Sport Participation History Among Young Females Diagnosed with Polycystic Ovary Syndrome

Thesis

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Abstract

Background: Polycystic Ovary Syndrome (PCOS) is the most common endocrine disorder in women of reproductive age, affecting up to 20% of women. Physical activity is important to maintaining good health, promotes lean muscle mass preservation and weight management, reduces risks of chronic diseases, and has been proven beneficial in symptom management of PCOS. However, little is known about sport participation and PCOS patients.

Objective: The purpose of this study is to ascertain sport participation, position group history, and physical activity among a cohort of adolescent and young adult women with a diagnosis of PCOS.

Methods: This cross-sectional phone survey queried parents of PCOS patients and/or the patients themselves on sports participation and physical activity history using open-ended questions. Participants were females aged 10 – 28 with diagnosis of PCOS confirmed by the healthcare provider. Self-reported data by participants for the common name for sport, as well as the number of hours per week and years in sport were used to quantify data collected. The amount of sport participation (hours/week) was used to assess each participant's athlete level (non-athlete, recreational, average, performance, high performance). Descriptive statistics were used to outline the sample and to determine means and frequencies.

Results: Participants (n=34) reported participating in one sport (56%), two sports (26%) or three or more sports (18%) with a total of nineteen unique sports. Four (11.8%) participants reported no sport history. Soccer, softball and dance were reported most frequently, with half of soccer athletes playing defense, and all of softball athletes playing outfield. Thirteen athletes (38.2%) were considered average, performance, or high-performance athletes because they participated in their highest level of sport for greater than ten hours/week. Overall, 88.2% of participants engaged in sports for more than two years. Ten individuals (29.4%) are currently involved in sports, however after the age of 18, zero participants took part in competitive or team-based sports. Thirteen individuals (38.2%) reported participating in regular physical activity, however 38.2% qualify as sedentary at the time of survey.

Conclusions: Most participants were involved in sports for at least two years. While sport participation was widely distributed within this sample, trends amongst position groups were identified. Additionally, the attrition rate of sport participation, combined with the low physical activity outside of sport indicates a need for increased education on the benefits of regular physical activity can play on symptom management of PCOS.

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Amenorrhea	An abnormal absence of menstruation
Androgens	Male sex hormones
Anovulation	Ovulation does not take place due to the ovaries not releasing an oocyte during a menstrual cycle
Body Mass Index	A height-to-weight ratio used as an indicator of obesity or being underweight
Bone Mineral Density	Reflects the strength of bones as represented by calcium content
Eumenorrhea	Normal or regular menstruation
Glycemic Index	A system that ranks food on a scale from 1 to 100 based on their effect on blood sugar levels
Hyperandrogenism	Also known as androgen excess. Medical condition characterized by

	excessive levels of androgens in the female body
Lean Body Mass	A component of body composition that is equal to body weight minus body fat. Also known as fat free mass
Oral Contraceptive	A pill to prevent pregnancy. Most include both estrogen and progesterone to suppress the release of an egg for fertilization

List of Abbreviations

5-diol	Androstenediol
BMD	Bone Mineral Density
BMI	Body Mass Index
DHEA	Dehydroepiandrosterone
EMR	Electronic Medical Record
Etio-G	Etiocholanolone glucuronide
FDA	United States Food and Drug Administration
GI	Glycemic Index
LBM	Lean Body Mass
OCP	Oral Contraceptive Pill
PCOS	Polycystic Ovary Syndrome
RED-s	Relative Energy Deficiency in Sport
T2DM	Type 2 Diabetes Mellitus

Chapter 1. Introduction

Background

Polycystic Ovary Syndrome (PCOS) is the most common endocrine disorder in women of reproductive age, affecting up to 20% of individuals in this population.[1] PCOS is heterogeneous in nature; however, common clinical and biochemical manifestations of this syndrome include hyperandrogenism, menstrual dysfunction (commonly seen as oligo-ovulation or anovulation), and polycystic ovaries.[2] The cause of PCOS is likely multifactorial, as there are four prominent phenotypes of PCOS; however, there is no definitive etiology for these phenotypes identified in the existing literature.[1]

Menstrual dysfunction is one of the clinical characteristics and complaints associated with PCOS,[3] and is additionally seen in over-trained/under-fueled female athletes.[4] Menstrual dysfunction is inconsistently defined in the literature,[5] and prevalence of amenorrhea varies from 3.4-66% in athletes.[6–8] In the PCOS population, menstrual dysfunction is typically seen in as oligomenorrhea and/or amenorrhea, and those who are amenorrheic are typically seen as having a more severe presentation of PCOS.[2] The published literature reflects that 15% of athletes with menstrual disorders were diagnosed with PCOS.[9] Limited studies to date have been published assessing athletes with PCOS, highlighting a need for further research in this population.

Physical activity is important to maintaining good health, and promotes the maintenance of lean muscle mass, improves sleeping habits, enhances mental health status, and helps to reduce the risk of chronic diseases.[10] Adolescent participation in sport can contribute to overall physical activity needs.[11] Additionally, there is a potential benefit to elevated androgens in female athletes (as seen in athletes with PCOS) in regards to explosive power, lean mass, and cardiovascular fitness.[12,13] Given that PCOS might be a reason for an athlete to be amenorrheic, it behooves the sports dietitian to be familiar with the clinical features and modalities for treatment of PCOS. Very little is known about sport participation and PCOS patients considering that physical activity is an important part of weight and disease management.[14–16] An examination of the distribution amongst sports may lend to a better understanding of which athletes should be screened more often for PCOS and how the characteristics of the syndrome may play a role into sport selection.

Research Objective

1. To ascertain sport participation/position group history and physical activity among a cohort of adolescent and young adult women with the diagnosis of PCOS.

This study highlights sport participation and physical activity participation history in adolescent/young adult women diagnosed with PCOS. Results discovered will hopefully inspire future studies to help educate on the benefits of physical activity for symptom management of PCOS, identify relationships amongst sport participation and position type in athletes diagnosed with PCOS, and further educate and bring awareness to sports medicine professionals and athletes alike.

Chapter 2. Review of the Literature

Background of PCOS

Polycystic Ovary Syndrome (PCOS) is an endocrine disorder that affects reproductive health, and is typically identified through the clinical expression of oligo-ovulation or anovulation, hyperandrogenism, and/or the presence of polycystic ovaries.[2] This syndrome is the most common endocrine disorder among women of reproductive age, affecting between 6-20% of this population, and approximately 5 million women in the United States alone.[1,17] Current studies report the prevalence of female athletes who present with menstrual dysfunction to be higher than the general population.[7] Menstrual dysfunction related to PCOS has been reported to be around 15%, but only a handful of studies have looked at PCOS prevalence in athletes, indicating a need for more research in this area.[6,9,18]

Clinical health outcomes for women who are diagnosed with PCOS include increased risk for infertility, dysfunctional bleeding, endometrial cancer, obesity, type 2 diabetes mellitus (DM), dyslipidemia, hypertension, and cardiovascular disease.[19] Given that PCOS can result in many different clinical health outcomes, the proper diagnosis of PCOS is essential for knowing how to manage the symptoms and mitigate risk associated with the potential negative health and reproductive outcomes.[20]

Menstrual Dysfunction

Terms for menstrual dysfunction are typically described by frequency of bleeding. Amenorrhea is the lack of or discontinuance of a monthly period.[21] There are two subsets of amenorrhea: primary and secondary amenorrhea. Primary amenorrhea is the absence of a first period by the age of 15 in adolescent females, in relation to standard pubertal development (i.e. breast development, pubic hair growth).[21–23] Secondary amenorrhea is the cessation of previously normal menstrual cycles for at least three months, or less than five menses within one year.[22] Oligomenorrhea is a condition where the menstrual cycle is irregular and unpredictable, commonly with cycles ranging between 36-90 days in length.[6,22] While eumenorrhea is a normal menstrual cycle, oligomenorrhea is along the spectrum towards amenorrhea where the cycle is absent.

In athletes, menstrual dysfunction is often assumed as a concomitant element of Relative Energy Deficiency in Sport (RED-S). Formerly known as the Female Athlete Triad, the combination of insufficient energy intake, irregular menstrual cycles and poor bone health was realized to affect many aspects of physiological function including immunity, cardiovascular health, and psychological health.[24] Female athletes who have irregular or missing periods are oftentimes placed under the RED-S umbrella; however, there are other causes of menstrual dysfunction including PCOS.

In trying to diagnose the underlying reason for the menstrual dysfunction, other causes of amenorrhea or oligomenorrhea may need to be ruled out. These causes might include things like ovarian insufficiency, reproductive organ abnormalities, or hyperprolactinemia.[23] PCOS is distinctly different from these conditions and can be described in biochemical and metabolic terms.

Biochemical and Metabolic Characteristics

Biochemical disturbances fundamental to PCOS include hyperandrogenism, hyperinsulinemia, and ovarian dysfunction. Many of the biochemical characteristics of PCOS exacerbate each other, further increasing the severity of the syndrome in a cyclic nature. Treating PCOS demands an understanding of these inter-related biochemical issues.

Biochemical hyperandrogenism is the most commonly expressed feature of PCOS. Clinical markers may exist to identify hyperandrogenism in an individual, however biochemical hyperandrogenism can be assessed through a measurement of serum free testosterone or the free androgen index.[25,26] Serum total testosterone greater than 4.8 nmol/L is in the 95th percentile for testosterone in women, so indicates a need to further assess the androgen profile.[27] Sex-hormone binding globulin (SHBG) is bound to testosterone, thus can be used to evaluate the free androgen index.[27] In a 1995 study by Balen and colleagues looking at 1,741 women with PCOS, roughly 30% of participants presented with elevated serum testosterone.[27,28] In a case-control study by Kindi et al., it was found that there were statistically significant differences for calculated free testosterone and the free androgen index between controls and the four PCOS patient groups, concluding that utilizing these methods should be used to assess hyperandrogenism.[29] Dehydroepiandrosterone (DHEA) acts as the main precursor for androgens, and increased serum levels have been found in up to 50% of women with PCOS.[27,30] Elevated serum levels of DHEA may further confirm hyperandrogenism.[31] Assessment of serum androgens is paramount in the clinical assessment of PCOS.

In PCOS, levels of luteinizing hormone (LH) and testosterone are elevated.[32] LH and follicle stimulating hormone (FSH) are interdependent hormones from the pituitary, and play a role in the ovulation process regarding follicle stimulation and maturation.[33] The presence of androgens are necessary for normal development of follicles and the synthesis of estradiol. However, in the case of PCOS and increased androgen levels, there is limited follicular maturation and even follicular death.[27] An increased LH:FSH ratio is common within PCOS patients compared to controls, as seen by Malini & George in a study of 745 PCOS patients where the LH/FSH ratio was 1.68 ± 0.03.[34] Assessing LH/FSH ratios could be utilized as a measure for assessing PCOS status.

Metabolic abnormalities, such as hyperinsulinemia and insulin resistance are represented in 75% of patients with PCOS.[18,19] It has been identified in the literature that insulin sensitivity is decreased in women with PCOS irrespective of BMI and other metabolic abnormalities.[37] Hyperinsulinemia has been found to increase endogenous androgen levels as well as ovulatory dysfunction and fertility issues. Specifically, increased insulin decreases production of SHBG, increasing serum free testosterone, exacerbating hyperandrogenism.[27] Hyperinsulinemia and the sequelae that follow may influence fertility in a lot of patients and should be considered.

Ovulatory dysfunction is identified as a component in each of the three definitions of PCOS,[17,38] and nearly 75% of patients diagnosed with PCOS present with menstrual dysfunction.[39] Despite the name, polycystic ovaries are not required for a diagnosis of PCOS, and are represented in 20-30% of women not diagnosed with PCOS in the general population.[19] However, in women who are diagnosed with PCOS with polycystic ovaries, hyperandrogenism is thought to be fundamental to the ovulatory dysfunction. The antral

follicles, which have arrested in development, are the "cysts" described in the syndrome, which are thought to be present due to hyperandrogenism reducing estradiol synthesis and halting follicular maturation.[27] Biochemical and metabolic characteristics of PCOS each lead into and exacerbate one another, indicating the need to focus on how best to manage symptoms associated with these characteristics.

Clinical Characteristics

The clinical characteristics of PCOS are heterogeneous among diagnosed individuals, but each represents a disturbance in reproductive, endocrine, and metabolic function.[27] These clinical manifestations include menstrual abnormalities, hirsutism, acne, alopecia, weight gain and/or obesity.[3]

Clinical Characteristics: Hirsutism, Acne and Alopecia

There are many external manifestations of PCOS as a result of hyperandrogenism including hirsutism, acne, and alopecia.[25,40] Hirsutism, acne, and alopecia are good objective physical signs that may reveal androgen excess in adults; however, biochemical evaluations need to be assessed to utilize these markers as part of diagnostic criteria.[41] Hirsutism is the only sufficient substitute of biochemical hyperandrogenism in adolescents, as acne is common during this time period and alopecia is very uncommon.[41] These physical signs should be noted in any clinical exam.

Hirsutism is the appearance of dark, course hair in a male -like pattern in women.[35] Hirsutism is a very common sign of PCOS, presenting in approximately 75% of women with PCOS [3,42] compared to the 5-15% in the general population.[19,38] Severity of hirsutism is visually scored based on the modified Ferriman-Gallwey scale (mFG), which is the current gold standard in assessment.[35] The mFG scores 9 body sites—upper

lip, chin, chest, upper and lower back, upper and lower abdomen, arms, and thighs. Total scores are ranked out of 36, and hirsutism is recognized as mild up to 15 and severe above 25.[43] Hirsutism is an outward sign of elevated androgens.

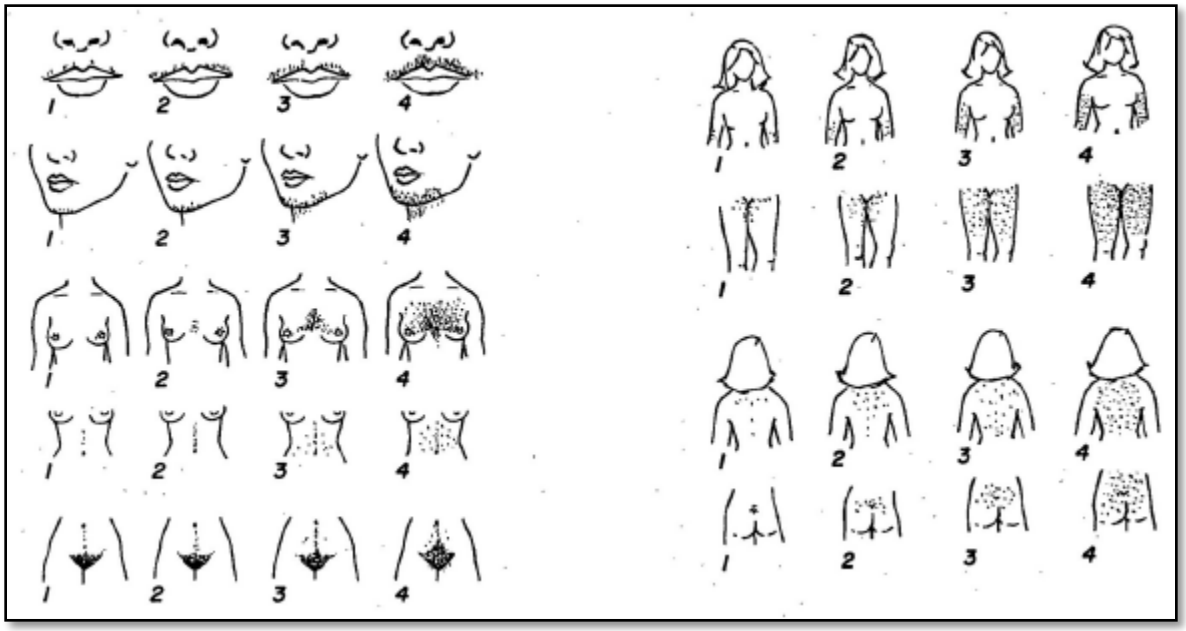

Figure 2.1: Visual representation of the Modified Ferriman-Gallwey (mFG) scale to assess hirsutism in females from mild (grade 1) to severe (grade 4).[44]

Acne and androgenic alopecia are not essential to the diagnosis of PCOS; however, these symptoms are seen frequently within this population. Acne is a common complaint among many women, and is found more frequently post-adolescence in women with PCOS than those in the general population. Also, the presenting acne is typically resistant to many topical treatments.[3] In a cross-sectional study by Uysal et al.,

out of 207 women presenting with acne, 39.6% of participants were diagnosed with PCOS.[45] Individuals with resistant acne, alongside additional clinical symptoms of PCOS, deserve further biochemical explorations to identify if a diagnosis may be present.

Alopecia is defined as the thinning of hair or scalp hair loss in women.[2] Similar to alopecia in men, it typically presents itself later in life, affecting approximately 36.6% of women with PCOS,[3] and therefore is not seen frequently in adolescents. In a cross-sectional study by Quinn et al., androgenic alopecia was found in 22% of patients with PCOS, but this clinical finding was not tied to increased hyperandrogenism or other metabolic parameters (i.e. insulin, fasting glucose, cholesterol panel, etc.).[46] Genetic or environmental factors may also play a role related to hair loss in individuals with PCOS versus the nature of the syndrome itself, and should be studied more extensively to identify trends.

Clinical Characteristics: Weight Gain/Obesity

Weight gain and obesity commonly accompany a diagnosis of PCOS,[47] with studies showing that up to 60% of women with PCOS in the US present with obesity.[3,42] Obesity can exacerbate many aspects of PCOS such as hyperandrogenism, menstrual dysfunction, and hyperinsulinemia.[38,47] For example, evidence suggests that obesity in patients with PCOS decreases insulin sensitivity, which inhibits SHBG and increases androgens delivered to adipose tissue, contributing to hyperandrogenism.[38,47] Also, women with PCOS who are overweight or obese have more frequent menstrual abnormalities, such as chronic oligo-anovulation, compared with the normal-weight PCOS population.[38,48] With characteristics of the syndrome worsened by weight gain

and/or obesity, lifestyle behaviors such as diet and exercise need to be evaluated in managing weight related issues in the specific PCOS population.

Clinical Characteristics: Polycystic Ovaries

Polycystic ovaries (PCO) in women, while in the name of the syndrome, do not guarantee a diagnosis of PCOS.[26] In 2003, the Rotterdam Criteria incorporated PCO as part of the diagnostic criteria, defining the morphology as 12 or more follicles in each ovary measuring 2-9 mm or an ovarian volume of greater than 10 cm^3.[25,26] It is important to note that ovary volume and follicle count change with age, and are greatest in adolescence and young adulthood.[35] The use of PCO as part of diagnostic criteria should be in combination with characteristics of hyperandrogenism and/or ovulatory dysfunction.[25]

Clinical Characteristics: Menstrual Dysfunction

Regular menstruation is typically seen as a marker of healthy women of reproductive age.[49] The absence or disruption of menstruation is a signal to the individual and health care professionals that the body is not functioning in the way it is intended.[50] Irregular cycles may be caused by anovulation and it has been suggested that 6-10% of women who do not ovulate have underlying PCOS.[50] Menstrual abnormalities occur along a spectrum of issues.

While chronic anovulation is commonly found in women with PCOS, spontaneous ovulation has been reported in 32% of PCOS menstrual cycles,[2] making anovulation less than universal among patients with PCOS. PCOS patients who do ovulate have been found to have less extreme androgenic and metabolic features compared to women who are anovulatory.[39] Studies have shown that women with PCOS

who are amenorrheic typically have more severe PCOS phenotypes.[2] While the cause of this syndrome remains elusive, there is a positive correlation of irregular menstruation and PCOS phenotype expression.

Exact prevalence of menstrual disorders in PCOS is difficult to determine as many studies do not use consistent definitions of what constitutes as a menstrual disorder.[5] However, in a study by Azziz et al., it was established that 22.8% of the study population reported atypical menstrual cycles. Patients with PCOS have a higher incidence of presenting with oligomenorrhea (76%) versus amenorrhea (24%).[21,26] It is prudent to identify menstrual status of PCOS patients, as the severity of PCOS will play a role in PCOS management.

Diagnostic Criteria

Polycystic Ovary Syndrome (PCOS) is a hormone disorder that has been observed and noted for centuries; however, the definition of the syndrome continues to evolve as new research findings emerge.[19] Differing diagnostic standards create controversy and inconsistency. In 1990, the National Institute of Health (NIH) created diagnostic criteria for PCOS to be used as the standard for diagnosis for researchers and practitioners.[17] The Rotterdam Criteria was proposed at a consensus workshop in 2003; and in 2006, the Androgen Excess (AE) and PCOS Society proposed their own diagnostic criteria for the syndrome.[17] There is controversy surrounding the criteria for diagnosis, as the Rotterdam Criteria allows for more phenotypes to be diagnosed, creating a higher prevalence statistic. Despite the PCOS diagnostic criteria utilized, it is generally established that two out of three conditions must be met: chronic anovulation (CA), hyperandrogenism

(clinical or biochemical), and polycystic ovaries.[41] The different combinations possible for a diagnosis of PCOS illuminate the complexity of the syndrome.

	NIH 1990 (2/3 REQUIRED)*	ROTTERDAM 2003 (2/3 REQUIRED)	AE AND PCOS SOCIETY 2006 (2/3 REQUIRED)*
CLINICAL AND/OR BIOCHEMICAL HYPERANDROGENISM	+	+/-	+
OLIGO- OR ANOVULATION	+	+/-	+/-
POLYCYSTIC OVARIES	+/-	+/-	+/-

Table 2.1 Side-by-side comparison of diagnostic criteria for PCOS from National Institute of Health, Rotterdam and Androgen Excess (AE) and PCOS Society.[38,51]
*** NIH criteria does not require PCO for diagnosis, and AE and PCOS Society requires hyperandrogenism in their diagnosis**

With much debate over the diagnostic criteria for PCOS, a multidisciplinary committee from the NIH endorsed the need to specifically identify the phenotype of the individual patient.[1] The four phenotypes identified include all permutations of the three diagnostic criteria include:[17]

1. Androgen excess and ovulatory dysfunction;
2. Androgen excess and polycystic ovarian morphology;
3. Ovulatory dysfunction and polycystic ovarian morphology; and
4. Androgen excess, ovulatory dysfunction and polycystic ovarian morphology

The identification of the presenting phenotypes is to help researchers and clinicians more accurately diagnose and provide individualized care to the patient.

PCOS and Athletes

Amenorrhea is highly reported in athletic populations,[4] with studies identifying the prevalence occurring in 3.4-66% of female athletes, compared to 2-5% of women with amenorrhea in the general population. [6–8] Dadgostar et al. reported that 9% of elite Iranian female athletes presented with amenorrhea/oligomenorrhea, and among those individuals, 15.5% were diagnosed with PCOS.[9] Similarly, Hagmar studied thirteen Swedish Olympic athletes who exhibited menstrual disturbances and reported increased mean free androgen indices and decreased serum levels of FSH compared to athletes who menstruated regularly.[18] Of these individuals, six were diagnosed with PCOS, indicating that PCOS was potentially the leading cause of menstrual dysfunction in this particular sample of Olympic athletes.[18] Assuming amenorrhea in athletes is due to improper fueling is likely a mistake, and proper hormonal assessment is undoubtedly important to designing effective dietary interventions.

PCOS and Athletes: Impact on Sport Performance

The hormonal status of an athlete impacts health and performance. While amenorrhea associated with low energy availability has been demonstrated to decrease performance, the hormonal profile in PCOS where androgens are higher may actually improve performance. Androgens have been found to be integral in the preservation of bone and muscle tissue.[52] While it represents pharmacological intervention, research on exogenous androgenic-anabolic steroid use shows improvement in athletic performance through decreased fatigue, increased power and lean body mass.[53,54] Skeletal muscle is highly responsive to testosterone, and aids in increases of skeletal muscle mass, which can in turn increase power performance and affect body composition.[55,56] A meta-analysis

on exogenous testosterone indicated that supplementation benefited body composition in men by increasing lean mass and decreasing fat mass.[57] Body composition data on women with PCOS who exhibit endogenous androgenic profiles highlights an increase in fat mass compared to non-PCOS controls, in addition to an increase in lean mass.[58–60] Endogenous androgens in women have been less studied related to athletic performance; however, the prevalence of athletes with PCOS may reflect an advantage to sport performance related to hyperandrogenism.[53,61]

Naturally present androgen metabolites and precursors, such as serum testosterone, DHEA, Androstenediol (5-diol) and Etiocholanolone glucuronide (Etio-G), have all been associated with performance outcomes in female athletes.[12,13,61,62] Cardinale et al. revealed that there is a positive correlation involving the presence of serum testosterone and explosive performance in female athletes.[13] Similarly, serum DHEA, 5-diol and Etio-G were strongly linked to both explosive power and lean mass- two critical components of athletic success.[61] Rickenlund and colleagues found higher maximal oxygen uptake (VO_2 max) exhibited in hyperandrogenic oligomenorrheic or amenorrheic athletes compared to normoandrogenic athletes.[12] These findings suggest athletes with PCOS potentially being at a competitive strength advantage; however, more research is needed.

PCOS and Athletes: Impact on Bone Health

Strong bone density requires a balance in the process of bone formation and resorption.[62] Research supports that athletes have increased bone mineral density (BMD) compared to their non-athlete counterparts.[63] Physical activity impacts the bone where it is maximally stressed, as well as increased muscle mass and strength, promotes the

formation of bone.[62,64,65] Athletes typically have higher lean body mass (LBM) compared to non-athletes, and it has been found that the skeleton acclimatizes to greater muscle mass by increasing BMD to better support increased LBM.[62] These findings indicate that sports competition and physical exercise promote high BMD through increased muscle mass and mechanical loading.[62,66]

Sufficient energy intake is essential for maintaining bone health, as well as other factors of health.[24] Insufficient energy intake related to exercise intensity or volume can lead to aspects of the Female Athlete Triad such as loss of menstrual cycle and increased risk of fractures.[22] Estrogen has been observed as being a critical component in regulating bone metabolism. The rate of bone resorption is too fast for bone formation, causing a net loss of bone in an estrogen deficient state.[67] Loss of the menstrual cycle from poor fueling can result in decreased estrogen, further causing decreased BMD and increased risk of fractures.[22,62] The impact of a low energy diet on estrogen and bone mass cannot be overlooked.

In contrast to amenorrheic RED-S athletes, women with PCOS have been found to be at lower risk of having decreased BMD.[62,68] In theory, elevated androgens offer protection from effects of amenorrhea and/or oligomenorrhea, such as loss of BMD related to decreased estrogen.[69,70] A study by Rickenlund et al. demonstrated this notion through reports of hyperandrogenic athletes with menstrual dysfunction exhibiting BMD comparable to eumenorrheic athletes, as well as elevated BMD when compared to normoandrogenic athletes with menstrual dysfunction.[12,62] However, it is still in question if additional bone mass is acquired related to increased levels of testosterone in women with PCOS.[71]

Additional factors may play a role in elevated BMD in athletes with PCOS. For example, it has been identified that in women with PCOS, insulin resistance and hyperinsulinemia may provide protection against bone mineral loss.[71] Body weight and BMD have been linked together as well. Higher body weight has been purported to be more favorable for BMD compared to individuals at a lower weight because more load is put upon the skeleton, thus strengthening it.[72] The correlation between body weight and BMD was looked at by a subgroup of the Framingham Osteoporosis Study, and they found that on load-bearing bones, body mass index showed an association with bone density.[72] The cause for increased BMD in PCOS athletes despite menstrual disturbances may be multi-factorial.

PCOS and Athletes: Position Group/Body Type

Many sports comprise multiple positions within the sport type itself. When assessing body types within and comparatively between sport positions, anecdotally observations and trends can be identified. In the literature it has been reported that within field sports such as soccer, lacrosse and field hockey, defenders and goalies are taller and heavier than their teammates in midfield and forward type positions.[73–75] However, it is important to note that differences in body composition are not statistically significant between positions. In a 2016 study by Hirsch et al., it was reported that when track and field athletes were separated by event group and body composition was assessed, throwers had the highest body weight and fat mass compared to other event athletes such as sprinters, mid-distance or jumpers.[76] More research is needed to elucidate positional trends within sport types, as well as to assess PCOS trends within those positions.

PCOS Treatment

PCOS Treatment: Pharmacotherapy

Common medications that are currently being used by and prescribed to women with PCOS include oral contraceptives (OCPs) and Metformin.[25,77] OCPs are traditionally used as a form of birth control among many women. They are also commonly prescribed to help regulate menstrual cycles and alleviate symptoms of the premenstrual cycle (PMS) and endometriosis through the addition of synthetic female hormones: estrogen and progesterone.[78] OCPs are used to help treat PCOS through balancing hormone levels in the body—decreasing androgen levels and increasing SHBGs, impacting clinical symptoms of PCOS and regulating the menstrual cycle.[79] Metformin is an anti-hyperglycemic medication typically used to treat type 2 diabetes. Metformin is also used clinically to manage hyperandrogenism and reproductive function in women with PCOS.[41,80] PCOS is a chronic condition, and long-term health outcomes related to using Metformin and/or OCPs are still controversial.[25,79]

Emerging research on insulin sensitizers, such as inositol, as a treatment method for PCOS have recently been reported. Inositol is a chemical compound with structural similarity to glucose, made up of nine different stereoisomers. The most common form of inositol found in nature is myo-inositol. Myo-inositol is a precursor to inositol triphosphate (InsP3) which acts as a second messenger and regulates hormones including TSH, FSH and insulin.[81,82] In a study by Ciotta et al., it was found that six months of treatment with myo-inositol or D-chiro inositol both significantly improved menstrual cycle regularity and decreased acne, as well as decreased serum androgen levels (DHEA, DHEA-S and Free Testosterone).[83] Additionally, lipid levels, insulin and insulin

resistance using the homeostatic model assessment for insulin resistance (HOMA-IR) were improved.[83] Pizzo et al. demonstrated significant improvements with six months of myo- or D-chiro-inositol administration in LH, LH/FSH ratio and the HOMA index.[84] Nordio and Proietti found that a combination of myo-inositol and D-chiro inositol in a ratio of 40:1, respectively, was more effective in reducing free testosterone, glucose, and insulin concentrations, and improved ovulation in overweight patients with PCOS compared to myo-inositol alone.[85] The results of these studies suggest inositol should be offered as a first-line treatment for PCOS versus OCPs and/or metformin considering the benefits identified, however further research is still needed.

PCOS Treatment: Medical Nutrition Therapy

PCOS Treatment: Medical Nutrition Therapy: General

Women with PCOS have important underlying hormonal and metabolic differences compared to the general healthy population.[86] Unfortunately, there is no conclusive research regarding what type of dietary composition is best for these women.[86] Weight loss, irrespective of specific diet, has been shown to improve reproductive, metabolic, and psychological features of PCOS, so long-term sustainability is imperative when considering dietary changes.[86]

The Mediterranean diet consists of high consumption of vegetables, fruits, whole-grain cereals, legumes and nuts, and moderate consumption of meat, eggs, dairy products and seafood. Red and processed meats, and foods high in sugar and saturated fats are limited, and the main source of dietary fat comes from olive oil.[87,88] Research has shown that this type of diet has been proven beneficial to many different patient populations such as individuals with type 2 diabetes mellitus (T2DM), cardiovascular disease (CVD),

and individuals with cancer.[87,89] The Mediterranean diet has been associated with a positive effect on glycemic control and similar weight loss trends compared to hypocaloric and low-carbohydrate diets.[89,90] Women with PCOS are at risk for both T2DM and CVD, therefore it is plausible that this dietary pattern could play a beneficial role in the treatment of these conditions**,** but more research is still needed.[88]

Glycemic index (GI) is a scoring system used to show how the consumption of carbohydrates in foods affect blood glucose when compared to a control (white bread or glucose).[91] PCOS patients with reduced insulin sensitivity could benefit from a diet that is high fiber, low-GI as this helps to dampen the insulin spike after eating carbohydrate rich foods, keeping blood sugar more stable.[91,92] Marsh and colleagues found that a low-GI diet improved insulin sensitivity three-fold when compared to a conventional healthy diet (CHD).[93] Also, 95% of individuals consuming the low-GI diet and who were not taking metformin improved menstrual regularity compared to the CHD group.[93] It is interesting to note that in a study where there was a spectrum of lean and overweight/obese phenotypes, an iso-caloric, low-GI diet provided small improvements in insulin sensitivity.[94] Adoption of low-GI dietary habits show promise for treatment of patients with insulin resistance.

Carbohydrates are the main source of energy for the body. However, carbohydrate consumption often results in high blood glucose in individuals who are insulin resistant.[95,96] Researchers and individuals with PCOS alike are looking to other macronutrients to take over as the main fuel for the body. Diets like very-low-carbohydrate, ketogenic diets have been postulated as good alternatives for individuals with PCOS or who have insulin resistance, but evidence is lacking.[88,96] A pilot study was

conducted by Mavropoulos et al., which found that 24 weeks of a low-carbohydrate, ketogenic diet improved weight, free testosterone levels, LF/FSH ratio, and fasting serum insulin in the five women who completed the study.[97] Limitations to this study included a low sample size, low adherence to the diet (only five out of eleven individuals completed the study), and a lack of control subjects/diet to assess if changes were significantly different compared to other diets.[97] Additional studies looking at low-carbohydrate/ketogenic diets are needed to determine the efficacy of this nutritional intervention on symptom management of PCOS.

Higher protein diets are another alternative to standard macronutrient ranges recommended for the general population.[86,98] In a study by Sorensen et al, women with PCOS were assigned to either a high-protein (HP) diet (>40% of energy from protein, 30% energy from fat) or a standard protein (SP) diet (<15% of energy from protein, 30% energy from fat).[98] After 6 months, the women consuming the HP diet had a greater weight loss than SP, and significantly improved glucose metabolism independent of weight loss. While glycemic index was not a focus of this study, the HP participants were encouraged to avoid white and whole grain breads, but the SP diet participants were not restricted in their bread choices. This is obviously a limitation in the design of the study.[98] High protein diets also deserve further exploration as a potential dietary tool to help PCOS patients.

It is also important to consider common insufficiencies related to restrictive diets, which may not be nutritionally adequate for women of reproductive age.[86] Low-carbohydrate, ketogenic diets are limited in amount of fruit, starch and specific vegetables, thus limiting access to some micronutrients and adequate fiber.[86,99] These

common insufficiencies can be combatted through education on how to properly utilize these diets to ensure essential nutrients are consumed, while under the supervision of a dietitian. The ideal diet would be complete in required nutrients yet would help the PCOS patient manage weight and blood glucose levels.

PCOS Treatment: Medical Nutrition Therapy: Supplements

Dietary and lifestyle changes are promoted in the treatment and management of PCOS.[2] In regards to treatment of symptoms that commonly affect women with PCOS, many of the traditional medications prescribed come with unwanted side effects, which makes compliance difficult.[77] There are a number of specific dietary supplements that are purported in the research literature to help conditions like those of PCOS patients.

Cinnamon has been purported to improve insulin resistance and glycemic control.[100,101] Recent studies have confirmed this in PCOS subjects. Daily supplementation with 1.5 g cinnamon for 12 weeks resulted in decreased levels of the HOMA-IR, low density lipoprotein (LDL) and high density lipoprotein (HDL) compared to controls.[102] Similarly, Borzoei et al. found that supplementation with three 500 mg cinnamon capsules daily for eight weeks resulted in a 10.63% decrease in serum glucose, 12.63% decrease in insulin, and 20.25% decrease in HOMA-IR serum levels.[103] Kort & Lobo found that six months of cinnamon supplementation (1.5 g/day) improved menstrual regularity in a double-blinded randomized controlled trial, however insulin resistance measures did not significantly change.[104] With continued research in this area, cinnamon may be a low-risk, low-cost option to assist in glucose control.

Chromium supplementation has been found effective in reducing clinical symptoms of diabetes, through increasing the effect of insulin action.[105] In a meta-

analysis by Heshmati et al., it was concluded that chromium supplementation improves insulin resistance among women with PCOS.[106] Amr & Abdel-Rahim specifically examined a daily dose of 1000 ug chromium picolinate supplementation in adolescent females diagnosed with PCOS.[107] They reported that six months of supplementation improved menstrual cycle regularity, decreased ovarian volume and free testosterone levels.[107] Chromium supplementation could be a viable option in the treatment algorithm of PCOS to help alleviate clinical symptoms.

Vitamin D and Omega-3 fatty acids are two commonly used dietary supplements. Vitamin D deficiency approximately affects 67-85% of women with PCOS.[108] Negative correlations have been found with vitamin D status and adiposity levels, fasting glucose and insulin levels, and insulin resistance (HOMA-IR, HOMA-B).[88,108,109] While supplementation did not have a significant effect on metabolic and endocrine features, it did significantly reduce markers of inflammation and oxidative stress such as high-sensitivity C-reactive protein (hs-CRP), Malondialdehyde, and Total Antioxidant Capacity (TAC).[108] Supplementation with Omega-3 fatty acids, both short term and long-term, has been found to be effective in improving regularity of menstruation in women with PCOS compared to controls.[110,111] Consuming vitamin D and/or Omega-3 fatty acid supplements could serve as an additional symptom management tool in individuals with PCOS.

With the current evidence looking at dietary supplementation on treatment and management of PCOS, it would be prudent to discover if there are different effects of consuming these nutrients through the diet versus supplementation. Dietary supplements are not regulated by the food and drug administration (FDA), so for safety and efficacy

reasons, education on safe supplementation is necessary for individuals choosing to use this route for treatment.

PCOS Treatment: Medical Nutrition Therapy: Sports Nutrition

As discussed, general nutrition recommendations for individuals with PCOS are not well-defined, and there is an even larger gap in the literature for sports nutrition specific recommendations for athletes with PCOS. This gap is likely due to the unrealized prevalence of PCOS in athletes, and the heterogeneity of the syndrome. Nutrition recommendations should always be personalized, and managing nutrition for an athlete with PCOS should be no different.[112] Many nutrition recommendations for athletes will remain true for this particular population; consume a varied and balanced diet, rich in whole grains, fruits and vegetables, lean proteins, and healthy fats. Proper meal timing and eating consistently throughout the day will be important as well. However, with characteristics like insulin resistance being common among PCOS athletes, carbohydrate recommendations can be difficult to identify. Carbohydrates are the main fuel source for exercise, and athletes are typically recommended to consume 5-10 g/kg depending on the sport and intensity level.[112,113] Education surrounding carbohydrate timing around sport and in the proper amounts, as well as pairing carbohydrate sources with lean protein and healthy fats to promote stabilization of blood sugar will be areas to focus on for athletes with PCOS.[112,114]

PCOS Treatment: Lifestyle Behaviors: Physical Activity

Physical activity is important to maintaining good health in the general population.[115] Physical activity promotes the maintenance of lean muscle mass, improves sleeping habits, enhances mental health status, and helps to reduce the risk of chronic

diseases such as obesity, cardiovascular disease, and type 2 diabetes mellitus.[10] The current recommendations for physical activity are sixty minutes/day of moderate-vigorous intensity activity for individuals under the age of 18. For adults (those who are 18 years or older), should aim to get 150 minutes/week of moderate-vigorous intensity activity, or more if physical activity is less intense.[116]

	School-Aged Children and Adolescents (Age 6-17 years old)	**Adults (Age 18+)**
Total activity recommendation	60 minutes/day	Minimum of 150 minutes/week, with additional benefits beyond 300 minutes/week
Aerobic	Most of 60 minutes	Most of 150 minutes/week at least 3x/week
Muscle Strengthening	Part of 60 minutes at least 3x/week	Part of 150 minutes/week 2x/week
Bone Strengthening	Part of 60 minutes at least 3x/week	

Table 2.2 Visual Representation of Physical Activity Guidelines for Americans, 2nd Edition[116]

Participation in sports can contribute to overall physical activity needs of adolescents and young adults.[11] In relation to intensity level of sport participation, sports/physical activity types are categorized into calorie burning groups by the 2018 Physical Activity Guidelines for Americans and Center for Disease Control (CDC):[116,117]

1) Moderate-intensity sports/activities:

a) Archery, bowling, baseball/softball, cheerleading, diving, horseback riding, golf, marching band, volleyball, yoga, etc.

2) Vigorous-intensity sports/activities:

a) Basketball, field hockey, football, ice hockey, lacrosse, rowing, running, soccer, swimming, synchronized swimming, tennis, track and field, water polo and wrestling.

As with similar disease states, lifestyle modifications should be used as the first line treatment, and in conjunction with any essential medications.[118] In a cross-sectional study by Mario et al. on PCOS participants, androgen levels were found to be decreased in active individuals versus those defined as sedentary.[14] Similarly, Lamb and colleagues identified that active women with PCOS had better metabolic profiles compared to non-active women with PCOS, however only fasting blood glucose was statistically significant.[16] Additionally, it was reported that 58.7% patients with PCOS reported physical activity that met recommended guidelines.[16] Physical activity is an important behavior to adopt in an individual, and can be introduced as part of the clinical management of PCOS.

Patient understanding and knowledge about their diagnosis of PCOS, as well as the implications of sedentary behaviors is critical in identifying education needs of patients. In particular, the knowledge behind the benefits of physical activity in PCOS patients has been found to be lower compared to healthy controls.[15] Eleftheriadou et al. identified a statistically significant increased number of girls without PCOS (54%) compared to a low proportion of girls with PCOS (8%) were informed about health

benefits of exercise and physical activity.[15] Increasing the health literacy of patients is critical to increasing health promoting and symptom management behaviors.

Conclusion

Physical activity offers a variety of benefits on health for the general population, as well as PCOS populations.[10] The literature has identified physical activity participation being reduced in females with PCOS compared to the general population, as well as a lack of awareness of the benefits physical activity plays on symptom management.[15] Moreover, the prevalence of PCOS in athletes has limited data to date. Assessing sports participation and position group history may help to identify trends in which sports medicine providers within female athletic teams can be aware of to ensure proper medical and nutrition therapies are utilized for these individuals. The need for further research on prevalence of PCOS within athletic populations is paramount to understanding specific needs of these athletes.

Chapter 3. Methodology

Summary

This study was a cross-sectional study using a phone survey with parents of Polycystic Ovarian Syndrome (PCOS) patients and/or the patients themselves. The study purpose was to obtain the patients' (female, adolescent/young adult) sport and physical activity participation history to explore the distribution of sport participation. The patient population and contact information were sourced from a singular pediatric endocrinology practice in Columbus, Ohio. This pediatric endocrinology practice accepts commercial health insurance and patients predominately represent communities of middle- to upper-class families. We expected to find a correlation between type of sport athlete and PCOS. Knowledge of this relationship may prompt future studies on the prevalence of PCOS within sports types and/or educational interventions on physical activity, which could lead to improved clinical or athletic health care.

Study Objectives:

1. To ascertain sport participation/position group history and physical activity among a cohort of adolescent and young adult women with the diagnosis of PCOS.

Study Design & Methodology

This cross-sectional, observational study analyzed potential links between patients with known PCOS and their sports and physical activity participation history. Participant selection criteria was limited to females aged 10 to 28 with a confirmed diagnosis of PCOS in their electronic medical record (Diagnosis Code E28.2). Individuals with PCOS who were not patients

at this particular pediatric endocrinology practice were not included in this study. Patient confidentiality was maintained, as the pediatric endocrinology practice protected and retained client names and associated diagnostic information within its system. Data provided by the clinic and used in this study had all patient identifiers removed. Subject numbers were assigned.

This study aimed to contact as many eligible prospective participants from the pediatric endocrinology practice list. Contact telephone numbers were provided by the pediatric endocrinology practice for their patients with PCOS, according to usual clinical practice. Two graduate students were provided access to the list and permitted to call the numbers associated with the diagnosed patient. The students made all calls to patients from within the pediatric endocrinology practice with the permission of the physicians and administration. Research staff tried to reach each patient a total of three times during the data collection phase, and strategies such as calling at different times of the day were employed. The students utilized and adhered to an approved script to obtain verbal consent from the patients' parent/legal guardian at the start of the call. Consent was obtained prior to asking any relevant questions of the patient. Data relating to sports participation history (i.e. age, current sport participation, past sport participation, position within sport, number of hours/week and years competing) and current physical activity if not currently participating in sports, as outlined in the script, were recorded without the patient name. If participant reported they were not currently reporting in sport, this was considered sport attrition. The questions consisted of open-ended responses. Data obtained was analyzed and summarized. The resulting research report outlines observed trends among this particular PCOS patient population.

Data Management and Statistical Analysis

The data collected in the survey represents the basis for study and analysis. No follow up information is required from these participants. Data were recorded in a Microsoft Excel spreadsheet. The spreadsheet was used to record the information received from participants or their surrogates, for each question from the survey script. The spreadsheet does not contain any patient identifiers and simply contains anonymous response data.

Survey response data were organized and analyzed using SPSS (version 25).[119] Descriptive statistics were used to outline the sample of PCOS patients within the following characteristics:

- Age (years)
- Current Competitive or Team-Based Sport Participation
- Competitive or Team-Based Sport Participation > 2 years
- Sport(s) Played
- Position in Sport
- Amount of Sport (hours/week)
- Years in Sport
- Physical Activity Outside of Sport Participation
- Types of Physical Activity
- Amount of Physical Activity (hours /week)

- After data was collected, athlete level was determined based on the greatest number of participation hours per week in the subject's primary sport. Primary sport was identified by the greatest number of years in a sport if multiple sports were listed. It is important to note, there

are no solid definitions of "athlete" in the literature. Athlete level was stratified into 5 categories:

- 0 = Non-Athlete (0 hours/week participating in a sport)
- 1 = Recreational Athlete (< 5 hours/week participating in a sport)
- 2 = Average Athlete (5-9 hours/week participating in a sport)
- 3 = Performance Athlete (10-14 hours/week participating in a sport)
- 4 = High-Performance Athlete ($\geq$ 15 hours/week participating in a sport)

Frequency analyses were performed to establish the frequency of age reported, sport(s) played, and athlete level. Cross-tabulations were conducted to assess athlete level by physical activity participation.

Chapter 4. Results

Results:

In total, 150 patients of the pediatric endocrinology practice with the diagnosis for PCOS, or their surrogate respondents, were telephoned. Thirty-four (22.6%) participants responded to survey questions. Mean participant age was 18.2 years old with a standard deviation of $\pm$ 3.42 years. Participant ages ranged from 10 to 28 years old. With a relatively even split, 47.1% of participants were under the age of eighteen and 52.9% of participants were eighteen years or older in age (Figure 4.1).

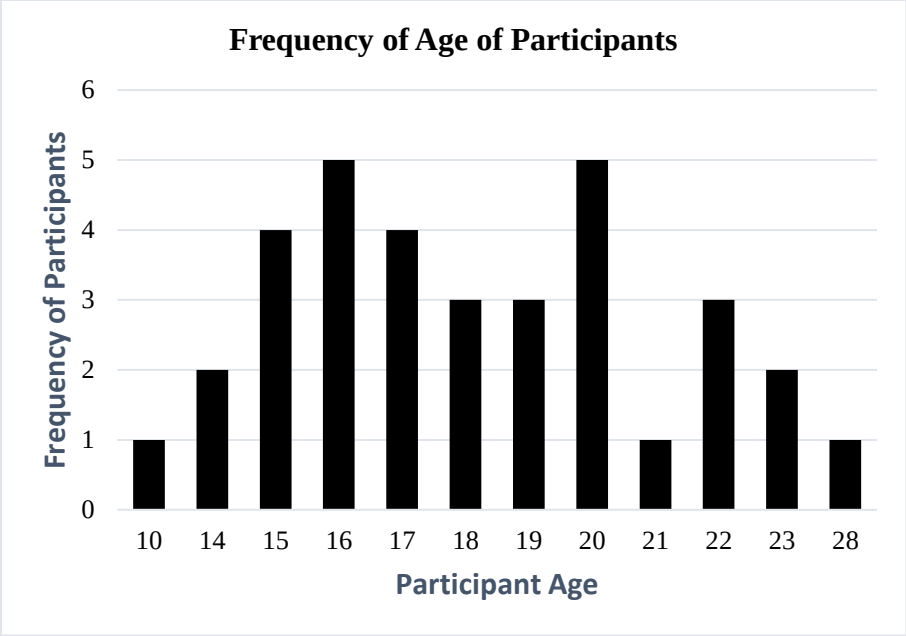

Figure 4.1 Frequency of Age of Participants (n = 34) Among Patients with PCOS from a private endocrinology practice

Reports included all activities for thirty-four subjects who participated in one sport (56%), two sports (26%) or three or more sports (18%), with a total of 52 accounts of sports played and 19 unique sports identified. Figure 4.2 demonstrates the frequency of sports reported in the survey. Sports reported by thirty-four participants included (percentage based on frequency out of 52 reports of sports): Archery (2%); basketball (4%); bowling (4%); cheerleading (6%); color guard (2%); dance (10%); field hockey (6%); golf (2%); horseback riding (2%); indoor drumline (2%); marching band (4%); martial arts (2%); soccer (23%); softball (12%); swimming (6%); tennis (6%); track and field (6%); volleyball (4%); and water polo (2%). Four individuals did not participate in a competitive or team sport for more than two years, accounting for 11.8% of participants (Figure 4.2).

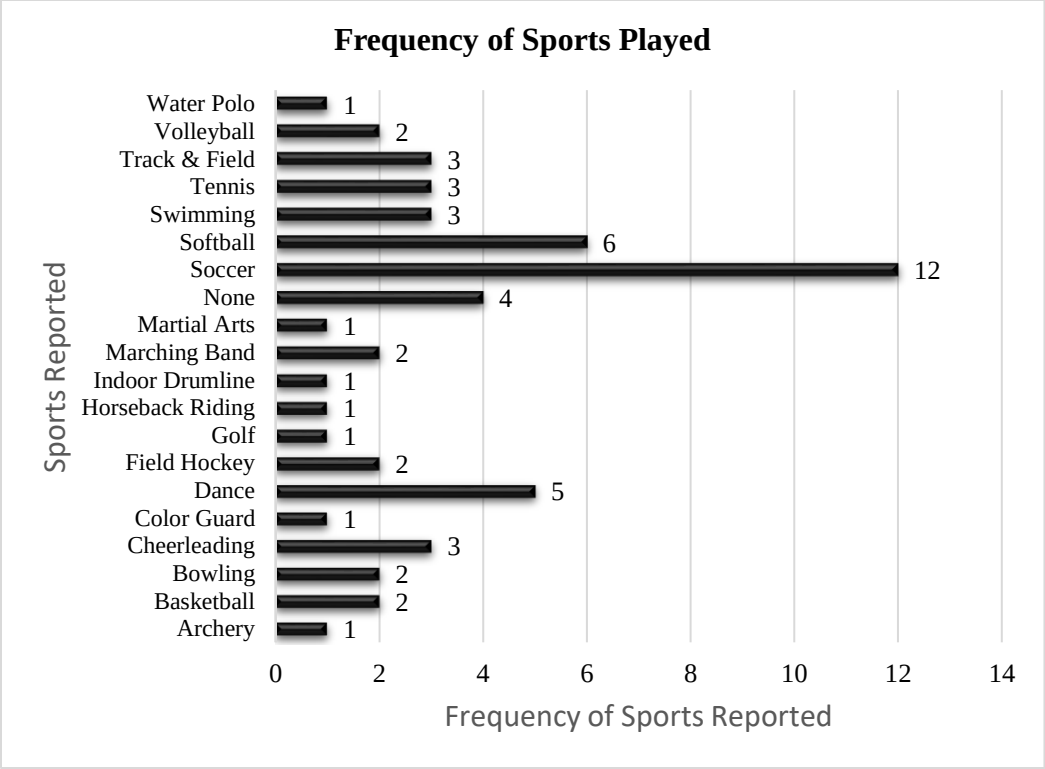

Table 4.2 Frequency of Sports Played (n = 52) Among Patients with PCOS from a private endocrinology practice

Sports reported can be categorized by moderate and vigorous intensity. Moderate intensity sports would include volleyball, softball, marching band/drumline, horseback riding, golf, color guard, cheerleading, bowling and archery. Vigorous intensity sports would include water polo, track and field, tennis, swimming, soccer, martial arts, field hockey, dance, and basketball. Twenty (38.4%) reports accounted for moderate intensity sport activities and thirty-two (61.5%) reports were vigorous intensity sport activities.

Within each sport, position type was reported by subjects to assess trends as many sports have distinctive physical characteristics by position. The three sports with the highest frequency of participation included soccer, softball and dance. Results showed that amongst the

individuals who reported a position in soccer, six played defense, two were midfielders, two were forwards and one was a goalie. Of the softball players (n = 6), all six reported playing outfield, while three indicated they additionally played third base, two were catchers, and one was a pitcher. Within this group, many of the individuals reported playing two to three positions. While dance may include many different genres, this study was unable to establish a higher prevalence in any particular style. Additional sports that had multiple positions stated when specified, include track & field (two-thirds of subjects described themselves as throwers) and field hockey (one goalie and one defender).

Considering each participant's highest level of sport participation, participants were categorized according to self-reported average hours engaged in sport/activity. Figure 4.3 demonstrates the frequency of participants and the categories. Thirteen of thirty-four (38.2%) individuals reported participation in their sport for ten or more hours per week. Of those thirteen, eight individuals classified as high-performance athletes, participating/competing in their sport for fifteen or more hours per week (Figure 4.3). Sports played at the two highest levels of participation included basketball, dance, field hockey, golf, marching band, softball, swimming, and tennis. The distribution among these sports are quite equal as visualized in Figure 4.4.

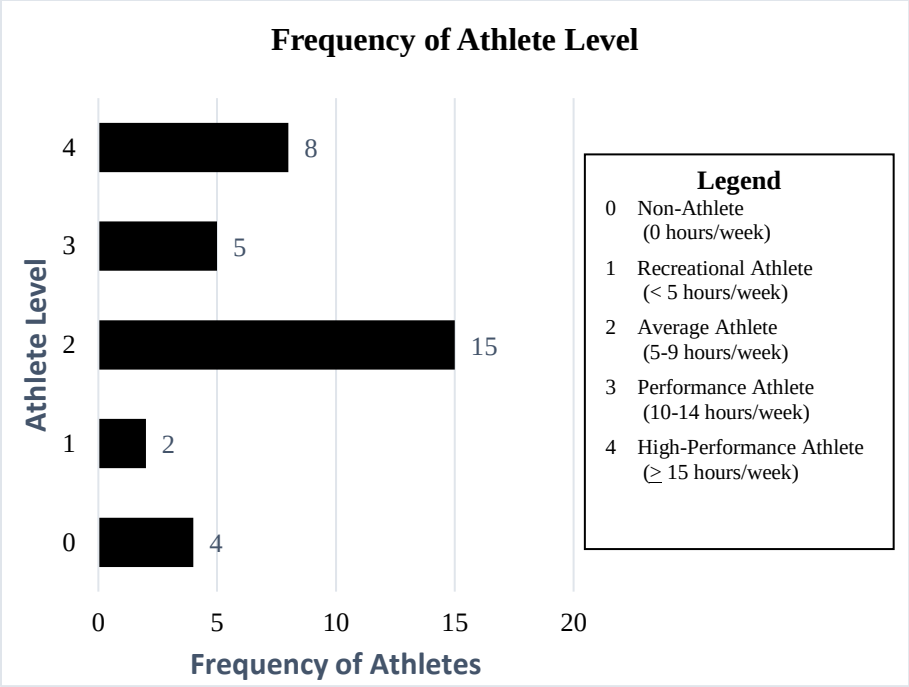

Figure 4.3 Frequency of Athlete Level (n = 34) Among Patients with PCOS from a private endocrinology practice

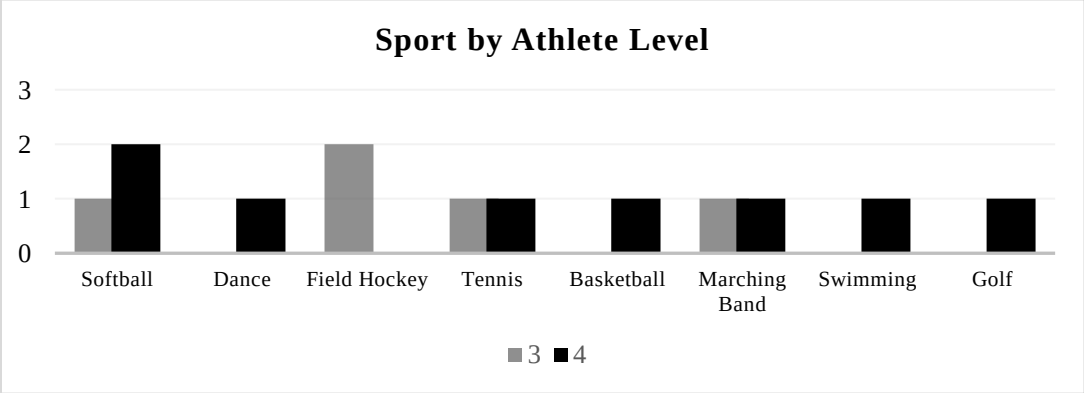

Figure 4.4 Sport(s) Played within Athlete Levels 3 and 4 (n = 13) Among Patients with PCOS from a private endocrinology practice

Current physical activity participation was reported by each subject. While 88.2% of subjects participated in sports for more than two years, only 29.4% were currently involved in sports, and 38.2% reported present participation in regular physical activity. On average, participants under the age of eighteen took part in physical activity for 1-4 hours/week. As seen in Table 4.1, physical activities listed among this group included walking, fitness classes, personal training, and Wii fitness. Individuals eighteen years and older participated in physical activity from 2-7 hours/week. Reported physical activities within this older group included personal training, working out at a gym, playing sports for fun, and waitressing. The individual data is displayed by age in Table 4.2 to allow for assessment of prior and current sport as well as physical activity outside of sport. It is noticeable that thirteen subjects do not currently participate in a sport or report current physical activity.

Age	Physical Activity	Hours/Week
15	Gym class and Wii Fitness	4
15	Group Fitness (Running group, yoga, cardio based classes)	4
15	Dance Class	2
17	Personal Training	1
17	Walking	2
18	Personal Training	2
19	Basketball (pick-up games); Basketball (intramurals)	5
20	Cardio-1 mile and/or 30 minutes free weights	3
20	Gym-elliptical and lifting	2
20	Gym-bike, treadmill, elliptical, or lifting	5
22	Goes to Gym-no specific report of usual activity	3
23	Runs/jogs and/or lifts weights; plays volleyball for fun occasionally	7
23	Waitress	4

Table 4.1 Age by Physical Activity Type by Hours per week (n = 13) Among Patients with PCOS from a private endocrinology practice

Age	Sport Participation > 2 Years	Currently Participating in Sport	Currently Physically Active Outside of Sport
10	No	No	No
14	Yes	Yes	No
14	Yes	No	No
15	No	No	Yes
15	Yes	Yes	Yes
15	Yes	No	Yes
15	Yes	Yes	No
16	Yes	Yes	No
16	No	No	No
16	Yes	Yes	No
16	Yes	Yes	No
16	Yes	Yes	No
17	Yes	Yes	No
17	No	No	Yes
17	Yes	Yes	Yes
17	Yes	No	No
18	Yes	Yes	Yes
18	Yes	Yes	No
18	Yes	No	No
19	Yes	No	Yes
19	Yes	No	No
19	Yes	No	No
20	Yes	No	No
20	Yes	No	Yes
20	Yes	No	No

Continued

Table 4.2 Age by Sport Participation History by Physical Activity History (n = 34) Among Patients with PCOS from a private endocrinology practice

Age	Sport Participation > 2 Years	Currently Participating in Sport	Currently Physically Active Outside of Sport
20	Yes	No	Yes
20	Yes	No	Yes
21	Yes	No	No
22	Yes	No	Yes
22	Yes	No	No
22	Yes	No	No
23	Yes	No	Yes
23	Yes	No	Yes
28	Yes	No	No
Totals	30/34	11/34	13/34

Table 4.2 Age by Sport Participation History by Physical Activity History (n = 34) Among Patients with PCOS from a private endocrinology practice

Within the data collection phase of this study, individuals who were phone called did not always want to participate in the research. One example includes a father of a patient who at first seemed interested in participating in the research study, but as soon as it was mentioned that questioning was surrounding sport participation history, he decided he no longer wanted to take part in the research. This could be due to the parent not wanting to disclose true activity status of the child. Additional reasons that participants did not want to take part in the research included being disgruntled and not understanding that calls were coming from within the clinic and that their phone number was not distributed. A physician from within the clinic responded to their concerns and clarified the situation to ensure all patients and families were understanding of the situation.

Discussion

In this study, the majority of participants reported they are or were athletes, with a history of 88.2% participating in sport at some time point. The definition of athlete is elusive, and studies in the literature involving athletes each have their own definition of what constitutes an athlete. In the literature, many different athlete types have been used while assessing PCOS status, albeit those studies are few and far between.[9,12,18,120] This study confirms the heterogeneity of sport participation, as nineteen unique sport types were reported by participants. Soccer had the highest prevalence, with softball and dance athletes as the second and third most prevalent sport types. When comparing our sample to the 2018 Women's Sport Foundation Report: *Teen Sport in America-Why Participation Matters*, volleyball (11.4%) was the most popular sport amongst adolescent females, followed closely by softball (11.0%), basketball (11.0%) and soccer (10.5%), however dance was not included in this report.[121] The results of our study are similar in terms of sports reported, suggesting that young females with PCOS align in their sport choices with the general population and may not choose one type of sport more frequently. Additionally, geographic location and social economic status may play a role in the frequency of the sports reported in this study compared to if this study were to be done in another region of the United States.

Position groups within sports were also assessed within our sample to identify trends. The data highlight the increased number of participants with defense as their identified position in soccer and outfield and third base in softball. Literature shows that defenders and goalies within field sports (i.e. soccer, lacrosse, and field hockey) are taller and heavier than their teammates in other positions. However, these same studies qualify that body composition differences are not statistically significant between positions.[73–75] More literature looking at

female body composition characteristics by sport and position type and PCOS prevalence is needed to further elucidate positional trends found within our study.

As there is no concrete definition for athlete in the literature, the study team categorized athlete level by hours per week of participation in individual sport. Most participants (62%) reported participation less than ten hours per week and the most frequently reported participation hours were between five and ten hours. While the aim of our study was to assess regular sport participation within this population, based on the data provided, recreational sport activities were more frequently reported.

Performance and high-performance athletes played a variety of sports. The CDC lists softball, golf, and marching band as moderate intensity activities, whereas the remaining sports played (basketball, tennis, field hockey, swimming and dance) by the performance and high performance athletes in our study fall under the vigorous intensity activity category.[117] These descriptors may help to further identify athlete levels in future studies.

Past sport participation was reported by 88.2% of the participants in this study, which is higher than current statistics in youth sports (68%).[122] When broken down by gender, 61.1% of high school aged girls participate in at least one sport.[121] Additionally, it has been identified that 51% of youth (boys and girls) who participate in at least one sport, exercise vigorously everyday compared to the 15% of youth who exercise vigorously every day but do not participate in sports.[121] These findings help to strengthen the notion that sport participation keeps adolescents and young adults active. As participants aged out of high school, sport participation reduced significantly. This trend is similar to the 2016 Victoria Sport Participation Research Summary, which indicated that the highest rate of sport participation was between the

ages of five and fourteen years old, and then dropped significantly for those fifteen through nineteen years of age.

Our study also queried physical activity participation outside of organized sport. Based on the 2018 American Guidelines for Physical Activity, sixty percentsubjects under the age of eighteen who reported participating in physical activity failed to meet the recommended 60 minutes/day of physical activity.[116] However, for individuals eighteen years and older, 87.5% of subjects involved in physical activity met the recommended 150 minutes/week.[116] Additionally, when considering sport and physical activity categories, 4/16 (25%) subjects under 18 years old qualify as sedentary, while 9/18 (50%) of the young adult participants are sedentary.

A 2012 study by Eleftheriadou et al. highlighted the increased inactivity of adolescents with PCOS compared to adolescents without PCOS.[15] In the Eleftheriadou study, it also noted that only 8% of the girls with PCOS were aware of the health benefits of exercise.[15] Physical activity and its positive impact on blood glucose and insulin sensitivity has been identified many times in the literature.[16,123–126] Physical activity and regular exercise can additionally improve menstrual function in individuals with and without PCOS.[127] Understanding why the gap between physical activity and sport participation levels among participants is reduced is critical to understanding how to best educate on the impact exercise and sports can play on symptom management of PCOS.

Strengths and Limitations

A limitation to this study and others is the lack of a definition for what amount of sport constitutes the definition of an athlete. Defining athlete levels, as we did in our study, can help to establish stronger data for prevalence of PCOS. Athlete level definitions based on the

assumption that subjects had been in their sport for more than two years. We then narrowed down each subject's hours per week spent participating in their respective sport(s). We acknowledge that different sports may require different levels of training and hours involved per week, so establishing comprehensive definitions for both adult and adolescent athletes will benefit researchers and the subsequent recommendations.

Geographic location and social economic status of study participants may have contributed to the types of sport types reported. This study was conducted from within a private pediatric endocrinology practice which only takes commercial health insurance, which limits the participants that could be included in the study. Additionally, the clinic is located within a middle- to upper-class address within the Columbus, Ohio area, again speaking to the potential income status of the families represented at this clinic. Moreover, Columbus, Ohio is in the Midwest which may play into the sports offered in the surrounding community, thus affecting the sport types reported in this study.

This descriptive study had open-ended questions querying about sport participation history. We had hoped to identify "NCAA sponsored" sports within this history, and all other activities to be listed truly as activities. However, when open to subject interpretation, all physical activities counted as sports. This may be related to subjects or their surrogate respondents wanting to seem more active than they are, which could limit our data. Additional limitations to this study is the nature of the study itself. External phone surveys have an average 7-16% response rate.[128] Our study produced a 22.7% response rate, and while having a higher response rate than the average phone survey, this may have limited the data that could be acquired from the pediatric endocrinology practice. Future research related to sports participation history may consider utilizing an online or paper survey to be filled out at patient

visits as part of the usual care. Additionally, PCOS researchers may look to collegiate athletic departments to further identify sport specific trends within the female athlete population.

Conclusions

Overall, while sport participation was widely distributed amongst nineteen unique sports within our sample, trends amongst position groups were identified. Larger studies are needed to confirm these trends. Additionally, the attrition rate of sport participation, combined with the low physical activity outside of sport indicates a need for increased education on the benefits exercise can play on symptom management of PCOS.

Implications for Practice

Implications for the Dietitian

Each individual has their own unique nutritional needs, and women with PCOS are no different. Working with a dietitian can help patients feel confident in making lifestyle changes that can improve symptoms and prevent chronic conditions such as diabetes and cardiovascular disease. It is within the dietitian's scope of practice to educate and empower clients/patients to set health and wellness goals, which can include speaking on the benefits of setting physical activity goals in addition to nutrition goals.[129]

Implications for the Physician

The 2018 International Evidence Based Guidelines for the Assessment and Management of PCOS indicate that lifestyle modifications such as healthy eating and physical activity should be recommended, and in conjunction with any essential medications.[118] Physicians can assess physical literacy of their patients and ensure there is proper education on the benefits that physical activity can play on maintaining or obtaining a healthy weight and improving hormonal outcomes.

Implications for the Parent

Research has been reported that if parents lead a healthy and physically active lifestyle, their children are found to be more physically active as well.[130] Parents should look to adopt healthy behaviors in their own life, if not currently present, to encourage their children and daughters with PCOS to additionally adopt healthy lifestyle behaviors. Sport participation can help to meet physical activity guidelines, so supporting opportunities to be involved in sport(s) can be important in helping children meet those guidelines.

Chapter 5. The Need for Physical Activity in Polycystic Ovary Syndrome Patients

Abstract:

Polycystic Ovary Syndrome (PCOS) is the most common endocrine disorder in women of reproductive age, affecting up to 20% of women.[1] Physical activity is important to maintaining good health, and promotes the maintenance of lean muscle mass, improves sleeping habits, enhances mental health status, and helps to reduce the risk of chronic diseases.[10] The purpose of our study was to assess sport participation history among patients diagnosed with PCOS at a pediatric endocrinology practice in Columbus, Ohio. A phone survey was conducted to question patients and parents of PCOS patients on sports participation history and physical activity history. 88.2% of subjects participated in sports for greater than two years, only 29.4% currently are involved in sports, and 38.2% presently participate in regular physical activity. The attrition rate of sport participation, combined with the low physical activity outside of sport indicates a need for increased education on the benefits exercise can play on symptom management of PCOS.

Introduction

Polycystic Ovary Syndrome (PCOS) is the most common endocrine disorder in women of reproductive age, affecting up to 20% of individuals in this population[1]**.** PCOS is heterogeneous in nature, however common clinical and biochemical manifestations of this syndrome include hyperandrogenism, menstrual dysfunction (commonly seen as oligo-

ovulation or anovulation), and polycystic ovaries[2]. The cause of PCOS is likely multifactorial, as there are four prominent phenotypes of PCOS, however, there is no definitive etiology for these phenotypes identified in the existing literature[1].

Physical activity is important to maintaining good health in the general population.[115] Physical activity promotes the maintenance of lean muscle mass, improves sleeping habits, enhances mental health status, and helps to reduce the risk of chronic diseases such as obesity, cardiovascular disease, and type 2 diabetes mellitus.[10] The current recommendations for physical activity are sixty minutes/day for individuals under the age of 18. For adults (those who are 18 years or older), should aim to get 150 minutes/week of moderate-vigorous intensity activity, or more if physical activity is less intense.[116]

As with similar conditions, lifestyle modifications should be used as the first line treatment, and in conjunction with any essential medications.[118] In a cross-sectional study by Mario et al., androgen levels were found to be decreased in active individuals versus those defined as sedentary.[14] Similarly, Lamb and colleagues identified that active women with PCOS had better metabolic profiles compared to non-active women with PCOS, however only fasting blood glucose was statistically significant.[16] Additionally, it was reported that 58.7% patients with PCOS reported physical activity that met recommended guidelines.[16] Physical activity is an important behavior to adopt in an individual, and can be introduced as part of the clinical management of PCOS.

Methods

This cross-sectional, observational study analyzed potential links between patients with known PCOS and their sports and physical activity participation history. Participant selection criteria was limited to females aged 10 to 28 with a confirmed diagnosis of PCOS in their

electronic medical record (Diagnosis Code E28.2). Individuals with PCOS who were not patients at this particular pediatric endocrinology practice were not included in this study.

This study aimed to contact as many eligible prospective participants as is possible from the pediatric endocrinology practice list. Contact telephone numbers were provided by the pediatric endocrinology practice for their patients with PCOS, according to usual clinical practice. Two graduate students were provided access to the list and permitted to call the numbers associated with the diagnosed patient. The students made all calls to patients from within the pediatric endocrinology practice with the permission of the physicians and administration. Research staff tried to reach each patient a total of three times during the data collection phase. The students utilized and adhered to an approved script to obtain verbal consent from the patients' parent/legal guardian at the start of the call. Consent was obtained prior to asking any relevant questions of the patient. Data relating to sports participation history (i.e. age, current sport participation, past sport participation, position within sport, number of hours/week and years competing) and current physical activity if not currently participating in sports, as outlined in the script, were recorded without the patient name. The questions consisted of open-ended responses. Data obtained was analyzed and summarized. The resulting research report outlines observed trends among this particular PCOS patient population.

Survey response data were organized and analyzed using SPSS (version 25).[119] Descriptive statistics were used to outline the sample of PCOS patients within the following characteristics:

- Age (years)
- Current Competitive or Team-Based Sport Participation
- Competitive or Team-Based Sport Participation >2 years
- Sport(s) Played
- Position in Sport
- Amount of Sport (hours/week)
- Years in Sport
- Physical Activity Outside of Sport Participation
- Types of Physical Activity
- Amount of Physical Activity (hours/week)

After data was collected, athlete level was determined based on greatest number of participation hours per week in the subject's primary sport. Primary sport was identified by the greatest number of years in a sport if multiple sports listed. It is important to note, there are no solid definitions of "athlete" in the literature. Athlete level was stratified into 5 categories:

- 0 = Non-Athlete (0 hours/week participating in a sport)
- 1 = Recreational Athlete (< 5 hours/week participating in a sport)
- 2 = Average Athlete (5-9 hours/week participating in a sport)
- 3 = Performance Athlete (10-14 hours/week participating in a sport)
- 4 = High-Performance Athlete ($\geq$ 15 hours/week participating in a sport)

Frequency analyses were performed to establish the frequency of age reported, sports played, and athlete level. Cross-tabulations were conducted to assess athlete level by physical activity participation.

Results

In total, 150 patients of the pediatric endocrinology practice with the diagnosis for PCOS, or their surrogate respondents, were telephoned. Thirty-four (22.6%) participants responded to survey questions. Participant ages ranged from 10 to 28 years old. With a relatively even split, 47.1% of participants were under the age of eighteen and 52.9% of participants were eighteen years or older in age (Figure 5.1).

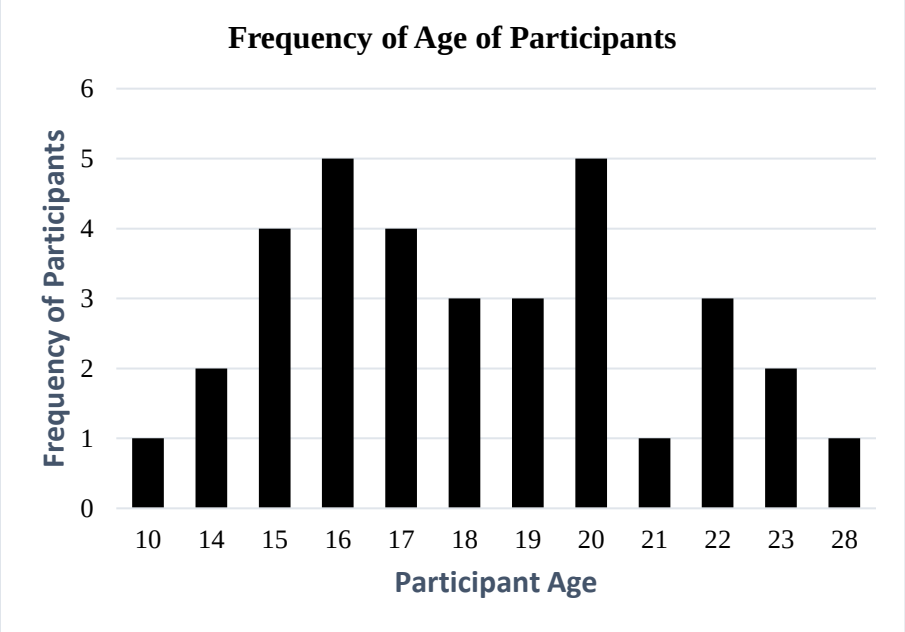

Figure 5.1 Frequency of Age of Participants (n = 34) Among Patients with PCOS from a private endocrinology practice

Reports included all activities for thirty-four subjects, with a total of fifty-two accounts of sports played and nineteen unique sports identified. Figure 4.2 demonstrates the frequency of sports reported in the survey. Sports reported included (percentage based on frequency out of 52 reports of sports): Archery (2%); basketball (4%); bowling (4%); cheerleading (6%); color guard (2%); dance (10%); field hockey (6%); golf (2%); horseback riding (2%); indoor drumline (2%); marching band (4%); martial arts (2%); soccer (23%); softball (12%); swimming (6%); tennis (6%); track and field (6%); volleyball (4%); and water polo (2%). Four individuals did not participate in a competitive or team sport for more than two years, accounting for 11.8% of participants (Figure 5.2).

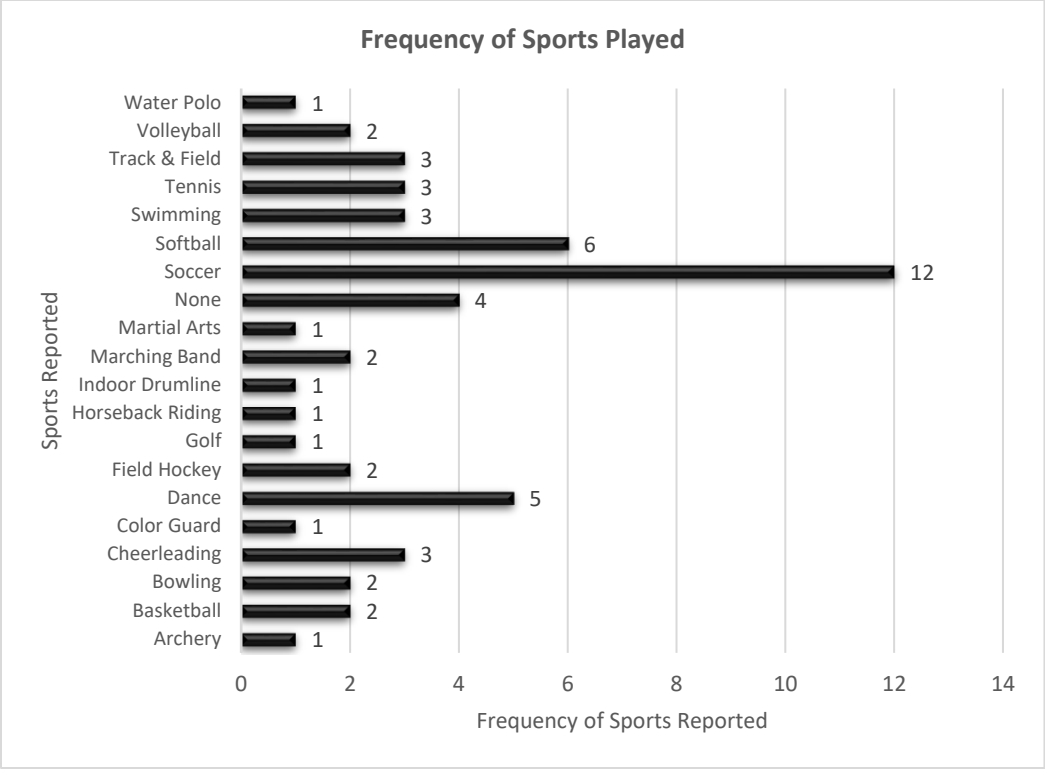

Figure 5.2 Frequency of Sports Played (n = 52) Among Patients with PCOS from a private endocrinology practice

Within each sport, position type was reported by subjects to assess trends as many sports have distinctive body types by position. The three sports with the highest frequency of participation included soccer, softball and dance. Results showed that amongst the individuals who reported a position in soccer, six played defense, two were midfielders, two were forwards and one was a goalie. Of the softball players (n = 6), all six reported playing outfield, while three indicated they additionally played third base, two were catchers, and one was a pitcher—within this group, many of the individuals reported playing two to three positions. In this study, dance was reported as a sports activity. While it has many different genres, no trends were established among this group. Additional sports that had multiple positions stated when

specified, include track & field (two-thirds of subjects described themselves as throwers) and field hockey (one goalie and one defender).

Current physical activity participation was reported by each subject. While 88.2% of subjects participated in sports for more than two years, only 29.4% were currently involved in sports, and 38.2% reported present participation in regular physical activity. On average, participants under the age of eighteen took part in physical activity for one to four hours/week. As seen in Table 4.5, physical activities listed among this group included walking, fitness classes, personal training, and Wii fitness. Individuals eighteen years and older participated in physical activity from two to seven hours/week. Reported physical activities within this older group included personal training, working out at a gym, playing sports for fun, and waitressing. The individual data is displayed by age in Table 4.6 to allow for assessment of prior and current sport as well as physical activity outside of sport. It is noticeable that thirteen subjects do not currently participate in sport or report current physical activity.

Age	Physical Activity	Hours/Week
15	Gym class and Wii Fitness	4
15	Group Fitness (Running group, yoga, cardio based classes)	4
15	Dance Class	2
17	Personal Training	1
17	Walking	2
18	Personal Training	2
19	Basketball (pick-up games); Basketball (intramurals)	5
20	Cardio-1 mile and/or 30 minutes free weights	3
20	Gym-elliptical and lifting	2
20	Gym-bike, treadmill, elliptical, or lifting	5
22	Gym	3
23	Runs/jogs and/or lifts weights; plays volleyball for fun occasionally	7
23	Waitress	4

Table 5.1 Age by Physical Activity Type by Hours per week (n = 13) Among Patients with PCOS from a private endocrinology practice

Age	Sport Participation > 2 Years	Currently Participating in Sport	Currently Physically Active Outside of Sport
10	No	No	No
14	Yes	Yes	No
14	Yes	No	No
15	No	No	Yes
15	Yes	Yes	Yes
15	Yes	No	Yes
15	Yes	Yes	No
16	Yes	Yes	No
16	No	No	No
16	Yes	Yes	No
16	Yes	Yes	No
16	Yes	Yes	No
17	Yes	Yes	No
17	No	No	Yes
17	Yes	Yes	Yes
17	Yes	No	No
18	Yes	Yes	Yes
18	Yes	Yes	No
18	Yes	No	No
19	Yes	No	Yes
19	Yes	No	No
19	Yes	No	No
20	Yes	No	No
20	Yes	No	Yes
20	Yes	No	No

Continued

Table 5.2 Age by Sport Participation History by Physical Activity History (n = 34) Among Patients with PCOS from a private endocrinology practice

Age	Sport Participation > 2 Years	Currently Participating in Sport	Currently Physically Active Outside of Sport
20	**Yes**	**No**	**Yes**
20	Yes	No	Yes
21	Yes	No	No
22	Yes	No	Yes
22	Yes	No	No
22	Yes	No	No
23	Yes	No	Yes
23	Yes	No	Yes
28	Yes	No	No
Totals	30/34	11/34	13/34

Table 5.2 Age by Sport Participation History by Physical Activity History (n = 34) Among Patients with PCOS from a private endocrinology practice

Discussion

In this study, the majority of participants reported they are or were athletes, with a history of 88.2% participating in sport. The definition of athlete is elusive, and studies in the literature involving athletes each have their own definition of what constitutes as an athlete. In the literature, many different athlete types have been used while assessing PCOS status, albeit those studies are few and far between.[9,12,18,120] This study confirms the heterogeneity of sport participation, as nineteen unique sport types were reported by participants. Soccer had the highest prevalence, with softball and dance athletes as the second and third most prevalent sport types. When comparing our sample to the 2018 Women's Sport Foundation Report: *Teen Sport in America-Why Participation Matters*, volleyball (11.4%) was the most popular sport amongst adolescent females, followed closely by softball (11.0%), basketball (11.0%) and

soccer (10.5%), however dance was not included in this report.[121] The results of our study are similar in terms of sports reported, suggesting that young females with PCOS align in their sport choices with the general population and may not choose one type of sport more frequently. Additionally, geographic location and social economic status may play a role in the frequency of the sports reported in this study compared to if this study were to be done in another region of the United States.

Position groups within sports were also assessed within our sample to identify trends. The data highlight the increased number of participants with defense as their identified position in soccer and outfield and third base in softball. Literature shows that defenders and goalies within field sports (i.e. soccer, lacrosse, and field hockey) are taller and heavier than their teammates in other positions. However, these same studies qualify that body composition differences are not statistically significant between positions.[73–75] More literature looking at female body composition characteristics by sport and position type and PCOS prevalence is needed to further elucidate positional trends found within our study.

Past sport participation was reported by 88.2% of the participants in this study, which is higher than current statistics in youth sports (68%).[122] As participants aged out of high school, sport participation reduced significantly. This trend is similar to the 2016 Victoria Sport Participation Research Summary, which indicated that the highest rate of sport participation was between the ages of five and fourteen years old, and then dropped significantly for those fifteen through nineteen years of age.

Our study also queried physical activity participation outside of organized sport. Based on the 2018 American Guidelines for Physical Activity, 60% subjects under the age of eighteen who reported participating in physical activity failed to meet the recommended 60 minutes/day

of physical activity.[116] However, for individuals eighteen years and older, 87.5% of subjects involved in physical activity met recommended 150 minutes/week.[116] Additionally, when considering sport and physical activity categories, 4/16 (25%) subjects under 18 years old qualify as sedentary, while 9/18 (50%) of the young adult participants are sedentary.

A 2012 study by Eleftheriadou et al. highlighted the increased inactivity of adolescents with PCOS compared to adolescents without PCOS.[15] In the Eleftheriadou study, it also noted that the only 8% of the girls with PCOS were aware of the health benefits of exercise.[15] Physical activity and its positive impact on blood glucose and insulin sensitivity has been identified many times in the literature.[16,123–126] Physical activity and regular exercise can additionally improve menstrual function in individuals with and without PCOS.[127] Understanding the gap between why physical activity and sport participation levels among participants is reduced is critical to understanding how to best educate on the impact exercise and sports can play on symptom management of PCOS.

Strengths and Limitations

Geographic location and social economic status of study participants may have contributed to the types of sport types reported. This study was conducted from within a private pediatric endocrinology practice which only takes commercial health insurance, which limits the participants that could be included in the study. Additionally, the clinic is located within a middle- to upper-class address within the Columbus, Ohio area, again speaking to the potential income status of the families represented at this clinic. Moreover, Columbus, Ohio is in the Midwest which may play into the sports offered in the surrounding community, thus affecting the sport types reported in this study.

This descriptive study had open-ended questions querying about sport participation history. We had hoped to identify "NCAA sponsored" sports within this history, and all other activities to be listed truly as activities. However, when open to subject interpretation, all physical activities counted as sports. This may be related to subjects or their surrogate respondents wanting to seem more active than they are, which could limit our data. Additional limitations to this study is the nature of the study itself. External phone surveys have an average 7-16% response rate.[128] Our study produced a 22.7% response rate, and while having a higher response rate than the average phone survey, this may have limited the data that could be acquired from the pediatric endocrinology practice. Future research related to sports participation history may consider utilizing an online or paper survey to be filled out at patient visits as part of the usual care. Additionally, PCOS researchers may look to collegiate athletic departments to further identify sport specific trends within the female athlete population.

Conclusions

Overall, while sport participation was widely distributed amongst nineteen unique sports within our sample, trends amongst position groups were identified. Larger studies are needed to confirm these trends. Additionally, the attrition rate of sport participation, combined with the low physical activity outside of sport participation indicates a need for increased education on the benefits exercise can play on symptom management of PCOS.

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Appendix A. IRB-Approved Phone Scripts and Data Sheet

Phone Consent Script for Parent:

Good afternoon (morning, evening), my name is ___ and I am a student in the sports nutrition laboratory at Ohio State University. We are partnering on a research study with Dr. Dyer/Ziff and Lozano and COPEDS, can I have a few minutes of your time?

We have been in multiple conversations with Dr. Dyer and some other staff at the office talking about PCOS and how much of it we might see in athletes. We are hoping to recruit as many patients as possible and the protocol is approved for 400 patients. This phone call will take about two minutes and will complete our data for your daughter. Because this is a research study we are required to get your consent to participate prior to asking you questions about your daughter's sports participation. We feel there is no risk to these questions, and the study may help us better understand the PCOS risk associated with certain sports. Please know that you are not required to participate, and choosing not to participate will not affect your relationship with COPEDs or Ohio State. Please know that all documents related to the study will be maintained here at the doctor's office, and our sports nutrition laboratory group will only be looking at the de-identified data. For questions, concerns, or complaints, or you feel you have been harmed as a result of participation, you may contact Ms. Jackie Buell at 614 292-9812. For questions about your rights as a participant or to discuss study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251. May we ask you or your daughter a few questions about her participation in sports?

If parent agrees to answer questions, ask interview questions.
If parent agrees for child to answer questions, get assent from child.
If parent declines: Thank you, have good day.

Phone Assent Script for Minor Assent or Young Adult Consent:

Good afternoon (morning, evening), my name is ___ and I am a student at Ohio State University. We are partnering on a research study with Dr. Dyer/Ziff and Lozano and COPEDS, can I have a few minutes of your time?

We have been in multiple conversations with Dr. Dyer and some other staff at the office talking about PCOS and how much of it we might see in athletes. We are hoping to recruit as many patients as possible and the protocol is approved for 400 patients. This phone call will take about two minutes and will complete our data for you. Because this is a research study we are required to get your consent to participate prior to asking you questions about your sports participation. We feel there is no risk to these questions, and the study may help us better understand the PCOS risk associated with certain sports. Please know that you are not required to participate, and choosing not to participate will not affect your relationship with COPEDs or Ohio State. Please know that all documents related to the study will be maintained here at the doctor's office, and our sports nutrition laboratory group will only be looking at the de-identified data. For questions, concerns, or complaints, or you feel you have been harmed as a result of participation, you may contact Ms. Jackie Buell at 614 292-9812. For questions about your rights as a participant or to discuss study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251. May we ask you a few questions about your participation in sports?

If minor/young adult agrees, ask question.
If minor/young adult declines: Thank you, have good day.

Telephone Script for PCOS Questions

1. Phone number is called (if patient is 18+ years old, the questions must be divulged to them. If patient is 17 years or younger, the survey can be discussed with the parent/guardian OR the patient with verbal consent of the parent/guardian).
    a. If no answer, hang up and move on. No voicemail will be left.
    b. If answer, follow protocol for minors or adults

2. Obtain consent (see above).
    a. If yes, go to step 3
    b. If no, "Thank you for your time, have a good day," and hang up

3. Does your daughter currently participate in a competitive or team sport?
    a. If yes, ask how old they are and proceed to steps 4-7
    b. If no, proceed to step 8

4. What sport/sports do you/your daughter play?
5. What position do you/does your daughter play?
6. How many hours per week do you/your daughter participate in this sport?
7. How many years has she been playing?

8. Have you/has your daughter played competitive sports for >2 years, even if not currently playing?
    a. If yes, how old were you when they first played this sport, go to steps 4-7
    b. If no, proceed to step 9

9. Are you/is your daughter physically active?
    a. If yes, ask how old they are and proceed to steps 10-12
    b. If no, "Thank you. That is all we need. Have a nice day."

10. What type of physical activity do you or your daughter participate in?
11. How many hours per week do you/your daughter participate in this activity?
12. How many years have you been doing this activity?

Data Sheet Utilized for Data Collection

Participant	Age:	Current sport participation (Y/N)	Sports >2 yr participation (Y/N)	Sport	Position	Hrs/wk in sport	Years in sport	PA (Y/N)	PA Type	Hrs/wk PA	Years in PA	Notes