Original Research Article

THE IMPACT OF HYPERTHECOSIS ON SPORTING PERFORMANCE OF FEMALE PLAYERS

ABSTRACT

Testosterone is an anabolic hormone that increases muscle mass and strength, stimulates erythropoiesis, promotes competitive behavior and enhances the sporting performance of female athletes. A comparative study was designed on forty female athletes who were selected from the three public and private sector universities of Lahore, they had been diagnosed with HTC by a qualified gynecologist based on clinical features and lab tests. At the same time, a healthy group of female athletes (n=40) was selected from participants of the same population and having regular menses and showed no clinical features of HTC. The main objectives of the study included: 1) to compare both the groups of female athletes on clinical features of HTC, and 2) to compare both the groups on self-perceived sports performance. Data collection was done using two different instruments involving the "Hyperthecosis Questionnaire (HTCQ)" and "Athlete's Subjective Performance Scale (ASPS)". Data analyses involved descriptive analysis followed by an "Independent Sample t test' to compare the physical and psychological impact of HTC and ANOVA was applied to analyze the impact of HTC on sports performance. There were significant differences between female athletes with HTC and those with Non-HTC on physical and psychological conditions. it can be concluded that female athletes with HTC were more concerned about their physical and psychological conditions. Moreover, their sporting performance was statistically significantly higher than Non-HTC athletes, which is attributed to higher energy levels caused by HTC itself.

Key Words: *polycystic ovary syndrome, HTC, female athletes, sporting performance*

Introduction

Hyperthecosis (HTC) is perhaps the most widely recognized endocrine issue in females of reproductive age, influencing up to 20% of individuals of this populace. It is worth mentioning that HTC is heterogeneous; normal clinical and biochemical indications of this condition incorporate hyperandrogenism, menstrual dysfunction, and polycystic ovaries. The specific reason for HTC isn't known to date. As per scientific examinations, it has all the earmarks of

being a blend of three unique elements, including the genes, environmental and components like hormonal imbalance (Hossein, 2015).

1.1 Genetics

There is evidence of a genetic component based on the existence of family clusters and twin studies have shown a two-fold increase in HTC concordance in genetically identical twins compared to non-identical twins (Unluturk, 2007). Despite numerous association, studies focusing primarily on genes associated with androgen and insulin synthesis and metabolism, how HTC is inherited remains unclear. Recent efforts, using modern mapping techniques, have made some progress in identifying promising candidate genes. So far, two promising candidate genes have emerged. The first, a locus on the chromosome is associated with a high susceptibility to HTC and the second is the gene associated with fat mass and obesity, whose polymorphism has been associated with HTC (Mutharasan, 2013). However, studies involving these two loci need to be confirmed in larger studies and other populations of different age groups and different nations.

Many other studies have suggested that there is an increased risk of HTC in young females with a family history of HTC. It is observed that many young females with low birth weight and those with a family history of diabetes or premature cardiovascular disease are at increased risk of developing HTC. Metabolic disturbances begin early in adolescence and also exist in adolescent relatives of females with HTC, even before clinical signs of HTC become apparent (Melin, 2019).

1.2 Environmental factors

Regarding the origin of HTC, environmental factors such as prenatal exposure to androgens known as a male sex hormone, such as testosterone (T) and weight gain have been discussed as contributing factors (Tukan, 2016); therefore, genetic factors can lead to high susceptibility to HTC and the syndrome to develop only in the presence of a specific environment, most likely with exposure during fetal life or early childhood (Costello, 2014). Excess fetal exposure to maternal androgens is believed to contribute to inducing the HTC phenotype (Gur, E. B., 2015) in children based on experimental data from animal studies (Makieva, 2014), as well as clinical material from pathological conditions in humans and higher levels of T have been observed, which they were elevated to male levels found in the umbilical vein in girls born to mothers with

HTC (Arentz, 2017). However, the only prospective study of the relationship between prenatal androgen exposure and the development of HTC during female adolescence did not confirm any association between these variables.

1.3 Biochemical and Metabolic Issues

The key biochemical irregularities of HTC incorporate hyperandrogenism, hyperinsulinemia, and ovarian brokenness. A considerable lot of the biochemical attributes of HTC worsen one another, further expanding the seriousness of the repeating condition. Treatment of HTC requires a comprehension of these interrelated biochemical issues. Biochemical hyperandrogenism is the most normally communicated component of HTC. There might be clinical markers to distinguish hyperandrogenism in an individual, in any case, biochemical hyperandrogenism can be surveyed by an estimation of serum androgen list (Hosseini, 2017).

In HTC, the degrees of luteinizing hormone (LH) and T are raised. LH and follicle invigorating chemicals (FSH) are associated chemicals of the pituitary and assume a part in the ovulation cycle concerning incitement and development of the follicle (Bensoussan, 2017). The presence of androgens is essential for typical follicle improvement and estradiol combination. In any case, on account of HTC and expanded androgen levels, there is restricted follicular development and surprisingly follicular demise. An expanded proportion of LH and FSH is normal in HTC (Saadia Z. 2020).compared to controls. Metabolic irregularities, for example, hyperinsulinemia and insulin opposition, are addressed in 75% of youthful females with HTC (Nimrouzi, 2018). It has been recognized in the writing that insulin affectability is diminished in these females paying little mind to BMI and other metabolic irregularities. Hyperinsulinemia has been found to increment endogenous androgen levels, just as ovulatory brokenness and richness issues (Arena, 2015).

In these females, hyperandrogenism is accepted to be integral to ovulatory brokenness. Antral follicles, which have been captured being developed, are the "pimples" depicted in the condition, which are accepted to be available because of hyperandrogenism that diminishes estradiol amalgamation and stops follicular development. The biochemical and metabolic components of HTC drive and worsen one another, demonstrating the need to zero in on how best to deal with the manifestations related to these elements (Najem, 2018).

1.4 Impact of HTC on Sport Performance

The hormonal status of an athlete affects health and performance. While amenorrhea related with low energy accessibility has been displayed to diminish execution, the hormonal profile in HTC, where androgens are higher (Bruinvels, 2016). Androgens have been observed to be a necessary piece of the safeguarding of bone and muscle tissue. While addressing a pharmacological intercession, research on the utilization of exogenous androgenic anabolic steroids shows an improvement in athletic execution through diminished exhaustion, expanded force. Skeletal muscle is exceptionally receptive to T and helps increment skeletal bulk, which thus can expand energy execution and influence body creation. A meta-examination on exogenous T showed that supplementation helped body synthesis in men by expanding fit mass and diminishing fat mass. Body structure information from females with HTC showing endogenous androgenic profiles feature an increment in fat mass contrasted with controls without HTC, notwithstanding an expansion in slender mass. Endogenous androgens in youthful females have been less concentrated comparable to brandishing execution; notwithstanding, the predominance of competitors with HTC might reflect an advantage for sporting performance (Hirschberg, 2020).

1.5 Significance

Physical activity (PA) is important for maintaining good health and promotes the maintenance of lean muscle mass, improves sleep habits, improves mental health, and helps reduce the risk of chronic diseases. Teen participation in sports can contribute to general PA needs. Additionally, there is a potential benefit of elevated androgens in female athletes when it comes to explosive power, lean mass, and cardiovascular fitness. Since HTC can be a reason for an athlete to have amenorrhea, the sports dietitian must be familiar with the clinical features and treatment modalities of HTC. Very little is known about the sports participation of female athletes with HTC considering that PA is an important part of the disease and weight control. An examination of female athletes with HTC and non-HTC may help to better understand which athletes should be most frequently screened for HTC and how characteristics of the syndrome may influence sports selection.

Literature Review

Current studies report the prevalence of female athletes who present with menstrual dysfunction to be higher than the general population. Menstrual dysfunction related to HTC has been reported to be around 15%, but only a handful of studies have looked at HTC prevalence in

female athletes, indicating a need for more research in this area as reported by Lebrun, (2010). Clinical health outcomes for females who are diagnosed with HTC include increased risk for infertility, dysfunctional bleeding, endometrial cancer, obesity, type 2 diabetes, dyslipidemia, hypertension, and cardiovascular disease. Given that HTC can result in many different clinical health outcomes, the proper diagnosis of HTC is essential for knowing how to manage the symptoms and mitigate risk associated with the potential negative health and reproductive outcomes (Lua, A., 2018).

The clinical characteristics of HTC are heterogeneous among diagnosed individuals, but each represents a disturbance in reproductive, endocrine, and metabolic function. These clinical manifestations include menstrual abnormalities, hirsutism, acne, alopecia, weight gain and obesity. These females are also at risk of developing psychological problems. Long-term effects of the disease may lead to serious complications (Kitzinger, 2012).

2.1 Menstrual Abnormalities

Menstrual dysfunction is one of the clinical characteristics associated with HTC and is additionally seen in over-trained or under-fueled female athletes as reported by Hosseini, (2017). Menstrual dysfunction is inconsistently defined in the literature and the prevalence of amenorrhea is reported to be 66% in female athletes (Janse, 2013). In the HTC population, menstrual dysfunction is typically seen as amenorrhea, and those who are amenorrheic are typically seen as having a more severe presentation of HTC (Goodman, 2005). The published literature reflects that 15% of female athletes with menstrual problems were diagnosed with HTC. Limited studies to date have been published assessing female athletes with HTC, highlighting a need for further research in this population. Current evidence supports a close relationship between the degree of cycle irregularities and the grade of endocrine and metabolic disorders among these females (Constantin, 2015).

2.2 Hirsutism

Hirsutism is the only sufficient substitute for biochemical hyperandrogenism in adolescents, as acne is common during this period and alopecia is very uncommon (Spritzer, 2016). These physical signs are particularly noted in any clinical exam. Hirsutism is the appearance of dark, coarse hair in a male-like a pattern in females, which is a very common sign of HTC, presenting in approximately 75% of young females with HTC (Kopera, 2010). The severity of hirsutism is

visually scored using mFG, which is the current gold standard in assessment. The mFG scores body sites including upper lip, chin, and chest, upper and lower, back, upper and lower abdomen, arms, and thighs. Total scores are ranked out of and hirsutism is recognized as mild up to 15 and severe above 25 (Ekbäck, 2011). Hirsutism is an outward sign of elevated androgens.

2.3 Acne

Acne and androgenic alopecia are not essential to the diagnosis of HTC; however, these symptoms are seen frequently within this population (Chuan, 2010). Acne is a common complaint among many females and is found more frequently post-adolescence in females with HTC than those in the general population. Also, the presenting acne is typically resistant to many topical treatments. In a study by Gainder, (2019) females presenting with acne, 39.6% of participants were diagnosed with HTC (Tukan, 2016). Females with resistant acne, alongside additional clinical symptoms of HTC, require further biochemical explorations to identify if a diagnosis may be present.

Alopecia is defined as the thinning of hair or scalp hair loss affecting approximately 36.6% of females with HTC (Gainder, 2019). In a cross-sectional study by Misso, (2018) androgenic alopecia was found in 23% of patients with HTC, but this clinical finding was not tied to increased hyperandrogenism or other metabolic parameters. Genetic or environmental factors may also play a role related to hair loss in these females.

2.4 Obesity

Obesity is commonly seen in females with HTC, although not all females with HTC are obese. Obesity has been shown to contribute to HTC symptoms, and the amount of visceral fat, in particular, has been shown to play a key role (Sam S. 2007). Visceral adipose tissue releases several adipocytes, including adiponectin. Adiponectin has decreased expression in obesity and has been linked to insulin resistance. Adiponectin is an insulin-sensitizing, anti-inflammatory molecule ((Nimrouzi, 2018). A meta-analysis in 2014 noted lower total adiponectin levels in HTC females compared with normal controls, independent of BMI. Visceral fat likely contributes largely to insulin resistance, which leads to the development of impaired glucose tolerance and type 2 diabetes. The conversion rate of insulin resistance to diabetes is estimated to range from 2.5% to 3.6% annually throughout 3 to 8 years ((Nimrouzi, 2018).

2.5 Psychological Effects

Females with HTC are more prone to have depression, anxiety, low self-esteem, a negative body image and psychosexual dysfunction. There are concerns with feminine identity and body image, largely thought to be attributed to increased prevalence of obesity, acne, excessive male-pattern hair, infertility, and long-term health consequences (Keegan, 2013). These are thought to lead to poor body image, and mood disturbances as reported by Bazarganipour, (2013) who evaluated the symptoms of depression, anxiety, and perceived stress in females reporting HTC and females without HTC. The findings indicated that even after adjusting for BMI, infertility diagnosis, sociodemographic factors, females with HTC were still more likely to be depressed, anxious and have a higher level of perceived stress (Dokras, 2012).

2.6 Long-Term Complications

Young females with HTC are at a higher danger for comorbidities (Mousiolis, 2012), for example, weakened glucose resistance, metabolic disorder, hypertension, dyslipidemia, and endometrial hyperplasia (a state of the female conceptive framework wherein the coating of the uterus turns out to be surprisingly thick a direct result of having such a large number of cells). Endometrial hyperplasia, if not treated, can lead to endometrial cancer (Teede, 2014). Young females with HTC are also likely to be at increased risk for cardiovascular disease (CVD) later in life (Barrack, 2013). The presence of stoutness in teenagers with HTC further adds to this intricacy as it is connected with the thickening of the intima-media of the carotid supply route (Enns, 2010). These females will in general have a higher BMI and systolic pulse than solid females, which expands their danger for carotid conduit sickness to that of grown-ups with the illness (Abasian, 2018). Mental issues like gloom, tension, bipolar turmoil, and voraciously consuming food issues are likewise noted to be among the drawn-out difficulties found in people with HTC (Loucks, 2012). Early conclusion, counteraction, and treatment are thusly significant (Kozica, 2016).

The main objectives of the present study included: 1) to compare both the groups of female athletes on clinical features of HTC, and 2) to compare both the groups on self-perceived sports performance.

3. Methodology

The comparative study was designed and conducted in which a sample of female athletes (n=40) who had been diagnosed with HTC by a qualified gynecologist based on clinical features and lab tests. At the same time, a healthy group of female athletes (n=40) was selected from participants of the same population and having regular menses and showed no clinical features of HTC. Data was collected from The University of Punjab, The University of Lahore, and The University of Lahore College for Women. Data collection was done using two different instruments involving the "Hyperthecosis Questionnaire (HTCQ)" and the "Athlete's Subjective Performance Scale (ASPS)". Data analyses involved descriptive analysis followed by an "Independent Sample t test' to compare the physical and psychological impact of HTC and ANOVA was applied to analyze the impact of HTC on sports performance.

4. Results

Results of the present study are given below.

Table1

Descriptive Analysis

Condition		Age	BMI	Experience
HTC	Mean	24.2750	31.4500	2.6000
	N	40	40	40
	Std. Deviation	1.86723	1.13114	.59052
Non-HTC	Mean	24.2250	25.0250	2.6500
	N	40	40	40
	Std. Deviation	1.84651	.91952	.53349
Total	Mean	24.2500	28.2375	2.6250
	N	80	80	80
	Std. Deviation	1.84528	3.39114	.55972

The mean age of female athletes with HTC was (M=24.27, SD=1.86) and Non-HTC female athletes (M=24.22 SD=1.84); BMI of female athletes with HTC was (M=31.45, SD=1.13) and Non-HTC female athletes were (M=25.02, SD=0.919); the experience of playing team sports of female athletes with HTC was (M=2.60, SD=0.590) and Non-HTC female athletes were (M=2.65, SD=0.53) as shown in Table-1.

Table-2

Physical and psychological conditions of female athletes with HTC and Non-HTC

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Weight Issues	Equal variances assumed	.024	.877	15.104	78	.000	1.82500	.12083	1.58445	2.0655
Body Hair	Equal variances assumed	9.267	.003	25.108	78	.000	2.72500	.10853	2.50893	2.9410
Menstrual Problems	Equal variances assumed	9.513	.003	20.976	78	.000	2.25000	.10727	2.03645	2.4635
Helplessness	Equal variances assumed	4.356	.040	17.775	78	.000	2.05000	.11533	1.82039	2.2796
Low Mood	Equal variances assumed	27.739	.000	8.449	78	.000	1.42500	.16866	1.08923	1.7607

Table-2 indicates that there were significant differences between female athletes with HTC and those with Non-HTC on physical and psychological conditions. Weight issues t (78) =15.104, (p= .000), Body Hair t (78) =25.108, (p= .000), Menstrual Problems t (78) =20.976, (p= .000), Helplessness t (78) =17.775, (p= .000), and Low mood t (78) =8.449, (p= .000).

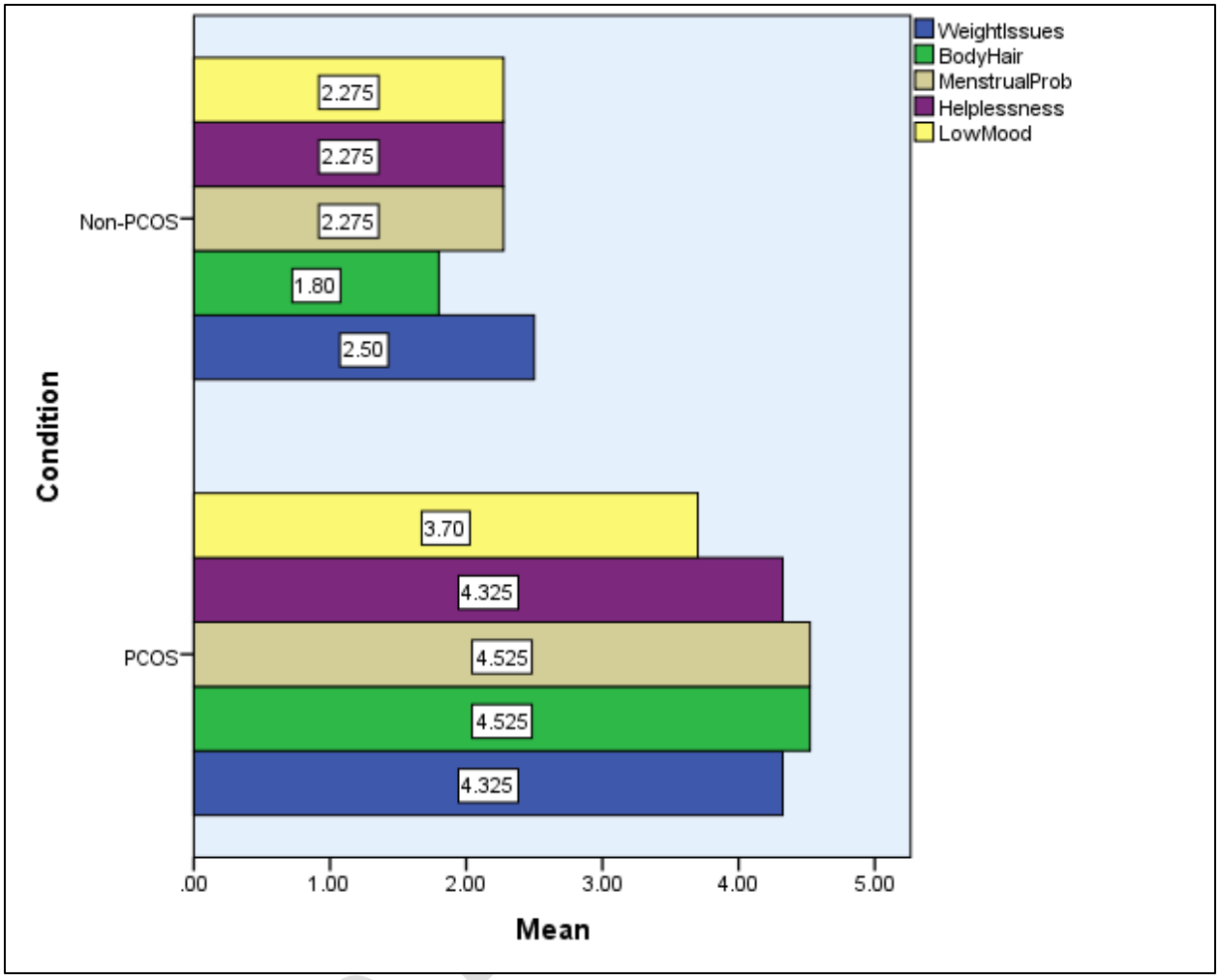

Figure-1: *Mean comparisons of physical and psychological conditions of female athletes with HTC and Non-HTC*

Table-3

Impact of Hyperthecosison Sporting Performance

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	27.612	1	27.612	58.566	.000
Within Groups	36.775	78	.471		
Total	64.387	79			

Table-3 indicates that the significance value (p = .000), which is below 0.05 and, therefore, there is a statistically significant difference in the mean sporting performance.

5. Discussion

The findings of this study indicated a significant effect of HTC on sporting performance. A few studies had shown that T levels in the blood may not accurately predict enhanced sports performance in female athletes showing levels within the normal female range, there are grounds to claim that very high levels of blood T increase sporting performance in females with androgen sensitivity (Banfi, 2016).

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 HTC where androgens are higher may show improved sporting performance. Androgens are integral in the preservation of bone and muscle tissue (Hardy, 2013). While it represents pharmacological intervention, research on exogenous androgenic-anabolic steroid use shows improvement in sporting performance through decreased fatigue, increased power and lean body mass (Mario, 2012). Skeletal muscle is highly responsive to T level, and aids in increases of skeletal muscle mass, which can in turn increase power performance and affect body composition on T level indicated that supplementation benefited body composition in men by increasing lean mass and decreasing fat mass (Carmina, 2009). Body composition data on the female with HTC who exhibit endogenous androgenic profiles highlights an increase in fat mass compared to non-HTC controls, in addition to an increase in lean mass. Endogenous androgens in females have been less studied related to sporting performance; however, the prevalence of female athletes with HTC may reflect an advantage to sporting performance (Hirschberg, 2020).

Naturally present androgen metabolites and precursors, such as T levels, Androstenediol and Etiocholanolone glucuronide, have all been associated with performance outcomes in female athletes. Wood, (2012) revealed that there is a positive correlation involving the presence of increased T level and explosive performance in female athletes. Similarly, serum was strongly linked to both explosive power and lean mass- two critical components of sporting performance in female athletes. Arngrímsson, (2004) found higher maximal oxygen uptake (VO2 max) exhibited in hyperandrogenism or amenorrheic athletes compared to non-HTC athletes. These findings suggest athletes with HTC potentially being at a competitive strength advantage; however, more research is needed.

Female athletes are more likely to have higher T levels, which should be taken into consideration by sporting regulations, according to new research. According to the findings of a few studies, researchers show that top female athletes are more likely to have higher T levels and mild disorders, as well as more severe and rarer conditions that increase T levels (Hirschberg, 2020). These findings suggest that higher T levels can enhance sporting performance in females, to levels more comparable to male physiology, and raises questions on how to ensure fairness of competition in female athletes.

Athletes must have separate male and female events to maintain fair game, as men naturally have physical advantages in strength, speed, and endurance. These characteristics are widely accepted to be due to men having 15- to 20-fold greater levels of T than children or females at any age (Wood, 2012). Recent regulations introduced by the International Association of Athletics Federation (2020) and the International Olympic Committee (2019) on the management of naturally high T levels in female athletes have been controversial. The new regulations require females with high levels to medically reduce them to be allowed to compete, however, the fairness and morality of these rules have been challenged by human rights and academic experts.

The reasons behind a high level of T levels in females are complex and may be caused by common disorders like HTC or rarer conditions such as having the male Y chromosome. Studies in men show a clear relationship between T levels and enhanced sporting performance but fewer studies have examined this relationship in females. Many studies have shown that females with very high testosterone levels develop muscle mass and physical endurance more similar to that of men. They also found that top female athletes were more likely to have higher naturally occurring levels of testosterone and to have HTC (Handelsman, 2018).

6. Conclusion

Based on the results, it can be concluded that female athletes with HTC were more concerned about their physical and psychological conditions. Moreover, their sporting performance was statistically significantly higher than Non-HTC athletes, which is attributed to higher energy levels caused by HTC itself. Future research must focus on measuring the energy level of female athletes with HTC and Non-HTC to confirm that the higher energy level among female athletes is due to naturally occurring T levels.

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