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ORIGINAL

THE RELATIONSHIP BETWEEN IRREGULAR MENSTRUAL CYCLE AND BONE STRESS INJURIES IN FEMALE ATHLETES

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ABSTRACT

Irregular menstrual cycle (IMC) is commonly observed among women athletes due to different internal and external factors such as continuous exercise, increase stress, pressure and other associated factors. Therefore, an IMC not only impact the reproductive wellbeing of women, it also negatively impacts their psychological and physical wellbeing. The usage of hormonal contraceptives (HC) is commonly observed among women athletes with IMC. This study mainly focuses on the association between IMC, HC usage and bone stress injuries (BSI) among women athletes from “Youth and Sport Administration” (YSA) in Turkey. It is a cross-sectional study. For this study, the data was collected via online survey. About 1010 women athletes from YSA participated in this study. The mean age of the selected participants was greater than 18 years. An online survey was conducted to determine different factors which influence the IMC and HC usage among women athletes. The results obtained from this study showed that 480 of the participants had a past history of IMC while 530 had no past history of IMC. There was a significant association between IMC and the current usage of HC (p= 0.0031). The women athletes with past IMC have higher menarche age than the athletes who did not have IMC in the past (p< 0.0011). Additionally, 255 of the women athletes stated to have a past history of BSI. The use of HC was prevalent among the women athletes. Most of them utilized HC for birth control and maintaining their menstrual cycle. Therefore, it is difficult to monitor IMC among the women athletes who are taking HC.

KEYWORDS: Women Athletes, Hormonal Contraceptives, Bone Stress Injuries, Turkey, Irregular Menstrual Cycle

1. INTRODUCTION

Menstrual irregularity (MI), which is characterized by amenorrhea, oligomenorrhea, luteal phase deficit, or anovulation, is common in female athletes (Carson et al., 2022). It also comprises the Female Athlete Triad (Triad) (Beaudry et al., 2022). Along with low bone mineral density (BMD) and bone stress injuries (BSIs), the Triad also includes poor energy availability. The most frequent reasons for MI in female athletes are low energy availability or improper nutrition. Long-term health effects of the Triad may include infertility, a failure to reach optimum bone mass, an increased risk of stress fractures, nutritional inadequacies, and psychological issues (Łuszczki et al., 2021). Low BMD has been associated with MI, which presents as secondary amenorrhea during the teenage years, among elite female athletes older than 20 years old(Nose-Ogura et al., 2020). Female athletes frequently use hormonal contraceptives (HCs), particularly oral contraceptive pills (OCPs), which contain exogenous estrogen and progestins, for birth control, to treat Triad-associated MI, to lessen menstrual symptoms (such as bloating and cramping), to lessen conditions brought on by excessive monthly blood loss, and to treat Triad-associated MI (Sendra-Perez et al., 2023). In advance of athletic activities, OCPs can also be utilized to regulate the time and/or beginning of breakthrough bleeding (Prado et al., 2022). HCs are routinely used in the general population, but research on female athletes is scant. Unfortunately, HCs can have negative impacts on female athletes who are at risk for or already have the Triad because they enable them to confuse the withdrawal bleed for a monthly cycle (Beaudry et al., 2022). Cheng et al. (2021)the group of female collegiate athletes frequently used HC, and almost half of them had previously experienced MI. The desire for regular menstrual cycles was cited as the primary motivator for 24% of female athletes, indicating the need for greater athlete knowledge to prevent MI and the Triad from being covered up with HCs. Adolescent/young female athletes with BSI in high-risk areas (e.g., the femoral neck, the sacrum) may have underlying risk factors (e.g., poor general bone health, low energy availability) that should prompt extra workup and referral to enhance these athletes' health (Holtzman et al., 2022). Adolescent/young female athletes with BSI in high-risk areas (femoral neck, sacrum) may have underlying risk factors (such as poor general bone health, low energy availability), which may urge further workup and referral to improve these female athletes' health (Holtzman et al., 2022). Through a number of interconnected pathways, such as hypogonadism, decreased insulin-like growth factor-1, and the uncoupling of osteoclast and osteoblast activity (De Souza, Nattiv, et al., 2019), low EA may be a factor in compromised bone health, which can result in low BMD or an increased risk of bone stress injuries (BSIs) (Ackerman et al., 2019), These overuse fractures or responses, also known as stress fractures or stress reactions, commonly affect women athletes who perform repetitive mechanical loading-intensive tasks. Due to the fact that low EA states diminish the typical increases in skeletal health that occur from participating in sports, these women

athletes are more likely to have low BMD and BSI than their colleagues who have access to sufficient amounts of energy(Ackerman et al., 2019). Several of those risk injuries have additional health risks if they are not treated right once. A tension-sided femoral neck BSI, for instance, raises the possibility of nonunion and necessitates surgical treatment (Egol et al., 2020). Advanced compression-sided femoral neck BSI may result in decreased blood flow and femoral head osteonecrosis. Reviewing the severe effects of energy deprivation and available methods for effective management is crucial as young athletes face a time of rapid change and unpredictably high societal demands. There are few research examining the connections between HC use, BSIs, and MI among female collegiate athletes. This study's objective is to look into any connections between irregular menstrual cycles and the frequency of bone stress injuries in female athletes. We want to provide insights into the variables that may increase a female athlete's vulnerability to bone stress injuries and to inform tactics for injury prevention and management by investigating menstrual cycle patterns and their effect on bone health.

2. Literature Review

Recent years have seen a rise in interest in the link between irregular menstrual cycles and bone stress injuries in female athletes due to potential implications for women's athletic performance and general health. Although several limits and contradictions should be taken into account, numerous studies have looked at this link and shed light on various elements of the problem. Female athletes with irregular menstrual cycles had a higher rate of stress fractures than those with normal cycles, according to early research by (Holtzman & Ackerman, 2021) . According to their research, hormonal imbalances brought on by monthly irregularities may result in a reduction in bone mass and an increase in the risk of stress injuries. Similarly, (Beck & Drysdale, 2021) discovered that female athletes with amenorrhea, a severe type of monthly irregularity, had decreased bone mineral density and a higher prevalence of bone fractures. A more recent study by (Nose-Ogura et al., 2020) refuted this association by arguing that there may be more nuance in the relationship between menstrual irregularity and bone health. Their study stressed the significance of energy availability, diet, and body composition in affecting female athletes' risk of injury and bone density. They argued that dealing with these issues might be just as important as or perhaps more important than menstrual regularity alone. (Maya & Misra, 2022) thorough systematic review and meta-analysis also included the results of other investigations. They confirmed that female athletes who had irregular periods were more likely to sustain bone stress injuries, but they also emphasized the variety of study populations and study methodology. To further understand the mechanisms underlying this, they underlined the need for more research. Bishop et al. (2021) argued that because of a variety of distinct intrinsic and extrinsic risk factors, females are more likely than males to sustain bone stress

injuries. Bone stress injuries must be properly identified and treated since they can cause serious morbidity, pain, lost time from exercise, and financial hardship. Bone stress injuries are a continuum that result from accumulated microdamage to the bone that occurs more quickly than bone healing. Nutritional issues and characteristics particular to the health of female bones are just two of the many distinct risk factors that female athletes experience(Hegedus et al., 2023). Three interconnected disorders are referred to as the "Female Athlete Triad": (i) a lack of energy (energy deficiency), which can manifest with or without disordered eating, (ii) menstrual disorder, and (iii) a lack of bone density. From mild to intermediate subclinical health concerns to severe clinical results including eating disorders, amenorrhea, and osteoporosis, each of these illnesses can exist on a continuum of severity (De Souza, Koltun, et al., 2019). This review updates the latest research on the availability of energy and how it relates to reproductive function while providing a succinct overview of the Female Athlete Triad. It also lays the foundation for an initial working model of a similar syndrome in men based on currently available evidence, which will subsequently be defined and referred to as a Male Athlete Triad by the newly designated Female and Male Athlete Triad. Most low risk stress fractures can be treated with a time frame of rest and activity modification, while some high risk or severe stress fractures may require surgical treatment. (Bishop et al., 2021).

The Triad model's foundation is the impact of decreased availability of energy on the cycle of menstruation and bone health, which are the most clinically important complaints among female athletes and exercisers. Despite the presence of additional symptoms including endothelial dysfunction, the physiological effects of decreased availability of energy on the cycle of menstruation and bone are the most clinically important because they both have negative health repercussions (O'Donnell et al., 2019), altered lipid profiles (Friday et al., 2021), and, in one instance, poor sport performance (VanHeest et al., 2019). Mammals' available oxidizable fuel is split into compartments that are essential for viability and nourishment in areas such as thermoregulation, cellular maintenance, locomotion, growth, immune function, and reproductive function. However, current study suggests a potential link between female athletes' bone stress fractures and irregular menstrual cycles. While some studies have found evidence for this relationship, more recent study has shown the intricate interplay of variables, including diet and energy availability, which may affect bone health in female athletes. Women should focus on maintaining their long-term bone health during their adolescence and early adulthood (Izci et al., 2022). Young female athletes enjoy a rigorous lifestyle with higher nutritional needs to support their high energy demands and keep their energy balance (Maya & Misra, 2022). Reviewing the severe effects of energy deprivation and available methods for effective management is crucial as young female athletes face a time of rapid change and unpredictably high societal demands.

3. Method

3.1 Participants

For this study, women athletes were selected from “Youth and Sport Administration” (YSA) in Turkey. Initially, 1030 women athletes were recruited for this study. However, complete surveys were only filled by 1010 women athletes from YSA for this study.

Exclusion and Inclusion Criteria: An effective inclusion and exclusion criteria was defined for this study for the selection of required participants. For this study only women athletes from YSA were taken into account to prevent any inconvenience for the researcher. No other sports organization was taken into consideration for this purpose. Voluntary participation was encouraged and no participants were included in this study who were not volunteer. All the participants were above the age of 18 years to ensure the ethical guidelines. Additionally, the women athletes with any time of neurological or other medical issues were not included in this study. For this study women athletes with past history of IMS and BSIs were included.

3.2 Data Collection

This was a cross-sectional study. For this study, an online questionnaire was developed inspired by Cheng et al. (2021). This questionnaire included different questions concerning the usage of HC, IMC and bone fractures. The Google Docs was used for the development of the questionnaire and it was distributed online among the selected audience. The participants were also encouraged to motivate their peers for filling the surveys.

3.3 Data Analysis

The “combined oral contraceptive” (COC) analysis was also conducted inspired by Cheng et al. (2021). For this statistical analysis, the continuous variables were presented as standard deviation and means. However, the discrete variables were presented as percentages and frequencies. For this purpose, descriptive analysis was conducted. The prevalence rates for the HC usage was reported as “95% confidence interval” (CI). Moreover, two-sample-t-test was utilized for the continuous variables analysis and the “Pearson’s chi-square test” was utilized for discrete variables. The level of significance was stated to be less than 0.05.

3.4 Ethical Considerations

For this study, important ethical guidelines were also taken into consideration to prevent any ineffective outcome. Initially, the objectives of the study were presented to the selected participants to ensure that they clearly

understand the aim of the study. All queries of the participants were answered by the researcher to avoid any ineffective outcome. This also helped in improving the association between the researcher and the participants. Moreover, the involved participants for this study were also given the authority to leave the study whenever they wanted without any consequence. Additionally, the confidentiality of the participants was also maintained. This helped in achieving positive outcomes from this study, which helped in determining the association between IMC, HC usage and BSIs.

4. Findings

For this study, a sample of 1030 women athletes from the “Youth and Sport Administration” in Turkey, were selected. However, the complete surveys were attained from only 1010 women athletes. The mean age of these athletes was found to be 19.5 ± 2.4 years, andthe mean response rate was found to be 97.5 ± 6.7%. Figure 1 shows the types of HC which are used by the selected participants. It has been observed that more than 70% of the participants used OCP while more than 20% participants used IUD and more than 10% participants used implants. However, less than 10% participants used injectable HC, patch and Nuvaring (NR).

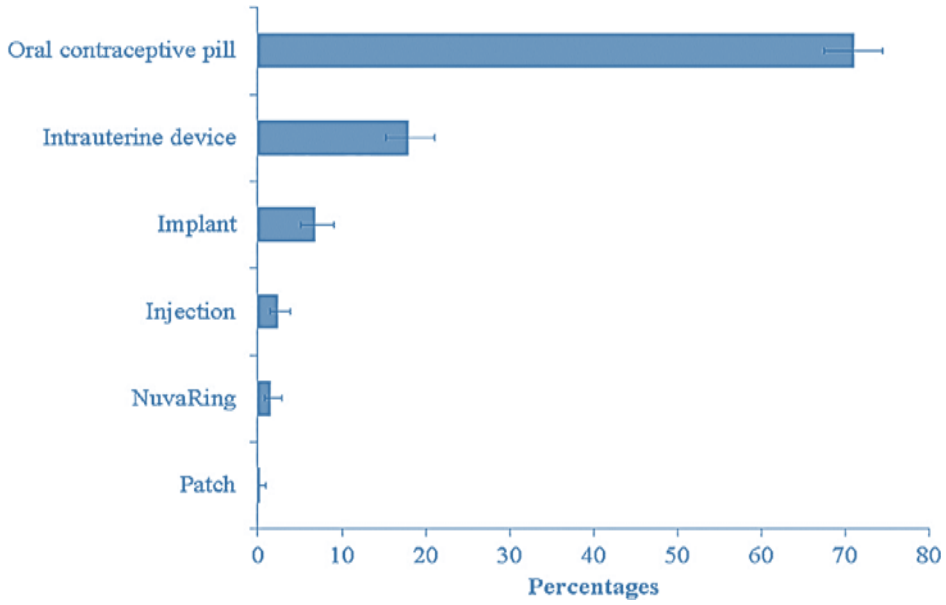

Figure 1: Hormonal contraceptive (HC) distribution among the women athletes

Figure 2 shows different reasons which encouraged the women athletes to utilize different types of HC. From figure 2 (A), it has been observed that more than 35% of the participants used HC for birth control while more than 30% of the women athletes used HC to reduce their symptoms and more than 15% of the participants used HC for consistent menstrual cycle. It has also been observed that more than 10% of the participants used HC for decreasing bleeding and about 2% of the participants use HC for controlling their period

timing. Figure 2 (B) shows that more than 50% of the participants were prescribed by the doctor to utilize HC while more than 30% of the participants used HC to reduce period severity and they also preferred daily pill. However, 3% and 2% of the participants were recommended by their family and coach to use HC.

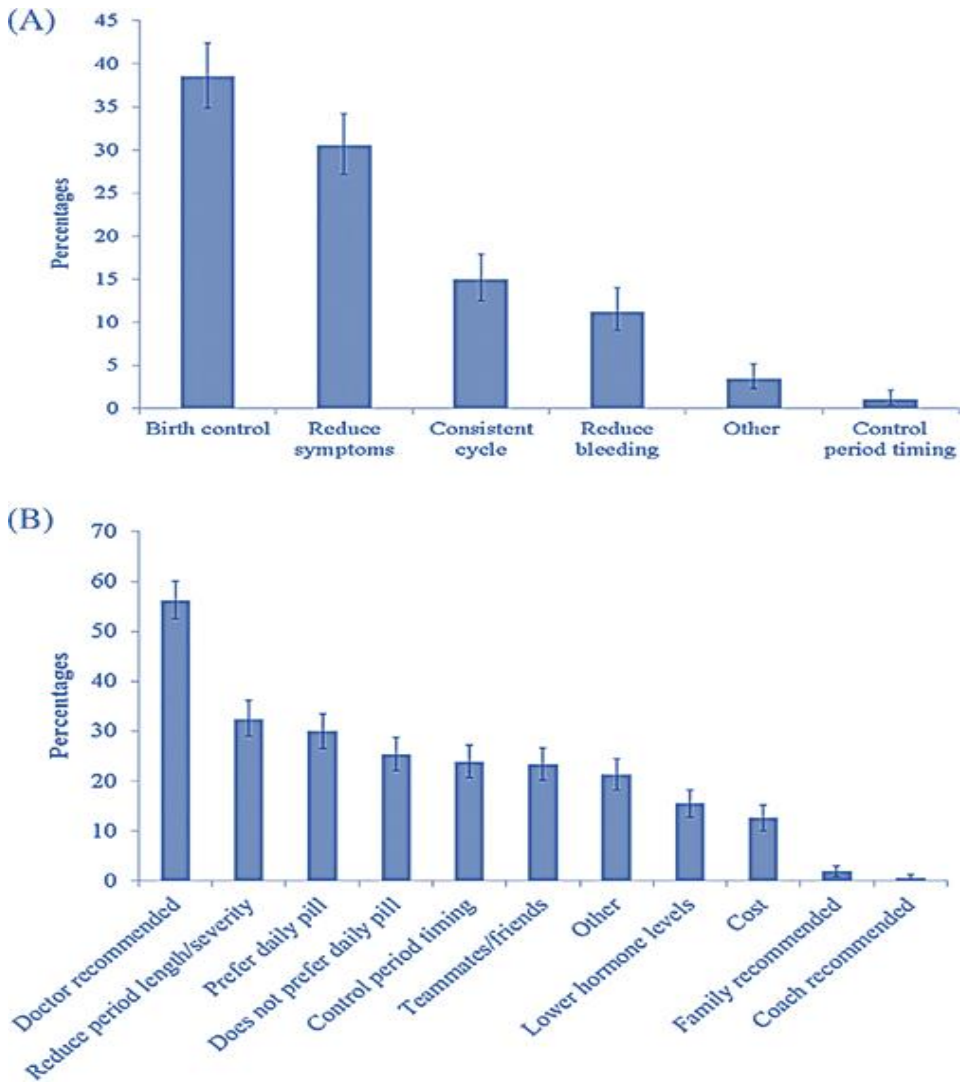

Figure 2: (A) Reasons for HC usage and (B) Other factors contributing to HC usage

Table 1 shows the past IMC and utilization of HC among the selected participants for this study. From this table it has been observed that the women athletes with past IMR have higher menarche age (13.5) and compared to the women athletes who did not have IMC in the past ($p < 0.0011$). The utilization of HC was also found to be greater in women with pat IMC than the women athletes with no past history of IMC ($p < 0.0011$). It has been observed that 480/1010 women athletes for this study, had IMC in the past while 530 women athletes did not suffer from IMC in the past. The most commonly used type of HC was OCP in both groups followed by IUD, implants, injectable HC and RG. Most of these athletes used HC for birth control

Table 1: Past irregular menstrual cycle (IMC) and utilization of HC

	IRREGULAR MENSTRUAL CYCLE			
	Y (N=480) (N, %)	**N(N=530) (N, %)**	**95%CI(DIFF)**	**P**
AGE (YRS)	19.7(1.5)	19.5(1.5)	0.0,0.31	.108
MENARCHE AGE (YRS)	13.5(1.7)	12.8(1.5)	0.41,0.81	<.0011
PRESENT USAGE OF HC	350(73)	300(57)	10.4=5%,21.8%	<.0011
TYPE OF HCTYPE				
OCP	265(55)	205(68)	−1.6%,12.3%	.141
IUD	65(14)	56(19)	−7.1%, 4.8%	.697
IMP.	15(3)	28(9)	−7.8%, 0.3%	.055
INJ.HC	10(2)	5(2)	−1.6%, 3.3%	.474
RG	5(1)	6(2)	−2.8%, 1.2%	.382
PATCH	0(0)	2(0.3)	−1.1%, 0.4%	.282
INITIAL REASONS FOR HC UTILIZATION				
BC	115(33)	133(44)	−18.4%, −3.6%	.004
REDUCESYMP.	90 (26)	107(35)	−15.4%, −1.3%	.023
MORECC	84(24)	14(4)	15.1%,25.1%	<.0011
RB	44(12.5)	31(10)	−4.5%, 5.4%	.858
CP	2(1)	5(2)	−2.6%, 0.6%	.181
OTHER	15(4)	10(3)	−3.1%, 2.7%	.882

OCP= oral contraceptive, inj= injectable, RG= ring, BC= birth control, CC= consistent cycle, symp= symptoms, RB= reduced bleeding, CP= control period, IUD= intrauterine device, diff= differences, imp= implant, Y= yes, N= no

Table 2 shows the logistic regression for past IMC. The results obtained showed that past IMC only has a significant association with the current usage of HC (p= 0.0031) and no other significant association is observed.

Table 2(a): Logistic regression for past IMC

	OR	**95% CI**	***P***
CURRENT USAGE OF HC	0.71	0.51,0.91	.0031
HCTYPE(OCP)			
NR	0.51	0.11,1.91	.328
IUD	0.91	0.61,1.31	.477
INJHC	1.31	0.51,3.71	.595
IMP	0.51	0.31,1.01	.051
OCPUSAGE (NOUSE OF OCP)	1.31	0.91,1.81	.128

Table 2(b): Logistic regression for past IMC

	OR	95% CI	*P*
LE COC(HIGH)	1.41	0.91,2.21	.144
LA COC(HIGH)	1.51	0.81,3.11	.241
LP POTENCYCOC(HIGH)	1.01	0.61,1.51	.886

NR= nuvaring, LE= Low estrogenicity, LA= Low androgenicity, LP= Low progestational, OR= odds ratio

Table 3 shows that 255 of the women athletes had a past history of bone stress injuries (BSI). It has been observed that 165 of these athletes were currently using HC. Most of them utilize OCP (60%) while 7% use ring and 21% use IUD. 5% have injectable HC and 9% have implants. It has been observed that most of the women athletes with past BSI were likely to suffer from amenorrhea.

Table 3: Present HC usage among the athletes with past history of bone stress injuries

	NO. OF ATHLETES (N= 255) (N, %)
PRESENT HC USAGE	165 (65)
TYPE OF HC	
OCP	100 (60)
PATCH	0 (0)
RG	7 (4)
IUD	35 (21)
INJ. HC	8 (5)
IMP.	15 (9)

The odds of a past history of BSI mainly depend on the past IMC, sports type and types of HC used by the women athletes. Table 4 shows the logistic models for BSI. It has been observed that the usage of OCP has lower odds concerning a history of BSI (p= 0.044). Similarly, the usage of injectable HC also presents a lower odd of having a past history of BSI (p= 0.03). At the same time, the women athletes involve in lean and aesthetic sports also had a less chance of past history of BSI (p< 0.011).

Table 4(a): Logistic models for BSI

	OR	95% CI	*P*
L/ AS	1.91	1.3,2.4	<.0011
HCUSAGE TYPE OF HC	0.91	0.6,1.1	.444
NR	2.31	0.7,8.3	.197
IUD	1.31	0.8,2.2	.215
INJ. HC	4.51	1.512.4	.003
IMP.	1.11	0.6,2.4	.746

Table 4(b): Logistic models for BSI

	OR	95% CI	*P*
OCPUSAGE	0.71	0.6,1.2	.044
LE COC	0.61	0.4,1.3	.086
LACOC	0.71	0.2,1.3	.294
LP POTENCY	1.01	0.7,1.6	.984
PAST IMC	1.31	0.8,1.3	.111
L/ AS WITH HC USAGE	1.71	1.1,3.4	.064

L= lean, AS= aesthetic sport

5. Discussion

Regardless of the female athlete's MI status, the top two reasons for using HCs were birth control and symptom alleviation. However, female athletes with a history of MI were more likely to use HCs to control the regularity of their menstrual cycles. 25% (95% CI: 22.6%, 28.0%) of female athletes reported having experienced a stress fracture in the past; compared to OCP use, injectable HC use was linked to higher probabilities of stress fractures. However, no links between stress fractures and COC androgenicity, potency, estrogenicity, or prior MI were found. Additionally, compared to female athletes who participated in non-lean/non-aesthetic sports, female athletes who practice lean/aesthetic sports were less likely to report current HC use and more likely to report a history of stress fractures; however, past MI and current HC use characteristics were similar. There are less studies in Turkey on the prevalence and characterization of HC use among collegiate girls, especially in female athletes, despite an increase in studies looking at the connection between the menstrual cycle or HC usage and sports performance. Studies done in different nations have shown prevalence rates in varied demographics ranging from 19.6% to 67%. (von Rosen et al., 2020). Another study revealed a 17% population-wide frequency of COC use among women between the ages of 15 and 44.24 Our HC usage prevalence of 65% is at the higher end of the range for college-aged women reported in the literature. According to (Somerson et al., 2019). 25%of NCAA basketball players and 70% of NCAA soccer players use HCs. In a more recent study, Martin et al. discovered that 69.8% of elite female athletes had used HCs in the past (Oxfeldt et al., 2020). Collectively, these findings imply that collegiate female athletes are more likely to use HC than non-athletes, although further study should be done to confirm this. COCs were the most prevalent type among all HC users (59%; 55.1%, 62.8%). Other studies found that between 64% and 90% of HC users also used COC. Numerous COC formulations are available, and they all contain EE and progestins, which can have an impact on the musculoskeletal and other systems of the body (Santana et al., 2023). Lower BMD, another element of the Triad, is linked to BSIs, particularly stress fractures. Female Athletes with proven stress fractures are

more likely to have a current MI and use less OCPs, according to research by (Kaffel et al., 2019). Additionally, a number of studies have demonstrated that previous MI has a detrimental effect on BMD (Haines et al., 2023) and that the combined effect of previous and ongoing MI is a predictor of bone geometry (Joy et al., 2014), The new study confirmed earlier findings by finding that female athletes with a history of stress fractures had a greater prevalence of primary amenorrhea, one type of prior MI (Duckham et al., 2021). In contrast, there was no connection in our study between prior MI and a history of stress fractures. In our sample of collegiate athletes, lack of OCP use was linked to an increased risk of having a history of stress fractures, supporting the findings of (Barrow & Saha, 2019) that runners are more than twice as likely to have experienced a stress fracture if they never used OCPs. Despite the fact that Barrow et al. did not examine the impact of various OCP components on stress fractures, other research has shown a connection between OCPs with low estrogenicity or low androgenicity progestin and decreased BMD. In contrast to (Hartard et al., 2019)No connection between a history of stress fractures and poor estrogenicity, androgenicity, or progestin potency was discovered in our investigation. Instead, BMD in women in their high school years was associated with poor estrogenicity, androgenicity, and progestin potency.

6. Conclusion

Results showed that 65% (95% CI: 61.9%, 67.8%) of the female athletes in our sample were currently using HC. OCPs, which mostly consisted of COCs, were the most often utilized HC. The prevalence of MI in female athletes is 47% (44.4%, 50.5%). Athletes having a history of MI utilized more HC when compared to those without one. Women who had previously experienced MI were also more likely to take HCs to regulate the regularity of their menstrual cycles. The foot was the most common site for stress fractures, and they didn't appear to be correlated with the hormones present in OCPs. However, the likelihood of stress fractures was raised by injectable HC use and previous MI status. The results of the study will provide useful information about HC usage in collegiate athletes for female athletes, coaches, and sports health specialists. Because HCs are so frequently utilized and have the potential to alter a number of musculoskeletal tissues, additional study describing the effects of HC compounds on sports-related injury and performance is required. It is crucial to comprehend how hormonal contraceptives (HCs) affect collegiate athletes because of the widespread use of these drugs' potential impact on musculoskeletal tissues, which calls for additional research on the consequences for injury and performance.

7. Research Implications

The study's conclusions have theoretical and practical ramifications that could have a big impact on the female players' lives and help the field of sports

medicine and gynecology. The study's findings are useful for players, coaches, sports medicine specialists and, gynecologist from a practical aspect. College female athletes frequently use hormonal contraceptives (HC), especially oral contraceptive pills (OCPs), which highlights the need of making well-informed decisions. Understanding the potential effects of these contraceptives on a person's general health and athletic performance is advantageous for female athletes. They can choose their contraceptive method with confidence. The study also clarifies how menstrual irregularities (MI) in female athletes should be managed. It demonstrates that women athletes who have experienced MI are more prone to utilize HCs to control their menstrual periods. By customizing an women athlete's care for MI, sports medicine professionals and gynecologist may be able to enhance both the women athlete's general health and performance. These female athletes can benefit from close coaching and training from coaches and trainers who will make sure they receive the proper care and support. The study also reveals critical stress fracture risk variables. In particular, it emphasizes the link between injectable HC use and a history of MI and a higher risk of stress fractures. Sports injury prevention techniques may require this knowledge in their development. This study emphasizes the significance of comprehending how HCs may affect female athletes' musculoskeletal health from a theoretical standpoint. It emphasizes how intricately HCs and athletic health are related. There is an obvious need for more research into the effects of HC compounds on sports-related injuries and performance given the widespread usage of these contraceptives and their potential to alter many musculoskeletal elements. The practical implications of this study highlight the value of informed decision-making, improved MI treatment, and improved injury prevention techniques in female athletes. Theoretical ramifications emphasize the necessity for ongoing investigation into how HCs affect musculoskeletal health, advancing our knowledge of an important facet of women's sports wellbeing.

8. Limitations and Future Research

Different limitations are observed in this study which are discussed in this section. For instance, this study has only focused on the association between IMC, HC usage and BSI among women athletes, however, no focus has been given on the psychological wellbeing of women athletes in this regard, limiting the scope of the study. Additionally, the sample size incorporated in this study was also limited to 1010. This negatively impact the overall performance of the study. Another limitation observed in this study is its quantitative nature due to researcher bias. Therefore, future research can focus on the association between IMC and psychological wellbeing of women athletes. For this purpose, the usage of HC can also be focused. Moreover, a larger sample size can also be taken into account for future research. Additionally, qualitative study can be conducted in the future to understand the concepts and thoughts of the women athletes concerning the association between HC usage, IMC and BSI.

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