Bernard KP, et al., J Cardiol Stud Res 2021, 6: 017
DOI: 10.24966/CSR-768X/100017

HSOA Journal of Cardiology: Study & Research

Cross-Sectional Study

Prevalence and Determinants of Insulin Resistance in Asymptomatic Black Congolese with Essential Hypertension: A Cross-Sectional Study

Kianu Phanzu Bernard[1,2*], Nkodila Natuhoyila Aliocha[3], Masolo Muze[4], Kintoki Vita Eleuthère[1], M'Buyamba Kabangu Jean-René[1] and Longo-Mbenza Benjamin[1]

[1]*Unit of Cardiology, University Hospital of Kinshasa, Kinshasa, DR Congo*

[2]*Centre Médical de Kinshasa (CMK), Kinshasa, Democratic DR Congo*

[3]*Department of Biostatistics, Public Health School, Kinshasa, DR Congo*

[4]*University of Technology, Bel Campus, Faculty of Medicine, Kinshasa, Democratic Republic of Congo*

Abstract

Background and aims: Hypertensive patients with Insulin Resistance (IR) have an increased cardiovascular risk compared with those without IR. Thus, data on the prevalence and determinants of IR in essential hypertension are crucial to understanding the impact of this health problem and defining intervention or prevention strategies.The present study aimed to assess IR prevalence and identify its determinants in a consecutive hospital series of Black Congolese with essential hypertension.

Methods: A total of 105 asymptomatic, non diabetic participants with essential hypertension (56 men, 53.3%) aged 57 ± 11 years were consecutively selected during outpatient consultations in Lomo Médical Clinic, Kinshasa, Democratic Republic of Congo. IR was defined as homeostatic model assessment-IR of ≥2.5.

Results: IR prevalence was 48.5% (51/105). In multivariate analysis, adjusted for age, body weight, waist circumference, and BMI, the risk of IR was independently and significantly (p<0.05) associated with cigarette smoking (Odds Ratios [OR],3.1; 95% Confidence Interval [CI], 1.2-8.5), hypertriglyceridemia (OR,2.4; 95% CI, 1.1-5.3), hyperuricemia (OR,2.7; 95% CI,1.3-5.6), and uncontrolled hypertension (OR,4.2; 95% CI,2.1-7.4).

Conclusion: Almost half of the patients with essential hypertension appear to be insulin-resistant, and cardiovascular risk factors are more prevalent in this subset of patients. Smoking cessation, treating hypertriglyceridemia and hyperuricemia, and improving hypertension management could help prevent IR and the associated risks of morbidity and mortality in Black Congolese with essential hypertension.

Keywords: Black; Congolese; Determinants; Essential hypertension; Insulin resistance; Prevalence; Sub-Saharan African

Background

Essential hypertension is commonly associated with metabolic abnormalities, including Insulin Resistance (IR), the inability of a known quantity of exogenous or endogenous insulin to increase glucose uptake and utilization in an individual as much as it does in a normal population [1]. IR is a cardiovascular risk factor [2]. Indeed, IR assessed by Homeostatic Model Assessment (HOMA) has shown to be independently predictive of cardiovascular disease in several studies; one unit increase in IR is associated with a 5.4% increase in cardiovascular disease risk [3].The link between IR and hypertension was confirmed by the European Group for the Study of IR, which demonstrated that Blood Pressure (BP) is directly correlated with IR and insulinemia, independently of age, gender, and obesity [4]. This correlation has serious consequences because IR and its manifestations have been shown to play a key role in the development of cardiovascular complications in patients with hypertension. Thus, insulin-resistant patients with hypertension would have an increased cardiovascular risk compared with non-insulin-resistant patients with hypertension and would require special medical attention [5-9]. Since almost all this information comes from studies conducted on Caucasian, American, and Asian populations, this study aims at determining the prevalence of IR and identifying its determinants in a Black Congolese population with essential hypertension. Indeed, data on the prevalence and determinants of IR in a population with hypertension is essential to understanding the importance of this health issue and defining intervention or prevention strategies.

Methods

Cross-sectional analysis was performed on data from 105 asymptomatic non diabetic participants with hypertension (56 men, 53.3%) aged 57 ± 11 years. The participants were consecutively selected during outpatient consultations from January 5, 2012, to January 5, 2013, in Lomo Medical Clinic, a private hospital center in Limete, Kinshasa, Democratic Republic of Congo.

The inclusion criteria were age of 20 years and above; absence of previous cardiovascular history, including stroke, acute coronary

***Corresponding author:** Kianu Phanzu Bernard, Unit of Cardiology, University Hospital of Kinshasa, Kinshasa, DR Congo, Tel: +243 997 622 019; E-mail: doctorkianu@gmail.com

Citation: Bernard KP, Aliocha NN, Muze M, Eleuthère KV, Jean-René MBK, et al. (2020) Prevalence and Determinants of Insulin Resistance in Asymptomatic Black Congolese with Essential Hypertension: A Cross-Sectional Study. J Cardiol Stud Res 6: 017.

Received: February 26, 2021; **Accepted:** March 10, 2021; **Published:** March 17, 2021

syndrome, and heart failure; and clinical or laboratory evidence of secondary hypertension and renal or hepatic disease. Participants in a gestational state were excluded from the study.

Participants were thoroughly assessed by a previously trained investigator for demographic data (age, sex), hypertension duration, and risk behavior (excess alcohol intake, cigarette smoking) using an ad hoc questionnaire. Anthropometric measurements (body weight in kg, height in cm, and waist circumference in cm) were taken of all participants using standard methods. Body Mass Index (BMI) was calculated as body weight (kg) divided by the square of body height (m^2).

BP was noninvasively measured by home BP monitoring using an OMROM M6 BP monitor (OMRON Healthcare Co., Ltd., Kyoto, Japan) with a suitable cuff. The procedure was adequately explained to each participant.

Carbohydrate metabolism parameters (glycemia, insulin, glycated hemoglobin, HOMA-IR), lipid metabolism parameters (total cholesterol, high-density lipoprotein [HDL-C], low-density lipoprotein [LDL-C], triglycerides), and purine metabolism parameters (serum uric acid [SUA]) were assayed using standard methods. For all analyses, blood samples were collected between 7 a.m. and 9 a.m. from the cubital vein after an overnight fasting from 10 p.m. of the previous day. All analyses were conducted at the Lomo Médical Laboratory.

Operational definitions

IR was defined as a HOMA-IR of ≥ 2.5 [10]. Uncontrolled hypertension was defined as an average home BP measurement greater than the treatment targets, i.e. > 130/80 mmHg [11]. Cigarette smoking was defined as regular smoking for at least 30 days before the present study, regardless of the number of cigarettes [12].

Excessive alcohol consumption was defined as drinking > 2 glasses of beer/day or the equivalent amount for at least one year. Hyperinsulinemia was been as fasting insulin of >90 mmol/L.

Abdominal obesity was defined as waist circumference of > 94 cm for males and > 80 cm for females [13]. Dyslipidemia was defined as HDL-C of <40 mg/dL for males and <50 mmol/dL for females, an LDL-C of ≥130 mg/dL, total cholesterol level of ≥185 mg/dL, and/or triglyceride level of ≥150 mg/dL [14]. Hyperuricemia was defined as a uric acid of >7 mg/dL [15].

Statistical Analysis

Data were expressed as mean ± standard deviation or relative frequency (%). Pearson's simple correlation coefficients were calculated to establish the relationship between two continuous variables. The independent determinants of IR were assessed using multiple linear regression.

Chi-square test and Student-s t-test were used to compare the proportions and means of groups and subgroups, respectively.

Odds Ratios (ORs) and 95% Confidence Intervals (CI) were derived using logistic regression analysis to assess the relative contribution of each factor to the risk of a high HOMA-IR index. For the selection of variables in the logistic regression model, the minimum significance level to be included in the model was p <0.05, which was considered the threshold of statistical significance. p<0.01 was considered the highly significant threshold, and p <0.001was considered the very significant threshold.

Ethical Considerations

This research was conducted in strict compliance with the recommendations of the Helsinki Declaration III. Approval to conduct the study was obtained from the National Health Ethics Committee (no. 219/CNES/BN/PMMF/2020). All respondents were debriefed on the results of the study.

Results

Study participants (n = 105) were all aged 35 yearsand over, with a mean age of 50 ± 6 years (range, 35–60 years). Fifty-six (53.3%) were males and 49 (46.7%) were females. Men and women were distributed at a sex ratio of 1.14.

Table 1 illustrates similar values (p> 0.05) of age, sex, hypertension duration, hypertension treatment, height, glycated hemoglobin, total cholesterol, and LDL-C in insulin-resistant group compared to non-insulin-resistant. Weight, WC, BMI, glycemia, insulinemia, and triglycerides were, on average, significantly higher (p <0.05) in the insulin-resistant group than in the non-insulin-resistant group. However, HDL-C was lower in the IRgroup.

Parameters	Whole group (n =105)	IR+ (n = 51)	IR– (n = 54)	p
Age (years)	57 ± 11	57.1 ± 11.2	57.8 ± 13.4	0.750
Males (%)	56 (53.3)	32 (62.7)	24 (44.4)	0.342
HTN duration (years)	10 ± 9.4	11 ± 6.7	10.8 ± 3.5	0.781
Weight (kg)	87 ± 15	90.5 ± 14.8	71.1 ± 10.6	0.000
Height (cm)	1.6 ± 0.1	1.6 ± 7.8	1.6 ± 6.8	0.989
Waist circumference (cm)	99.3 ± 11.6	102.4 ± 9.6	85.0 ± 9.7	0.000
BMI (kg/m2)	32.4 ± 6.1	33.6 ± 5.7	26.4 ± 4.4	0.000
Glycemia	100 ± 41	105 ± 10	95 ± 13	0.03
Insulinemia (µU/mL)	13.2	17 ± 16	10 ± 5	<0.001
HOMA-IR	8.7 ± 3.4	9.8 ± 2.7	2.1 ± 2.0	0.012
Glycated hemoglobin (%)	5.0 ± 2	5.5 ± 1	5.1±1	0.42
Total cholesterol (mg/dL)	190 ± 22	200 ± 20	195 ± 37	0.81
HDL-C (mg/dL)	48.7 ± 12	40 ± 09	55 ± 10	0.012
LDL-C (mg/dL)	123 ± 22	125 ± 28	122 ± 34	0.45
Triglycerides (mg/dL)	170 ± 54	190 ± 81	118 ± 75	<0.001
SUA	7.5 ± 5	9.2 ± 3	6 ± 5	<0.001

Table 1: Demographic, clinical and biological characteristics of the study population.

IR: Insulin Resistance; HTN: Hypertension; BMI: bodymass index; HOMA-IR: Homeostatic Model Assessment for Insulin Resistance; HDL-C: High-Density Lipoprotein Cholesterol; LDL-C: Low-Density lipoprotein Cholesterol; SUA: Serum Uric Acid

The data presented in Table 2 indicate a statistically similar proportion of participants with heavy alcohol intake, overall obesity, high total cholesterol, and high LDL-C in the IR and non-IRgroups. In contrast, the smoking rate, abdominal obesity, HDL-C, hypertriglyceridemia, and hyperuricemia were, on average, significantly higher in the IRgroups.

Table 3 shows the IR prevalence of the study population and different subgroups of this population. At the threshold for defining

IR (HOMA-IR ≥ 2.5), the hospital IR prevalence rate was 48.5% (51/105). In patients with uncontrolled BP, the prevalence was 64.2% (45/70); in those with controlled BP, the prevalence was 26% (7/35). In obese hypertensive patients, the prevalence was 62.7% (42/67) vs. 39.5% (15/38) in non-obese hypertensive patients with hypertension who are nonobese.

Parameters	IR+ (n = 51)	IR– (n = 54)	p
Alcohol intake	25.4 (13)	5.5 (3)	0.051
Cigarette smoking	14 (7)	5.6 (3)	0.032
WC> 94 cm (males)	43.1 (22)	22.2 (12)	<0.001
WC> 80 cm (females)	39.2 (20)	26 (14)	<0.001
BMI> 30 kg/m²	51 (26)	46.3 (25)	0.075
TC > 185 mg/dL (%)	39.2 (20)	29.6 (16)	0.27
HDL-C < 50 mg/dL (female)	19.6 (10)	7.4 (4)	<0.001
HDL-C < 40 mg/dL (male)	45 (23)	9.2 (5)	<0.001
LDL-C ≥ 130 mg/dL	27.4 (14)	24.1 (13)	0.20
Triglycerides ≥ 150 mg/dL	68.6 (35)	22.2 (12)	<0.001
SUA> 7 mg/dL	64.7 (33)	29.6 (16)	0.012

Table 2: Cardiovascular risk factors according to the presence of IR.

IR: Insulin Resistance; WC: Waist Circumference; BMI: Body Mass Index; TC: Total Cholesterol; HDL-C; High-Density Lipoprotein Cholesterol; LDL-C; Low-Density Lipoprotein Cholesterol; SUA: Serum Uric Acid

Subgroups	Prevalence % (n)
Whole group	48.5 (51/105)
Participants with uncontrolled HTN	64.2 (45/70)
Participants with controlled HTN	26 (7/35)
Obese participants	62.7 (42/67)
Nonobeseparticipants	39.5 (15/38)

Table 3: Prevalence of IR in the study population and different subgroups of this population.

IR: Insulin Resistance; HTN: Hypertension

The risk factors for IR (Table 4) included age ≥ 55 years, uncontrolled BP, smoking, hypertriglyceridemia, total hypercholesterolemia, and hyperuricémie.

In multivariate analysis adjusted for age, body weight, waist circumference, and BMI, the risk of IR was independently and significantly (p <0.05) associated with cigarette smoking, hypertriglyceridemia, hyperuricemia, and uncontrolled hypertension (Table 5), as according to the following equation:

Y= −1.404 + 1.054 cigarette smoking+ 0.872 hypertriglyceridemia + 0.983 hyperuricemia + 0.852 uncontrolled hypertension.

Discussion

To our knowledge, this is the very first study to assess IR prevalence and determinants in a Congolese Black hypertensive in-hospital population. Cigarette smoking, hypertriglyceridemia, hyperuricemia, and uncontrolled hypertension appear to be independent determinants of IR. Additionally, a higher frequency of cardiovascular risk factors was noted among IR participants.

Independent Variables	OR (95% CI) (% vs. %) P
Age <55yearsvs. ≥55 years	2.1 (1.3-10) 84.7 vs. 15.3 0.03
Uncontrolled HTN Yes vs. No	9.8 (4.9-10) 64.2 vs. 33.4 0.017
Cigarette smoking Yes vs. No	3.1(1.2-8.5) 14.0 vs. 2.0 0.03
Triglycerides ≥ 150 mg/dL Yes vs. No	2.7(1.3-5.6) 68.6 vs. 22.2 <0.01
Total cholesterol (mg/dL) ≥185 mg/dL vs. <185mg/dL	9.9(5-10.2) 39.2 vs. 29.0 0.008
SUA> 7 mg/dL (%) >6.5%mg/dLvs. ≤6.5% mg/dL	2.2(1.8-5.6) 64.7 vs. 29.6 0.04

Table 4: IR risk factors.

IR: Insulin Resistance; HTN: Hypertension; SUA: Serum Uric Acid

Independent variables	Nonstandardized coefficients			OR (95% CI)	p
	ß	SE	χ2		
Cigarette smoking Yes vs. No	1.054	0.552	4.647	3.1(1.2-8.5)	0.049
Hypertriglyceridemia Yes vs. No	0.872	0.406	4.619	2.4(1.1-5.3)	0.032
Hyperuricemia Yes vs. No	0.983	0.381	6.652	2.7(1.3-5.6)	<0.0001
Uncontrolled HTN Yes vs. No	0.852	0.381	8.293	4.2(2.1–7.4)	<0.0001
Constant	−1.404	0.258	29.512		<0.0001

Table 5: Independent determinants of IR in the study population.

IR: Insulin Resistance; OR: Odds Ratio; CI: Confidence Interval; HTN: Hypertension

Some studies have found a similar IR prevalence of almost 50% in essential hypertension [16-18]. However, Garcia-Puig et al. [19] obtaineda prevalence of 9.3%, whereasMohteshamzadeh et al. [20] obtained a prevalence of 20%. These results greatly differ from ours. Several explanations can justify this disparity, including the methodology used to characterize IR and, for studies that also used the HOMA-IR index, the definition thresholds used. For example, Garcia-Puig, et al. set the threshold arbitrarily at 3.8, whereas it was set at 3.0 in the study by Mohteshamzadeh, et al. [19,20]. Studies using direct diagnostic methods for IR, such as that by Lima, et al. [18], also concluded that nearly 50% of patients with essential hypertension were insulin-resistant, whether treated or not.

The HOMA-IR index has been the subject of numerous validations and has shown a satisfactory correlation (r = 0.72–0.82, depending on the studies) with the hyperinsulinemic-euglycemic clamp, the gold standard for measuring insulin sensitivity, without any notable

difference, depending on sex, age, weight, diabetic status, and elevated BP [21]. HOMA-IR has the advantage of ease of implementation. No standard HOMA-IR threshold has been established to define IR in the population of Sub-Saharan Black with hypertension. The threshold of 2.5 used in this study has been used in various studies conducted in African [22], African American [10], Euro-American [23], Caucasian [24], and Asian populations [25,26].

The present study identified cigarette smoking, hypertriglyceridemia, hyperuricemia, and hypertensive failure as independent determinants of IR inessential hypertension. Numerous studies have shown that smoking is associated with both insulin secretory deficiency and IR [27,28]. Insulin secretory deficiency is thought to be due to a direct deleterious effect of nicotine on the β cells of the islets of Langerhans. Indeed, nicotine has been found to influence insulin secretion by binding to nicotinic acetylcholine receptors located on the β cells of the islets of Langerhans and increase the apoptosis of these β cells [29-31]. According to some studies, smoking is associated with the hypertrophy of visceral adipose tissue, which is linked to IR [32]. Indeed, Canoy, et al. [33] demonstrated in a large British population study that the waist/hip ratio was higher in smokers compared with non smokers after adjusting for age, BMI, alcohol consumption, total energy intake, and physical activity level. The same study found that a higher waist/hip ratio was directly associated with the number of pack-years in current smokers and former smokers and conversely with the time since smoking cessation in former smokers. The effects of smoking on IR may therefore be mediated, at least in part, by visceral fatty tissue hypertrophy and subsequent systemic inflammation.

IR has been shown to be often accompanied by dyslipidemia as part of the metabolic syndrome. In fact, the current dominant paradigm is that IR leads to dyslipidemia. However, recent evidence from epidemiological, genetic, and interventional studies suggest that hypertriglyceridemia may also cause IR through mechanisms not yet understood [34].

The identification of hyperuricemia as a determinant of IR is in agreement with the study by Han, et al. who found that hyperuricemia may be a causative factor in the development of IR [35]. De Miranda et al. found a 91% increase in the chance of insulin resistance for every increase of 1 mg/dL in serum uric acid levels [36]. Another solid evidence of this causal relationship has been provided by Takir, et al. by demonstrating that the decrease in uric acid in hyper uricaemic is effective in improving insulin resistance [37].

No previous study has demonstrated a link between uncontrolled BP and IR. This result is in agreement with the study by Izzo et al. [38] who demonstrated in a prospective cohort of nondiabetic patients with hypertension that uncontrolled hypertension doubled the risk of developing type 2 diabetes mellitus regardless of age, BMI, BP, basal blood sugar, or fasting blood sugar.

The present study showed a higher frequency of smoking, abdominal obesity, low HDL-C, hypertriglyceridemia, and hyperuricemia in IR participants. This is in agreement with the many previous studies that have shown that IR patients with hypertension have an increased cardiovascular risk. As often described in the literature, the development of cardiovascular risk factors tends to aggregate to form IR syndrome or cardio metabolic syndrome [39].

The present study acknowledges the following methodological limitations:

1. The cross-sectional design of this study did not allow the establishment of causal links.
2. The single-center aspect of this study limits the generalization of the obtained results to the entire population with hypertension.
3. The alternative method of IR assessment used in the present study, although having been widely validated elsewhere for the assessment of IR in patients with hypertension, has relatively lower sensitivity compared with the standard reference method. This implies the possibility that the IR prevalence of IR obtained in the present study may be an underestimate.

To overcome these limitations, further studies are needed, and these studies should be longitudinal and community-based and, if possible, should define IR prevalence by the reference method. Notwithstanding these methodological limitations, the present study is the first to describe IR as a cardiometabolic risk factor in a population of Black Congolese with hypertension. Furthermore, the present study is the first to establish that the lack of BP management increases predisposition to IR.

Conclusion

The present study showed that IR is present in almost half of the population of Black Congolese with hypertension. Cigarette smoking, hypertriglyceridemia, hyperuricemia, and uncontrolled hypertension appear to be independent determinants of IR. Furthermore, IR people with hypertension have a higher prevalence of cardiovascular risk factors, which suggests an increased risk of cardiovascular events.

Acknowledgments

The authors are grateful to the medical and administrative staff of LomoMédical Clinic for accepting and facilitating the completion of this study.

Contributorship

KPB, LMB, and MKJR: design and concept of study
KPB, MM, and NNA: data acquisition
KPB and MM: manuscript draft
NNA, KPB, MM, KVE, LMB, and MKJR: data analysis and interpretation
All authors have read and approved the final manuscript.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

Approval to conduct the study was obtained from the National Health Ethics Committee (no. 219/CNES/BN/PMMF/2020). All respondents were debriefed on the results of the study.

References

1. Lebovitz HE (2001) Insulin resistance: Definition and consequences. Exp Clin Endocrinol Diabetes 109: 135-148.
2. Adeva-Andany MM, Martínez-Rodríguez J, González-Lucán M, Fernández-Fernández C, Castro-Quintela E (2019) Insulin resistance is a cardiovascular risk factor in humans. Diabetes Metab Syndr 13: 1449-1455.

3. Reddy KJ, Singh M, Bangit JR, Batsell RR (2010) The role of insulin resistance in the pathogenesis of atherosclerotic cardiovascular disease: an updated review. J Cardiovasc Med (Hagerstown) 11: 633-647.

4. Ferrannini E, Natali A, Capaldo B, Lehtovirta M, Jacob S, et al. (1997) Insulin resistance, hyperinsulinemia, and blood pressure: role of age and obesity. European Group for the Study of Insulin Resistance (EGIR). Hypertension 30: 1144-1149.

5. Reaven GM (2003) Insulin resistance/compensatory hyperinsulinemia, essential hypertension, and cardiovascular disease. J Clin Endocrinol Metab 88: 2399-2403.

6. Jeppesen J, Hein OH, Suadicani P, Gyntelberg F (2000) High triglycerides and low HDL cholesterol and blood pressure and risk of ischemic heart disease. Hypertension 36: 226-232.

7. Edelson GW, Sowers JR (1993) Insulin resistance in hypertension: a focused review. Am J Med Sci 306: 345-347.

8. Abbasi F, Feldman D, Caulfield MP, Hantash FM, Reaven GM (2014) Relationship Among 25-Hydroxyvitamin D Concentrations, Insulin Action, and Cardiovascular Disease Risk in Patients With Essential Hypertension. American Journal of Hypertension 28: 266-272.

9. Bonora E, Capaldo B, Perin PC, Prato SD, Mattia GD, et al. (2008) Hyperinsulinemia and insulin resistance are independently associated with plasma lipids, uric acid and blood pressure in non-diabetic subjects. The GISIR database. Nutr Metab Cardiovasc Dis 18: 624-631.

10. Vardeny O, Gupta DK, Claggett B, Burke S, Shah A, et al. (2013) Insulin resistance and incident heart failure the ARIC study (Atherosclerosis Risk in Communities). JACC Heart Fail 1: 531-536.

11. Williams B, Mancia G, Spiering W, Rosei EA, Azizi M, et al. (2018) 2018 ESC/ESH Guidelines for the management of arterial hypertension. Eur Heart J 39: 3021-3104.

12. Peretti-Watel P, Constance J, Seror V, Beck F (2009) Cigarettes and social differentiation in France: is tobacco use increasingly concentrated among the poor? Addiction 104: 1718-1728.

13. Alberti KG, Zimmet P, Shaw J (2006) Metabolic syndrome--a new worldwide definition. A Consensus Statement from the International Diabetes Federation. Diabet Med 23: 469-480.

14. Wu L, Parhofer KG (2014) Diabetic dyslipidemia. Metabolism 63: 1469-1479.

15. Kerola T, Kauppi J, Sares-Jäske L, Anttonen O, Junttila MJ, et al. (2019) Long-term prognostic impact of hyperuricemia in community. Scand J Clin Lab Invest 79: 148-153.

16. Zhou MS, Wang A, Yu H (2014) Link between insulin resistance and hypertension: What is the evidence from evolutionary biology? Diabetol Metab Syndr 6: 12.

17. Zavaroni I, Mazza S, Dall'Aglio E, Gasparini P, Passeri M, et al. (1992) Prevalence of hyperinsulinaemia in patients with high blood pressure. J Intern Med 231: 235-240.

18. Lima NK, Abbasi F, Lamendola C, Reaven GM (2009) Prevalence of insulin resistance and related risk factors for cardiovascular disease in patients with essential hypertension. Am J Hypertens 22: 106-111.

19. Garcia-Puig J, Ruilope LM, Luque M, Fernández J, Ortega R, et al. (2006) Glucose metabolism in patients with essential hypertension. Am J Med 119: 318-326.

20. Mohteshamzadeh M, Wilkinson R, Thomas SH (2005) Insulin resistance in men with treated hypertension at increased risk for cardiovascular disease: results of a 3-year study. Am J Hypertens 18: 452-456.

21. Bonora E, Targher G, Alberiche M, Bonadonna RC, Saggiani F, et al. (2000) Homeostasis model assessment closely mirrors the glucose clamp technique in the assessment of insulin sensitivity: Studies in subjects with various degrees of glucose tolerance and insulin sensitivity. Diabetes Care 23: 57-63.

22. On'kin J, Longo-Mbenza B, Tchokonte-Nana V, Nge Okwe A, Kabangu NK, et al. (2017) Hyperbolic relation between beta-cell function and insulin sensitivity for type 2 diabetes mellitus, malaria, influenza, Helicobacter pylori, Chlamydia pneumoniae, and hepatitis C virus infection-induced inflammation/oxidative stress and temporary insulin resistance in Central Africans. Turk J Med Sci 47: 1834-1841.

23. Owei I, Umekwe N, Provo C, Wan J, Dagogo-Jack S, al. (2017) Insulin-sensitive and insulin-resistant obese and non-obese phenotypes: role in prediction of incident pre-diabetes in a longitudinal biracial cohort. BMJ Open Diabetes Res Care 5: 000415.

24. Ramos-Lopez O, Riezu-Boj JI, Milagro FI, Cuervo M, Goni L, et al. (2019) Interplay of an Obesity-Based Genetic Risk Score with Dietary and Endocrine Factors on Insulin Resistance. Nutrients 12: 33.

25. Yamada C, Mitsuhashi T, Hiratsuka N, Inabe F, Araida N, et al. (2011) Optimal reference interval for homeostasis model assessment of insulin resistance in a Japanese population. J Diabetes Investig. 2: 373-376.

26. Singh Y, Garg MK, Tandon N, Marwaha RK (2013) A study of insulin resistance by HOMA-IR and its cut-off value to identify metabolic syndrome in urban Indian adolescents. J Clin Res Pediatr Endocrinol 5: 245-251.

27. Morimoto A, Tatsumi Y, Deura K, Mizuno S, Ohno Y, et al. (2013) Impact of cigarette smoking on impaired insulin secretion and insulin resistance in Japanese men: The Saku Study. J Diabetes Investig 4: 274-280.

28. Kim KW, Kang SG, Song SW, Kim NR, Rho JS et al. (2017) Association between the Time of Length since Smoking Cessation and Insulin Resistance in Asymptomatic Korean Male Ex-Smokers. J Diabetes Res 2017: 6074760.

29. Xie XT, Liu Q, Wu J, Wakui M (2009) Impact of cigarette smoking in type 2 diabetes development. Acta Pharmacol Sin 30: 784-787.

30. Barton SE, Maddox PH, Jenkins D, Edwards R, Cuzick J, et al. (1988) Effect of cigarette smoking on Langerhans' cells. Lancet 2: 1028.

31. Yoshikawa H, Hellstrom-Lindahl E, Grill V (2005) Evidence for functional nicotinic receptors on pancreatic beta cells. Metabolism 54: 247-254.

32. Han TS, Sattar N, Lean M (2006) ABC of obesity: Assessment of obesity and its clinical implications. BMJ 333: 695-698.

33. Canoy D,Wareham N, Luben R, Welch A, Bingham S, et al. (2005) Cigarette smoking and fat distribution in 21,828 British men and women: a population-based study. Obes Res 13: 1466-1475.

34. Li N, Fu J, Koonen DP, Kuivenhoven JA, Snieder H, et al.(2014) Are hypertriglyceridemia and low HDL causal factors in the development of insulin resistance? Atherosclerosis 233: 130-138.

35. Han T, Lan Li, Qu Rongge, Qian Xu, Jiang R (2017) Temporal Relationship Between Hyperuricemia and Insulin Resistance and Its Impact on Future Risk of Hypertension. Hypertension 70: 703-711.

36. Miranda JAD, Almeida GG, Martins RIL, Cunha MB, Belo VA, et al. (2015) The role of uric acid in the insulin resistance in children and adolescents with obesity. Rev Paul Pediatr 33: 431-436.

37. Takir M, Kostek O, Ozkok A, Elcioglu OC, Bakan A, et al. (2015) Lowering Uric Acid With Allopurinol Improves Insulin Resistance and Systemic Inflammation in Asymptomatic Hyperuricemia. J Investig Med 63: 924-929.

38. Izzo R, Simone G, Chinali M, Iaccarino G, Trimarco V, et al. (2009) Insufficient control of blood pressure and incident diabetes. Diabetes Care 32: 845-850.

39. Ding EL, Smit LA, Hu FB (2010) The metabolic syndrome as a cluster of risk factors: Is the whole greater than the sum of its parts?: comment on "The metabolic syndrome, its component risk factors, and progression of coronary atherosclerosis". Arch Intern Med 170: 484-495.

Advances In Industrial Biotechnology | ISSN: 2639-5665

Advances In Microbiology Research | ISSN: 2689-694X

Archives Of Surgery And Surgical Education | ISSN: 2689-3126

Archives Of Urology

Archives Of Zoological Studies | ISSN: 2640-7779

Current Trends Medical And Biological Engineering

International Journal Of Case Reports And Therapeutic Studies | ISSN: 2689-310X

Journal Of Addiction & Addictive Disorders | ISSN: 2578-7276

Journal Of Agronomy & Agricultural Science | ISSN: 2689-8292

Journal Of AIDS Clinical Research & STDs | ISSN: 2572-7370

Journal Of Alcoholism Drug Abuse & Substance Dependence | ISSN: 2572-9594

Journal Of Allergy Disorders & Therapy | ISSN: 2470-749X

Journal Of Alternative Complementary & Integrative Medicine | ISSN: 2470-7562

Journal Of Alzheimers & Neurodegenerative Diseases | ISSN: 2572-9608

Journal Of Anesthesia & Clinical Care | ISSN: 2378-8879

Journal Of Angiology & Vascular Surgery | ISSN: 2572-7397

Journal Of Animal Research & Veterinary Science | ISSN: 2639-3751

Journal Of Aquaculture & Fisheries | ISSN: 2576-5523

Journal Of Atmospheric & Earth Sciences | ISSN: 2689-8780

Journal Of Biotech Research & Biochemistry

Journal Of Brain & Neuroscience Research

Journal Of Cancer Biology & Treatment | ISSN: 2470-7546

Journal Of Cardiology Study & Research | ISSN: 2640-768X

Journal Of Cell Biology & Cell Metabolism | ISSN: 2381-1943

Journal Of Clinical Dermatology & Therapy | ISSN: 2378-8771

Journal Of Clinical Immunology & Immunotherapy | ISSN: 2378-8844

Journal Of Clinical Studies & Medical Case Reports | ISSN: 2378-8801

Journal Of Community Medicine & Public Health Care | ISSN: 2381-1978

Journal Of Cytology & Tissue Biology | ISSN: 2378-9107

Journal Of Dairy Research & Technology | ISSN: 2688-9315

Journal Of Dentistry Oral Health & Cosmesis | ISSN: 2473-6783

Journal Of Diabetes & Metabolic Disorders | ISSN: 2381-201X

Journal Of Emergency Medicine Trauma & Surgical Care | ISSN: 2378-8798

Journal Of Environmental Science Current Research | ISSN: 2643-5020

Journal Of Food Science & Nutrition | ISSN: 2470-1076

Journal Of Forensic Legal & Investigative Sciences | ISSN: 2473-733X

Journal Of Gastroenterology & Hepatology Research | ISSN: 2574-2566

Journal Of Genetics & Genomic Sciences | ISSN: 2574-2485

Journal Of Gerontology & Geriatric Medicine | ISSN: 2381-8662

Journal Of Hematology Blood Transfusion & Disorders | ISSN: 2572-2999

Journal Of Hospice & Palliative Medical Care

Journal Of Human Endocrinology | ISSN: 2572-9640

Journal Of Infectious & Non Infectious Diseases | ISSN: 2381-8654

Journal Of Internal Medicine & Primary Healthcare | ISSN: 2574-2493

Journal Of Light & Laser Current Trends

Journal Of Medicine Study & Research | ISSN: 2639-5657

Journal Of Modern Chemical Sciences

Journal Of Nanotechnology Nanomedicine & Nanobiotechnology | ISSN: 2381-2044

Journal Of Neonatology & Clinical Pediatrics | ISSN: 2378-878X

Journal Of Nephrology & Renal Therapy | ISSN: 2473-7313

Journal Of Non Invasive Vascular Investigation | ISSN: 2572-7400

Journal Of Nuclear Medicine Radiology & Radiation Therapy | ISSN: 2572-7419

Journal Of Obesity & Weight Loss | ISSN: 2473-7372

Journal Of Ophthalmology & Clinical Research | ISSN: 2378-8887

Journal Of Orthopedic Research & Physiotherapy | ISSN: 2381-2052

Journal Of Otolaryngology Head & Neck Surgery | ISSN: 2573-010X

Journal Of Pathology Clinical & Medical Research

Journal Of Pharmacology Pharmaceutics & Pharmacovigilance | ISSN: 2639-5649

Journal Of Physical Medicine Rehabilitation & Disabilities | ISSN: 2381-8670

Journal Of Plant Science Current Research | ISSN: 2639-3743

Journal Of Practical & Professional Nursing | ISSN: 2639-5681

Journal Of Protein Research & Bioinformatics

Journal Of Psychiatry Depression & Anxiety | ISSN: 2573-0150

Journal Of Pulmonary Medicine & Respiratory Research | ISSN: 2573-0177

Journal Of Reproductive Medicine Gynaecology & Obstetrics | ISSN: 2574-2574

Journal Of Stem Cells Research Development & Therapy | ISSN: 2381-2060

Journal Of Surgery Current Trends & Innovations | ISSN: 2578-7284

Journal Of Toxicology Current Research | ISSN: 2639-3735

Journal Of Translational Science And Research

Journal Of Vaccines Research & Vaccination | ISSN: 2573-0193

Journal Of Virology & Antivirals

Sports Medicine And Injury Care Journal | ISSN: 2689-8829

Trends In Anatomy & Physiology | ISSN: 2640-7752

Submit Your Manuscript: https://www.heraldopenaccess.us/submit-manuscript