Chapter 21
Polycystic Ovarian Syndrome (PCOS)

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Introduction

Polycystic ovarian syndrome (PCOS) is a common hormonal imbalance that typically presents during adolescence and affects both the reproductive and metabolic systems. It is characterized by a wide spectrum of clinical symptoms including hirsutism, acne, irregular menses, increased adiposity, insulin resistance, and related comorbidities. Nutrition has been shown to play a major role in both the development and management of PCOS, and adolescence is the prime time to cultivate habits that may influence health throughout the life course (see Chap. 12). Given the increased associated lifetime risk of type 2 diabetes (T2DM) and cardiovascular disease,

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early diagnosis and management may prevent sequelae later in life. In this chapter, we provide an overview of PCOS in adolescents, and then focus on strategies for nutritional assessment, diagnosis and management.

Medical Background

PCOS is the most common endocrine disorder in women of reproductive age, affecting upwards of 10% of females in the general population [1, 2]. Rates vary significantly by racial and ethnic background, with women from East Asia having lower prevalence (5%) compared to Caucasian women (11–21%) [3]. The etiology of PCOS remains unclear, but is likely multifactorial. Genetics and environmental exposures are thought to play a role; it is inherited in an autosomal dominant pattern though phenotypic expression is variable [4, 5]. Evidence suggests that endocrine disrupting chemicals (EDCs), such as foods and other consumer products that interfere with hormone biosynthesis and metabolism, may be implicated as well. Some studies have shown that prenatal exposure to androgen-like EDCs may contribute to metabolic dysfunction and PCOS during adulthood [6]. Certain medications, such as valproate, an antiepileptic drug, have also been shown to increase the likelihood of developing a PCOS phenotype [7].

Pathogenesis

Multiple hormonal factors contribute to the development of the PCOS phenotype. Increased production of luteinizing hormone (LH) and insufficient follicle-stimulating hormone (FSH) lead to elevated production of testosterone by the ovaries, resulting in menstrual dysfunction. Elevated levels of insulin also increase ovarian and adrenal production of free testosterone [8, 9]. In addition, increased adiposity may be associated with higher androgen concentrations, possibly making the phenotype of PCOS more severe [10]. One study

has shown that as BMI increases in adolescent girls, free testosterone concentration rises proportionally [11].

Diagnosis

The diagnosis of PCOS generally requires the presence of clinical hyperandrogenism (hirsutism, acne) or hyperandrogenemia (elevated serum androgen levels), as well as some form of menstrual dysfunction [12]. Historically, there have been three distinct diagnostic criteria used to define PCOS, sometimes making identification a challenge. Diagnosis in adolescents is even more complicated given that irregular menses and acne are often normal physiological findings at this age. The National Institutes of Health (NIH) PCOS criterion were the first to emerge in 1990 [13], followed by the Rotterdam consensus in 2003 [14], and finally the Androgen-Excess PCOS (AE-PCOS) Society in 2006 [15] (see Table 21.1). In 2012, an NIH evidence-based methodology PCOS workshop convened in attempt to merge these divergent criteria, resulting in reinforcement of the broader and more inclusive 2003 Rotterdam criteria, with the addition of a phenotypic classification system to help with diagnosis. This classification describes four distinct PCOS phenotypes, each with varying degrees of clinical severity [16].

Table 21.1 Diagnostic criteria for polycystic ovarian syndrome

Diagnostic criteria	Hyperandrogenism (clinical or biochemical)	Ovulatory dysfunction (oligo- or anovulation)	Polycystic ovaries on ultrasound
NIH (1990)	X	X	
Rotterdam (2003)	2 of 3 required		
	X	X	X
AE-PCOS Society (2006)	X	1 of 2 required	
		X	X

Clinical Presentation

About two-thirds of adolescents with PCOS will present with menstrual irregularities. However, it is difficult to distinguish what is normal physiology in young women from oligomenorrhea secondary to PCOS, given that anovulatory cycles can persist until 5 years after menarche [17]. As such, workup for PCOS would be warranted in the setting of: primary amenorrhea in adolescents who have otherwise completed pubertal development, secondary amenorrhea with cycles absent for greater than 3 months, or persistently irregular bleeding with cycles lasting fewer than 21 days, especially if there is evidence for hyperandrogenism [9, 17].

The hyperandrogenism that is seen with PCOS includes moderate to severe hirsutism or acne. Hirsutism in women is the presentation of excessive, coarse hair appearing in a male-type pattern which can be objectively quantified using the Ferriman-Gallwey scoring system [18]. This scoring system was validated in white female adults, so generalizing its use to adolescents of varying racial and ethnic backgrounds is not without its limitations. Given that many adolescents develop acne during puberty, only more extreme cases should be considered an indication of hyperandrogenism. A finding of moderate to severe inflammatory acne as defined by greater than 11 inflammatory lesions, unresponsive to topical medications, would be reason to pursue further laboratory workup [17]. Table 21.2 lists some of the common clinical and biochemical findings of PCOS in adolescents.

Medical Workup

The recommended initial step for assessment of laboratory abnormalities is measurement of serum free testosterone, which is the most sensitive indicator of elevated androgens. Total testosterone and sex hormone binding globulin (SHBG) can also be evaluated to determine the amount of circulating free testosterone. Elevated levels of dehydroepiandrosterone sulfate (DHEA-S), an adrenal steroid and precursor of

Table 21.2 Common clinical and laboratory findings of PCOS in adolescents

Physical exam
Moderate to severe inflammatory acne
Excessive "male-type pattern" hair growth (hirsutism)
Alopecia
Acanthosis nigricans
Measurements
Hypertension
Elevated Body Mass Index (BMI)
Laboratory evaluation
Elevated free or total testosterone
Elevated DHEAS
Normal or elevated LH:FSH ratio
Elevated AMH
Elevated fasting glucose
Elevated HbA1c
Elevated fasting insulin level
Hypercholesterolemia or hypertriglyceridemia
Transaminitis

[a]PCOS presents with a wide range of phenotypes. The table lists potential findings that may be present in some, but not all, patients. Please refer to Table 21.1 for diagnostic criteria

testosterone, is also an indicator of hyperandrogenism [19]. Though non-specific, an LH to FSH ratio greater than 2.5 is frequently observed in patients with PCOS; however, this is more commonly seen in lean patients with PCOS, as BMI is negatively correlated with LH levels [20, 21]. Recent studies have suggested that the measurement of a patient's serum anti-müllerian hormone (AMH) may be an emerging clinical tool in the diagnosis of PCOS. AMH is involved in ovarian follicular development, and is significantly higher in women with PCOS, though a clear diagnostic cut-off value has not yet been defined [22]. Further laboratory workup is needed to monitor for development of metabolic and cardiovascular comorbidities (see below). Depending on the clinical presentation, it is also recommended that other etiologies of androgen excess, amenorrhea and/or oligomenorrhea be ruled out

before a diagnosis of PCOS is made; these include androgen-producing tumors, late onset congenital adrenal hyperplasia (CAH), Cushing's syndrome, premature ovarian insufficiency, hyperprolactinemia and thyroid disorders.

Pelvic ultrasound is an additional tool, which can be useful for diagnostic clarification in adolescents with suspected PCOS. Polycystic ovarian morphology (PCOM) is due to an excess number of small ovarian follicles that have arrested before pre-ovulatory development. PCOM diagnosis was previously based on the presence of a minimum of 12 follicles or an ovarian volume of greater than 10 cm^3 in at least one ovary, though with improved transducer frequencies, this definition was recently updated to include at least 25 follicles in adult patients using transvaginal ultrasonography. In adolescents, however, follicle counts may be less reliable with transabdominal imaging, which is the preferred method in this age group. In addition, due to normal physiological changes associated with pubertal development, these findings can be present in up to half of asymptomatic adolescents, particularly within the first 2 years after menarche. Given these frequently misleading findings, the Endocrine Society guidelines caution against use of PCOM as diagnostic criteria for adolescents. As such, ultrasound use in adolescents is reserved only for patients with an unclear diagnosis [17, 23, 24].

Comorbidities

Additional factors to consider in the presentation and management of PCOS are comorbidities associated with insulin resistance, which can lead to multiple metabolic complications including pre-diabetes, T2DM, hyperinsulinemia, dyslipidemia, cardiovascular disease, hypertension (together often referred to as metabolic syndrome), and non-alcoholic fatty liver disease (NAFLD) [25]. An estimated 50–80% of adolescents with PCOS are overweight or obese [26], further increasing their risk of developing metabolic disturbances. The prevalence of hypertension in adolescents with PCOS

and a BMI in the obese range has been reported to be as high as 27% [27]. About 30–35% of women in the U.S. with classic PCOS have impaired glucose tolerance, and 8–10% develop diabetes [26]. A recent meta-analysis demonstrated that the odds of developing metabolic syndrome among adolescents with PCOS was 6.1-fold higher than among adolescent healthy controls [28]. While all girls with PCOS are at higher risk for developing these comorbidities, the risk increases with higher BMI [27]. Another study showed that obese adolescents with PCOS who had normal blood pressures and lipid profiles were found to have greater carotid artery thickness, greater arterial stiffening and more atherogenic lipid metabolisms, thus putting them at increased risk of poor cardiovascular outcomes, when compared to obese youth without PCOS [29].

Given the prevalence of significant comorbidities with PCOS, current guidelines recommend screening for T2DM and for cardiovascular risk. It is generally recommended to perform a fasting lipid profile and a 2-hour oral glucose tolerance test (OGTT); alternatively, a hemoglobin A1c (HbA1c), which is often easier to obtain in youth, can be performed in place of an OGTT [30]. Most guidelines recommend screening for these comorbidities at the time of diagnosis of PCOS, and repeating every 1–5 years depending on patient characteristics (interval weight gain, signs/symptoms of T2DM), though there is no clear consensus on frequency of repeat screening [23, 26]. Although there are no formal recommendations regarding the evaluation of hyperinsulinemia or liver function, it may be useful to obtain a fasting insulin level and alanine aminotransferase (ALT) to guide management, particularly in patients with increased adiposity or signs of insulin resistance.

A potential consequence of ovarian dysfunction in adult women with PCOS is infertility, though this is not an issue that is typically of immediate concern for adolescents. Reassurance should be provided that many women with PCOS conceive with or without fertility therapies. As such, sexually active adolescents should be counselled that they

can indeed become pregnant and should use contraception. Endometrial cancer is a possible late complication of prolonged anovulation as unopposed estrogen stimulation of the uterus can lead to endometrial hyperplasia. The lifetime risk of endometrial cancer among women with PCOS is estimated to be as high as 9% [26].

Other notable and all-too-often overlooked comorbidities associated with PCOS include depression and anxiety. The social and emotional aspects of the physical presentation of acne, unwanted facial hair, and increased adiposity can be quite distressing, leading to significant declines in health-related quality of life in these patients [31]. Providers evaluating for PCOS should be mindful of potential body image concerns, disordered eating, weight stigma and bullying, and thorough mental health screening should be performed. Several instruments have been created to specifically evaluate the quality of life in patients with PCOS; the PCOS Health-Related Quality of Life Questionnaire (PCOSQ) and the 36-item Short Form Health Survey (SF-36) are the two most commonly used [32]. Another option, the Patient Health Questionnaire 9 (PHQ-9), is a brief general screening tool for depression which has been validated in adolescents and is often readily available in primary care settings [33].

Medical Management of PCOS

Treatment of PCOS in the adolescent should generally focus on managing symptoms of hyperandrogenism and menstrual irregularities as well as preventing or treating any comorbidities such as dyslipidemia, insulin resistance, and increased adiposity. The main treatment modalities consist of lifestyle modifications and pharmacotherapy [34], however, given the variety of treatment options, we recommend a shared decision-making approach with the adolescent and, if applicable, their parent or guardian, to focus on the symptoms that are most bothersome to the individual patient. It should also

be emphasized that not all adolescents are bothered by their acne, hirsutism, or menstrual dysfunction, so working with patients based on their concerns is critical.

Current literature suggests that in patients with an elevated BMI, a decrease in body weight and increase in physical activity have been effective in improving the endocrine and metabolic complications of PCOS. Several studies have demonstrated that a 5–10% reduction of body weight can improve hyperandrogenism, insulin resistance, dyslipidemia, menstrual regulation, and emotional wellbeing [35–37]. It is unclear if similar reductions in body weight will improve the PCOS phenotype in women with BMIs in the normal range. The 2013 Endocrine Society guidelines for PCOS recommend lifestyle modifications, with a goal of weight loss, as the first line treatment for adolescents with PCOS in the overweight or obese categories [23]. Although data on bariatric surgery outcomes in adolescents with PCOS is not yet available, adult data has shown resolution of hirsutism and ovarian dysfunction in 96% of adult women with PCOS who underwent surgery [38]. That said, psychosocial outcomes of bariatric surgery in adolescents continue to be poorly understood [39, 40]. It is also important to note that evidence on the feasibility and long term sustainability of weight loss in adolescents is limited, and further research is needed to evaluate the unintended consequences of weight as a target for health interventions [41]. We recommend focusing less on weight loss, and more on a healthy and balanced approach to eating and exercise (see Chap. 12).

For pharmacologic therapies, combined hormonal contraceptives (CHCs) remain the mainstay of treatment in adolescents who do not have contraindications to estrogen use. CHCs serve to decrease ovarian androgen production and thus lower serum free testosterone levels. They also increase the liver's production of sex hormone binding globulin, which further reduces serum free testosterone. This results in a reduction of hirsutism and acne, as well as regulation of menses, thereby providing endometrial protection [42]. Spironolactone, an aldosterone antagonist and potassium-sparing diuretic, inhibits

the action of androgens as well as the biosynthesis of adrenal and ovarian androgens; it is often used as adjunct or even individual therapy for clinical signs of hyperandrogenism, but its teratogenicity must be considered. Topical or oral acne medications as well as hair removal techniques (waxing, laser, and electrolysis) can also be offered based on the severity of the patient's symptoms and their goals of treatment [21].

Insulin sensitizing medications, which are primarily used to treat T2DM, are often prescribed for adolescents with PCOS and insulin resistance. Metformin, a commonly used insulin sensitizer, improves glucose tolerance and has been shown to decrease triglycerides, reduce hyperinsulinemia, lower BMI, decrease cardiovascular risk, and lower serum testosterone levels in patients with PCOS [43]. Metformin use can result in menstrual regulation; thus it is often used in adult women with PCOS who are seeking fertility. Given the potential side effect of lactic acidosis, it is important to counsel patients to avoid alcohol use while on metformin, and to discontinue use if they develop vomiting or diarrhea. Metformin can also affect the absorption of Vitamin B12, thus patients should be encouraged to take a multivitamin [44]. Newer insulin sensitizers are becoming available, but have not yet been studied in adolescents.

In addition, there is some evidence to support the role of vitamin D supplementation in the management of PCOS as it has been found to decrease levels of free testosterone [45], though this association has not yet been well established.

Finally, as noted above, improving quality of life by supporting adolescents' mental health needs with counseling, if applicable, is critical in decreasing the psychological morbidity often present in PCOS [32].

Nutrition Assessment

A nutrition assessment has five distinct components including: food and nutrition history, anthropometric measurements, biochemical data, the nutrition focused physical exam, as well as health history [46]. These components should be

tailored to fit the medical and emotional needs of an adolescent with PCOS. The goal of this assessment is to conceptualize a nutrition intervention.

Food and Nutrition Related History

Given the preponderance of nutrition myths, it is important to begin by gauging an adolescent's understanding of nutritional recommendations as they pertain to PCOS. Thereafter, a clinician should gather information regarding the adolescent's current and past eating patterns, including a 24 hour dietary intake, and assess for eating disordered behaviors. For an individual with PCOS, it is important to be cognizant of current nutrition habits within the context of their unique health risks.

Dietary Intake

A 24-hour diet recall is the standard method to assess for typical dietary intake. The literature regarding dietary intake for adolescents with PCOS reveals a number of differences compared to adolescents without PCOS. These include the fact that adolescents with PCOS have higher caloric and dietary fat intakes than individuals without PCOS [47], as well as higher saturated fat intake and lower fiber intake [48] compared to their non-PCOS peers. From a micronutrient prospective, adolescents with PCOS are at a higher risk of a vitamin D deficiency [49]. A clinician should note dietary sources of vitamin D as well as inquire about supplement use.

Given the heightened risk of insulin resistance and a predisposition to T2DM, it is relevant to assess for intake of sugar-sweetened beverages as well as refined carbohydrates. Additionally, given the metabolic and cardiovascular risks associated with PCOS, dietary sources of items high in saturated fats, trans-fats, sugar and sodium should be noted. Finally, with the known benefits of small, frequent meals for blood glucose stability, meal frequency and portion size should be assessed during a dietary recall.

Assessing for Disordered Eating in Adolescents with PCOS

A part of any adolescent nutrition history should include a screening for eating disorders. There is an established link between PCOS and heightened risk of eating disorder behaviors as well as body dissatisfaction [50]. Research shows that adolescents with PCOS are at particular risk of engaging in a variety of eating disordered behaviors [51]. Specifically, there is an increased risk of binge eating behaviors in adolescents who have both PCOS and higher body weight. Additionally, adolescents with PCOS have been found to have higher food craving scores, which are often linked to increased rates of binge eating behaviors and elevated weight status [52]. It is important to note that dieting, or intentional caloric restriction, is also highly correlated with higher food cravings. Thus, a clinician must be careful not to make recommendations that could contribute to or perpetuate restrictive eating. There is also a growing body of literature which shows a connection between dieting and weight dissatisfaction with decreased health and health related-quality of life [53]. Thus, any discussion about weight, body size and eating patterns should be done in a sensitive matter. If an adolescent does endorse eating disorder behaviors, refer the patient to a treatment team specializing in this field.

Below are examples of screening questions for eating disorder behaviors in adolescents with PCOS:

- *How often, if ever, have you skipped meals to change your body weight?*
- *How often, if ever, do you eat in a way that feels out of control (as if you cannot stop if you wanted to)?*
- *How often, if ever, have you restricted carbohydrates to change your body size?*
- *How much time do you spend wishing to change your body? How does this compare to a friend or family member - less time, about the same or more time?*

Anthropometric, Biochemical and Growth Chart Data

Adolescents with PCOS are at an increased risk for type 2 diabetes (T2DM), coronary artery disease, and elevated weight [54]. Lab values, as noted above, and growth, should be reviewed in the context of dietary patterns and physical activity. A CDC growth chart should be used from the ages of 2–20 and weight status for a pediatric and adolescent population (up to age 18) is determined by BMI percentiles. A BMI between the 85th and 95th percentile is considered the overweight category and a BMI equal to or greater than the 95th percentile is the obese category. Upward deviations in BMI and lab value abnormalities will inform the nutrition diagnosis and subsequent recommended intervention.

Nutritional Interventions for PCOS

The first-line treatment for PCOS is lifestyle intervention that focuses on healthful eating patterns, physical activity, and, potentially, weight loss [55]. Nutrition plays a key role in these behavior changes. Despite proven symptom resolution with lifestyle change, such change can prove challenging. This is especially true for adolescents, as they may have an established eating routine, and may not want to eat differently from their peers. Many adolescents also dislike foods deemed "healthy," and teens are often not responsible for purchasing or preparing the food that is available to them at home.

Weight Loss and Dietary Modification

Though weight loss of approximately 5% has been shown in the short term to reduce symptoms of PCOS (such as menstrual dysfunction, infertility, hyperandrogenemia, and cardiometabolic comorbidities), it is more difficult for adolescents with PCOS to lose weight when compared to their peers

[56, 57]. That is in part because women with PCOS have been found to have a lower basal metabolic rate than those without PCOS [58]. Additionally, one study found that levels of ghrelin and cholecystokinin, hormones that help regulate appetite, are impaired in women with PCOS [59]. This could lead to increased appetite and excess nutrient consumption, as well as compromised awareness of body hunger and fullness cues.

All young women with PCOS can benefit from dietary modification. Evidence suggests that this holds true even for normal weighted women, per CDC BMI classification, for whom weight loss is not the goal [55]. Studies have shown that in adolescents with PCOS and elevated BMI, the mechanism for weight loss is not as important as the actual weight loss itself [55]. There is no specific "PCOS diet," per se, so dietary recommendations should be individualized [34]. Particularly in adolescent women, providers should be wary of excessive calorie restriction or elimination of food groups which can lead to or exacerbate disordered eating. This is especially true for young women with PCOS who have been shown to have an increased risk of disordered eating and body dissatisfaction [50, 51].

Adolescents are impressionable, and may attempt to make impulsive, drastic dietary changes, or to follow "fad diets" that may seem to be quick solutions. Fad diets are typically unsustainable, often resulting in higher body weight over time [60]. Such "yo-yo dieting" and weight cycling contribute to a gradual slowing of metabolism, making long-term weight loss increasingly more difficult [60]. Educating an adolescent on a healthful dietary approach and guiding them to elicit dietary change using motivational interviewing will be more effective and sustainable.

If appropriate, engaging parents or caregivers in supporting an adolescent in making dietary changes can be impactful, especially if caregivers are responsible for food shopping and meal preparation. While important to give the patient autonomy, ask if it would be helpful to include the caregiver in the discussion. Caregivers may benefit from education on the importance of dietary changes and their intended impact on

PCOS symptoms. Providers should encourage caregivers not to stigmatize their teen about their body size or eating patterns. Rather, a shift towards changing the entire family's health behaviors would likely support the adolescent in adherence to any lifestyle change.

Lifestyle Change and Motivational Interviewing

Motivational Interviewing (MI) is an evidence-based style of counseling for adolescents. Use of MI is recognized to be effective in helping to motivate individuals to change behaviors. MI, addressed in other sections of this book, is a patient-centered model of care which helps in assessing motivation and readiness for making change [61]. For example, if an adolescent wants to lose weight, a follow-up question might include, "How might you accomplish that?" The provider can then guide them to help set attainable goals, while providing nutrition education when appropriate. In some short-term studies, motivational interviewing in tandem with counseling on healthy behaviors has been shown to be effective for weight loss in adolescents [62]. A skilled clinician can help to elicit change while providing nutrition education on healthful balanced eating.

When using motivational interviewing, it is important to meet the adolescent where they are and to help them to make SMART (specific, measurable, achievable, realistic, time-based) goals. Ideally, the adolescent will follow-up with a healthcare provider to track progress with their specific goals in order to keep them accountable. The following are examples of SMART goals for an adolescent with PCOS:

- *Ask parent to purchase broccoli when grocery shopping for the week. Add broccoli to dinner Monday night and Thursday night. On follow-up try increasing vegetables to four nights per week.*
- *When eating at a restaurant on Friday night, order seltzer water to drink instead of soda. On follow-up try limiting soda to 1 cup per week.*

- *Bring one piece of fruit to eat with lunch at least 3 days in the next school week. On follow-up try increasing to fruit daily with lunch.*
- *Over the weekend, make trail mix using whole-grain cereal, nuts, pumpkin seeds, and dark chocolate chips. Snack on 1 cup after school each day. On follow-up discuss whether this helped to satisfy craving for sweet and salty treats.*

Nutrition Recommendations for Adolescents with PCOS

Regardless of weight status, young women with PCOS should attempt to have a balance of nutrients at each meal consisting of lean protein, whole-grain, high-fiber carbohydrates, heart healthy fats, fruit, and vegetables. The USDA MyPlate helps illustrate a ratio of these nutrients by dividing the plate into four equal sections: fruit, vegetable, carbohydrates, and protein, as well as a glass of milk [63]. Another tool is the Harvard Medical School Healthy Eating Plate (Fig. 21.1) which specifies the grains should be whole grains, the proteins should be lean and plant-based when possible, the fats should be heart-healthy, and the vegetables should be the largest portion on the plate.

Both of these plates are appropriate for adolescents with PCOS, especially within the context of what they leave out: processed foods, refined grains, sugar, and sugar-sweetened beverages. The intake of food and beverages high in sugar should be limited in adolescents with PCOS due to their negative effects on insulin and blood sugar [60]. Additionally, trans-fats and saturated fats should be minimized due to their effect on cardiovascular health and risk of metabolic syndrome. It is important to counsel *moderation* rather than *elimination* to prevent any foods or food groups seeming "off limits," which can lead to higher desirability and/or overconsumption. Additionally, it is important to be sensitive to the fact that processed foods may be the most readily available

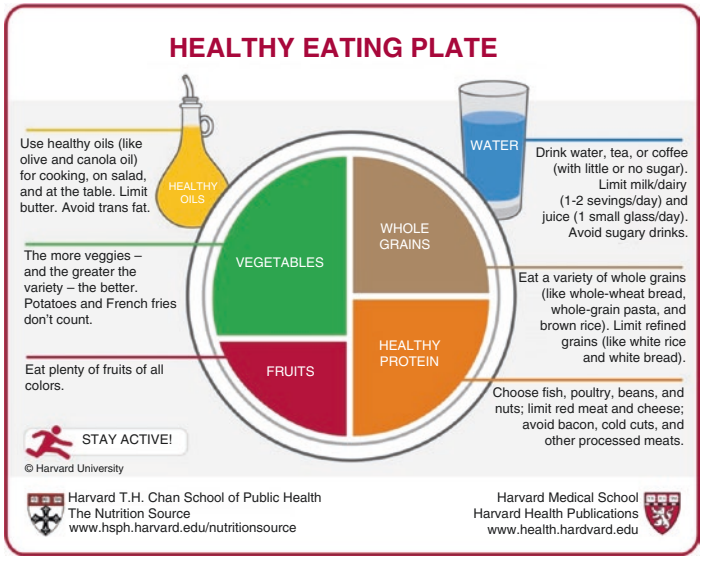

Figure 21.1 The Healthy Eating Plate. (Copyright © 2011 Harvard University. For more information about The Healthy Eating Plate, please see The Nutrition Source, Department of Nutrition, Harvard T.H. Chan School of Public Health, http://www.thenutritionsource.org and Harvard Health Publications, health.harvard.edu)

and affordable options to a family. Consider a discussion about which of these options are the least processed.

Other styles of eating that are appropriate for adolescents with PCOS are the DASH Diet (Dietary Approaches to Stop Hypertension) and Mediterranean Diet. Both of these eating patterns promote high-fiber intake through fruits and vegetables as well as unsaturated fat intake found in items such as nuts, oils, and fish [64–66]. Both diets promote limiting intake of red meat, sugar-sweetened foods and beverages, and processed foods.

Young women with PCOS should try to consume small, frequent meals eaten consistently throughout the day in order to help maintain even serum glucose levels. This is in contrast to a more typical intake of small or skipped breakfast,

medium-sized lunch, and large dinner with evening snacks. An example of small frequent meals might be whole grain toast with eggs and fruit for breakfast, yogurt with slivered almonds for morning snack, quinoa with beans, veggies, and avocado for lunch, carrot sticks with hummus for afternoon snack, salmon with baked sweet potato and sautéed spinach for dinner, and mixed berries with a dollop of whipped cream for dessert. The goal of eating approximately every 3 hours helps prevent spikes and dips in blood sugar that can occur with larger, less-frequent meals, particularly those that are carbohydrate-heavy [60]. Additionally, pairing carbohydrates with foods that contain fat and protein will result in slower absorption into the bloodstream. Fiber-rich foods such as fruits, vegetables, legumes, and whole grains also help to slow absorption, resulting in a more gradual increase in blood sugar. Ensuring that meals and snacks all have a source of protein and a source of fiber will lead to prolonged satiety [60].

Although limiting refined carbohydrates and sugars is recommended, a diet high in protein and low in carbohydrates has not been shown to lead to lasting symptom resolution or to any sustained weight loss in PCOS patients. In addition, restriction of carbohydrates can result in limiting the intake of healthy fruits, vegetables, and whole grains. Excessive protein intake can also be harmful to the kidneys [60]. Despite this, reducing carbohydrate intake may be an effective strategy for short-term weight loss in adolescents with excess carbohydrate consumption [67]. As stated above, moderation rather than elimination of any one specific type of nutrient is key. Counseling on the quality and type of carbohydrate rather than the amount or percentage of carbohydrate in the diet may be better and more flexible for adolescents [59]. It is important that adolescents understand that they should not eliminate all carbohydrates from their diet due to the important fuel this nutrient provides, especially to the brain [60].

A low-glycemic index diet is often recommended for women with PCOS. Glycemic index refers to the ability of a particular food to raise blood glucose levels, when compared

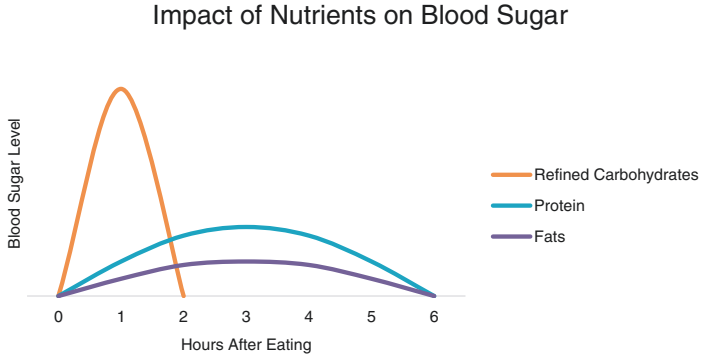

FIGURE 21.2 This graph approximates the increase in blood sugar level that occurs with ingestion of refined carbohydrates, protein, and fat

to a reference food. Because it is suggested that young women with PCOS eat foods and follow meal patterns that help maintain a low blood sugar level, a low-glycemic index diet is often suggested in the treatment setting of PCOS despite having been developed originally for patients with diabetes [59]. Glycemic load takes into account the glycemic index as well as the amount of fiber in a given food. Glycemic index and load only indicate how any one specific food might affect blood sugar [60]. However, a food is rarely eaten in isolation, and the effect on blood sugar changes when mixed with foods containing fat and/or protein (see Fig. 21.2). Therefore, counseling on this approach might not be as effective as general healthful eating with a focus on small, frequent meals, and foods high in fiber.

PCOS and Specific Nutrients

More research is needed to evaluate the impact that specific nutrients have on adolescents with PCOS. Currently, there is an abundance of misinformation available on the internet, which is

often confusing and misleading to patients. The following foods or food groups are often referenced in the media as categories to be avoided by women with PCOS:

- **Dairy**: There is a widely held belief that dairy should be avoided in PCOS as it can cause acne and alter hormones. There is also concern about the carbohydrate content due to the lactose. Few scientific studies have looked at the association between dairy intake and PCOS. One small study showed weight reduction following a low starch, low dairy, energy-restricted diet; however, it is unclear whether this was due to the decrease in carbohydrate content [68]. In fact, other studies have shown a link between dairy intake and weight loss, and posited that whole milk can lead to decreased intake of refined carbohydrates due to increased satiety [69].
- **Gluten:** Gluten is the protein found in certain grains such as wheat, barley, malt, and rye. Individuals with diagnosed celiac disease or non-celiac gluten sensitivity must avoid eating or drinking products containing gluten, as exposure can damage their digestive tract. To date, there are no scientific studies linking gluten to PCOS. In order to compensate for the lack of flavor that wheat provides, gluten-free products often contain more calories, sugar or other refined carbohydrates than gluten-containing foods. As such, in the absence of a confirmed celiac diagnosis, young women with PCOS should not restrict gluten.
- **Sugar**: Women with PCOS should indeed limit their intake of sugar, due to corresponding hyperinsulinemia [70]. However, it is important to remember that removing sugar altogether is likely not practical or sustainable; counseling instead on healthy alternatives (for example, mixing fruit into plain yogurt rather than eating fruit-flavored yogurt) is a preferable approach.
- **Soy**: Foods containing soy have phytoestrogen, which can alter estrogen levels in the body, leading some to believe that it is harmful for women with PCOS. However, the science

suggests that soy may be beneficial for women with PCOS given its potential to lower cholesterol levels and decrease body mass index [70].

Physical Activity

As stated above, the first-line treatment for PCOS is lifestyle modification, which includes physical activity [55]. An increase in physical activity can provide benefits such as the potential for weight loss and improved cardiovascular health with a subsequent decreased risk of metabolic syndrome. Providers can use motivational interviewing to help persuade an adolescent to increase their physical activity. Adolescents who engage in a form of physical activity they enjoy may be more likely to sustain this lifestyle change.

The Centers for Disease Control and Prevention (CDC) recommends 60 minutes or more of moderate to vigorous activity each day, as well as at least 3 days per week where the activity is vigorous. Terms such as moderate and vigorous can be too vague when making suggestions to an adolescent, thus it may be helpful to provide specific examples. Given the health benefits of increased physical activity such as decreased insulin sensitivity as well as the risks of long-term weight gain in women with PCOS, finding a way to incorporate physical activity into daily life is essential to symptom reduction [66].

Use of Interdisciplinary Teamwork (IDT)

When possible, a registered dietitian/nutritionist (RD or RDN) should be utilized for individualized nutrition counseling. Dietitians are in a unique position to devote an entire appointment to lifestyle change and can help to empower an adolescent in making these changes. Mental health providers are essential for discussing co-occurring depression, the stress

related to symptoms of PCOS, body image, and motivation for behavior change. A multidisciplinary approach including medical, nutrition, and mental health will benefit the adolescent [71]. Depending on the age and level of independence, including the parents or guardians in the treatment process can be helpful [34]. Some studies have shown that the degree of readiness to change on the part of the parent or guardian can have an impact on the outcome of treatment for the adolescent with PCOS [34, 55]. It may also be helpful to incorporate the expertise of other clinical specialists, such as physical therapists, personal trainers, and members of a bariatric surgical team, if deemed appropriate.

Monitoring and Evaluation

A comprehensive, interdisciplinary approach to follow up is recommended for adolescents with PCOS. This includes consideration of the patient's symptoms, dietary modifications, emotional well-being, physical exam and anthropomorphic measurements, as well as lab tests, if indicated.

Medical follow up visits should be tailored to the specific treatment approach taken. If hormonal contraceptives or insulin sensitizers were prescribed, a clinician should assess for adherence, any side effects the patient may be experiencing, as well as medication effect. It is important to review the adolescent's interim menstrual history, and ask about changes in acne and hirsutism. A physical exam should evaluate for any objective changes in signs of hyperandrogenism or insulin resistance, as patients on metformin may show improvements in acanthosis nigricans, if initially present. As discussed above, a clinician may choose to repeat lab work periodically to monitor the trajectory of metabolic risk, though there are no evidence-based guidelines regarding the frequency of biochemical follow-up in adolescents with PCOS [34].

From a nutrition perspective, an adolescent should be monitored for changes in dietary habits (such as meal and snack

content, portions, or frequency), body satisfaction and eating disorder behaviors. At a follow up visit, the provider can reference the SMART goals that the adolescent created to track progress and set new goals, if appropriate. Regarding weight changes for an adolescent, multiple examples in the literature do demonstrate improvement in PCOS symptoms with weight loss for adolescents with a BMI greater than or equal to the 95th percentile [35–37]. While intentional weight loss can improve symptoms, there are risks to consider. Harmful side effects of calorie or food group restriction include eating disorders, weight cycling, and reduced self-esteem if the weight is regained. In the setting of weight loss, monitoring for any unsafe practices such as compulsive exercise, excessive restriction, purging, or use of laxatives, diuretics, or weight loss medication should be done at each follow-up appointment. Sometimes, lifestyle change results in cessation of weight gain, which is a success in and of itself for some adolescents. A Health at Every Size (HAES) perspective would consider measuring lab values and behavior changes versus weight as markers of health improvement (see Chap. 12).

It is still important for the provider to give positive reinforcement to the adolescent for keeping follow-up visits, even if they have not made any behavioral changes. A discussion with the adolescent around barriers to making changes as well as potential motivators may help the clinician to problem solve and offer additional useful information.

Example Case

Nutrition Assessment

Patient history: Mia is a 17-year-old female with irregular menses, acne, and visible coarse hair on her upper lip and lower abdomen who presents to clinic for an initial visit. Lab work performed by her primary care provider reveals elevated free testosterone and DHEA-S, which in combination with her oligomenorrhea confirms the diagnosis of PCOS.

Food and Nutrition Related History

Mia reports she generally eats 2 meals and 2–3 snacks per day. She does not typically have time for breakfast. Mia denies any bingeing, purging, or diet pill or laxative use. She does endorse a desire for weight loss and notes she has tried different fad diets over the past 18 months, but has recently given up because "nothing seems to work." She weighs herself "a few times" per week and her body weight now is ultimately higher than it was when she began the first of her dieting attempts. The dietitian asks Mia about her motivation for making any nutrition related change. Mia offers, "I'd like to lose weight but I'm not sure it's possible. I also don't really understand why my doctor sent me here since I already know all about dieting."

24 Hour Dietary Recall

- 7 am – wake up
- 9 am – bagel and fat-free chocolate milk or juice at school, sometimes will skip breakfast
- 12 pm – 1 slice of pizza or snacks such as: gummy fruit snacks & chips, water to drink; sometimes school lunch
- 4 pm – snack at home: bowl of cereal or crackers with cheese, sweetened iced tea
- 7 pm – rice, beans, meat (1–2 plates), sugar-free diet juice
- 9 pm – hot chocolate, cookies

Anthropometric Measurements

- BMI is 32.4 kg/m^2 (5′3″; 183 lb; above the 95th percentile for BMI)
- HbA1c is 5.8% (elevated)
- Cholesterol is normal (HDL of 43, LDL of 90)

BMI growth chart indicates she has continuously grown along the 90th percentile until age 13, when her weight accelerated beyond what was expected per her growth pattern.

Assessment

Mia's intake reveals irregular eating patterns, a desire for weight loss and a nutrition-related knowledge deficit. The provider notes an elevated HbA1c in the context of Mia's intake of sugar-sweetened beverages (fat free chocolate milk, sweetened iced tea and hot chocolate). The provider also notes that on the days that Mia does not eat breakfast, she goes up to 5 hours without eating. Finally, the provider recognizes Mia's drive for weight loss is likely a result of her body dissatisfaction.

Nutrition Diagnoses

1. Nutrition-related knowledge deficit related to lack of prior nutrition counseling as evidenced by diet recall high in refined carbohydrates and inadequate in fiber intake.
2. Altered nutrition lab values (glucose) related to elevated insulin levels in the setting of PCOS as evidenced by elevated HbA1c of 5.8%.

Nutrition Intervention

Mia and the dietitian make a SMART goal. Because Mia is unsure of what she would like to start with, the dietitian offers different ideas such as eating breakfast containing a protein and whole grain daily, or minimizing intake of sugar-sweetened beverages (SSB). Mia suggests she would rather work on minimizing intake of SSBs. Mia decides she will aim to have only one SSB per day. They agree that Mia will return to clinic in 2–3 weeks for follow-up.

Summary

PCOS is a common hormonal imbalance presenting during adolescence, but typically persisting throughout the reproductive years. Many women struggle with acne, hirsutism, increased body weight, and menstrual dysfunction. Health care providers who work with adolescents should be aware of the symptoms, common laboratory findings, associated cardiometabolic comorbidities, as well as the risk of psychosocial concerns and disordered eating. While there is no individual evidence-based dietary intervention that has shown to be superior in the management of PCOS, lifestyle modifications to promote healthy eating and physical activity, along with hormonal contraceptives, continue to be the first-line treatment. In caring for young women with PCOS, it is important to allow the patient's concerns and preferences to guide management. Finally, a comprehensive, interdisciplinary approach to care utilizing the expertise of medical, nutrition, and mental health professionals is strongly recommended.

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Patient Resources The Center for Young Women's Health, Boston Children's Hospital Adolescent/Young Adult Medicine Clinic, PCOS patient booklet: https://youngwomenshealth.org/wp-content/uploads/2014/10/PCOS-Resources-for-a-Healthier-You.pdf

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