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Risk factors of Non Alcoholic Fatty Liver Disease in Patients with Polycystic Ovary Syndrome

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ABSTRACT

Background and Objectives: Non-alcoholic fatty liver disease (NAFLD) is a progressive disease that can lead to severe complications, including liver cirrhosis, hepatocellular carcinoma and death. The increased prevalence of NAFLD in women with polycystic ovarian syndrome (PCOS) suggest its greater significance in this population. Therefore, the present study investigated the frequency and risk factors of NAFLD among women with PCOS.

Materials and Methods: This study was performed on 294 women with PCOS, among whom the frequency of NAFLD was investigated. A wide range of variables including demographic (age, educational level, marital status, and income), life style variables (including smoking and exercise), clinical variables (including body mass index), gynecological variables (including menstrual pattern) and serum parameters (including thyroid stimulating hormone, luteinizing hormone, and follicle stimulating hormone, prolactin, and vitamin D) were investigated for their direct and indirect effect on NAFLD in this population using LISREL software.

Results: Mean age of the study population was 29.16±6.16 years; 154 women (52.4%) had NAFLD. Correlation analysis showed that NAFLD had a reverse but weak association with educational level and direct association with BMI, FBS, obesity, and age ($P<0.05$). The model showed that the several factors had an indirect effect on NAFLD.

Conclusion: The high frequency of NAFLD among women with PCOS calls for greater attention of gynecologists to diagnose this liver disease in this specific population, especially in the high-risk group. More studies are required to understand the exact pathophysiology of NAFLD in women with PCOS and how these factors affect this association.

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Introduction

Non-alcoholic fatty liver disease (NAFLD) is a progressive disease that can lead to severe complications, including liver cirrhosis or hepatocellular carcinoma (in 2.6% of patients with nonalcoholic steatohepatitis [1]. Worryingly, the population at risk of NAFLD is increasing and projected to increase by 56% in the next decade; patients are being affected at an earlier age that gives them more time for developing severe complications [2, 3]. Changes in dietary composition and urbanism, and the growing epidemic of obesity and type 2 diabetes mellitus (DM) are the main factors of the increasing incidence of NAFLD [2, 3]. Endocrinopathies, like hypothyroidism, hypopituitarism, growth hormone deficiency, hypercorticolism, and polycystic ovarian syndrome (PCOS) are also listed as the extrahepatic manifestations of NAFLD [4, 5].

Polycystic ovarian syndrome (PCOS) is the most common endocrine disorder among women of reproductive age that affects about 20% of all women and is characterized by ovulatory dysfunction, hyperandrogenism, and/or polycystic ovary morphology. As suggested, obesity and insulin resistant are also present in women with PCOS with main role in its pathogenesis, which is similarly the main risk factors of NAFLD [6]. Accordingly, increased prevalence of NAFLD is reported in women with PCOS (50.6% versus 34.0% in controls), suggesting 2.5-fold increased risk [7, 8]. The main risk factors of this association include high serum level of androgens, obesity (especially abdominal fat accumulation), and insulin resistance, which suggest the contact point between these two diseases, namely PCOS and NAFLD [9]. Some have suggested biomarker of apoptosis and adipokines associated with NAFLD in patients with PCOS, which suggests the role of inflammation in PCOS, which induce/progress NAFLD [10-12].

This issue is of great significance, not only for the significance of the accurate diagnosis of NAFLD among women with PCOS, which enables on time and appropriate treatment that in turn decrease the risk of complications, but also for the choice of treatments used for women with PCOS; importantly, contraceptives that are contraindicated in NAFLD, administration of which for the treatment is PCOS can deteriorate the patients' condition and necessitate urgent therapies [9]. Therefore, the present study investigated the frequency and risk factors of NAFLD among women with PCOS. Considering the multifactorial nature of both conditions, we investigated a wide range of variables, including demographic, life style, clinical, gynecological variables and serum parameters to investigate their direct and indirect effects on NAFLD.

Materials and Methods

The present study was designed as a prospective cross-sectional study and approved by the Ethics Committee of Islamic Azad University of Medical Sciences (code: IR.IAU.TMU.REC.1402.215). All women, aged ≥15 years, who referred to the hospitals affiliated to Islamic Azad University, Tehran Branch from spring 2022 to 20th March 2024 and were diagnosed with PCOS were included into the study by convenient (non-random) method, after they gave written consent for participation. Diagnosis of PCOS was by the presence of two of the three Rotterdam criteria [13]. Menopause women, those with alcoholic fatty liver, morbid obesity, overt DM, immunological disease, physical or movement disorders, and those with positive history of corticosteroids and neurological drugs were not included in the study.

The patients' demographics, including age, body mass index (BMI), educational level, occupation, marital status, and income level were recorded in the study's checklist. Patients with a BMI ≥ 30 kg/m^2 were considered as obese. Also, the smoking status, exercise, and menstruation pattern, DM, and hypothyroidism were asked from the patients and recorded. Women with a menstrual cycle shorter than 21 days were considered as polymenorhea and those with infrequent menstrual period as oligomenorrhea. A venous blood sample was taken from the patients in fasting status and the serum levels of thyroid stimulating hormone (TSH), luteinizing hormone (LH), and follicular stimulating hormone (FSH), fasting blood sugar (FBS), anti-Müllerian hormone, prolactin, and vitamin D3 were recorded. NAFLD was considered as positive, when non-alcoholic steatosis was detected (by imaging or histology) and other liver diseases were excluded [14]. Patients who were lost to follow-up were excluded from the study.

Statistical Analysis

Results were presented as mean ± standard deviation (SD) for quantitative variables and were summarized by frequency (percentage) for categorical variables. Correlation analysis was performed using Pearson's correlation coefficient and reported as figure. LISREL software was used for modeling and evaluating data route. A conceptual model was primarily designed that hypothesized the potential association between variables (like BMI, serum level of insulin, and other metabolic factors). Then, each model was tested by LISREL software to determine the causal relationships and determine the risk factors of NAFLD in the study population (women with PCOS). Route evaluation was also performed to determine the factor with the greatest effect and whether the effects are direct or indirect.

Results

A total of 294 patients completed the study with mean age of 29.16±6.16 years. The baseline characteristics of the study population is provided in table 1; the clinical characteristics and mean values of serum parameters are shown in table 2. As indicated, 154 women (52.4%) had NAFLD.

Table 1: The Demographic and Baseline Characteristics of the Study Population

Variable	Categories	Value
Age (years), mean±SD		29.16±6.16
Body mass index (Kg/m^2), mean±SD		25.65±4.7
Educational level, N(%)	Illiterate	34(11.6)
	High school	65(22.1)
	Bachelor	157(53.4)
	Master	29(9.9)
	PhD	9(3.1)
Job status, N(%)	Housewife	98(33.3)
	Employee	95(32.3)
	Student	49(16.7)
	Freelancer	141(13.9)
	Unemployed	11(3.7)
Marital status, N(%)	Single	111(37.8)
	Married	183(46.9)
Income level, N(%)	Weak	6(2)
	Moderate	150(51)
	High	138(46.9)
Smoking status, N(%)	Non-smoker	227(77.2)
	Habitual smoker	40(13.6)
	Heavy smoker	27(9.2)
Exercise, N(%)	None	287(97.6)
	Scarcely	5(1.7)
	Regular	2(0.7)

Correlation analysis showed that NAFLD had a reverse but weak association with educational level and direct association with BMI, FBS, obesity, and age (P<0.05; figure 1). Age had a reverse association with menstrual cycle and serum level of LH and FSH; as the age progressed, the cycle would turn to amenorrhea and LH and FSH levels would turn to abnormal. Educational level was associated with income directly and positively, but negatively with obesity, BMI, TSH, and FBS. Menstrual cycle had a direct and positive association with exercise. BMI had a direct and positive association with FBS and reverse association with educational level, smoking, and serum level of vitamin D^3 (P<0.05; figure 1).

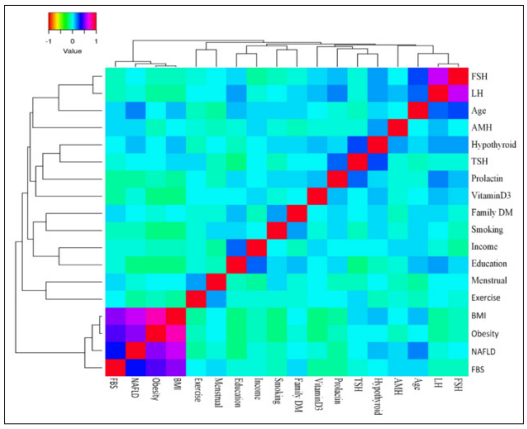

Figure 1: Pearson's Correlation Coefficient for the Association of Variables

The model was tested for studying the effect of variables on NAFLD and RMSEA=0.157, CFI= 0.897, GFI=0.912, df=78, and X2=637.49 showed the good fit of the model. The results showed the greatest direct and positive effect for obesity (β=0.13) and the least for LH, while the greatest reverse association was related to the educational level. Demographics and other factors, like age, income, exercise, and other serum parameters may also influence NAFLD indirectly, as they are associated with the factors that have direct effect on the disease.

Table 2: The Clinical Characteristics and Serum Parameters in the Study Population

Variable	Categories	Value
Menstrual cycle, N(%)	Amenorrhea	2(0.7)
	Normal	119(40.6)
	Oligomenorrhea	159(54.3)
	Polymenorrhea	13(4.4)
Obesity, N(%)	Yes	220(74.8)
	No	74(25.2)
Family history of diabetes, N(%)	Yes	72(24.5)
	No	222(75.5)
Hypothyroidism, N(%)	Yes	51(17.3)
	No	243(82.7)
NAFLD, N(%)	Yes	154(52.4)
	No	140(47.6)
Thyroid stimulating hormone, mean±SD		2.38±1.66
Luteining hormone, mean±SD		6.68±5.37
Follicle stimulating hormone, mean±SD		5.29±4.45
Fasting blood sugar, mean±SD		91.87±11.72
Anti Müllerian hormone, mean±SD		5.06±11.73
Prolactin, mean±SD		18.58±29.41
Vitamin D3, mean±SD		29.08±15.44

The greatest indirect and positive association for income was related to prolactin level and the greatest indirect reverse association was FSH; the higher the income, the higher the prolactin and the higher the chance of NAFLD; but the lower the FSH level and thus the lower the chance of NAFLD (figure 2).

The greatest indirect and positive association for educational level was related to LH level and the greatest indirect reverse association was BMI; the higher the educational level, the higher the LH level and the higher the chance of NAFLD; but the lower the BMI and thus the lower the chance of NAFLD (figure 2). Considering age, the greatest indirect and positive association was related to LH and FSH levels (β=0.20) and the greatest indirect reverse association was prolactin (β=-0.18); the higher the age, the higher the LH and FSH levels and the higher the chance of NAFLD. The higher the age, the lower the prolactin level and thus the lower the chance of NAFLD (figure 2).

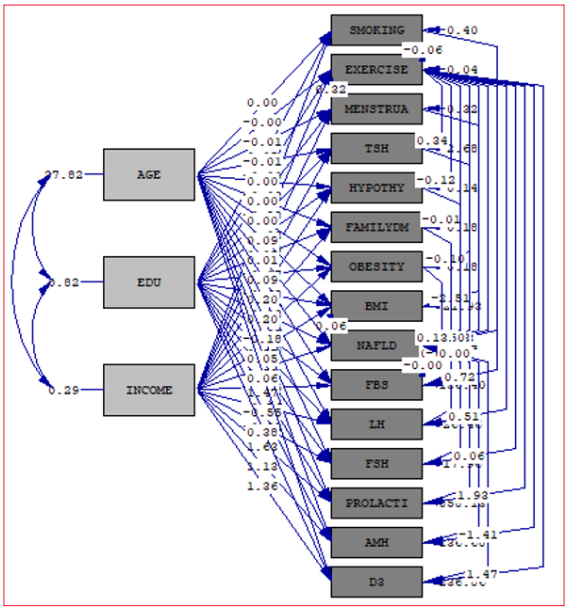

Figure 2: The Indirect Effect of Variables on NAFLD

Considering exercise, the greatest indirect and positive association was related to prolactin level and the greatest indirect reverse association was BMI; the higher the exercise, the higher the prolactin level and the higher the chance of NAFLD; but the lower the BMI and thus the lower the chance of NAFLD (figure 2).

Discussion

The results of the present study showed a high prevalence of NAFLD in women with PCOS (52.4%) and identified the possible risk factors that can be associated directly or indirectly with NAFLD among women with PCOS. This incidence rate is close to that reported by Eslamin et al (53.5%) in an Iranian population and Macut et al. (50.6%); although they have compared them with control group, as well (34.0%) [15, 7]. This is while others have reported a lower frequency (23.8% vs. 3.3% in controls) and others have reported a higher frequency (as much as 71%) [16, 17]. Meta-analysis of 17 studies indicated 2.5-fold increased risk of NAFLD among women with PCOS [8]. These results are all in line with the results of the present study, indicating a high prevalence of NAFLD among women with PCOS, which calls for greater attention to this issue.

Several factors have been found to play a role in the increased prevalence; nonetheless, the pathophysiology is still unknown. The results of the present study showed that BMI, FBS, obesity, and age had a direct and positive association with NAFLD, while educational level as the factor with a reverse association; several other factors, including LH, FSH, and prolactin could also have an indirect association (through income, educational level, or age). Considering the fact that race has been mentioned as an important influential factor for the incidence of NAFLD in women with PCOS, it is more appropriate to compare our results with other studies on Iranian population [8]. Meta-analysis of 55 studies on Iranian adult population indicated the significant effect of 18 factors including age, BMI, waist circumference, waist-to-hip circumference, total cholesterol, high-density lipoprotein, low-density lipoprotein, triglyceride (TG), alanine aminotransferase, asparat aminotransferase, hypertension, systolic blood pressure, diastolic blood pressure, FBS, homeostatic model assessment for insulin resistance (HOMA-IR), DM, metabolic syndrome, and physical activity in the incidence of NAFLD. However, gender and smoking had insignificant effect [18]. The results obtained are

similar to that reported in the present study; although we did not evaluate some other factors, including lipid profile, liver enzymes, and insulin resistance in the present study.

The association of age with NAFLD is predictable, as the older one gets, the more sensitive they become to oxidative damage, caused by the oxidative stress that plays an important role in the pathogenesis of NAFLD [19]. Furthermore, older individuals have a higher fat accumulation in the liver, muscle, and bone marrow tissue; the shift from subcutaneous adipose tissue to visceral tissue can also lead to insulin resistance that plays an important factor in the pathogenesis of NAFLD [20]. Therefore, it is necessary to pay greater attention to diagnosis of NAFLD in the elder women with PCOS.

Also, the results of the present study showed the greatest direct effect for obesity, while BMI was also directly associated with NAFLD. These results are in line with the results of the review of studies, which listed obesity among the factors strongly associated with NAFLD among patients with PCOS [9, 10]. The relationship between obesity/BMI and NAFLD is a complex phenomenon, affected by several metabolic pathways. Firstly, the higher amount of free fatty acid (FFA), released from adipose tissue and circulating TG, delivered to the liver in obese people, as well as higher expression of liver lipase and lipoprotein lipase genes causes the imbalance between FFA entering the liver and its output that is the main factor for steatosis [21]. Therefore, lifestyle modifications including appropriate dietary regimen, weight loss, and exercise should be recommended to women with PCOS, especially those with concomitant NAFLD, as an appropriate initial therapeutic intervention [22].

The third significant factor influencing NAFLD directly in the present study was FBS, although we excluded patients with overt DM, in order to investigate the pure effect of FBS; this finding is also in line with previous report of the review study, indicating insulin resistance and DM as important factors for NAFLD in women with PCOS [9]. Others have also reported higher FBS in PCOS women with NAFLD, compared to non-NAFLD group [15]. It has to be kept in mind that DM, hyperlipidemia, obesity, and PCOS have shared mechanism and are commonly presented together the higher prevalence of NAFLD in women with PCOS and their association with DM, abdominal obesity, insulin resistance, and other components of the metabolic syndrome may suggest the same shared mechanism in NAFLD, as well [23, 24]. Accordingly, controlling blood sugar may also be beneficial in women with PCOS, especially those with concommitant NAFLD.

The indirect effect of prolactin, LH, and FSH are another important finding of the present study. Prolactin has various biological functions, including reproduction and lactation, osmotic regulation, immune modulation, and metabolic homeostasis [25]. Evidence has also shown the association of serum prolactin with insulin resistance, DM, and beta-cell dysfunction in women with PCOS considering the shared risk factors in NAFLD, prolactin may influence NAFLD in the same way [26-28]. In another study on patients with NAFLD, lower serum level of prolactin was found in patients with ultrasound-diagnosed NAFLD, compared to the non-NAFLD group and in patients with biopsy-proven severe hepatic steatpsis, compared to those with mild-to-moderate hepatic steatosis in both men and women; this study also showed the reduced gene reduction of hepatic prolactin that has been associated with lipid content and CD36, as well [29]. Considering the complex role of this hormone in the body, more studies are required to understand the exact pathophysiology of its association with NAFLD, especially in women with PCOS.

The last, but not the least, is the indirect association of LH and FSH with NAFLD in the study population; this finding is also consistent with the results of previous research, indicating the higher levels of LH, LH/FSH in women with PCOS, complicated with NAFLD, than the control group with NAFLD [30]. It has been also demonstrated that increased secretion of LH and androgens can be influenced by insulin, as well; therefore, the impaired LH and FSH is not purely a hallmark characteristic of PCOS, but can also increase the risk of NAFLD [31, 32]. Further studies are required to investigate the possible mechanism underlying this association.

One of the limitations of the present study is the cross-sectional nature of the study, which limited us from reported causal relationship between the variables and the main variable. Also, retrospective analysis of the medical records is another limitation of the present study; therefore, any bias in data recording could influence the results. Furthermore, the patients were selected non-randomly from limited centers in one city; therefore, it may not represent the whole population. Considering the multifactorial nature of both diseases, investigated in the present study, including PCOS and NAFLD, there may be other factors influencing the results of the study, which have not been investigated in the present study and confound with the results.

Conclusion

The high frequency of NAFLD among women with PCOS, suggested by the results of the present study, calls for greater attention of gynecologists to diagnose this liver disease in this specific population and consider the liver function, when administrating medications for PCOS. This issue is of significant importance in the high-risk group, demonstrated to include elder obese women with higher serum level of FBS. More studies are required to understand the exact pathophysiology of NAFLD in women with PCOS and how these factors affect this association.

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