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Prediction of insulin resistance by triglyceride glucose (TyG) index *versus* log (TG)/HDL-C Indices in non-diabetic participants

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Abstract

Introduction: Insulin resistance (IR) syndrome, is described as being the primum movens of several pathologies and having a close link with numerous diseases. Glucides metabolism impairment mostly encompassed by lipid disorders is found in pre-diabetic patients, and even in normoglycemic ones.
Materials and Methods: We carried out this study for approximately one year. All volunteers above 18 years were eligible to participe. For participants naive of diabetes, blood samples were taken in different tubes for each intended analyses after 10 to 12 hours of fasting from the day before. Standard analyses (fasting glucose, total cholesterol, triacylglycerols, HDL cholesterol) have been run and we also registered anthropometrics parameters to calculate TyG and modified TyG ratios along with athorogenic index of plasma (AIP).
Results: 33% of participants had a TyG index above the normal range. Meanwhile, a positive statistical correlation have been highlighed between mean values of AIP, TyG BMI and TyGWC with TyG index for mean values more and more elevated. A positive statistical correlation has been found between TyG BMI and AIP, TyG index and TyGWC, similarly TyGWC with different biochemical parameters investigated showed a sustainable increasing of the mean value of fasting glyceamia, triacylglycerols, total cholesterol and LDL cholesterol. Concerning AIP index, 76% of participants had a mean value over 0.11 and within them 64% had a mean value above 0.21. AIP index was positively correlated with other biological parameters including TyG index, TyGBMI and TyGWC but not with BMI and Waist circumference.
Conclusion: its emerges that moreover clinical set tools, for instance HOMA-IR, the TyG index along with its modified trygliceride indices should be a good routinely indicator for insulin resistance. Nonetheless, It should be important to implement such a study on a larger population and carry out studies in conjunction with HOMA-IR in the same conditions.

Keywords: Insulin resistance, Triglyceride glucose index, Atherogenic index of plasma

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1. Introduction

Hypoglycemic hormon synthetised by pancreatic β cells, insulin plays a pivotal role in maintaining glucides balance along with that of homeostasis by its actions on other pathways such as lipides, protides and etc. Its biological activity is in connection with some tissues as liver, squeleton muscle, adipose tissue and others, however some disturbances may occur and prevent this one at the different peripheral sites.[1] These alterations have gathered as insulin resistance syndrome, described as being the primum movens of several pathologies and having a close link with obesity, diabetes, hypertension, polycystic ovary syndrome, etc.[1]

The hyperinsulinemic euglycemia clamp remains the gold standard for measuring insulin resistance (IR),[2] however its practical clinical application is limited by the labor intensiveness and cost and by ethical concerns. For these reasons, many other methods have been implemented for exploring IR in healthy individuals or illness ones. In 2008, the TyG index emerged as an alternative to HOMA-IR, serving as a surrogate marker for detecting IR in healthy individuals.[3] The calculation of the TyG index requires only two routine biochemical parameters: triglycerides and fasting plasma glucose. The triglyceride-glucose (TyG) index,[3] has emerged as a reliable surrogate marker for identifying IR and metabolic disorders due to its simplicity and practicality.[4-5]

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The TyG index has high sensitivity and specificity compared with the euglycemic hyperinsulinemic clamp test for recognizing IR.[6] The superiority of the TyG index in identifying IR was also reported in many other studies,[7,8,9] With these findings, a highly efficient substitute measure to establish IR can be easily applied in clinical setting. As evidence increasingly suggests that obesity exhibits a close relationship with IR a combination of obesity and TyG can potentially identify IR more strongly than other surrogate markers. Thus, in this investigation, we compare, TyG and TyG related parameters (TyG-WC,TyG BMI) for earlier identification of IR. We analyzed whether a combination of TyG with BMI or WC can be a more powerful, simple and inexpensive clinical surrogate marker for IR.[10]

As IR is often accompanied by dyslipidemia, glucids metabolism impairment mostly encompassed by lipid disorders is found in pre-diabetic patients, and even in normoglycemic people.[11-12] Previous studies have reported that the triglyceride/ high-density lipoprotein cholesterol (TG/HDL-C) ratio was also a surrogate marker of IR. [13-14] this ratio could predict IR in caucasians, and IR is not really established yet in other populations.[15-16] In our West Africa countries, and in Côte d'ivoire particularly, fewer studies have focused on the assessment of IR stem from both different ratios, consequently through this study we decided to evaluate which one of both is the more accurate surrogate marker for detecting IR within a cohort of healthy participants naive of diabetes.

2. Materials and Methods

2.1. Study design

We carried out a case-controls study for approximately one year, from december 2020 to september 2021. This study which aimed to study a specific type of diabetes also required inclusion of non-diabetic participants as controls. Those one were naive of diabetes and had approximately the same social and demographic features than cases. This study took place in Cote d'Ivoire (West Africa), precisely in Bouaké in the centre of the country.

2.2. Inclusion criteria

Participants were all aged above 18 and were volunteers to participe in this study. They gave their lightened consent after getting all information about how this study would be conducted. They were naive of diabetes without any screening test of diabetes before there inclusion in the study. Participants were randomly included in this cohort amongst healthcare practionners regardless gender, lifestyle and other any medical report out of diabetes. We strove to recruit as many men as women in this study and we collected information on questionnaire devoted to this purpose.

2.3. Data collection and clinical measurements

We have recruited 100 participants and registered social and demographic informations through our study questionnaire. Anthropometrics (weight, height, body mass index (BMI) and its standard deviation (SD), waist circumference and their percentiles were also notified. Measurements of waist circumference (WC) (midway between the iliac crest and the costal margin) and hip circumference (HC) (at the level of the trochanters) were performed twice by the same observer, and the mean value was recorded. Weight and height were measured without shoes in light clothing, and body mass index (BMI) was calculated by dividing the body weight in kilograms by square of the height in meters. Blood pressure measurements were obtained twice with a standard mercury sphygmomanometer with the subjects at rest, and the mean value was calculated. Related to BMI range was defined as (underweight, <18.5 kg/m^2; normal weight, 18.5 to <25 kg/m^2; overweight, 25 to <30 kg/m^2; obese, 30 to <35 kg/m^2; and very obese, >35 kg/m^2) and for WC as follows: for men < 102 cm and for women < 88 cm.[17-18]

2.4. Laboratory examinations and assays

Blood samples were taken in different tubes for each intended analyses after 10 to 12 hours of fasting from the day before (red and grey). Standard analyses encompassed of routinely parameters fasting glucose, total cholesterol, triacylglycerols, HDL cholesterol have been run on Cobas C 300 according to instructor's recommendation. LDL cholesterol was calculated by Friedwald's formulation according to restriction due to triacylglycerols value. TyG related parameters was calculated as follows: TyG index: Log [TG (mg/dL) × FPG (mg/dL)/2][4] TyG-BMI: TyG index × BMI and TyG-WC: TyG index × WC. TyG index and modified TyG indices were grouped into tertiles (T) as follows: TyG, T1: <8.36, T2: 8.36–8.87, and T3: >8.87; TyG-BMI, T1: <177.9, T2: 177.9-223.1, and T3: >223.1; and TyG-WC, T1: <684.4, T2: 684.4-775.7, and T3: >775.7.[10] For atherogenic index of plasma we used this formula: (AIP) = Log (TG/HDLc) and interpretation was done in these ranges T1: < 0.11,T2: 0.11 – 0.21, and T3: > 0.21.[19]

2.5. Physical activity assessment

Physical activity has a large effect on total human energy expenditure, and contributes 20-30% to the body's total energy output. The amount of energy expended for different activities will vary with the intensity and type of exercise. For each person, the range for total daily energy expenditure is highly variable, it depends on many factors, including: activity level, age, gender, size, weight and body composition. This activity has been evaluated from metabolic equivalent task (MET) minutes per week which tells us how much energy you have expended while performing various activities throughout the whole week. (MET-minute/week) = 8 × time of activity (min) × days devoted to activity per week; and enabled us to catogorize participants into three

different classes: Intense activity: ≥ 1500 MET-minute/week; moderate activity: ≥600 MET-minute/week and Low activity: <600 MET-minute/week.[20-21]

2.6. Ethical considerations

Approval for the study was obtained from the agreement of the scientific and medical director of the different hospitals in which the survey took place. Written informed consent was obtained from all participants (patients and controls). For participants with sub-literacy, the consent form was read aloud and signed in the presence of a witness. We recruited some people to help us for interview.

2.7. Data analysis

We computed data as part of excel and running all statistical analyses with SPSS 20 sofware. Results were expressed in mean value ± standard deviation, The correlation between different parameters was done by Chi squarre test for qualitative parameters and pearson correlation test for quantitative ones. The difference was considered significant for P value < 0.0 5.

3. Results

33% of participants had a TyG index above the normal range for individuals having a mean value of fasting glycemia at 0.92 g/l and triacylglycerols at 0.83g/l. Besides the mean age of participants with TyG index above normal range was higher than those with normal index without significant difference related to gender. We also noted that the mean value of anthropometric indicators such as BMI and waist circumference was growing similarly as the TyG index value with a significant statistic link. Meanwhile, a positive statistic correlation has been highlighed between mean values of AIP, TyG BMI and TyGWC with TyG index for mean values more and more elevated (**Table 1**).

The mean value of BMI at 25.80 has really impacted the TyG BMI index with more than 81% of participants getting mean value above 177.9. We similarly notified a sustainable growing and significant statistical link of WC mean value with TyGBMI. Mean values of cardiometabolic parameters were increasing as this ratio was growing. Positive statistical correlation has been found between TyG BMI and AIP, TyG index and TyGWC (**Table 2**).

The mean value of waist circumference was above above the reference cut offs in women regarding NCEP guidelines consequently as 61% of participants were women, we registered 70% of them with TyGWC above 684.8 unlike 30% in normal range value. There has been found in our cohort a positive statistical link between TyGWC with different biochemical parameters investigated with a sustainable increasing of the mean value of fasting glyceamia, triacylglycerols, total cholesterol and LDL cholesterol. The statistic correlation between TyGBMI and AIP and TyG indices was signifant (**Table 3**).

Concerning AIP index, 76% of participants had a mean value over 0.11 and within them 64% had a mean value above 0.21. The mean value of cholesterol HDL for those participants was decreseasing as the one of AIP was growing unlike the mean value of triacylglycerols in comparaison to AIP. Moreover unlike fasting glyceamia there is no significant statistical correlation with other parameters, AIP index was positively correlated with other biological parameters together with TyG index, TyGBMI and TyGWC but not with BMI and Waist circumference (**Table 4**).

Table 1: Baseline characteristics of participants regarding TyG index.

		TyG Index (mean±SD)			
	Mean value	< 8.36	8.36 – 8.87	> 8.87	**P value**
TyG Index	8.153	67 (7.89±0.2)	24 (8.49±0.1)	09 (9.14±0.1)	-
Age, years	42.41	40.62	46.91	43.66	0.01*
Sex, %					0.26
Male	39	27 (7.91 ±0.2)	8 (8.55 ±0.1)	5 (9.18 ±0.1)	-
Female	61	41 (7.86 ±0.3)	16 (8.46 ±0.0)	4 (9.09 ±0.2)	-
BMI	25.80	25.30 ±4.9	26.69 ±3.3	27.11 ±4.3	0.01*
Waist Circumference	88.81	87.37 ±10.12	91.52 ±7.0	92.88 ±6.5	0.00*
Physical A. (MET/min)	184.4	182.08 ±366	163.33 ±292	257.77 ±382	0.89
Fasting blood glucose (g/l)	0.925	0.875 ±0.1	0.991 ±0.1	1.125 ±0.2	0.00*
HDL-C (g/l)	0.41	0.41 ±0.1	0.42 ±0.1	0.43 ±0.1	0.55
Triacylglycerols (g/l)	0.83	0.65 ±0.1	1.02 ±0.1	1.73 ±0.3	0.00*
Total cholesterol (g/l)	1.624	1.565 ±0.3	1.706 ±0.3	1.842 ±0.4	*0.01**
LDL-C (g/l)	1.041	1.02 ±0,3	1.08 ±0.2	1.06 ±0.4	*0.43*
AIP	0.284	0.20 ±0.1	0.38 ±0.0	0.60 ±0.1	*0.00**
TyG BMI	210.84	200.08 ±41.3	226.98 ±28.8	247.91 ±39.6	*0.00**
TyG WC	727.01	693.07 ±93.7	775.86 ±61.8	849.46 ±59.8	*0.00**

Table 2: Baseline characteristics of participants regarding TyG BMI index.

	Mean value	TyG BMI (mean±SD)			P value
		< 177.9	177.9 – 223.1	> 223.1	
TyG BMI	210.84	19 (154.2±14.9)	51 (203.8±2.9)	30 (259.7±27.7)	-
Age, years	42.41	37.7	45.1	40.9	0.58
Sex, %					0.45
Male	39	11 (155.7±14.2)	23 (203.2±12.1)	5 (250.8±16.5)	-
Female	61	8 (152.2±16.8)	28 (203.2±12.5)	25 (261.5±29.3)	-
BMI	25.80	19.8±1.4	25.1±1.6	30.8±3.7	0.00*
Waist Circumference.	88.81	79.3±7.6	88.5±6.6	95.3±9.2	0.00*
Physical A. (MET/min)	184.4	198±379	229±363	100±296	0.35
Fasting blood glucose (g/l)	0.925	0.89±0.10	0.92±0.15	0.95±0.17	0.05*
HDL-C (g/l)	0.41	0.40±0.10	0.44±0.12	0.40±0.10	0.59
Triacylglycerols (g/l)	0.83	0.60±0.13	0.79±0.28	1.07±0.45	0.00*
Total cholesterol (g/l)	1.62	1.45±0.28	1.66±0.39	1.68±0.42	0.02*
LDL-C (g/l)	1,04	0.94±0.25	1.06±0.30	1.07±0.35	0.11
TyG index	8.15	7.78±0.41	8.12±0.38	8.44±0.46	0.00*
AIP	0.28	0.18±0.14	0.25±0.15	0.40±0.21	0.00*
TyG WC	727.01	617.9±77.9	719.2±64.4	809.5±85.8	0.00*

Table 3: Baseline characteristics of participants regarding TyG WC index.

	Mean value	TyG WC (mean±SD)			P value
		< 684.4	684.4 – 775.7	> 775.7	
TyG WC	727.01	30 (612.9±56.4)	37 (724.0±27.6)	33 (834.1±48.3)	-
Age, years	42.41	39.3	41.9	45.7	0.05*
Sex, %			0.42		
Male	39	13 (634.1±45)	14 (730.3±26)	12 (821.2±38)	-
Female	61	17 (596.7±60)	23 (720.1±27)	21 (841.6±52)	-
BMI	25.80	22.5±3.41	25.5±3.11	29.1±4.59	0.00*
Waist Circumference.	88.81	78.1±5.8	89.6±3.3	97.6±6.2	0.00*
Physical A. (MET/min)	184.4	240±365	169.7±379	150.3±297	0.87
Fasting blood glucose (g/l)	0.925	0.90±0.11	0.88±0.14	1.00±0.17	0.00*
HDL-C (g/l)	0.41	0.39±0.12	0.43±0.12	0.43±0.10	0.04
Triacylglycerols (g/l)	0.83	0.62±0.12	0.79±0.27	1.10±0.45	0.00*
Total cholesterol (g/l)	1.62	1.45±0.31	1.63±0.41	1.77±0.37	0.00*
LDL-C (g/l)	1.04	0.94±0.22	1.05±0.35	1.13±0.31	0.01*
TyG index	8.15	7.84±0.36	8.08±0.35	8.51±0.44	0.00*
AIP	0.28	0.20±0.15	0.26±0.16	0.38±0.21	0.00*
TyG BMI	210.84	176.85±29,7	206.45±25.7	246.70±36	0.00*

Table 4: Repartition of participants according to AIP index.

	Mean value	AIP Index (mean±SD)			P value
		< 0.11	0.11 – 0.21	> 0.21	
AIP index	0,284	24 (0.04±0.03)	12 (0.15±0.03)	64 (0.40±0.13)	-
Age, years	42.41	24 (34.3)	12 (45.8)	64 (44.8)	0.00*
Sex, %			0.38		
Male	39	0.03±0.03	0.14±0.03	0.40±0.16	-
Female	61	0.04±0.03	0.15±0.02	0.39±0.12	-
BMI	25.80	24.61±4.35	26.82±7.27	26.05±3.93	0.07
Waist Circumference.	88.81	88.87±11.13	90.41±10.67	88.48±8.46	0.46
Physical A. (MET/min)	184.4	266.6±403	343.3±437	123.7±295	0.04
Fasting blood glucose (g/l)	0.925	0.91±0.10	0.94±0.15	0.93±0.17	0.22
HDL-C (g/l)	0.41	0.52±0.10	0.45±0.09	0.37±0.09	0.00*
Triacylglycerols (g/l)	0.83	0.56±0.09	0.65±0.13	0.98±0.37	0.00*
Total cholesterol (g/l)	1.62	1.82±0.37	1.74±0.30	1.53±0.38	0.00*
LDL-C (g/l)	1.04	1.19±0.34	1.17±0.21	0.96±0.28	0.00*
TyG index	8.15	7.75±0.35	8.00±0.30	8.33±0.43	0.00*
TyG BMI	210.8	191±37.01	214.7±60.2	217.6±36.7	0.00*
TyG WC	727.01	690.2±103	723.7±97	741.4±94	0.00*

4. Discussion

Insulin resistance syndrome is a metabolic disorders occuing during type 2 diabetes proceeding in overall and more scarcely in the course of type 1 diabetes and also in other metabolic diseases, this disorder more or less important may be present upstream and/or downstream in the onset of these diseases. IR plays an important role in type 2 diabetes, metabolic syndrome, and cardiovascular diseases.[22-24] Therefore, earlier detection of IR in people at risk for future cardio vascular diseases is important. In the management of type 2 diabetes, for instance, occurrence of insulin resistance syndrome undermine this disease and the need of reassessment of treatment in the aim to get a better metabolic balance is crucial. Subsequent researches consistently demonstrated that a high TyG index is associated with an increased risk of complications such as metabolic syndrome,[25] cardiovascular disease,[26-27] and type 2 diabetes mellitus (T2DM).

If it's admitted that insulin resistance is more frequent in the course of some diseases It's true that this metabolic disorder precede by far (many years before) the onset of cardiometabolic diseases and is more and more prevalent within lots of people, clearly younger and living out of western countries the prevalence of diabetes is much more growing in, and for those, IDF outlooks are alarming. Despite the lowest prevalence estimate of 4.5% among IDF Regions, the expected increase in the number of people with diabetes by 2045 is the highest at 129%, reaching 55 million. The Afric region is also predicted to have the highest increase of 107% in the number of people with impaired glucose tolerance by 2045, reaching 117 million. The proportion of undiagnosed diabetes is also highest in the Afric region at 53.6%.[28]

Many scientific reports have revealed the accuravy of TyG index and modified triglyceride glucose indices in line with AIP index in insulin resistance syndrome assessment in diabetic or non-diabetic participants.[29-32] In our study, more than a third of participants were in insulin resistance state in keeping with the mean values of TyG index. Our results are comparable to those reported by jayashaukar et al.[33] who found approximatly a prevalence of 20% in insulin resistance state which have developped diabetes after eight years of follow-up. These participants, in insulin resistance state, had a mean value of age higher than the others along with mean values of fasting glyceamia and triacylglycerols higher. These values were respectively 1.05g/l and 1.37g/l for glyceamia and triglyceridemia, this trend was altogether different from data reported by jayashaukar et al.[34] in their study. Participants included in our study were much older with higher mean values of different parameters.

Insulin resistance syndrome evolves in many different steps during which we may have a phasis of hyperglycemia associated with hyper insulinemia. Consequently the anabolic effect of insulin would initiate an important lipogenesis process responsible of hypertriglyceridemia status and farther lipodystrophy syndrome with adverses effects in many tissues.[29] Several studies have validated the relationship between the TyG index and insulin resistance. First, hypertriglyceridemia may increase hepatic glucose output with the increased transport of free fatty acids to the liver, making it one of the important risk factors for type 2 diabetes.[33-34] Researches have shown that TG elevation can induce insulin resistance through the impairment of muscle glucose metabolism.[35] Secondly, insulin accelerates adipocyte triglycerides stores by promoting triglyceride synthesis and inhibiting lipolysis as well as promoting the maturation of adipocytes.[33]

This chronic hyperinsulinism state have also adverse effects on other lipid parameters namely total cholesterol and LDL cholesterol levels by initiating a rising value of these parameters in insulino resistant participants in line with the decreasing mean value of HDL cholesterol. Definitively, these metabolical disturbances may end up to generate a process of weight's gaining to individuals in regard to highed mean value of BMI and waist circumference respectively to 26.9kg/m^2 and 92.2 cm. This trend is corroborated by pathophysiological mechanism explained away in literature.[36] While body mass index and waist circumference are the both important clinical indicators to assess cardiometabolic risk, the mean value of WC is more prevalent and pointed out to evaluate the issue of cardiometabolic diseases because measurement of central obesity, such as WC and WHtR, have been suggested as better indices than BMI because central obesity is closely associated with fat distribution but not BMI.

Atherogenic index of plasma (AIP) is also known as an indicator of cardiovascular diseases associated to several pathologies such as HTA, obesity and diabetes to name a few.[37] This ratio is, out of numerous, one of the best which help to calculate the vascular risk score more importantly than considering solely the different results of lipid parameters. Nonetheless, currently in literature we have noted that some authors have used this ratio to both assess atherogenic risk and insulin reisistance risk.[38-39]

Concerning AIP index, in our cohort, 76% of participants had a mean value over 0.11 within them 64% had a mean value above 0.21. This proportion for non-diabetic participants, randomly recruited, was widely above our expectations and seemed to be alarming for us. Many studies have shown that increasing triacylglycerols and decreasing HDL-C could cause insulin resistance. When circulating TG was at high levels, heparin activated lipoprotein lipase to increase intravascular lipolysis of TG, thus increasing the risk of tissue exposure to free fatty acids (FFAs). High free fatty acids could result in insulin resistance via oxidative stress pathways.[38-40] Our results are in line with those reported in literature in which previous studies have suggested that the prediction of lipid ratios for IR was influenced by confounding factors, such as sex, age, and BMI.[38] Profile of participants having higher AIP index shows that they were mostly older, had highest mean value of triacylglycerols and fasting blood glucose unlike of lowest mean value of HDL cholesterol, total cholesterol and LDL cholesterol. These features were in line with those observed with TyG index and might be in adequation with insulin resistance syndrome. Nonetheless, in our study, the declining in mean value of BMI and WC as AIP index was growing with respective value of 26.82 kg/m^2 against 26.05 kg/m^2 and of 90.41 cm against 88.48 cm was quite in opposition to TyG index. Notwithstanding AIP index was twice as TyG index, It emerges a positive statistical link between AIP index and TyG index, TyG BMI and TyG WC, and that could witness a close relationship between these different ratios and the key role played by triacylglycerols in the breaking of cardiometabolic syndrome.

At first glance, regarding the important gap between insulin resistance proportion and/or atherogenic risk for participants according to both TyG index and AIP index, we might state that in our context the former should be more precise and accurate than the latter for insulin resistance assessment. Accuracy and the choice of TyG index might explain away in one hand by using of fasting blood gucose in computing of this ratio may give more precision about glucose balance and in another hand because there was established a positive statistical correlation between TyG index and BMI, WC, triacylglycerols, fasting blood glucose and AIP index. Moreover, the positive correlation between AIP index with HDL cholesterol and LDL cholesterol, which are both parameters of atherogenic risk assessment, we deem advisable that AIP index may be more appropriate for atherogenic risk assessment in contrary to TyG index.

Correlated indices with TyG index, TyG BMI and TyG WC, were statistically correlated with AIP, BMI, WC and vice-versa thus the interest of these indices for appreciation of IR in young and adluts healthy individuals, this trend was in line with those found by *kyungchul song and al*,[29] and others.[41-42] This study had some limitations. This study was a cross sectional study designed to investigate the prediction of insulin resistance regarding two different ratios in non-diabetic participants, however, longitudinal study might be more convincing than this cross-sectional one. The size of samples was also a real limitation, and we are planning to continue researches in IR evaluation into different groups.

5. Conclusion

Pivotal element of prediabetes status along with in the pathophysiology of several cardio vascular and inflammatory diseases, insulin resistance syndrome is now the cornerstone of many biological investigations both for patients and apparently healthy people. The precision of clinical and biological tools required for a better assessment of this syndrome is important. At the end of or preliminary study focused on healthy participants, It emerges that moreover clinical set tools, for instance insulinemia and fasting glyceamia for homeostasis model assessment of insulin resistance (HOMA-IR) calculation, the TyG index along with its modified trygliceride indices (TyG BMI and TyG WC) should be a good routinely indicator for insulin resistance evaluation within ivorian populations in healthy or suffering from diseases which might be hosted cardio metabolic risks. To draw formal conclusions and adopt these indices as real indicators of insulin resistance, It should be important to implement such a study on a larger population and carry out studies in conjunction with HOMA-IR in the same conditions.

6. Source of Funding

None.

7. Conflict of Interest

None.

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