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The Relationship Between PCOS and Obesity: Which Comes First?

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Abstract

Polycystic ovary syndrome (PCOS) is recognized as the most common reproductive disorder in women. Obesity is believed to play a central role in the development of PCOS, as many women with this condition are reported to be overweight or obese. A strong correlational relationship exists between PCOS and obesity. This paper examines the relationship between PCOS and obesity in order to determine whether PCOS causes obesity as opposed to obesity causes metabolic changes that lead to PCOS. Analysis was conducted by reviewing and comparing many studies related to the topic. Factors such as insulin resistance, hyperandrogenemia and body fat distribution were examined in obese and non-obese PCOS subjects. Most studies included in this review could not conclusively determine whether PCOS contributed to obesity or vice versa. The important points raised in the literature showed that obesity could be an important factor to predict PCOS. In women who are predisposed to PCOS, the metabolic and hormonal issues that are present such as insulin resistance and hyperandrogenism, can lead to weight gain and eventually obesity. Obesity in turn can exacerbate the symptoms of PCOS such as further metabolic issues and reproductive abnormalities.

Introduction

Polycystic ovary syndrome (PCOS) is a common metabolic and endocrine disorder effecting 15- 20% of women of reproductive age. This disorder, originally known as Stein-Leventhal syndrome, was discovered in 1935. Its clinical features include obesity, hirsutism, acne, infertility, and oligomenorrhea. PCOS is also attributed to several hormonal and metabolic disturbances, including increased androgen production and disordered gonadotropin secretion leading to menstrual irregularity, hirsutism, and infertility. Aside from interfering with reproductive function, PCOS also disrupts the metabolism of women, affecting insulin action and β-cell function, increasing the risk for glucose intolerance and type 2 diabetes (Liu et al. 2017; Raisbeck 2009).

The origin of PCOS remains unclear, but research has shown that one of the characteristics of this disorder is the excess production of androgens in the ovaries (Alanbay et al. 2012). Androgen secretion is the result of abnormal response of the ovary to gonadotropins, insulin and insulin-like hormones such as insulin-like growth factor-1 (IGF-1), which enhances LH-stimulated androgen secretion by theca cells. Although the condition is not life threatening, the lack of treatment could lead to more serious health issues in the future, such as increased risk of infertility, dysfunctional bleeding, endometrial carcinoma, obesity, type 2 diabetes mellitus, dyslipidemia, hypertension, and increased risk for cardiovascular diseases (Raisbeck 2009).

Among the risk factors associated with PCOS, overweight (body mass index (BMI) 25–29.9 kg/m2) and obesity (BMI ≥30 kg/m2) have been considered as major contributing factor to overall health concerns among women worldwide. Obesity has also been a determined as a contributing factor to reproductive health problems such as anovulation. As body weight increases, incidence of anovulation also increases significantly. Another contributor to reproductive dysfunction is the accumulation of abdominal fat, indicating a higher risk associated with insulin resistance (IR). IR in obese women has been associated with anovulation and increased androgen secretion (Kuchenbecker et al. 2011).

Several studies relate obesity as a risk factor of PCOS (Reinehr et al. 2005; Soydinc et al. 2013). Some studies report that overweight and obesity incidence in females with PCOS is as high as 80%. The mechanisms by which obesity influences PCOS ' pathophysiology and clinical expression are not fully understood, but obesity is independently associated with IR (Rojas et al. 2014) and sex steroid imbalances that may lead to an increased risk of menstrual irregularities and hyperandrogenemia, similar to PCOS symptoms (Pasquali and Gambineri 2006). On the other hand, others proposed that regardless of physical condition PCOS could occur. PCOS may develop in women with a BMI in any range including both underweight and overweight women. (McEwen and Hartmann 2018). The consistent association between PCOS and obesity suggests a biological basis for this observation. Obesity exacerbates many of the reproductive and metabolic abnormalities associated with PCOS. Considering the close association between PCOS and obesity, the question remains whether PCOS causes obesity or does obesity cause metabolic changes that lead to PCOS?

Method

A critical appraisal of the literature on the topic was conducted. A search for related studies was conducted using the access of Touro's library in various databases, such as EBSCO, ProQuest, PubMed, MEDLINE, CINAHL, Cochrane Reviews, and Sage online publications. Other information was sourced from Google Scholar. Keywords used to obtain the relevant documents included PCOS, obesity, insulin resistance, reproductive health abnormalities and PCOS, metabolic anomalies and PCOS. In addition, a library search was also conducted for references in text books, relevant articles and other research findings using the same keywords.

Discussion

Metabolic Factors

One of the main contributors to PCOS is insulin resistance (IR). Insulin is an important hormone produced by beta cells in the pancreas. It is responsible for the metabolism of glucose reduction of blood glucose levels by stimulating the glucose intake in insulin-sensitive tissue such as those found in the skeletal muscles.

IR is common and an early predictor of metabolic diseases. IR is the "inability of insulin to optimally stimulate the transport of glucose into the body's cell" (McEwen and Hartmann 2018).

Several studies investigated IR among women diagnosed with PCOS regardless of BMI. Fasting insulin levels in both lean and obese women diagnosed with PCOS were determined and compared with control subjects. A total of 64 women with PCOS and 20 healthy subjects were evaluated using anthropometry, oral glucose tolerance tests, and insulin tolerance tests. Glucose levels were then measured using glucoseoxidase, whereas serum C-peptide and insulin levels were obtained using immunoradiometric assays. Insulin sensitivity and β-cell function were derived from fasting values of insulin and glucose or from oral glucose tolerance tests or insulin tolerance tests measurements. Results revealed that β-cell function is elevated in both lean and obese women with PCOS. In obese women suffering from PCOS, reduced values in fasting state-derived disposition index were found, whereas lean women suffering from PCOS were found to have increases in these variables when oral glucose tolerance tests were determined. The authors suggested that insulin hypersecretion may be an important mechanism in the pathogenesis of PCOS. Further, prevention of serious metabolic complications could be achieved with the early screening of impaired insulin action and secretion in women with PCOS (Vribikova et al. 2002).

Under normal conditions, the relationship between insulin secretion and sensitivity is constant to maintain normal glucose tolerance. If the sensitivity of insulin varies, the secretion of insulin also changes. Obese and lean females with PCOS have lower production of insulin sensitivity compared to the amount of insulin secreted in response to blood glucose levels than weight-matched healthy women (Dunaif 1999).

Another study investigated the association of IR to the increased risk for cardiovascular disease among women with PCOS. They examined the effects of IR on myocardial microcirculation and peripheral artery function in patients with PCOS. A total of 55 women (28 with PCOS without IR, 18 with PCOS and IR, and 11 normal controls) participated in the study. All subjects were examined using high-resolution vascular ultrasound and real time myocardial contrast echocardiography (RTMCE). Results indicated that women with PCOS and IR had depressed replenishment velocity and myocardial blood flow reserve, but no changes in endothelial dysfunction or intima–media thickness. By contrast, women with PCOS but without IR were found to have isolated depression in replenishment velocity, suggesting that this condition could be an early indicator of myocardial flow abnormality (Aldrighi et al. 2015).

IR and hyperinsulinemia are exacerbated in obese individuals. The accumulation of excess intra-abdominal fat increases IR because of its sensitivity to lipolysis and releases more free fatty acids in the circulation and produces several cytokines (i.e. tumor necrosis factor-α [TNF-α], IL-6, leptin, resistin) that occur in IR (Carpentier 2008). Circulating free fatty acids can accumulate in non-adipose tissues, causing lipotoxicity and insulin resistance. In obesity, IR is also related to TNF-α that enhanced serine phosphorylation of IRS-1 and inhibits insulin receptor signaling (Hotamisligil et al. 1996). Furthermore, IR associated to obesity induces leptin resistance and reduced adiponectin levels, which are two factors that may reduce fatty acid oxidation and promote lipotoxicity (Carpentier 2008).

The mechanisms causing insulin resistance in PCOS have many similarities with those seen in relation to visceral adiposity (Kabir et al. 2005). Excess free fatty acids derived from lipolysis/hydrolysis of acylglycerol in adipocytes accumulate in the hepatic portal veins, and this induces hepatic dysfunction. This condition contributes to elevated glucose secretion, stimulates pancreatic insulin secretion and glucose uptake in adipose tissue (Bergman et al. 2000). This specific insulin resistance, also known as hepatic insulin resistance, is only present in obese women with PCOS and not in healthy women of comparable body weight (Dunaif 1999). The results of these studies demonstrate only a correlational relationship rather than a causal one between obesity and PCOS on glucose production, which may highlight an important factor of the pathogenesis of glucose intolerance.

Another approach was taken to determine the effects of insulin resistance on PCOS. Researchers investigated the relationship between neuropeptide Y (NPY) and insulin resistance. NPY enhances appetite and is structurally and immunologically similar to the pancreatic polypeptide, which has 36 amino acids. NPY is found in the central and peripheral nervous system. NPY controls nutrient intake and body weight. NPY also has an inhibitor effect on the hypothalamohypophyseal-ovarian axis. A total of 45 patients with PCOS and 44 healthy reproductive age individuals participated in the study. At early follicular phase in patients with PCOS, insulin, fasting blood sugar, follicle-stimulating hormone (FSH), luteinizing hormone (LH), prolactin, testosterone, dehydroepiandrosterone sulfate (DHEA-S), thyroid stimulating hormone (TSH), cortisol, estradiol, and NPY levels were determined. Meanwhile, insulin, fasting blood sugar, prolactin, DHEA-S, TSH, cortisol, and 17-OH progesterone levels were obtained from the control group. Fasting insulin levels and homeostatic model assessment for IR (HOMA-IR) were more elevated in obese patients with PCOS than in patients with normal weight and healthy controls. NPY levels were also higher in obese-overweight women with PCOS compared with the control and normal weight patients, but they were not statistically significant. NPY levels did not differ in patients with and without IR (Koseci et al. 2019).

A study confirms the strong association between metabolic aberrations such as IR and PCOS. IR is clearly manifested among women with weight gain and who are genetically predisposed to develop PCOS. Conversely, weight reduction of women with PCOS reduces the negative impact of PCOS. Excluding obesity and fat mass, PCOS is related to metabolic aberrations

such as IR, dyslipidemia, and non-alcoholic fatty liver disease. Mechanisms attributed to the development of IR in PCOS have been established in previous studies. For example, the relationship between visceral adipose tissue and IR has been proven in other studies. Further investigation suggests that abdominal mass in women is proportional to the total fat mass regardless of PCOS status. This condition alone cannot completely explain the occurrence of IR in PCOS, however, fat distribution in women suggests an explanation as to why IR worsens as women with PCOS gain weight (Barber et al. 2016).

Biochemical Indicators

Many studies have used biochemical indicators as an approach to better understanding PCOS. One examined the impact of hyperandrogenemia on IR. Research has shown that impaired metabolism of glucose and IR is partially explained by high androgen concentrations. Women with PCOS have both hyperandrogenemia and IR. By activating androgen receptors, testosterone caused IR in subcutaneous adipocytes. This impairs glucose metabolism due to defects in downstream protein phosphorylation, kinase-C protein, which usually mediates insulin's impact on glucose transport (Corbould 2007).

In another study, the rationale for IR in PCOS patients was investigated. Adipocytes of women with PCOS had enhanced glycogen synthase kinase-3 (GSK3) action. Consequently, insulin-stimulated glucose transport was impaired, and IR developed. Furthermore, overexpression of GSK3 promoted androgen biosynthesis through direct stimulation of P450c17 enzyme activity (Chang et al. 2008). Results from these two studies verify that continuous exposure to androgens impairs insulin action and contributes to the development of IR.

Androgens have an important role in body composition because they determine the location of fat stored in the body. Androgens influence adipocyte function and distribution by the inhibition of adipocyte differentiation, which modulates lipolysis and lipogenesis (Dicker et al. 2004). In general, males have greater distribution of body fat in the upper portion of the body, whereas females accumulate fat in the posterior region of the body. Among women, distribution of adipose tissue differs between women with and without PCOS. Adipose tissues of women with PCOS have been found to be dispersed viscerally similar to that of males. For a given waist circumference, abdominal subcutaneous fat in women has been found to be higher than that of men regardless of age (Kuk et al. 2005).

To determine the possible developmental origins of PCOS, a model was constructed to trace the pathophysiology of PCOS involving excess androgens (including the signs and symptoms) at every stage of the disease. Androgen excess occurs in a vicious perpetual cycle. The gene expression of excess androgens in utero results in high LH and insulin concentrations, enhancing the enzyme activities in theca cells and encouraging the progression of primordial to preantral and small antral follicles. These interactions elevate androgen levels. The process is completed and revived when a female with excess androgen procreates and bears a female fetus, suggesting the genetic path of the syndrome (Homburg 2010).

Body fat distribution was researched among females with and without PCOS. The subjects were matched for age and BMI. They also looked at the connection between concentrations of androgen, IR, and fat distribution. A total of 31 women with PCOS and 29 healthy subjects as controls participated in the study. Women with PCOS demonstrated higher fat mass value in the trunk and arms. Fat accumulation occurs during puberty in the hips, thighs, and buttocks and is preserved throughout women's fertile stage. However, there is more upper body fat distribution for females who have been diagnosed with metabolic illnesses and PCOS. Excess androgens were ascribed to this disease. As a consequence of obesity, the impact of high androgens is increased due to lower concentrations of sex hormone-binding globulin (SHBG) and greater concentrations of freely circulating bioactive androgens. Insulin increases testosterone's impacts by suppressing SHBG. It functions as a co-gonadotropin and inhibits SHBG's hepatic synthesis excluding sex steroid impacts that contribute to hyperandrogenism. Insulin stimulates the synthesis of ovarian androgen and decreases the concentrations of SHBG circulation due to the high concentrations of complete serum and free testosterone. Consequently, there was more upper body fat distribution among females with PCOS. This research suggests that lowering the distribution and structure of fat may be useful in decreasing PCOS-related metabolic aberrations (Cosar 2008).

The relationship between abdominal and upper-body fat, glucose and lipid metabolism markers, and serum androgens in women with PCOS were investigated. The study included 40 women aged 19-49 years with BMI 18.7 – 53.8 kg/m2. The participants had at least two of the following features of PCOS, namely, oligomenorrhoea or amenorrhea, clinical and/or biochemical evidence of hyperandrogenemia, and polycystic ovaries in ultrasound imaging. All obese subjects had increased abdominal fat. A significant correlation was found between obesity and serum fasting glucose and insulin levels. The same result was found in homeostatic model assessment index of IR. A positive correlation was observed between estimates of obesity and serum triglycerides and between obesity and blood pressure. Subsequently, the researchers confirmed direct positive correlations between free androgen index, body weight and BMI (Kozakowski and Zgliczynski 2013).

Others also recorded the elevated incidence of upper-body obesity as evidenced by enhanced waist circumference and waist-hip ratio compared with BMI-matched control females, confirming the same results. Studies using dual-energy x-ray absorptiometry have disclosed enhanced accumulation of core fat

in females with PCOS in accordance with these results (Douchi et al. 1995). Chronic exposure in females with PCOS to greater concentrations of testosterone may alter the distribution of body fat in these females. Studies of androgen administration in non-obese females to male transsexuals leading to increased visceral fat and adverse impact on insulin sensitivity provide support for this hypothesis (Elbers et al. 1997). In both obese and normal-weight females, exposure to androgens increases visceral fat (Rosenfield 1999). In rats, administering a single elevated dose of testosterone early in life contributes to the growth of insulin resistance and centralization as an adult of adipose tissue mass (Nilsson et al. 1998). Early androgen exposure may adversely affect future distribution of body fat with higher core fat accumulation. Studies of isolated abdominal fat cells from females with PCOS have shown that there is a preferential abdominal accumulation of adipose tissue in both obese and non-obese females with PCOS compared to control females (Dunaif et al. 1992). In obese females with PCOS, femoral adipocytes are fewer than reproductively ordinary females, consistent with a change to the distribution of upper-body fat in females with PCOS. Observation of the increased distribution of visceral adipose tissue in PCOS can be ascribed to the impact of androgens, their metabolism, and tissue-specific steroid receptor expression (Blouin 2009). Since this visceral fat is biologically active (Kuchenbecker et al. 2011), it most probably contributes to further metabolic and endocrine disorders in PCOS.

Women with upper-body obesity have PCOS symptoms such as reduced sensitivity to insulin and are at greater danger of cardiac illness and diabetes (Vague 1956). It was observed that in females with upper-body obesity, the incidence of diabetes, hypertension, and atherosclerosis was greater than in lower-body obesity. Furthermore, it has been noted that the incidence of upper body obesity rises in females after menopause and females with upper body obesity tend to have hyperandrogenic characteristics such as hirsutism.

PCOS is defined by anomalies in the hormone releasing gonadotropin (GnRH), a pulse generator that leads to a rise in the release of LH over the follicle stimulating hormone (FSH). These abnormalities are obesity-independent. Healthy obese females have no defects in levels of 24-hour LH and FSH. Excess insulin stimulates hypothalamic GnRH secretion up to a certain point, thus inducing gonadotropin secretion (especially LH) from pituitary cells, which in turn stimulates the development of androgen in the ovaries. When hyperinsulinemia is found, the pituitary is led to secrete big quantities of LH, which tends to boost the LH / FSH ratio. LH stimulates androgens synthesis in the ovaries, and an absence of FSH impairs the aromatization of androgens in granulosa cells to estrogens. These modifications cause the tiny ovarian follicles to grow and hinder the maturation needed for the development of the dominant follicle that then appears as polycystic ovaries (Dunaif 2003).

Obesity and PCOS

Although it is true that obesity is a risk factor, the disease has also been diagnosed in lean females, although reproductive issues are generally discovered more frequently in obese females, regardless of PCOS. Obese females were more probable to have irregular menstrual cycles and anovulatory infertility compared to ordinary weight females. The risk of anovulatory infertility rises by 24 kg / m2 at BMI and continues to increase as BMI rises. But even a slight proportion of decrease in body fat can restore these women's menstrual cycles.

To understand which comes first, obesity or PCOS, studies have investigated this relationship in girls and adolescents. It was noted that girls with a high BMI in childhood had an increased risk of oligomenorrhea and a diagnosis of PCOS in young adulthood (age 24), yet the possibility that features of PCOS were already present in these girls cannot be excluded. The researchers investigated if PCOS (or its features) in adolescents is predictive of later class III obesity. Despite not using pelvic ultrasonography, PCOS was diagnosed using the Rotterdam criteria in 12 (40%) of 30 oligomenorrheic girls at age 14 years. Of these girls, 33% displayed class III obesity by 24 years of age versus 8.4% of girls without PCOS. Other predictors of class III obesity included low sex hormone binding globulin (SHBG), oligomenorrhea, high childhood insulin levels, increased cFT and MetS, all of which are recognized as PCOS phenotypes (Glueck et al. 2011). Meanwhile, others conducted a prospective study on 244 randomly selected postmenarchal girls from a large population-based birth cohort to investigate the influence of obesity on the development of abnormal ovarian morphology. They found PCOS in 61.1% of the obese girls, but only in 32.1% of the normal- weight girls, suggesting that obesity is a contributing factor (Hickey et al. 2011). These studies illustrate that obesity and PCOS are correlative in their pathogenesis.

Additional trials explored the differences between obese and nonobese Croatian females with PCOS in clinical, hormonal and metabolic characteristics. The research included a total of 74 obese and 208 nonobese females with PCOS. Obese females with PCOS were discovered to be at greater danger of developing oligomenorrhea, but at a lower risk of developing hirsutism and acne. Furthermore, obese subjects were more likely to develop hyperandrogenemia, insulin resistance, hypercholesterolemia, hypertriglyceridemia, and high serum CRP concentrations than nonobese females. Among obese females with PCOS, metabolic problems were more probable to happen than their healthy counterparts (Baldani et al. 2013).

Especially in females with upper-body obesity, the discovery of enhanced androgen production in obese females was revealed. Androgen clearance rates have also risen, however, the circulation of bioavailable androgens remains within the normal range. Similarly, due to hyperinsulinemia, SHBG concentrations are decreased in this state. SHBG concentrations in females

with or without PCOS are negatively associated with the circulating insulin concentrations or with the degree of insulin resistance. Reducing insulin concentrations with diazoxide in obese PCOS females, a drug that only reduces insulin secretion without altering insulin sensitivity, has been discovered to increase SHBG concentrations. This finding indicates that insulin may directly suppress the secretion of liver SHBG and compensatory hyperinsulinemia as opposed to IR, explaining low concentrations of SHBG in obese females with PCOS. Due to reduced SHBG secretion induced by insulin, hyperandrogenemia is further exacerbated. Consequently, obesity-related hyperinsulinemia is a significant contributor to ovarian production of androgens in PCOS. By directly stimulating steroidogenesis in ovarian theca and granulosa cells, hyperinsulinemia may lead to hyperandrogenemia. Similar studies have been done on mice and have shown that liver and muscle cells display insulin resistance during constant hyperinsulinemia, while insulin receptors remain sensitive in pituitary and ovarian cells, an adaptation that improves the secretion of pituitary hormones and ovarian androgen production (Nestler, et al 1991). This observation was used as a model to describe the insulinemic contribution to the advanced androgen production to PCOS in obese women.

A systematic and meta-analytical review on existing literature was conducted to determine the prevalence of obesity among women diagnosed with PCOS. Moreover, the researchers intended to determine whether ethnicity, geographic regions, and the diagnostic criteria of PCOS had confounding effects on this relationship. A total of 106 studies conducted before 2010 were included in the review. Among them, only 35 studies were included in the meta-analysis because the rest did not include a control group. They found that compared to non-obese women, obese women with PCOS were more likely to have poor clinical reproductive presentation. Evidence also suggested that PCOS contributed to obesity. Increased androgen levels in women regardless of PCOS status were found to affect the appetite for high-fat and carbohydrate rich foods. However, other metabolic factors such as hyperinsulinemia, reduced postprandial thermogenesis, and basal metabolic rate and alterations contributed to weight gain in women with PCOS. However, the question remains whether PCOS contributed to obesity or vice versa. Some studies showed that women with PCOS had a greater tendency to accumulate fat in the upper body. This effect had also been found even in normal weight women. Overall, it was concluded that women with PCOS were more likely to be overweight or obese compared to healthy counterparts. Caucasian with PCOS had greater risk for obesity than Asian women with PCOS (Lim et al. 2012).

Conclusion

In most health issues around the world, obesity is a significant characteristic. Such observation does not exclude PCOS. However, most of the research in this review has not been able to determine conclusively whether PCOS contributed to obesity or vice versa. However, the significant points raised in the literature showed that PCOS could be predicted by obesity as a significant factor. Overweight or obese females were at a higher risk of PCOS than ordinary weight females, but the weight problem does not exclude ordinary weight females from getting PCOS and its problems.

Researchers found that an elevated BMI among girls during childhood increases the risk of oligomenorrhea and a diagnosis of PCOS in young adulthood (age 24). They also investigated whether PCOS or its features were present in these adolescents, which could predict later class III obesity during adulthood. Among 12 of 30 oligomenorrheic girls at age 14, 33% of the girls were predicted to have class III obesity in a decade compared to 8.4% without PCOS (Glueck et al. 2011). Another study found PCOS in 61.1% of the obese girls, but only in 32.1% of the normal- weight girls, suggesting that obesity is a contributing factor (Hickey et al. 2011). These studies illustrated that obesity and PCOS are correlative in their pathogenesis.

By contrast, it was found that both lean and obese women with PCOS had elevated βF regardless of BMI. Lean PCOS subjects had elevated DI values when OGTTs were determined. Aside from body weight, insulin hypersecretion could be an important mechanism in the pathogenesis of PCOS. Early screening of insulin action in women with PCOS regardless of BMI could prevent serious metabolic complications (Vribikova et al. 2002). Meanwhile, others found that both obese and lean women with PCOS have lower product of insulin sensitivity compared to the amount of insulin secreted in response to blood glucose levels than weight-matched healthy women (Dunaif 1999).

Nevertheless, being overweight or obese is a significant contributory factor that aggravates the conditions of women with PCOS. IR among women with PCOS had been found to increase the risk of cardiovascular disease. Women with PCOS and IR demonstrated depressed replenishment velocity and MBFR, but no changes in endothelial dysfunction or IMT. However, women with PCOS but without IR were found to have isolated depression in replenishment velocity, suggesting that this condition could be an early indicator of myocardial flow abnormality (Aldrighi et al. 2015).

Other studies indicated that only a correlational relationship (rather than a causal one) exists between obesity and PCOS on glucose production. It was noted that IR and hyperinsulinemia are intensified in obese individuals. Accumulation of excess intra-abdominal fat increases IR because of its sensitivity to lipolysis and releases more FFAs in circulation and produces several cytokines (i.e. tumor necrosis factor-α [TNF-α], IL-6, leptin, resistin) that occur in IR (Carpentier 2008). The mechanisms causing IR in PCOS have many similarities with those seen in relation to visceral adiposity (Kabir et al. 2005). A specific IR

also known as hepatic IR is only present in obese women with PCOS (Dunaif 1999).

Researchers concluded that evidence in the literature suggested that PCOS contributed to obesity. Increased androgen levels in women regardless of PCOS status were found to affect the appetite for high-fat and carbohydrate rich foods. However, other metabolic factors such as hyperinsulinemia, reduced postprandial thermogenesis, and basal metabolic rate and alterations contributed to weight gain in women with PCOS. They also noted that women with PCOS were more likely to be overweight or obese compared to healthy counterparts. Caucasian with PCOS had greater risk for obesity than Asian women with PCOS (Lim et al. 2012).

The literature reviewed yielded significant information on PCOS. However, no conclusive evidence pointed to obesity as the main cause of PCOS or PCOS could cause weight gain. Biochemical and metabolic features that were impaired because of PCOS were suggested in these studies. Metabolic rate anomalies found in women with PCOS were more likely to cause their weight gain. Aside from weight gain, other PCOS features such as insulin hypersecretion, overproduction of androgens, reduced SHBG, relationship between IR and myocardial flow abnormality have been mentioned as contributing factors to more serious health issues among women with PCOS.

PCOS is not an exclusive condition for females who are overweight or obese. Normal weight females also exhibited PCOS, especially females deemed to be PCOS candidates due to biochemical and metabolic dysfunctions. Due to the confounding factors connected with body fat and PCOS, weight gain is feasible for these females. Nevertheless, it was discovered that more than half of the females with PCOS studied in this research were overweight or obese. To determine the connection between body mass and PCOS, a more comprehensive research should be performed.

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