

THE IMPACT OF POLYCYSTIC OVARIAN SYNDROME ON A FEMALE ATHLETE'S PERFORMANCE AND OVERALL HEALTH

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Athletes are reminded regularly of the importance of managing their sleep, nutrition, training, and stress in order to optimize athletic performance. Additional factors can be overlooked and are inadequately addressed, which may impede an athlete's ability to reach their potential. One barrier that can be a hindrance to female athletes is polycystic ovarian syndrome (PCOS). Although it has been debated whether aspects of PCOS, specifically hyperandrogenism, may be advantageous for athletes in competition, there are additional symptoms and complications of this syndrome that need discussion because of their potential negative effect on athletes with PCOS (10). PCOS is a general metabolic and endocrine disorder that affects the hormonal levels of around 10 – 20% of women (12). PCOS varies in onset, symptoms, and presentation. The etiology of this disorder is not yet fully understood. We do know that the symptoms and their presentations are interconnected as they are influenced by each other and can also be amplified by lifestyle choices, such as diet and exercise. It is necessary to better understand the symptoms and their potential complications in relation to strength training to better serve these athletes.

PCOS presents with symptoms ranging but not limited to: hormonal imbalances, infertility, irregular periods, hair loss, male pattern hair growth, pelvic pain, and weight gain (12,21). This population of women typically also suffer from insulin resistance (IR), high production of male hormones (hyperandrogenism), and potential comorbidities, such as obesity, type II diabetes, and cardiovascular disorders (13). Athletes who have experienced these symptoms have shown higher levels of free testosterone, increased levels of androgens and amenorrhea, and may have potentially advantageous biomarkers in terms of sport performance (3,6). However, struggling with IR has the potential to impede an athlete's ability to perform because of the body's inability to properly regulate insulin and more importantly, provide the body with glucose as a fuel source. IR and lack of proper storage and utilization of glucose, can hinder the athlete's recovery and subsequent hormonal pathways that are necessary for protein synthesis, muscle growth, bone density, and maintaining functional hormonal levels.

General hormonal imbalances are thought to be the major factor affecting a woman's menstrual cycle, their ability to conceive, and stimulate risks for other health complications, such as type II diabetes, obesity, and cardiovascular disease (13). Studies involving women with PCOS have varying criteria to identify women for analyses. A large majority utilize the Rotterdam criteria, a commonly used tool to diagnose women with suspected PCOS, where one must present at least two of the following: oligomenorrhea (infrequent menstrual cycles), hyperandrogenism, and polycystic ovaries (12). For the purposes of this article, those are the criteria utilized to establish a baseline for this population. To better serve these athletes, a critical review of

the scientific evidence is necessary to provide knowledge on the impact of exercise and daily living on this disorder. This article serves to educate strength and conditioning coaches on the influence exercise can have on the various hormonal pathways that are impacted by PCOS, including insulin resistance, cortisol, testosterone, follicle-stimulating, and luteinizing hormones.

INSULIN RESISTANCE

PCOS is classified as a metabolic disorder due to its potential connection to IR within women. IR occurs when the cells in the body become desensitized to insulin. The major effect of IR is that the cells are unable to effectively draw insulin from the bloodstream. In response, the pancreas releases additional insulin to help facilitate uptake of glucose out of the blood. When the cells remain resistant and there is an increase in insulin outside of the cell, fat storage is more likely to occur due to insulin's stimulation of fat storage by nature of the hormone. As the cyclic relationship between insulin and high blood pressure expands, an increased risk of developing type II diabetes occurs. However, molecular signaling pathways and GLUT4 (a glucose transporter) expression can be stimulated by exercise, which allows glucose transport into the cell (4). By allowing glucose to enter the cell, less insulin will be produced and over time the cells can become more sensitive to insulin.

The relationship between insulin resistance and athletic performance needs to be understood in order to prepare PCOS athletes for success. While there are no direct studies formulating a program for athletes with PCOS, studies with the general population have seen improvements with IR as a result of both aerobic and anaerobic training. Studies by Hutchinson et al. and Kahlil et al. found significant differences in IR and positive improvements in triglycerides levels in PCOS when performing moderate- to high-intensity aerobic training over a 12-week and 24-week period (8,17). Kahlil et al. found that women with PCOS (both with and without diabetes) were able to increase insulin sensitivity through mitochondrial biogenesis, improving glucose tolerance and insulin action (8). Additional improvements were seen in a study where the general population performed anaerobic high-intensity interval training (HIIT) workouts three times a week, resulting in significant improvements in insulin sensitivity in the experimental group (4). Programming for athletes with PCOS should entail both aerobic and anaerobic prescriptions, given the data from general population studies and lack of studies inclusive to the athletic population. Seeing improvements that benefited the general population has brought to light the lack of evident exercise programming in the field to better help athletes with PCOS. If left untreated and unmanaged, IR can cause cardio-metabolic complications; therefore, to prevent a metabolic diagnosis such as type II diabetes, women with PCOS must prioritize these training methods (4). For strength and conditioning coaches who are responsible for women's training

programs, it is critical to pay attention to their resistance training prescriptions and levels of intensity in aerobic prescriptions.

CORTISOL AND TESTOSTERONE

When working with athletes with PCOS, it is necessary to be aware of the hormonal responses to exercise and how these responses can affect their sport performance and daily lives. Exercise and the body's response to exercise releases a cascade of endocrine pathways in athletes with PCOS; these pathways influence cortisol and testosterone levels and their systemic release. PCOS makes it difficult to maintain normative cortisol levels that affect fuel substrate utilization, gluconeogenesis, immune suppression, and inhibition of insulin (20). Low levels of cortisol influence moods in athletes without PCOS. This is compounded in athletes with PCOS due to the hormonal imbalances. In response to exercise, too low or too high levels of cortisol can influence an athlete's lack of recovery, specifically protein synthesis which is negatively influenced by high levels of cortisol (16). This results in a negative calcium balance which may cause muscle atrophy and loss of bone mass. The wide spectrum of health issues in the athlete with PCOS includes having higher levels of testosterone, or excessive androgen production, which in turn will influence estrogen, a prominent hormone in development and maintenance of bone mineral density (16,20).

On the contrary, exercise can enable not only the release, but usage of testosterone for performance benefits (6). This hormone is the primary androgen, "muscle building" hormone with anabolic effects on every tissue (i.e., a receptor site on tissues). Release of testosterone is related to large muscle mass exercises, sprinting at maximal efforts, and ballistic (e.g., Olympic-style weightlifting) or plyometric training. Because testosterone has direct interaction with the nucleus, through DNA transcription and translation, protein synthesis will aid in recovery and muscle growth while increasing glycogen storage efficiency (16). It has been hypothesized that testosterone level recovery following training may present an athletic advantage in athletes with PCOS (6,14).

A common hormonal side effect to resistance training in this population is low levels of testosterone following exercise. This is typical after strength training in men, where testosterone levels drop due to the presence of cortisol (14,19). Strength and conditioning coaches must understand how exercise can elicit a systemic response to an unbalanced system and ensure training programs account for adequate rest and recovery between training sessions to bring hormonal levels to equilibrium. PCOS symptoms can present differently depending on the individual. It is imperative to be aware of how individual athletes respond to training and be able to modify training, similarly to how exercises are adjusted for an injured athlete by an athletic trainer. Abnormal cortisol levels present signs, such as difficulty sleeping, inability to fully recover from training sessions, slow injury recovery, and intolerance to exercise (20). Monitoring of appearance and subjective reporting during and after training should occur, as well as emphasizing positive recovery habits and encouraging

athletes with PCOS to maintain constant communication with their physician or medical professionals.

LUTEINIZING HORMONE AND FOLLICLE-STIMULATING HORMONE

One of the main characteristics of PCOS is hyperandrogenism; a state characterized by excess production/secretion of androgens (9). This is usually manifested by acne, abnormal hair growth, or frontal alopecia. Two hormones affected by PCOS are luteinizing hormone (LH) and follicle-stimulating hormone (FSH), both of which play a role in encouraging ovulation (9). For individuals with PCOS, LH:FSH ratio is typically not within normal ranges, they have elevated LH levels and decreased FSH levels (8). Abnormal LH:FSH ratios can disrupt ovulation and negatively affect bone health. In a review conducted by Krishnan and Sridhar, decreased levels of FSH, accompanied by increased levels of LH, may lead to decreased bone mineral density (BMD) (9). This is important because women with PCOS may have LH levels 2 - 3 times the amount of FSH (9). In addition, there seems to be a correlation between collegiate distance runners' and competitive recreational runners' menstrual irregularities and the prevalence of stress fractures (20). Unfortunately, it is difficult to gauge BMD unless an injury occurs (20).

Strength and conditioning coaches need to be aware of how this information can be used. With the link between PCOS and decreased bone health, strength and conditioning coaches can play a vital role in increasing BMD of impacted athletes. Perhaps in endurance athletes, a reduction in initial overall load may be beneficial to the long-term bone health for these athletes. Because the cause of stress fractures may be increased load and fatigue over time, and athletes with PCOS may have compromised BMD, excess volume may cause more damage and limit the amount of adaptation (18). One possible avenue to combat this is a periodized resistance training program. Research shows that resistance training has a positive effect on increasing BMD and greater intensities of resistance training will promote greater degrees of bone formation when exercise is properly progressed (17). Athletes will be at a lesser risk of developing osteoporosis later in life because of healthier bones due to resistance training (17). Additional literature implies resistance training may increase FSH levels (2). Seeing improvements in FSH through resistance training would suggest a possible long-term beneficial adaptation to utilize when programming for athletes with PCOS (2). Conversely, the literature suggests that aerobic exercise may increase LH levels (11). Therefore, athletes with PCOS should primarily focus on strength training, while limiting excess aerobic training to best control their LH:FSH ratio. While there are no specific guidelines geared towards athletes with PCOS, following a properly structured training program with attentive coaching may result in increases in cardiovascular and bone health, as well as lead to improvements in LH:FSH ratio, which have direct performance benefits (17).

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PRACTICAL IMPLICATIONS

The mental health of an athlete is extremely important to assess throughout the season to ensure overall health. Changes in LH and FSH levels can have detrimental effects on mental and physical health in athletes with PCOS. Changes in physical appearance and impacted health can have negative effects on the athlete's ability to perform. Body image insecurities stemming from cystic acne, facial hair growth, and/or hair loss can contribute to athletes' anxiety, particularly at practices, team workouts, or simply being out on campus, stemming from societal views of facial hair on women. PCOS can significantly exacerbate mental health symptoms because of the substantial negative influence on mental health and already elevated levels of depression in collegiate female athletes (1,8,15).

PCOS is a lifelong health complication; however, it can be managed with proper monitoring, lifestyle support, and further learning. As a strength and conditioning coach that has daily communication with athletes, we must be aware how their performance can be affected and methods to help them succeed. Long-term health awareness should be prioritized for the athletes to improve their PCOS symptoms in the present and to set them up for success and maintenance of health in the future.

Strength and conditioning coaches and athletes should acknowledge the potential benefits to PCOS; for example, hyperandrogenism has been seen to be indirectly related to improved physical performance and greater overall ability to withstand greater loads (10). As stated earlier, increased levels of testosterone in athletes with PCOS can aid in recovery and strength building capabilities (6,14). Both of these hormonal imbalances for athletes with PCOS can be perceived advantages and should be considered when programming.

CONCLUSION

The purpose of this article is to review the hormonal effects of PCOS on athletes' performance and health. Understanding the impact of PCOS on insulin, cortisol, testosterone, LH and FSH may help athletes maintain health and improve performance. IR can directly affect the athlete's ability to utilize glucose. Impairments in performance can be improved by targeting their IR and increasing the cells' sensitivity to insulin. Improving IR through resistance training and HIIT aerobic workouts can help to prevent further metabolic conditions. Cortisol and testosterone levels are varied at baseline in PCOS, but essential in exercise recovery. The relationship between these hormones should be inverse after exercise, with cortisol levels rising and testosterone lowering, before returning to homeostasis. An athlete's ability to tolerate exercise and recovery for the following training sessions is determined by how well their central nervous system adapts after training sessions. Exercise for the athlete with PCOS does not have to solely be resistance training. Various studies used aerobic exercise as a substitute for resistance training and a therapeutic approach (e.g., 30 – 60 min of aerobic exercise), aiding in recovery

and systemic inflammation with hormonal levels remaining unchanged (4,7,11,12).

Considering the information in this article, resistance and specificity of aerobic training may be effective to shift serum LH and FSH levels within normal ranges and create performance benefits and healthier athletes. A better understanding of these metabolic and hormonal symptoms in athletes with PCOS will benefit them. These applications and potential health complications must be considered throughout training protocols, practice, and overall team requirements. Athletes' health throughout their careers at any level is as important as their performance on the field, however their health post-athletic career must be considered as well.

Future research should explore the specific group of athletes with PCOS. There is a clear need to dive deeper into the specific hormonal levels of these athletes and impact this syndrome can have on their performance, mental health, and life after athletics. Studying these athletes can help to identify a much clearer protocol to program their workouts, practices, and recovery to optimize performance. The current lack of evidence does not allow for a comprehensive understanding of their health, nor does it provide the ability to develop the athletes to their greatest potential.

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ABOUT THE AUTHORS

Avery Dravis-Stark recently completed her Master's degree at Sacred Heart University with the Department of Physical Therapy and Human Movement Science in May 2021. Previously, she completed her undergraduate Bachelor of Science degree in Kinesiology at Rutgers University. For the past seven years, Dravis-Stark has been coaching high school girls' club volleyball as both an assistant and head coach. After interning at Sacred Heart's Bobby Valentine Center as a certified personal trainer, she is currently working as a fitness professional and nutrition coach at Life Time Athletic Center in Montvale, NJ.

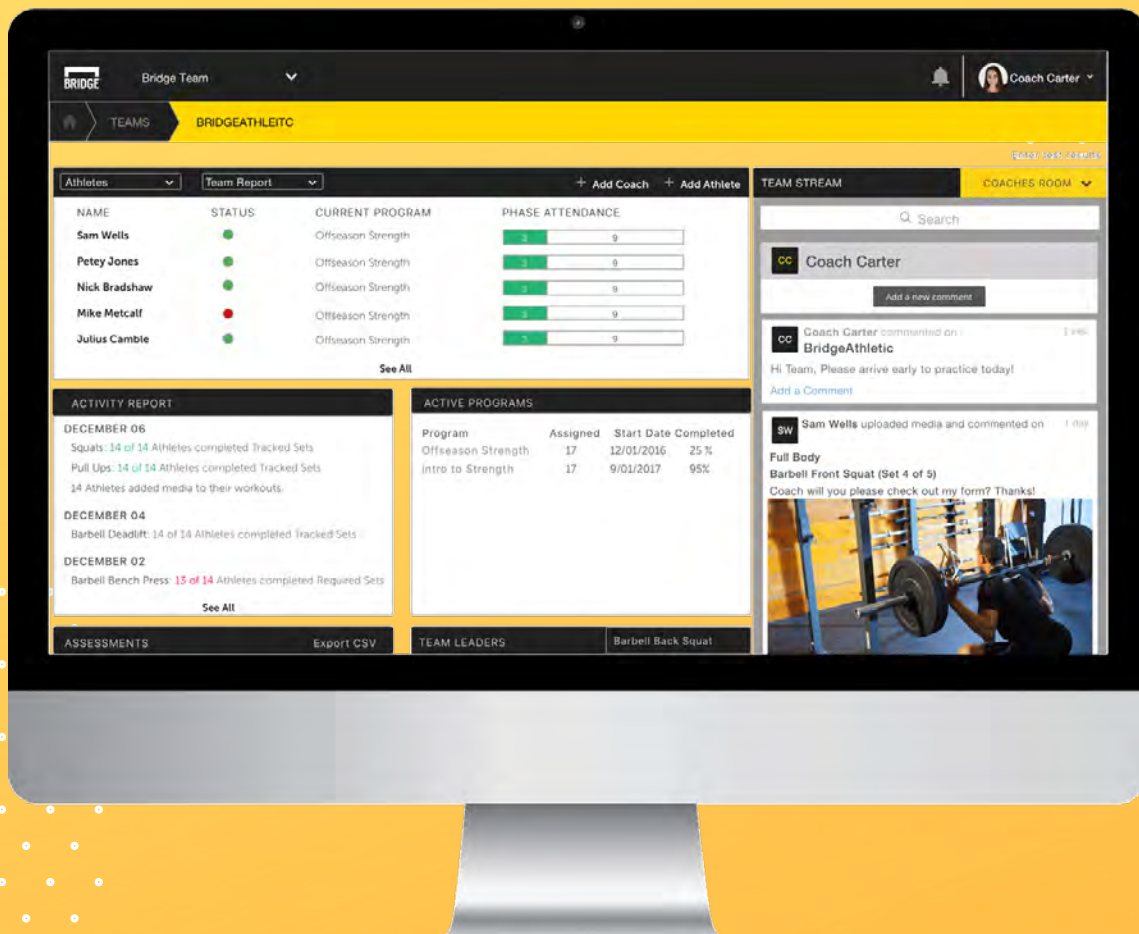
Winnie Victor is a recent graduate of Sacred Heart University's (SHU) Master of Exercise Science and Sport Nutrition program after graduating with an undergraduate degree from SHU in Athletic Training. She served as a Graduate Assistant at the SHU Fit Health and Wellness Center during her two years of her graduate studies. She interned with the SHU Elite Gymnastics team providing strength and conditioning and corrective exercise programs. With a background in athletic training, Victor has been working as an athletic trainer at various competition levels and is now working at Post University in Waterbury, CT.

Cait Finn is an educator and advocate with a background in college strength and conditioning. She holds a Master's degree in Exercise Science and Human Performance. Finn specializes in working with individuals with hormonal disorders, specifically polycystic ovary syndrome (PCOS), taking a whole-person approach to help them balance their hormones.

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