstract--- *The article provides information on recent scientific studies of the relationship of visceral obesity with complications from the cardiovascular system. The results of our own research on the frequency of occurrence of overweight and obesity among teenage schoolchildren of one of the schools in the city of Tashkent are presented, as well as data on the assessment of the lipid spectrum, echocardiographic studies of the structural state of the myocardium and identification of epicardial fat in overweight adolescents and exogenously constitutional obesity of the 1st degree.*

Keywords--- *Adolescents, Obesity, Dyslipidemia, Epicardial Fat Deposition.*

I. BACKGROUND

One of the most important public health problems nowadays is noncommunicable diseases caused by malnutrition. In most countries, the problem of obesity and overweight among children has already affected every fourth student. The population of the vast majority of countries with increasing frequency prefers a less healthy diet. The medical and social significance of the problem of obesity is determined not only by its progressive prevalence, but also by the severity of the complications. Numerous studies show that obese children have an increased frequency of a number of pathological conditions, such as arterial hypertension, impaired carbohydrate metabolism, hyperlipidemia and atherosclerosis, fatty hepatosis, osteoarthritis, and potential reproductive problems. These conditions are considered by many authors as complications or manifestations of morbid obesity. For a number of diseases, obesity is a well-studied risk factor - bronchial asthma, gastroesophageal reflux disease, etc. Obesity, in proportion to severity, worsens the prognosis of most chronic diseases [1,2]. Research in childhood obesity is becoming particularly relevant in terms of early prevention, diagnosis and treatment of its formidable complications.

According to the data provided by B. Rakhimov in his work “Features of the morbidity of children and adolescents of Uzbekistan who are obese,” the frequency of obesity in our country in 2012-2014. among adults it was about 31-34%, and among children - 50-66%. Over three years, an increase in indicators of overweight in children by 30% was noted [3].

Currently, the diagnosis of obesity in children and adolescents is made quite late, in addition, doctors at the primary health care level do not form a risk group for the development of obesity. The prognostic parameters of the

Agzamova Shoira Abdusalamovna, Tashkent Pediatric Medical Institute, Tashkent, Uzbekistan.
Hasanova Guzaliya Marsovna, Tashkent Pediatric Medical Institute, Tashkent, Uzbekistan.

DOI: 10.37200/IJPR/V24I5/PR201709
Received: 07 Feb 2020 | Revised: 01 Mar 2020 | Accepted: 18 Mar 2020

development of complications of obesity have been little studied. In this regard, the study of markers for predicting complications of obesity, especially from the cardiovascular system in childhood and adolescence, is of particular relevance.

In addition, medical science is accumulating more and more evidence of the error of verification of obesity only in terms of body mass index, as an indispensable factor that increases the risk of cardiovascular complications. Visceral fat deposition is the pathogenetic bridgehead for the formation of metabolic disorders, atherosclerosis and cardiovascular pathology. To better predict cardiometabolic risk, a direct assessment of visceral adipose tissue is necessary. The most accessible method for direct assessment of visceral adipose tissue is echocardiographic determination of the thickness of epicardial fat [4].

Epicardial fat is a depot of visceral fat around the heart, concentrated between the myocardium and visceral pericardium. Moreover, it is a source of biologically active substances that affect the heart muscle and coronary arteries. Epicardial fat and myocardium, due to the lack of fascia separating these structures, have a common microcirculation system and are supplied with branches of coronary arteries [5]. Epicardial adipose tissue produces a number of adipokines in the coronary blood flow (adiponectin, interleukins - IL-1, IL-6, tumor necrosis factor a, visfatin, leptin, angiotensin, etc.), which affect metabolic processes in the myocardium in different ways and can cause clinico-metabolic and cardiovascular complications associated with visceral obesity [6,7]. In particular, interleukin 1, interleukin 6, tumor necrosis factor-alpha, free fatty acids, angiotensin II produced by adipose tissue from the vessels enter the artery wall, causing irreversible changes in it, which leads to the development of atherosclerosis. The above biologically active substances secreted by epicardial fat directly affect the vascular, immune and inflammatory reactions. Excess epicardial fat is also deposited along coronary arteries, which turn out to be “chained” to the fat corset. Under such conditions, all pro-inflammatory cytokines and adipokines are directly secreted into the coronary arteries, which provokes the rapid formation of atherosclerosis. In particular, the secretion of such an inflammatory mediator as tumor necrosis factor alpha can aggravate vascular inflammation, plaque instability due to apoptosis and pathological overgrowth of new vessels (neovascularization). In addition, inflammatory mediators stimulate the flow of inflammatory cells into the walls of the arteries, spasm of the coronary vessels and micro-damage to the intima. At the same time, there is an opinion about the positive effects of the inflammatory reaction due to excess epicardial adipose tissue, namely the activation of the angiogenic reaction and the development of collateral circulation in patients with obstructive coronary atherosclerosis [8].

Epicardial fat has both positive and negative features, which are balanced under normal conditions, however, to date, the cause of the imbalance between them remains completely unexplored. Under normal physiological conditions, epicardial fat serves as an equilibrium system that absorbs excess toxic fatty acids. Increased production of the latter can lead to disorders in the formation and conduct of impulses in the conduction system of the heart and suggest the development of arrhythmias [9].

In this regard, the aim of our study was to study the frequency of overweight and obesity among teenage schoolchildren in Tashkent, differentiated by age and sex, as well as to study the thickness of epicardial adipose tissue as a marker of subclinical damage to the heart and blood vessels in relation to the parameters of the lipid spectrum in adolescents with exogenously-constitutional obesity of the 1st degree.

DOI: 10.37200/IJPR/V24I5/PR201709
Received: 07 Feb 2020 | Revised: 01 Mar 2020 | Accepted: 18 Mar 2020

II. MATERIAL AND METHODS

On the basis of school No. 246 of the Yunusabad district of Tashkent, 412 teenage students were examined, aged 13-17 years (average age 15.0 ± 0.45), of which 37 teenagers were divided into further in-depth examinations, which were divided into 3 groups: the main group - 17 adolescents with exogenously-constitutional obesity of the 1st degree, the comparison group - 10 adolescents with excess weight and the control group was represented by 10 adolescents with normal height-weight indicators.

During the study, anthropometric parameters were determined: height, weight, waist and hips. Body mass index (BMI) was calculated as the ratio of body weight in kilograms to square of height in meters (kg / m2). The ratio of waist to hips was determined by dividing the waist circumference by the circumference of the hips.

As a diagnostic criterion for overweight and obesity in children, we used the determination of the standard deviations of the body mass index (SD, BMI). Based on WHO recommendations, adolescent obesity was defined as a BMI of equal to or more than +3.0 SD BMI, and overweight from +2.0 to +3.0 SD BMI. Normal body weight was diagnosed with BMI values in the range of +1.0 and -1.0 SD, and body mass deficit was less than -2SD BMI [10].

Adolescents selected for further examination also underwent a biochemical blood test to assess the lipid spectrum and an echocardiographic study to study the structural state of the myocardium and the identification of epicardial fat.

The state of the serum lipid spectrum was evaluated according to the traditional results of the concentration of total cholesterol (mmol / l) and its forms: low density lipoproteins - LDL, high density - HDL, triglycerides (determined in blood serum using a Minray BS-200 biochemical analyzer (China) using commercial “Human” kits, Germany), and also the atherogenicity coefficient - AC (AC = (cholesterol - LDL) / HDL, norm 2.3 conditional units) was determined. To assess normal lipid profile parameters, age norms were used [11].

To assess the structural state of the myocardium and the thickness of the epicardial fat, a comparative analysis of morphometric and hemodynamic parameters was performed according to ECHOCG with current control groups having normal weight (n = 10), as well as their percentile values of healthy children and adolescents, depending on body surface area [12]. Conducted standard transthoracic echocardiographic examination in the B and M modes. Identification and assessment of the thickness of epicardial fat was carried out in B-mode from the left parasternal access along the long and short axis of the left ventricle. Epicardial fat was visualized as a hypoechoic space with a granular structure located between the free wall of the right ventricle and the visceral leaf of the pericardium. The measurement was carried out strictly at right angles to the free wall of the right ventricle and along the line most perpendicular to the fibrous ring of the aorta (anatomical landmark) at the end of systole in three cardiac cycles and the average value was displayed.

Exclusion Criteria

The study did not include adolescents with II and III degree of obesity, as well as with its secondary form: hypothalamic-pituitary (central) and associated with dysfunctions of other endocrine glands (peripheral) forms.

The study was conducted in compliance with the ethical principles imposed by the Helsinki Declaration of the

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World Medical Association (World Medical Association Declaration of Helsinki, 1964, 2013), and was performed with the informed consent of parents and patients. Statistical data processing was performed using the MS Excel for Windows 7 software. Statistical significance was determined using correlation analysis (Pearson method), at $p < 0.05$, differences were considered statistically significant.

III. Results And Discussions

A survey of 412 teenage students aged 13 to 17 years showed that 302 (73.3%) children had normal weight, 27 (6.5%) had a body mass deficit, 53 (12.9%) were overweight weight and 30 (7.3%) - obesity of varying degrees.

Depending on age, the children were divided into 2 groups. The distribution of children by gender and age is presented in table 1.

Table 1

Sex	Age		Total
	13-14	15-17	
Boys	108 (52,9%)	118 (56,7%)	226 (54,9%)
Girls	96 (47,1%)	90 (43,3%)	186 (45,1%)
Total	204	208	412

Depending on the standard deviations of the body mass index (SD BMI), obesity of the first degree was found in 17 people, the second degree of obesity in 7 schoolchildren, the third degree in 2, the morbid obesity in 1 teenager (Fig. 1).

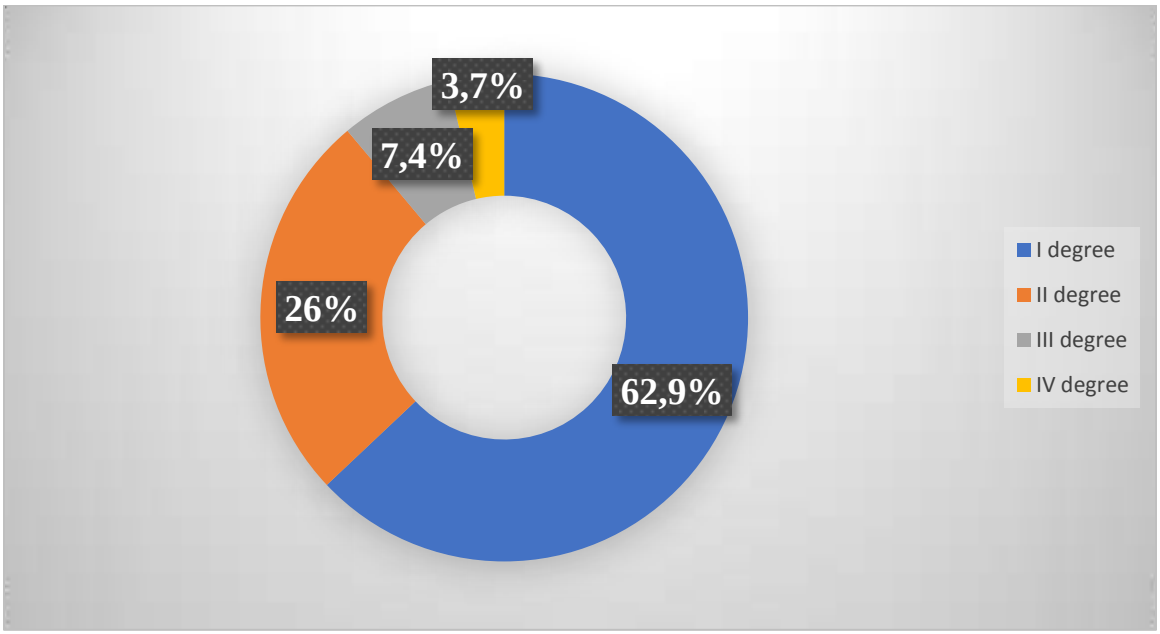

Figure 1: Distribution of Adolescents by Obesity

It should be emphasized that more than half of the examined adolescents with obesity had an abdominal type of obesity.

The distribution of the examined adolescents depending on the standard deviations of the body mass index is presented in table 2.

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Table 2: The Distribution of Adolescents Depending on the Standard Deviation of BMI in Different Age Groups

Mass to height ratio	**13-14 years (n = 204) (%)**	**15-17 years (n = 208) (%)**
Body mass deficiency ≤-2SD BMI	15 (7,3)	12 (5,8)
Normal body weight within +1.0 and -1.0 SD	151 (74)	136 (65,3)
Overweight risk from +1.0 to +2.0 SD BMI	6 (2,9)	9 (4,3)
Overweight from +2.0 to +3.0 SD BMI	20 (9,8)	33 (15,9)
Obesity ≥ + 3.0 SD BMI	12 (5,9)	18 (8,6)

As can be seen from the table. 2, the largest number of children with obesity and overweight were in the group of children 15-17 years old.

The frequency of overweight and obesity depending on gender and age is presented in table 3.

Table 3: The Quantitative Ratio of Overweight and Obese Boys and Girls in the Analyzed Groups

Mass to height ratio	13-14 years old Boys n = 101 Girls n = 103 (%)	**15-17 years old Boys n = 102 Girls n = 106 (%)**	**p**
	1	**2**	
The boys Overweight	8 (7,9)	15 (14,7)	P^{1-2}=0,031
The boys Obesity	5 (4,9)	6 (5,9)	P^{1-2}>0,05
Girls Overweight	14 (13,6)	16(15,1)	P^{1-2}>0,05
Girls Obesity	7 (6,8)	12 (11,3)	P^{1-2}=0,051

As can be seen from table 3, obesity and overweight in girls aged 15-17 were diagnosed statistically more often than in the other age group.

The results of the study indicate that with age, the number of children with obesity and excess body weight increases.

The average values of anthropometric indicators were: body mass index (kg / m2) in adolescents with obesity - 31.74 ± 0.73, overweight - 27.52 ± 0.96, in children with normal weight 22.51 ± 1, 32; waist circumference (cm) in adolescents with obesity - 98.32 ± 1.92, overweight - 90, 52 ± 1.86, in children with normal weight - 67.69 ± 2.77; hip circumference (cm) in adolescents with obesity - 106.59 ± 2.63, overweight - 100.39 ± 1.83, in children with normal weight - 90.69 ± 3.39; OT / OB - in adolescents with obesity - 0.88 ± 0.02, overweight - 0.82 ± 0.03, in children with normal weight - 0.78 ± 0.03.

To study lipid metabolism, we evaluated total cholesterol, triglycerides, high-density lipoproteins and low-density blood serum, as well as the atherogenic coefficient in 37 adolescents selected for further examination. The results of the study of the lipid spectrum in the analyzed groups are presented in table 4.

DOI: 10.37200/IJPR/V24I5/PR201709
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Table 4: The State of the Serum Lipid Profile in Adolescents with Obesity, Overweight and Normal Weight (M ± m)

Parameters	Main group n = 17 (P^1)	Comparison group n = 10 (P^2)	Control group n = 10 (P^3)	P^1-P^3
Cholesterol, mmol / L	4,95±0,86	4,5±0,85	4,02±1,08	
Triglycerides, mmol / L	2,05±0,17	1,82±0,44	0,92±0,48	<0,05
High Density Lipoproteins	0,98±0,02	1,10±0,06	1,21±0,08	<0,01
Low density lipoproteins	3,22±0,17	2,9±0,53	2,39±0,32	<0,05
AC	3,30±0,20	2,6±0,32	2,40±0,36	<0,05

It was established that there were no significant differences in the concentration of total cholesterol among the examined children. However, in overweight and obese children, changes in the cholesterol content of lipoproteins were detected. In overweight children (comparison group), average serum lipoproteins were within the optimal range, but HDL levels were lower and LDL levels were higher in relation to the control indicators. It should be noted a decrease in HDL to 0.98 ± 0.02 in children with obesity (P <0.010). It is known that a low level of HDL is associated with a high risk of developing atherosclerosis and coronary heart disease, which is associated with violations of their production from chylomicrons and very low-density lipoproteins in the intestine [13]. An unfavorable change in the composition of blood serum lipids in obese adolescents was a tendency to increase the low-density lipoprotein fraction, which is rich in cholesterol and triglyceride and represents the most atherogenic class of lipoproteins.

The results of echometric indicators of the heart in adolescents with obesity and overweight are presented in table 5.

Table 5: Comparative Analysis of the Average Parameters of Echocardiography of Adolescents with Obesity, Overweight and Normal Weight

Parameters	Main group **n=17**	Comparison group **n=10**	Control group **n=10**
LA, sm	3,08±0,5	3,02±0,3	2,07±0,9
FSS LV, sm	2,95 ±0,4	2,79±0,2	2,5±0,4
FDS LV, sm	4,76±0,7	4,52±0,5	4,0±0,7
FSV LV, ml	44,6±6,1	32,5±4,5	29,9±4,2
FDV LV, ml	125±4,2	104,6±5,5	90,9±7,1
TPW LV, sm	0,95±0,2	0,9±0,5	0,71±0,05
IVS, sm	1,0±0,8	0,88±0,1	0,8±0,1
RV, sm	2,0±0,4	1,74±0,3	1,45±0,2
SV, ml	80,4±0,6	72,1±6,0	61,9±5,6
EF, %	70,1±2,2	69,8±4,1	66,0±4,9
LVMM, г	116±7,3	84,0±8,7	94,9±8,3
LVMMI, г/м2	50,6±6,2	42,4±4,2	31,7±3,2
EFT	2 ±0,33 мм	-	-

Note:

LA - left atrium

FSS LV - the final systolic size of the left ventricle

FDS LV - the final diastolic size of the left ventricle

FSV LV - the final systolic volume of the left ventricle

FDV LV- the final diastolic volume of the left ventricle

TPW LV - the thickness of the posterior wall of the left ventricle

IVS- interventricular septum

RV - right ventricle

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SV - stroke volume

EF - ejection fraction

LVMM - left ventricular myocardial mass

LVMMI - left ventricular myocardial mass index

EFT - epicardial fat thickness

It was found that in children with obesity and overweight, the average parameters of echocardiography were within optimal values, however, in relation to the control parameters, ultrasound parameters of the heart were higher. In particular, an increase of 33% in the thickness of the left ventricle is 0.95 ± 0.2 cm in the main group versus 0.71 ± 0.05 cm in the control group, which may indicate an increase and / or expansion of the heart cavities due to volume overload.

Also, adolescents with obesity found additional signs of expansion of the heart chambers in the form of an increase in the diameter of the LA (3.08 ± 0.5 cm) and pancreas (2.76 ± 0.4 cm) in comparison with the control group 2.07 ± 0,9 cm and 1.45 ± 0.2 cm, respectively. It is likely that at this stage of structural and geometric myocardial rearrangement, the increase (expansion) of the LA and the pancreas are not true dilatation processes, but the element of primary adaptation (compensatory reaction) of the heart muscle, and / or these changes indicate the initial (functional, potentially reversible) signs diastolic dysfunction in conditions of an increase in the volume of circulating blood accompanying obesity.

In the comparison group, almost all of these indicators were higher than the echocardiographic parameters of normal-weight teenagers.

In adolescents with obesity, during echocardiography along the front wall of the pancreas, epicardial fat deposits with a thickness of 2 to 5 mm (average 2 ± 0.33 mm) were documented. In adolescents with excess and normal weight, epicardial fat was not visualized (Fig. 2).

Fig. 2: Echocardiogram Girl M. 16 Years Old

Diagnosis: Exogenously constitutional obesity of the I degree.

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Received: 07 Feb 2020 | Revised: 01 Mar 2020 | Accepted: 18 Mar 2020

In the mode: left parasternal access, the long axis of the left ventricle, epicardial fat with a thickness of 3.5 mm is visualized.

To obtain more complete information about the features of the relationship between the studied parameters, we performed a correlation analysis, which revealed a positive correlation with the thickness of epicardial fat, body mass index (r = 0.65; p = 0.01), and Waist / Hip index (r = 0,78; p = 0.001), as well as with indicators of lipid metabolism: LDL cholesterol (r = 0.57; p = 0.05), TG (r = 0.62; p = 0.1) and AC (r = 0.6; p = 0.01) (Fig. 3).

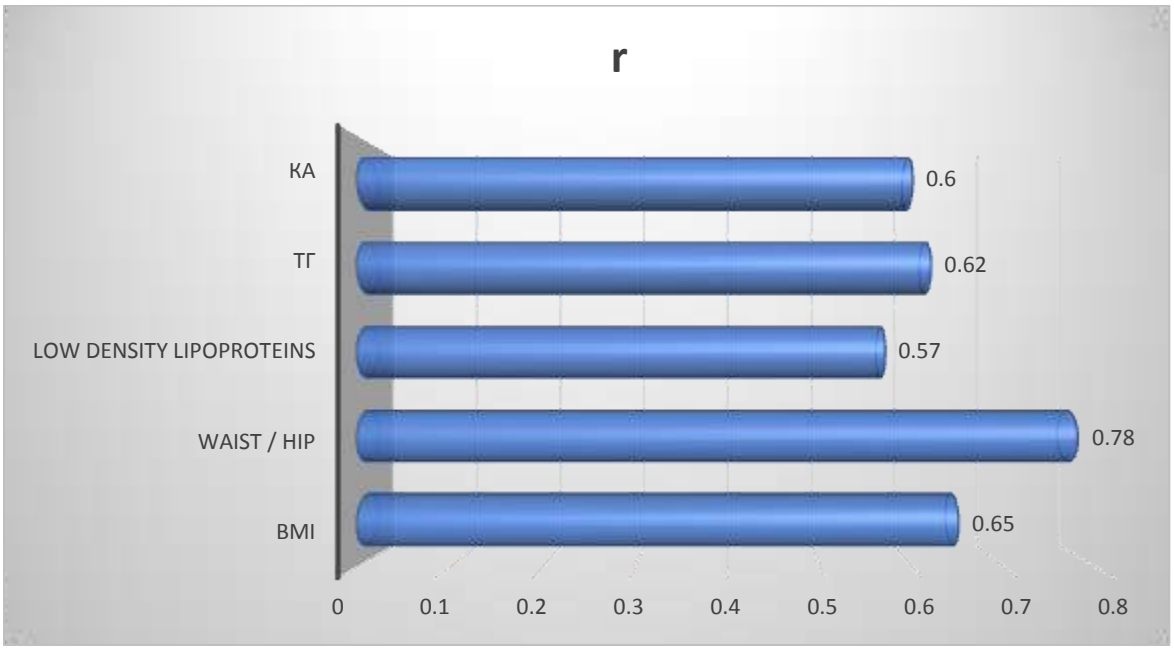

Fig. 3: The Correlation between the Thicknesses of the ECG, Physical and Metabolic Parameters

IV. CONCLUSIONS

1. Among the students examined by us, the largest number of children with obesity and overweight were in the group of children 15-17 years old.
2. In girls aged 13-17, obesity and overweight were diagnosed more often than in boys.
3. Teenagers with overweight and exogenously constitutional obesity of the first degree have a pro-atherogenic nature of changes in blood serum lipid profile, which is aggravated with an increase in the degree of excess weight.
4. Echocardiographic signs of enlargement of the heart chambers in the form of an increase in the diameter of the LA and RA , higher values of FSS LV, FDS LV, FSV LV and FDV LV in adolescents with overweight and exogenous-constitutional obesity of the 1st degree, compared with the control group, obviously , are elements of the primary adaptation of the heart muscle in conditions of an increase in the volume of circulating blood accompanying obesity, and with timely correction are potentially reversible.
5. Epicardial fat thickness greater than 2 mm is associated with increased levels of cholesterol and / or

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triglycerides, as well as a decrease in plasma HDL and cholesterol, which may contribute to the development of atherosclerosis in the future.

6. The resulting correlation between epicardial fat thickness and clinical and metabolic parameters may indicate the mutual influence of these factors, which must be taken into account when assessing cardiovascular risk in adolescents with obesity.

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DOI: 10.37200/IJPR/V24I5/PR201709
Received: 07 Feb 2020 | Revised: 01 Mar 2020 | Accepted: 18 Mar 2020