http://jmscr.igmpublication.org/home/
ISSN (e)-2347-176x ISSN (p) 2455-0450
crossref DOI: https://dx.doi.org/10.18535/jmscr/v8i3.81

IGM Publication
Journal Of Medical Science And Clinical Research
An Official Publication Of IGM Publication

Original Research Article

Non-lipid risk factors with gender on the severity of metabolic syndrome

Authors

Dr V.Srinivasa Babu[1], Dr R. Vijayaraghavan[2], Dr C. Ramaswamy[3], Dr V. Mahalakshmamma[4], Dr B.S. Mohan[5], N. Hanumanth[6]

[1]Research Scholar, Department of Research, Saveetha Institute of Medical and Technical Sciences, Thandalam, Chennai, Tamilnadu, India

[2]Director, Department of Research and Development, Saveetha Institute of Medical and Technical Sciences, Thandalam, Chennai, Tamilnadu, India

[3]Professor, Department of Physiology, Saveetha Institute of Medical and Technical Sciences, Thandalam, Chennai, Tamilnadu, India

[4]Professor and HOD, Department of Physiology, Nimra Institute of Medical Sciences and Research Foundation, Ibrahimpatnam, Vijayawada, Andhra Pradesh - 521456, India

[5]Homoeo Physician, Chairman and managing trustee, IPH foundation, College Road, Amalapuram, Andhra Pradesh, India

[6]Lecturer, Department of Community Medicine, Gayatri Medical College, Visakhapatnam, Andhra Pradesh, India

*Corresponding Author

Srinivasa Babu V

Assistant Professor, Department of Physiology, Nimra Institute of Medical Sciences and Research Foundation, Ibrahimpatnam, Vijayawada, Andhra Pradesh - 521456, INDIA

Abstract

Background: *It is recognized that inflammatory markers high sentive c-reactive protein, thyroid profile, and uric acid were collectively called as non-lipid risk factors also as added risks of metabolic syndrome (MS). There were sex-specific associations among various risk parameters in MS. A standardized incidence of MS in total was 24.2%, in that, 24.6% men and 23.8% women. A study existed the prevalence of SMS was 21.9% in adults aged 50 years, and in adolescents, it remains 8.0%. Also, women presented a higher incidence of SMS when compared to men aged <50 years, 76.3% women, and 20.7% men ≥50 years, 86.2% women, and 13.8% men.*

Methods: *A total of 450 participants (211 men and 239 women) aged ≥35 years divided into three groups (150 participants in each group), according to the number of parameters of MS risk factors. Group I: Subjects with less than any of the three components of MS (Control group), Group II: Subjects with any three variables of MS(MS group), Group III: Subjects with more than three components of MS(Severe MS group {SMS}). The data were analyzed by one-way ANOVA and with Student-Newman-Keul's multiple comparison method.*

Results: *The value of non-lipid risk parameters hs-CRP in MS, and SMS groups in male found a high significance than Control (P<0.001), but not significant (P = 0.156) in the female. The value of UA found high significance value (P = 0.001) in male and highly significant than Control (P<0.001) in MS, and SMS in the female. The T_3 of the Control group was, compared with MS, SMS groups, and not significant (P = 0.185) in males, was significant (P=0.039)in the female. In the case of thyroxin (T_4), values were significantly high in males and females (P = 0.002 and P<0.001), respectively. TSH (µIU/mL) Control group was significantly high (P = 0.009) in male MS and SMS groups, but not significant (P = 0.913) in female.*

Conclusion: *The comparison of specific non-lipid risk parameters like high-sensitivity C-reactive protein, uric acid, triiodothyronine, thyroxin, and TSH in MS and SMS in males and females that significantly differed in MS and SMS than the normal.*

Keywords: *Metabolic syndrome; Non-lipid risks; hs-CRP; Uric acid; TSH.*

Introduction

Health workers recognized the seriousness of metabolic syndrome (MS) in South Asians. Lifestyle modifications and early assessment through health awareness programs can reduce the morbidity of MS in South Asian people. MS was associated with chronic diseases like diabetes mellitus (T2 DM), obesity, dyslipidemia, and cardiovascular diseases (CVD). It is recognized inflammatory markers, thyroid dysfunction, and uric acid collectively called as non-lipid risk factors ~~also~~ as added risks of MS. Reduced inflammatory signs were evident in adults with MS and hypertension (HTN) by one-year yoga practice[1].

The incidence of MS in standard and non-standard workers was 13.5% and 26.1%. Usually, the occurrence was less in males (25.8%) than females (28.2%). In male and female participants, 71.1% and 43.4% were standard workers. Non-standard workers showed a high incidence rate of MS compared to conventional workers[2]. The prevalence of MS in men was the same as that in women reported in a study. A standardized incidence of MS in total was 24.2%, in that, 24.6% men and 23.8% women. There were sex-specific associations among various risk parameters in MS[3]. A study existed the prevalence of SMS was 21.9% in adults, aged 50 years, and in adolescents, it remains 8.0%. In adults, a significant association with increased components of SMS noted, more physical inabilities, and lower walking capacity in men and women. Also, women presented a higher incidence of SMS when compared to men aged <50 years, 76.3% were women, and 20.7% men; ≥50 years 86.2% were women, and 13.8% men[4].

A suitable justification that women contain high adipose tissue which was the source of pro-inflammatory cytokines[5]. Estrogen values varied in male and female plays a vital role in gender build-up, and even a positive effect on insulin and glucose homeostasis, division of adipose tissue, and pro-inflammatory markers. Women with a high significance of insulin-sensitizing hormone adiponectin due to variations in sex hormones and fatty tissue distribution[6]. The risks of MI, CVA, and T2 DM amplified by frequent manifestations of pro-thrombotic and pro-inflammatory states in MS individuals[7-9]. A study on pro-inflammatory markers, and different hormone replacement therapies (HRT) in women revealed a significant difference and high concentrations of CRP. But no change in the other markers of inflammation in HRT groups, compared among women. The higher CRP concentration reflects the estrogen effect on CRP expression rather than a systemic pro-inflammatory effect[10].

A positive relationship was noticed in serum uric acid levels (UA) with MS in both sexes. Serum UA and the incidence of MS rise along with aging in males and females, though it did not vary much within the same age group. High UA in middle-aged women leads to the development of MS. Therefore, it proposed that serum UA closely linked with MS in females than males[11]. In men without MS, UA found an unbiased risk factor for carotid atherosclerosis[12]. Serum uric acid was a reliable indicator of pre-MS, especially in obese individuals due to weight gain and BMI[13]. Estrogen promotes the excretion of UA in renal tubules. Elevated serum UA levels associated with CVD risks such as dyslipidemia, hypertension, and obesity, a cluster, found in the same person, characterizes theMS[14].

An increased thyroid-stimulating hormone (TSH) precedes adverse change with serum lipids, particularly decreased High-density lipoprotein cholesterol (HDL-C), increased low-density lipoprotein (LDL-C), also the ratio of LDL-C to HDL-C among older Caucasian women. Women with multiple lipid abnormalities were twice as likely to an elevated TSH level[15]. In a study by Garcia[16], the collectively used values of TSH and free thyroxin (T_4) was more significant than the T_4result. Below, the average levels of FT_4 significantly related to IR. These results were reliable with an increased CVD risk in individuals with hypothyroid function[17]. MS and thyroid dysfunction were risk factors for atherosclerosis

and CVD in south Indian women of 40-60 years. The coexistence of these two will substantially increase cardiovascular risk. So, MS has a high prevalence of thyroid dysfunction, which predisposes to cardiovascular events in females. Hence, the routine screening of thyroid function is necessary for females[18].

Aim and Objectives

Significance of non-lipid risk factors (hs-CRP, Uric acid, and TSH) with gender in the severity of MS.

Materials and Methods

A total of 450 participants (211 men and 239 women) aged ≥35 years attending Katuri Medical College and Hospital included in this study. The Institutional Ethics Committee approved the study protocol. All the participated individuals in this study gave their written consent. The, data collected from the participants after providing a detailed explanation of the procedure of the research. Need for their cooperation and willingness obtained by consent.

Criteria for Choosing The Subjects: As per the guidelines issued by the following international organizations: MetS defined according to the 2009 harmonizing definition set by a joint statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity, as the presence of three or more of the following five criteria:[19]

1) Waist circumference in South Asians >90 cm in men and >80 cm in women,2) Serum triglycerides levels >150 mg/dl, 3) Serum HDL cholesterol levels < 40 mg/dl in men and <50 mg/dl in women, under treatment, is an alternate indicator, 4) Systolic blood pressure >130 mmHg and/or diastolic blood pressure >85 mmHg) under treatment is an alternate indicator, and5) Fasting serum glucose levels >100 mg/dL under treatment.[19] The same standard stated in the modified NECP ATP III definition.[20]

The Inclusion Criteria For Patients: Insulin resistance, hypertension, type II diabetes mellitus, increased BMI, is ≥ 23, Increased waist circumference ≥ 36 inches (90cm) in males and ≥32 inches (80cm) in females and age limit is ≥35.

Exclusion Criteria: Any recent infections, Active lifestyle, fatty liver disease, and PCOD in women are excluded.

Baseline Parameters: Fasting blood samples drawn from the participants and tested on the same day.MS non-lipid risk factors such as hs-CRP, triiodothyronine, thyroxin, and TSH assessed by enzyme-linked immunosorbent assay (ELISA) method. And uric acid estimated by using ERBA EM-360, fully automated analyzer.

Further, the groups divided into three groups (150 participants in each group), according to the number of components of Metabolic syndrome risk factors mentioned above they acquired. Group I: Subjects with less than any of the three risks of metabolic syndrome (Control group), Group II: Subjects with any three elements of metabolic syndrome (MS group), Group III: Subjects with more than three factors of metabolic syndrome (Severe MS group {SMS})

Statistical Analysis: The data were entered on Excel and imported for analysis on SPSS v 16. Data analyzed by one-way ANOVA and with Student-Newman-Keul's multiple comparison method. Statistical analysis and graph plotting carried out by using Sigma Plot 13.0 (Systat Software, USA). Statistical significance considered if the P-value less than 0.05.

Results

Among the non-lipid risk parameters of the study groups, the inflammatory markers given in the table.1,such as high sensitive C-reactive protein (hs-CRP; mg/L), metabolic end product uric acid (UA; mg/dL), and Thyroid profile hormones T_3(ng/mL), thyroxin (T_4; µg/dL) and thyroid-stimulating hormone (µIU/mL) observed in MS and SMS of both male and female. The mean and

SE of hs-CRP of the control group (1.1 ± 0.1) was highly significant (P<0.001) than that of MS (2.0 ± 0.2) and SMS groups (1.8 ± 0.2) in male. The mean and SE of the control group (1.8 ± 0.2) was not significant (P = 0.156) than that of MS (2.4 ± 0.2) and SMS groups (2.2 ± 0.2) in the female. In advance, Figure.1 shows the value of non-lipid risk parameters like hs-CRP found a high significance between groups like I vs. II, and I vs. III in male (P<0.001),(P = 0.001). But in case of group II vs. III was not significant (P = 0.540) in male. But insignificant in between all intergroup analysis like I vs. II, I vs. III, and II vs. III infemale.

Table. 1: Comparison of high sensitive C-reactive protein (hs-CRP), uric acid (UA), triiodothyronine (T_3), thyroxin (T_4) and thyroid stimulating hormone (TSH) between males and females in Control, MS and SMS.

Variable	Gender	Control Group I	MS Group II	SMS Group III	Statistical information
Hs-CRP (mg/L)	Male	1.1 ± 0.1	2.0 ± 0.2	1.8 ± 0.2	Figure.1
	Female	1.8 ± 0.2	2.4 ± 0.2	2.2 ± 0.2	
UA (mg/dL)	Male	5.3 ± 0.1	5.3 ± 0.1	6.0 ± 0.2	
	Female	3.9 ± 0.1	4.8 ± 0.1	4.7 ± 0.1	
T_3 (ng/mL)	Male	0.9 ± 0.01	0.8 ± 0.03	0.8 ± 0.01	Figure.2
	Female	0.9 ± 0.02	1.0 ± 0.02	0.9 ± 0.03	
T_4 (µg/dL)	Male	8.0 ± 0.2	7.3 ± 0.2	7.3 ± 0.2	
	Female	7.7 ± 0.2	8.6 ± 0.1	8.0 ± 0.2	
TSH (µIU/mL or mIU/L)	Male	2.4 ± 0.1	3.5 ± 0.4	3.2 ± 0.2	
	Female	2.7 ± 0.2	2.9 ± 0.2	2.8 ± 0.3	

Values expressed as mean ± SE. (Male control n= 72, MS n= 75 and SMS n= 64; Female control n= 78, MS= 75 and SMS = 86 respectively)

On the other hand, UA mean and SE values in the MS group (5.3 ± 0.1) SMS groups (6.0 ± 0.2) were high than the control group (5.3 ± 0.1) in males. The UA values in MS (4.8 ± 0.1) and SMS groups (4.7 ± 0.1) were more than that of the control group (3.9 ± 0.1) in the females. It was highly significant (P = 0.001) in these three groups in males and (P<0.001) in females. Further, in figure.1 shows the values of UA found high significance (P = 0.002) in between groups I and III, and not significant (P = 0.855) in group I vs. II and in males. And a high significant value (P<0.001) in groups I vs. II and I vs. III in the female. The same figure shows groups II and III in males was high significant (P = 0.002) value and group II vs. III in the female it was (P = 0.515) insignificant.

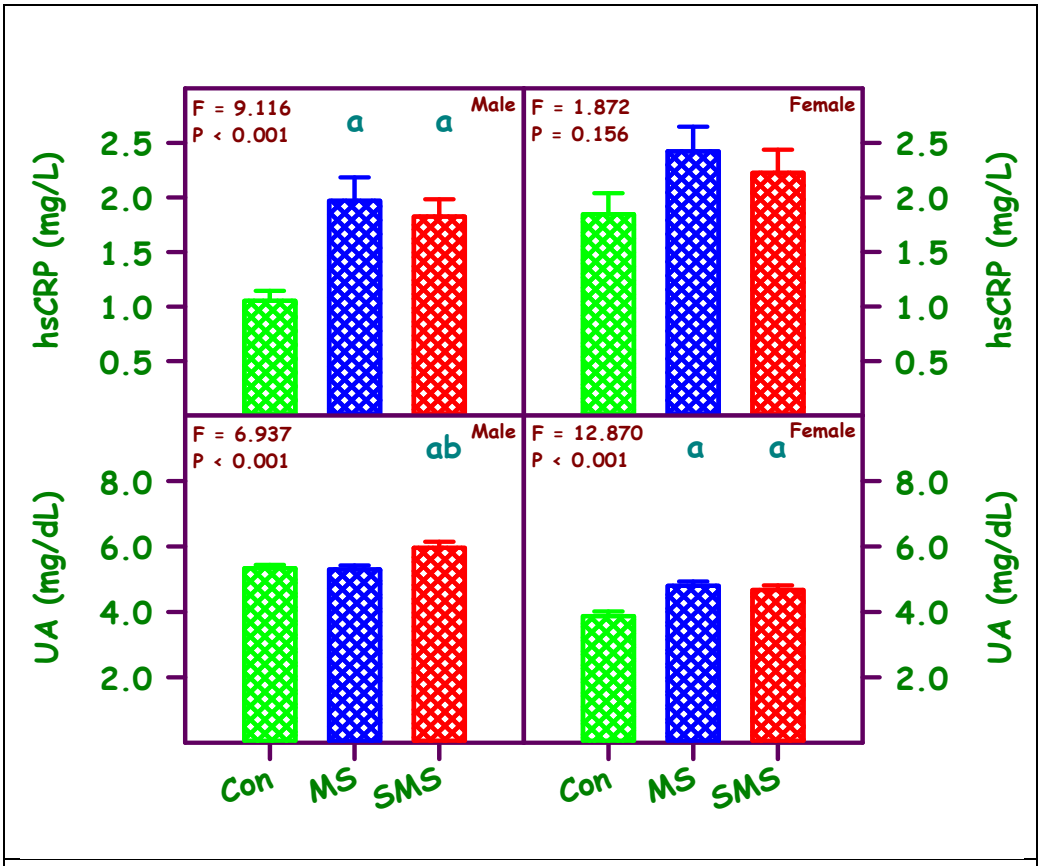

Figure.1: The levels of high sensitive C-reactive protein (hs-CRP) uric acid (UA) in control (Con), metabolic syndrome (MS) and severe metabolic syndrome (SMS) of males and females. Values are mean + SE

n – male – Con = 72; MS = 75; SMS = 64

n – female – Con = 78; MS = 75; SMS = 86

The 'F' and 'P' values are by one-way ANOVA with the Student Newman Keul's multiple comparison test.

[a] Significantly different from control group

[b] Significantly different from MS group

Among the Thyroid parameters of the study groups, values such as Triiodothyronine (T_3; ng/mL), Thyroxin (T_4; µg/dL), and thyroid-stimulating hormone (TSH; µIU/mL) given in table.1. The mean of T_3 of the control group was (0.9 ± 0.01), of MS (0.8 ± 0.03), SMS group (0.8 ± 0.01), and it was not a significant value (P = 0.185) in male. The mean and SE of T_3 in the control group (0.9 ± 0.02) was a significant difference (P=0.039) than that of MS (1.0 ± 0.02) and SMS group (0.9 ± 0.03) in the female. In advance Figure.2, the value of thyroid parameters likeT_3 found significant only in between I vs. II groups (P = 0.032), and not significant (P = 0.400) in I vs. III in females. And all groups in males were insignificant, including groups II vs. III, and II vs. III groups (P = 0.082) in the female; the value was also insignificant.

On the other hand, thyroxin (T_4) values were significantly high (P = 0.002) in MS (7.3 ± 0.2) and SMS groups (7.3 ± 0.2) than that of the control group (8.0 ± 0.2) in males. Mean, and SE values of T_4 were significantly high (P<0.001) in MS (8.6 ± 0.1) and SMS group (8.0 ± 0.2) than that of the control group (7.7 ± 0.2) in females. Further, in figure.2 showed that the value of T_4 was significance (P = 0.003) between I vs. II, and (P = 0.005) among I vs. III groups in males and with a highly significant (P<0.001), and between I vs. II in the female. But insignificant (P = 0.125) within groups I vs. III in the female. Further, not a significant (P = 0.738) among II vs. III groups in

males, but a significant value (P = 0.010) in groups II vs. III in the female.

The mean and SE of one of the pituitary hormones TSH (µIU/mL) of the control group (2.4 ± 0.1) was significantly high value (P = 0.009) than that of MS (3.5 ± 0.4) and SMS groups (3.2 ± 0.2) in male. The mean and SE of TSH of the control group (2.7 ± 0.2) was not significant (P = 0.913) than that of MS (2.9 ± 0.2) and SMS groups (2.8 ± 0.3) in the female. And Figure.2 showed that the TSH values had a significant difference between groups I vs. II and I vs. III in males (P = 0.008 and P = 0.030). Further, in figure.2 found that TSH values were not significant (P = 0.482) in groups II vs. III in males also insignificant in all groups (I vs. II and I vs. III and II vs. III) in the female.

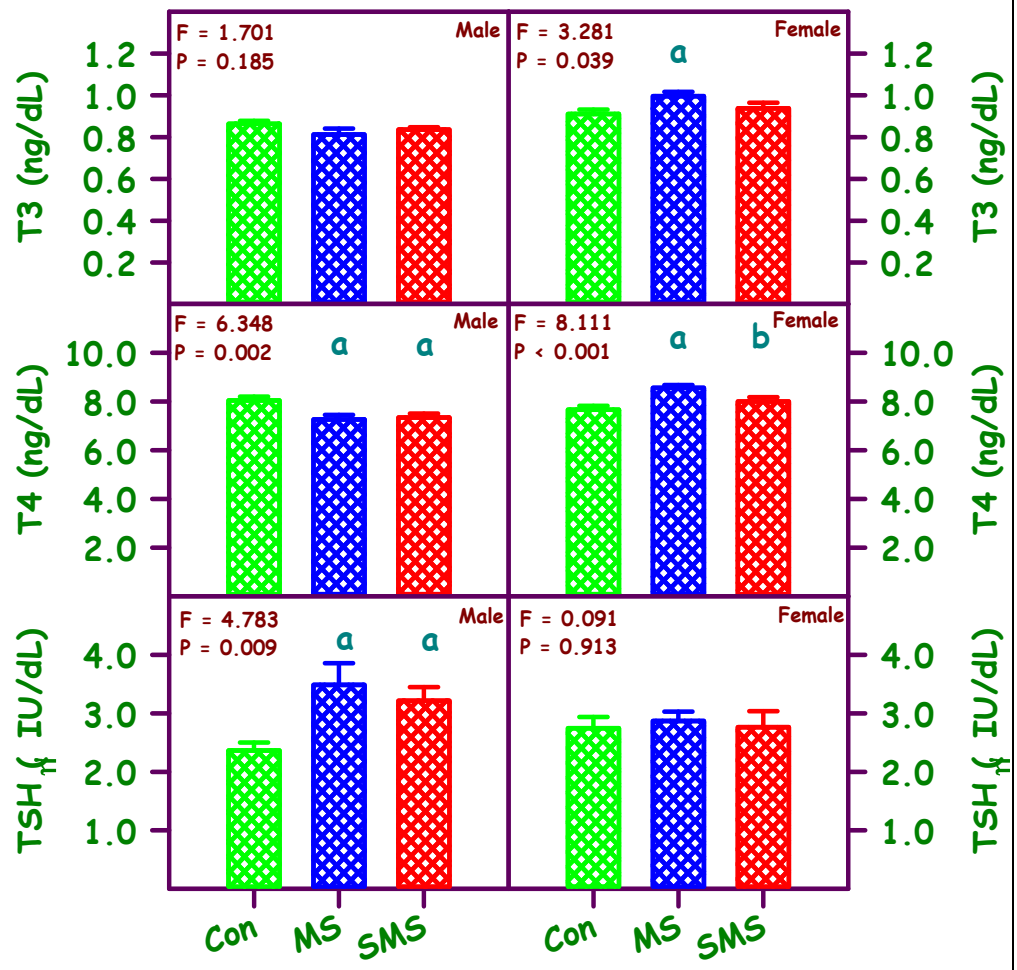

Figure.2: The levels of triiodothyronine (T_3), thyroxin (T_4) and thyroid stimulating hormone (TSH) in control (Con), metabolic syndrome (MS) and severe metabolic syndrome (SMS) of males and females.

Values are mean ± SE

n – male – Con = 72; MS = 75; SMS = 64

n – female – Con = 78; MS = 75; SMS = 86

The 'F' and 'P' values are by one-way ANOVA with the Student Newman Keul's multiple comparison test.

[a] Significantly different from control group

[b] Significantly different from MS group

Discussion

An earned emphasis considered, and it reported that women presented a higher prevalence rate of SMS compared to men[4]. The study on gender and C-reactive protein (CRP) data from the Multi-ethnic study of atherosclerosis (MESA) obtained a similar pattern[21]. In the present study, the CRP levels were higher in women compared with men for BMI and other variables. This gender difference maintained across all ethnic subgroups. These results suggest that the evaluation of gender-specific CRP cut points to guide the cardiovascular risk.

In the present study, women had high mean values of hs-CRP in MS than the SMS group. Study regarding sex differences on hs-CRP levels with MS risk factors concluded that women presented higher levels of hs-CRP when compared with men, also demonstrated that CRP levels predict the development of MS in women but not in men[5]. In this study, it observed that women with cardio metabolic risks, i.e., those with MS, T2 DM, or HTN, usually have higher hs-CRP levels than men. However, the individuals who had hs-CRP levels of less than 3 mg/L without MS had the best cardiovascular survival. Whereas those who had hs-CRP levels greater than 3 mg/L with MS had the worst survival rate[22,23]. Thus, gender variations with increased inflammatory markers were observed[24]. A South Asian study demonstrates that hs-CRP and serum uric acid associated with MS components. The combined rise of hs-CRP and uric acid associated with an increase in the severity of MS[25]. CRP levels were significantly higher ($P<0.01$) in diabetic than non-diabetic individuals in both males and females. The reported levels of uric acid also had considerable differences in men and women ($P<0.05$ and $P<0.01$, respectively). These data strongly suggest that compared to the non-diabetic participants, diabetic people significantly have higher levels of CRP and uric acid[26].

In the present study in figure.1 it is observed that the UA levels have a significant difference between control and SMS groups in males and among control, MS, also SMS groups in the female. It found that considerable variation in MS and SMS only in the male. This study indicated that those individuals with SMS have higher uric acid levels and the same results observed with MS, and UA considers an additional risk component of MS[27]. The serum UA level elevated significantly proportionate to the number of metabolic components that are similar this study. Abnormal TG had the most influence on serum UA. A prospective study warranted the prevention or treatment of hyperuricemia arrests the development of MS. In the present study it observed, serum UA levels were higher in men than women as reported earlier[14]. A South Indian study showed[28] in non-invasive methods that the salivary uric acid had a significant correlation with the different components of the MS, also increased proportionately with the severity of MS.

In the present study in the figure.2, observed that the T_3 levels revealed a significant difference between control and MS groups in the female, but was not a risk factor in males. Also, in this study, thyroxin (T_4) level signified with MS and SMS in male and the female. In contrast, this thyroxin study showed a positive correlation with HDL-C and an inverse relationship with HOMA-IR, WC, and FI[29]. In this study, in males and females, T_4 had a stronger association with the IR markers than TSH. The FT_4 and TSH provided complementary information for the evaluation of the effects of thyroid hormones on carbohydrate and lipoprotein metabolism[16]. This study supports that thyroxin shows a significant relation than T_3 and TSH in males and females.

In this study, TSH is a risk factor with MS and SMS in males, but not a risk factor in females. In contrast to this study, the association of each component of MS with thyroid dysfunction denoted in women, who had a higher incidence of thyroid disease as compared to the other components among WC[18]. Also, in this study, observed whereas the TSH levels increased, then T_4 levels decrease significantly with the MS and SMS in the male and increased considerably in

female participants. A study in Taiwan identified a slight increase of TSH in subclinical hypothyroidism as an MS risk factor[30]. The presence of IR existed not only in hypothyroidism but also in subclinical hypothyroidism. HOMA index and decreased Matsuda index suggest that IR happened in both fasting and post-glucose state and reported an increased CVD risk in these conditions[31]. A study published the same that the combined use of TSH and free T_4, compared with the assessment based on only free T_4, was a more convenient approach[16] to evaluate the association between thyroid dysfunction and metabolic variables.

Conclusion

The comparison of specific non-lipid risk parameters like high-sensitivity C-reactive protein, uric acid, triiodothyronine, thyroxin, and TSH in MS and SMS in males and females, and that there was a significant difference in MS and SMS in hs-CRP in males, UA in both genders, T_3 in females, T_4 in males and females, and TSH in males. However, there was no considerable relation of hs-CRP, TSH in MS and SMS in females, and T_3 in the male. There is a substantial relation to metabolic syndrome and severe metabolic syndrome in selected non-lipid parameters of metabolic risk with gender difference.

Acknowledgements

The author would like to thank the faculty members of the Department of Research Saveetha University Chennai India and the Department of Physiology, Nimra Institute of Medical Sciences, Vijayawada, Andhra Pradesh, India for their valuable advice, guidance and constructive criticism. The authors also acknowledge the subjects for their consent and participation in this study.

Funding: No funding sources.

Conflict of interest: None declared.

Ethical approval: The study approved by the Institutional Ethics Committee of Saveetha University, Chennai, India.

References

1. Supriya R, Yu AP, Lee PH, Lai CW, Cheng KK, Yau SY, Chan LW, Yung BY, Siu PM (2018). Yoga training modulates adipokinesin adults with high-normal blood pressure and metabolic syndrome. Scand J Med Sci Sports. 28:1130–1138.
2. Cho DY and Koo JW (2018). Differences in Metabolic Syndrome Prevalence by Employment Type and Sex. Int J Environ Res Public Health. 15(9):1798.
3. Li Y, Zhao L, Yu D, Wang Z, Ding G (2018). Metabolic syndrome prevalence andits risk factors among adults in China: A nationally representative cross sectional study. PLoSONE 13(6): e0199293.
4. Martin S, Bouchard Danielle R, Dionne Isabelle J, Martin B (2012). Lifestyle Habits and Physical Capacity in Patients with Moderate or Severe Metabolic Syndrome. Metabolic Syndrome and Related Disorders. June,10(3):232-240.
5. Han LL, Wang YX, Li J, Zhang XL, Bian C, Wang H, Du S, Suo LN (2014). Gender differences in associations of serum ferritin and diabetes, metabolic syndrome, and obesity in the China Health and Nutrition Survey. Mol Nutr Food Res. 58(11):2189-95.
6. Geer EB and Shen W (2009). Gender Differences in Insulin Resistance, Body Composition, and Energy Balance, Gen Med. 6(1): 60–75.
7. Ridker PM, Cushman M, Stampfer MJ, Tracy RP, Hennekens CH (1997). Inflammation, aspirin, and the risk of cardiovascular disease in apparently healthy men. N Engl J Med 336:973-979.
8. Pradhan AD, Manson JE, Rifai N, Buring JE and Ridker PM (2001). C-reactive protein, interleukin 6, and the risk of developing type 2 diabetes mellitus. JAMA. 286:327-334.
9. Freeman DJ, Norrie J, Caslake MJ. Gaw A, Ford I, Lowe GD, O'Reilly DS,

Packard CJ, and Sattar N (2002). C-reactive protein is an independent predictor of risk for the development of diabetes in the West of Scotland Coronary Prevention Study. Diabetes 51(5):1596-1600.

10. Margit F, Nikolai M, Hartmut H, Armin I, Angela D, Mark BP, Wolfgang K (2003). Markers of inflammation in women on different hormone replacement therapies. Annals of Medicine. 35:5:353-361.
11. Chiou WK, Wang MH, Huang DH, Chiu HT, Lee YJ, Lin JD (2010). The Relationship between Serum Uric Acid Level and Metabolic Syndrome: Differences by Sex and Age in Taiwanese. J Epidemiol. 20(3):219–224.
12. Kawamoto Ryuichi, Tomita Hitomi, Oka Yuichiro and Ohtsuka Nobuyuki (2006). Relationship between Serum Uric Acid Concentration, Metabolic Syndrome and Carotid Atherosclerosis Internal Medicine. 45:9:605-614.
13. Akram H.M Muhammad, Asif, Khan Usmanghani, Naveed Akhtar, Qaiser Jabeen, Asadullah Madni, Tariq saeed, Riazur Rehman, Khalil Ahmed and S.M Ali Shah (2011). Obesity and the risk of hyperuricemia in Gadap Town, Karachi. African Journal of Biotechnology. 10(6):996-998.
14. Lin SD, Tsai DH, Hsu SR (2006). Association between serum uric acid level and components of the metabolic syndrome. J Chin Med Assoc. 69(11):512-6.
15. Bauer DC, Ettinger B, Browner WS (1998). Thyroid functions and serum lipids in older women: a population-based study. Am J Med. 104(6):546-51.
16. Garcia-Garduno JJ, Romero EC, Ochoa AL, Romero-Figueroa S, Bravo GH, García RT, Montenegro-Morales P, Mendieta-Zerón H (2015). Thyroid function is associated with insulin resistance markers in healthy adolescents with risk factors to develop diabetes. Diabetol Metab Syndr. 7:16.
17. Roos A, Bakker SJL, Links TP, Gans ROB, Wolffenbuttel BHR (2007). Thyroid function is associated with components of metabolic syndrome. J Clin Endocrinol Metab. 92(2):491-6.
18. Sudhakar MK, Agarwal G, Mohini singh, Senthil N, Rajendran A (2011). The prevalence of thyroid dysfunction among South Indian women with Metabolic Syndrome. Journal of Clinical and Diagnostic Research. Apr, 5(2):213-216.
19. Alberti KG, Eckel, RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato, KA (2009). Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation; Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 120(16):1640-5.
20. Grundy S. M, Cleeman J. I, Daniels S. R., "Diagnosis and management of the metabolic syndrome: an American Heart Association/NationalHeart, Lung, and Blood institute scientific statement," Circulation, vol. 112, no. 17, pp. 2735–2752, 2005.
21. Lakoski SG, Cushman M, Criqui M, Rundek T, Blumenthal RS, D, Agostino RB Jr, Herrington DM. Gender and C-reactive protein (2006). Data from the Multiethnic Study of Atherosclerosis (MESA) cohort. Am Heart J. Sep. 152(3):593-8.
22. Ridker PM, Hennekens CH, Buring JE, Rifai N (2000). C-reactive protein and other markers of inflammation in the prediction of cardiovascular disease in women. N Engl J Med. 342:836–843.

23. Ridker PM, Buring JE, Cook NR, Rifai N (2003). C-reactive protein, the metabolic syndrome, and risk of incident cardio-vascular events. Circulation. 107:391–397.
24. Garcia VP, Rocha HNM, Sales ARK, Rocha NG, Nóbrega ACL (2016). Sex - Differences in High Sensitivity C-Reactive Protein in Subjects with Risk Factors of Metabolic Syndrome Arq Bras Cardiol. 106(3):182–187.
25. Sah SK, Khatiwada S, Pandey S, Kc R, Das BK, Baral N, Lamsal M (2016). Association of high-sensitivity C-reactive protein and uric acid with the metabolic syndrome components. Springer plus. 5:269.
26. Islam Safiqul Md, Islam Saiful Md, Yearul Kabir (2011). Association of C-reactive protein and uric acid with Type 2 diabetes. DUJBS. 20(2): 191-199.
27. Nejatinamini S, Ataie-Jafari A, Qorbani M, Nikoohemat S, Kelishadi R, Asayesh H, Hosseini S (2015). Association between serum uric acid level and metabolic syndrome components. J Diabetes Metab Disord.Sep 14:70.
28. Bhagyashree N, Ramaswamay C, Ganesh M (2016). A correlative study showing the relationship of salivary uric acid level with the metabolic syndrome components and its severity. Int J Applied Bio Phar Tech. 7(4):168-72.
29. Garduno-Garcia JJ, Alvirde-Garcia U, Lope-Carrasco G, Padilla Mendoza ME (2010). TSH and free thyroxine concentrations are associated with differing metabolic markers in euthyroid subjects. Eur J Endocrinol. 163:273-278.
30. Lakshmi K, Sherry P, Arthur Ch (2017). Hypothyroidism and the Metabolic Syndrome. Endocrinology and Metabolism International Journal. 5(2):115-18.
31. Maratou E, Hadjidakis DJ, Kollias A, Tsegka K, Peppa M, Alevizaki M, Mitrou P, Lambadiari V, Boutati E, Nikzas D, Tountas N, Economopoulos T, Raptis SA, Dimitriadis G (2009). Studies of insulin resistance in patients with clinical and subclinical hypothyroidism. European Journal of Endocrinology. 160:785-790.