Journal of Infertility and Reproductive Biology

J Infertil Reprod Biol, 2020, Volume 8, Issue 4, Pages: 84-89. https://doi.org/10.47277/JIRB/8(4)/84

Menstrual Period and Anthropometric Characteristics of Women with Secondary Infertility and Age Matched Control

Adesola Ojo Ojoawo[1]*, Olamide Oladoyin Bamidele[1], Stephen Olumide Akinsomisoye[2], Babalola Adebanjo Adeyemi[3]

[1] Department of Medical Rehabilitation, Faculty of Basic Medical Sciences, College of Health Sciences, Obafemi Awolowo University, Ile Ife, Nigeria

[2] Department of Physiological Sciences, Faculty of Basic Medical Sciences, College of Health Sciences, Obafemi Awolowo University, Ile Ife, Nigeria

[3] Department of Obstetrics and gynecology, Faculty of Clinical Sciences, College of Health Sciences, Obafemi Awolowo University, Ile Ife, Nigeria

Received: 26/08/2020 Accepted: 05/11/2020 Published: 20/12/2020

Abstract

The study investigated the anthropometric characteristics and menstrual cycle of women with secondary infertility and compared these with an aged matched control. Seventy six participants (38 women with secondary infertility and 38 aged matched fertile women participated in the study. The anthropometric parameters of weight, height, waist circumference (WC), hip circumference (HC), wrist circumference (WrC) and neck circumference (NC) were measured using standard protocol. Data was analyzed using IBM 23, descriptive and inferential statistics. Alpha level was set at 0.05. There was a significant difference in the body mass index of the women with secondary infertility and the control group ($t = 4.642$, $p < 0.05$). There was a significant difference in the waist-to-hip ratio ($t = 3.496$, $p < 0.05$) and waist to height ratio ($t = 4.292$, $p< 0.05$) of women with secondary infertility and the control group. There was also a significant difference in the average menstrual cycle length ($t = 2.702$, $p < 0.05$). There was a significant relationship between fertility and each of the anthropometric variables ($p<0.05$) except hip circumference. Those variables have a prediction of 54.8% and a predictive equation Y = 3.956 (Height) + 0.005(WC) +0.012 (NC) -0.216 (WrC) – 0.018 (Weight) – 1.076 was obtained. Women with secondary infertility carry more adiposity which contribute more that 50 % to the prediction of fertility and their menstrual cycle is longer than their fertile counterpart.

Keywords: Infertility, Body Mass Index, Waist circumference, Neck circumference, Menstrual period

Introduction

Infertility is a very critical issue for couples of childbearing age all around the world, the incidence of infertility has been elevated significantly due to lifestyle changes and the presence of diverse environmental stress (1). It has recently been identified as the third most serious disease following cancer and cardiovascular pathologies (2, 3). Available data suggested that at least 50 million couples around the world experience infertility; which is defines as a failure to achieve clinical pregnancy after at least 12 months of unprotected coitus (4, 5).

Primary and secondary infertility are the subtypes of infertility (6). Primary infertility in women has been described as a condition of being unable to get pregnant or to carry a baby to term as opposed to secondary infertility in women which has been described as the inability to carry a baby to term after a previous successful attempt (7). Roughly 2% of women aged between 20 to 44 years are unable to have their first life birth, 10.5% of women around the world experience secondary infertility (4). Elevated levels of secondary infertility occur in countries of Sub-Saharan Africa ranging from 5% in Togo to 23% in Central African Republic (8).

The main risk factor for primary infertility is high or extremely low body mass index while the risk factor for secondary infertility are being underweight or overweight, physical inactivity, number of abortions; for men, staying up late at night frequently and engaging in high temperature occupations (1). Even though infertility is not a disease as it were, and its treatment impacts every aspect of people's lives, which can lead to diverse emotional and psychological consequences including turmoil, frustration, depression, anxiety, hopelessness, guilt, and feelings of worthlessness in life (9). Jordan and Ferguson (10) found out that infertile women have higher distress scores on the Patient Health Questionnaire than do other women in family practice clinics.

Body Mass Index (BMI) and waist circumference (WC) are two common anthropometric measures of obesity in clinical and public health practice (11). It is known that as waist-to-hip ratio (WHR) and body mass index increase, there is a higher risk of suffering from diseases ranging from hypertension to diabetes, cancer, depression and fertility problems (12). Waist to height ratio (WHtR) has been found to be simple, rapid and more sensitive screening tool when compared to BMI (13, 14). Measures of frame size (FRS) has been proven to be significantly and positively correlated with fat free mass, body fatness, bone mass and body weight at all ages (15).

***Corresponding author:** Adesola Ojo Ojoawo, Department of Medical Rehabilitation, Faculty of Basic Medical Sciences, College of Health Sciences, Obafemi Awolowo University, Ile Ife, Nigeria. Email: adesolaojoawo@gmail.com

Journal of Infertility and Reproductive Biology
J Infertil Reprod Biol, 2020, Volume 8, Issue 4, Pages: 84-89. https://doi.org/10.47277/JIRB/8(4)/84

Wrist circumference (WrC) is one of the most reliable measurements to assess body frame size through Grant index (height in cm/ WrC in cm) (16).

Neck circumference (NC) has been recently been used to identify overweight and obesity and is observed to correlate with age, weight, waist and hip circumferences, waist-to-hip ratio and body mass index (17).

There is a dearth of studies that explore difference between anthropometric characteristics, especially frame size and neck circumference, which objectively measures the body composition, of women with secondary infertility compared to other women without the condition. This study aims to compare anthropometric parameters of women with secondary infertility with age matched control.

Materials and methods

Participants

Women with secondary infertility and the age matched fertile women attending out patients Obstetrics and Gynecology Clinic, at the Obafemi Awolowo University Teaching Hospitals Complex, Ile Ife. The control group consisted of aged matched fertile women within the same vicinity

Inclusion criteria

Fertile women between the ages of 20-45 years were included in the study. Women with inability to get pregnant or carry a baby to term for at least 12 months after a previous successful attempt without protected coitus between the ages of 20-45 years.

Exclusion criteria

Women with secondary infertility with significant co-morbidities such as diabetes and hypertension were excluded from the study.

Instruments

The following instruments were used in the study weighing scale (seca model 7621019008, Germany); Height meter (Seca model 222, Germany) and Tape measure, (0.7cm wide butterfly made from China)

Sampling technique

Purposive sampling technique was used to recruit subjects for this study.

Sample size determination

According to (Rosner, (18) this equation can be used for a study comparing two means

$$N = \frac{4S.D^2(Z_{crit} + Z_{pwr})^2}{D^2}$$

Where N is the total sample size (the sum of the sizes of both comparison groups),

S.D is the assumed standard deviation of each group and this assumed to be 15.

Z_{crit} is the standard normal deviate corresponding to selected significance criterion = 1.96

Z_{pwr} is the standard normal deviate corresponding to selected statistical power (i.e 0.8)

D is the minimum expected difference between the two means and is assumed to be 10.

Therefore,

$$N = \frac{4 \times 15^2(1.96 + 0.8)^2}{10^2}$$

$$N = 68.5584$$

The sample size was rounded up to 70 (35 for each group) to accommodate for possible attrition.

Research design

This work was a cross sectional study.

Procedure

The ethical approval for this study was obtained from the Ethics and Research Committee of Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC) (ERC/2019/09/25). The participants were fully informed about the purpose of the study and their consents were obtained before commencement of the measurements. Thirty eight women with secondary infertility were recruited for the Outpatient Obstetrics and Gynecology Clinic, OAUTHC, Ile Ife, Nigeria.

Considering the aged matched control group, for a subject with specific age, three women of the same age were approach for each patient of a certain age i.e if a subject is 30 years old, three fertile women of 30 years old that gave their consent to participate in the study were searched for. One out of those three was randomly picked as the age matched participants for the study. This was done to recruit thirty eight age matched fertile women for the study

Anthropometric data were obtained for both the patents and age matched control using the procedures according to Marfell-Jones *et al*. (19)

The height was measured with a height meter. Participants were asked to stand barefooted on the platform of the scale looking straight ahead while the horizontal bar attached to the height meter was adjusted to touch the vertex of the head. Weight was measured on a weighing scale with the participant in minimal clothing, barefooted and standing in an erect posture looking straight ahead.

Waist circumference was measured with an anthropometric tape measure. Participants were in standing position. The participants wore little clothing so that the tape may be correctly positioned. Clothing was restricted to light underwear that would not affect the measurement. The participant stood erect with the abdomen relaxed, the arms by the sides and the feet together. The measurer faced the measured at the level of the natural waist in horizontal plane which is the narrowed part of the waist which is the narrowest part of the torso as seen from the anterior aspect. The measurement was taken at the end of normal expiration. The recorder walked round the participant to make sure that the tape is parallel to the floor and that the tape is snug, but did not compress the skin. The measurement was made at minimal respiration to the nearest 0.1cm.

Hip circumference was measured using the anthropometric tape measure. The participant was asked to stand erect with feet together and weight evenly distributed on both feet. The participants were on light clothing. The examiner squatted on the right side of the participant and places the tape rule around the hip. The tape was placed at the maximum extension of the buttocks. The examiner then adjusted the tape and checked the front to ascertain that the plane of the tape was horizontal. The zero end of the tape was held under the measurement value. The tape was held snug but not tight. The examiner took the measurement from the right side and recorded the measurement to the nearest 0.1cm.

Neck circumference was taken in a plane as horizontal as possible, at a point just below the larynx (thyroid cartilage) and perpendicular to the long axis of the neck (the tape line in front of the neck at the same height as the tape line in the back of the

Journal of Infertility and Reproductive Biology
J Infertil Reprod Biol, 2020, Volume 8, Issue 4, Pages: 84-89. https://doi.org/10.47277/JIRB/8(4)/84

neck). While taking this reading the subject was asked to look straight ahead, with shoulders down, but not hunched. Care was taken not to involve the shoulder/neck muscles (trapezius) in the measurement. Wrist circumference was measured with participant in a seated position using a tension-gated tape measure positioned over the Lister tubercle of the distal radius and over the distal ulna. The Lister tubercle, a dorsal tubercle of the radius, was palpated at the dorsal aspect of the radius around the level of the ulna head, about 1 cm proximal to the radiocarpal joint space.

Period in days between the date of the last menstrual circle and the beginning of the other one were recorded for the last three months for the subjects and normal individuals. These were provided by the participants.

Data analysis

Data was analyzed using the descriptive statistics of mean and standard deviation. Inferential statistics of independent t-test was used to assess the difference between anthropometric characteristics and menstrual cycles of women with secondary infertility and the control group. Spearman Rho was used to assess the relationship between anthropometric variables and fertility types. Regression analysis was used to derive equation for the prediction of fertility. The alpha level was set at 0.05. The data analysis was carried out using SPSS IBM version 23 software.

Results

Physical characteristics of subjects

Shown in Figure 1 is the summary of physical characteristics of the subjects. The mean weight for the subject, control and total were 70.28 ± 10.54 kg, 62.31 ± 7.61kg and 66.30 ± 9.91 kg respectively. The mean body mass index were 28.48 ± 4.22 kg/m^2, 23.07 ± 1.99 kg/m^{2}and 25.77 ± 4.25 kg/m^2 for the subjects, control and total participants respectively.

Comparison between the anthropometric measurements of subjects and control group

Displayed in table 1 is the comparison between the anthropometric features of the subjects and the control group. There was a significant difference in the weight (t =2.451, P<0.05) and the height (t=2.993, P< 0.05) of the subjects and the control group. There was also a significant difference in the body mass index (t=4.642, P< 0.05). However, there was no significant difference in the hip circumference of the subjects and the control group (t =1.148, P> 0.05). Other parameters are outlined in table 2 below.

Comparison between the average menstrual cycle length of the subjects and control group

There was a significant difference between the average menstrual cycle length of the subjects and control group (t = 2.702, P< 0.05). There was also a significant difference in the first menstrual cycle of both groups (t = 2.505, P< 0.05). However, a difference was noted in the last two menstrual cycle lengths but not statistically significant.

Shown in table 3 is the relationship between fertility and anthropometric variables.

There was a significant relationship between fertility and each of all the anthropometric variables (P < 0.05) under consideration except hip circumference (P>0.05).

The prediction of fertility using anthropometric variables is shown in table 4a and b. The R^2 is 0.548 indicating that all the variables have a contribution of 54.8% to the prediction of secondary fertility of a woman.

The derived equation is Y = K+ aX+ bZ where K is the constant and X and Z are the anthropometric variables. The equation is Y = 3.956 Height + 0.005 (Wc) +0.012 (NeckC) - 0.216 (WrC) – 0.018 (Weight) – 1.076: W = waist, C= circumference.

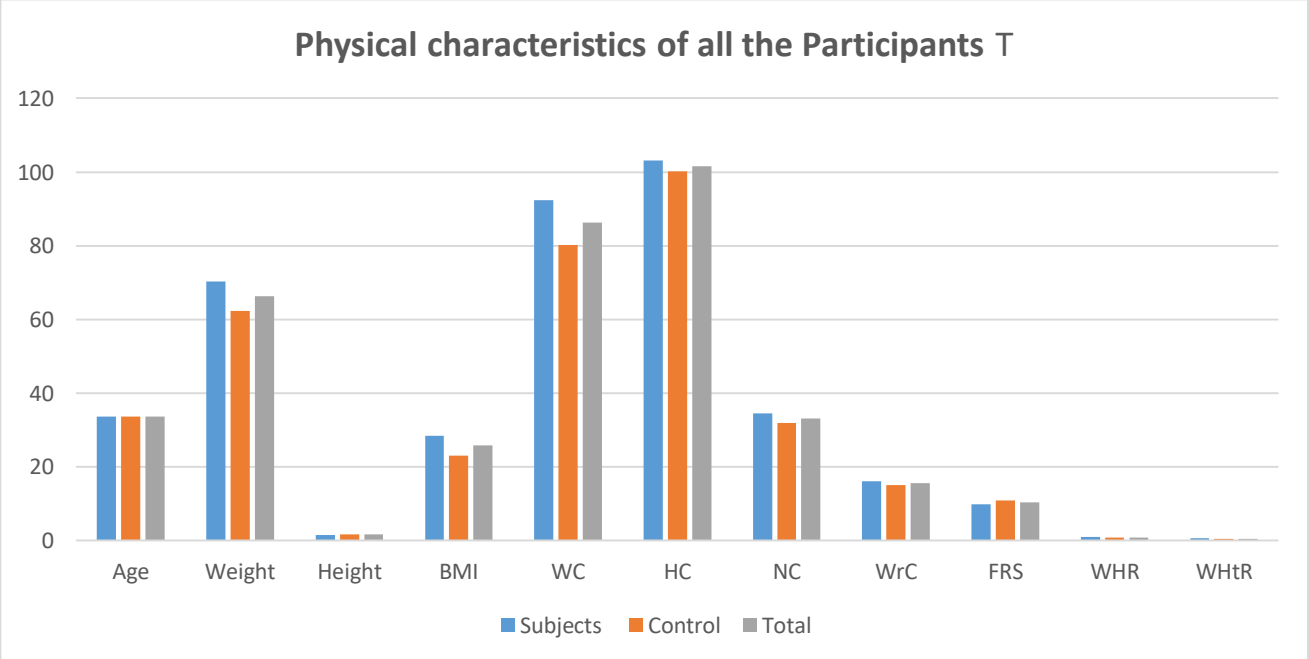

Figure 1. Chart representing the Physical Characteristics of all the participants. Key: BMI: Body Mass Index, WC: Waist Circumference, HC: Hip Circumference, WrC: Wrist circumference, NC: Neck Circumference, FRS: Frame Size, WHR: Waist to Hip Ratio, WHtR: Waist to Height Ratio.

Journal of Infertility and Reproductive Biology
J Infertil Reprod Biol, 2020, Volume 8, Issue 4, Pages: 84-89. https://doi.org/10.47277/JIRB/8(4)/84

Table 1: Comparison between the anthropometric measurements of subjects and control group (N= 76)

Variables	SUBJECT n =38 MEAN ±SD	CONTROL n=38 MEAN ±SD	t	P
Weight (kg)	70.28 ± 10.54	62.31 ± 7.61	2.451	0.020
Height (m)	1.57 ± 0.07	1.64 ± 0.06	-2.993	0.005
BMI (kg/m^2)	28.48 ± 4.22	23.07 ± 1.99	4.642	0.000
WC (cm)	92.36 ± 11.49	80.23 ± 8.54	3.389	0.002
HC (cm)	103.09 ± 7.32	100.18 ± 7.02	1.148	0.260
NC (cm)	34.46 ± 2.95	31.84 ± 2.00	2.942	0.006
WrC (cm)	16.04 ± 0.68	15.04 ± 0.82	3.723	0.001
FRS	9.83 ± 0.58	10.92 ± 0.51	-5.641	0.000
WHR	0.90 ± 0.09	0.80 ± 0.05	3.496	0.001
WHtR	0.60 ± 0.08	0.49 ± 0.05	4.292	0.000

BMI: Body Mass Index, WC: Waist Circumference, HC: Hip Circumference, WrC: Wrist Circumference, NC: Neck Circumference, FRS: Frame Size, WHR: Waist to Hip Ratio, WHtR: Waist to Height Ratio. t= coefficients of independent t- test

Table 2: Comparison between the menstrual cycle of subjects and control N=76

Variables	Subjects Mean+ SD	Control Mean+ SD	T	P
MC1 (days)	37.63 ± 16.39	27.19 ± 3.04	2.505	0.018
MC2 (days)	31.63 ± 13.18	26.88 ± 2.53	1.416	0.167
MC3 (days)	31.81 ± 14.57	26.25 ± 3.24	1.491	0.146
AMC (days)	33.69 ± 9.37	26.77 ± 2.74	2.833	0.008

MC1: length of the first menstrual cycle, MC2: length of the second menstrual cycle, MC3: length of the third menstrual cycle, AMC: average menstrual cycle length

Table 3: Relationship between fertility and anthropometric variables N=76

Variables	R	P
Age	.000	1000
Weight	-.408*	.020
Height	.480**	.005
BMI	-.647**	.000
WC	-.526**	.002
HC	-.205	.226
WHtR	-.617**	.000
WHR	-.538**	.000
WristC	.562**	.001
FrameS	.717**	.000
NeckC	-.473**	.006
AVMC	.350*	.049

BMI: Body Mass Index, WC: Waist Circumference, HC: Hip Circumference, WHtR: Waist to Height Ratio, C= Circumference, S: Size, AVMC: Average Menstrual Circle

Table 4: regression analysis for prediction of fertility using anthropometric variables. Coefficient of equation, N=76

Variables	B	Std Error	Beta	t	Sig
Constant	-1.076	2.929		-.367	.716
Weight	-.018	.016	-.360	-1.120	.273
Height	3.956	1.314	.572	3.011	.006
WristC	-.216	.115	-.381	-1.877	.072
NeckC	.012	.044	.064	.264	.794
WC	.005	.011	.109	.435	.667
R		**R^2**	**Adjusted R**		**SEE**
.740		.548	.461		.37287

Key: C = circumference. Y = 3.956 Height + 0.005WC+0.012NeckC-0.216WristC – 0.018Weight – 1.076

Discussion

This study was conducted to compare the anthropometric characteristics and menstrual cycle of women with secondary infertility with an aged matched control group. The study observed a significant difference in the body mass index of the subjects and the control group. The mean body mass index of the subjects was close to 30 which by the World Health Organization Classification is classified as overweight (20). The mean BMI for the control group was around 23 kg/m^2 which is classified as normal. This is consistent with studies that show a significant relationship between increased BMI,

J Infertil Reprod Biol, 2020, Volume 8, Issue 4, Pages: 84-89. https://doi.org/10.47277/JIRB/8(4)/84

indicative of total obesity or overweight, and infertility (21, 22).

There was a significant difference in the waist circumference, waist-to-hip ratio and waist-to-height, which are proxies of central obesity, between both groups. The women with secondary infertility had an elevated waist circumference which is more than the healthy cut-off value of 88cm. The mean waist-to-hip ratio of the subjects, 0.90 ± 0.09 and the mean waist-to-height ratio, 0.60 ± 0.08 were both above their respective cut-offs. This is consistent with studies that have established a relationship between central obesity and several conditions, infertility included (23, 24).

The study observed a statistically significant difference in the wrist circumference, hence frame sizes of both groups. The subjects were averagely large framed, while the control group was averagely small framed. This suggests that frame size is proxy for body composition which is related to fertility (15)

The study also observed a significant difference in the neck circumference. The subjects have an averagely larger neck circumference than the control. This is consistent with a study that have shown neck circumference as useful screening tool for overweight/obesity (17).

There was a significant but negative relationship of fertility with most anthropometric variables in this study. This implies that the increase in any of these variables may lead to reduction in fertility level of such individuals. Variables like weight, Body mass index, waist to height and waist to hip ratio were among them. The findings from this study were in line with the study of Casadei and Kiel (12). A direct correlation has been demonstrated between a higher body mass index (BMI) and a poorer fertility prognosis, also it is known that as waist-to-hip ratio and body mass index increase, there is a higher risk of suffering from fertility problems (12). In the female body composition parameters, weight status are also clearly associated with reproductive function and female reproductive function has been known to be associated with body composition characteristics (25). Twelve percent of all infertility cases are a result of a woman either being underweight or overweight (26). Both under and overweight women have irregular cycles in which ovulation does not occur or is inadequate and proper nutrition in early life is also a major factor for later fertility (27).

Obesity is a major contributor to a variety of underlying etiologies associated with infertility (28). Obesity has been established to be associated with various reproductive sequelae including anovulation, subfertility and infertility, increased miscarriages and poor reproductive outcomes. Most of the recent evidence has categorically demonstrated that obese women are at an increased risk of infertility. This is caused by an interaction between derangements in the hypothalamic-pituitary-ovarian axis, oocyte quality and endometrial receptivity (21). Obese women often have higher circulating levels of insulin, which is a known stimulus for increased ovarian androgen production (28). These androgens are aromatized to estrogen at high rates in the periphery owing to excess adipose tissue, affecting gonadotropin production. This manifests as menstrual abnormalities and ovulatory dysfunction (28). Hyperinsulinemia is highly implicated in the pathogenesis of the Polycystic Ovarian Syndrome (PCOS), characterized by oligomenorrhea and hyperandrogenism. Obesity has been found to contribute to insulin resistance and appears to worsen the symptoms of PCOS, with obese women often demonstrating a more severe phenotype (29). Elevated androgen levels in PCOS lead to visceral fat deposition, leading to insulin resistance and hyperinsulinemia, further stimulating ovarian and adrenal androgen production in a cycle (30). The prevalence of PCOS in some obese populations was found to approach 30%, although a causative role of obesity in the development of PCOS is yet to be established (31). Obesity has profound effects on the secretion of sex hormones and metabolism resulting in changes to the bioavailability of estrogen and androgens. The presence of adipocytes in large amounts results in production of estrogen in large amounts causing a sequence of events that occur in contraception (32)

The study observed a predictability of fertility in a woman using anthropometric variables to be about 54% and an equation Y = 3.956 Height + 0.005WC+0.012NeckC-0.216WristC – 0.018Weight – 1.076, was obtained for the prediction of the fertility. The inference from this is that there are other factors other than body adiposity that are contributing to the infertility of women. There are three major causes of infertility in couples which are the male factor, ovulatory dysfunction, and tubal-peritoneal disease. Most of the infertile couples have one of these three major causes (33). According to a research paper by Gnoth *et al.*, (34) there are three major factors affecting the spontaneous probability of conception include time of unwanted non-conception, age of the female partner and disease-related infertility. These factors may be responsible for the remaining predictions (45.2%) infertility of a specific woman.

The average menstrual cycle length of the subjects was significantly different from that of the control. This is consistent with studies that have shown a relationship between obesity/overweight, menstrual irregularities and infertility (35)

Conclusion

It was concluded in this study that women with secondary infertility are likely to be obese or overweight when compared to their fertile counterparts. An increase in body mass index, waist circumference, waist-to-hip ratio, waist-to-height ratio, neck circumference and frame size might have an impact on the reproductive system causing infertility.

Recommendation

It is recommended that weight reduction programs should be included in the treatment and management of obese and overweight women with secondary infertility. Also, it is recommended that a similar study be carried out using different methods to assess the body composition of women with both primary and secondary infertility using a larger sampling size.

References

1. Cong J, Li P, Zheng L, Tan J. Prevalence and risk factors for infertility at a rural site of Northern China. Plos One. 2016;11(5):e0155563.
2. Macaluso M, Wright-Schnapp TJ, Chandra A, et al. A public health focus on infertility prevention, detection and management. Fertility and sterility. 2010; 93(1):16-e1.
3. Trent M. Status of adolescent pelvic inflammatory disease management in the United States. Current opinion in obstetrics & gynecology. 2013; 25(5):350-6.
4. Mascarenhas MN, Flaxman SR, Boerma T, et al. National, regional and global trends in infertility: a systematic analysis of 277 health surveys. Plos Med (2012);9(12):e1001356.
5. Mirzaei M, Namiranian N, Firouzabadi RD, Gholami S. The prevalence of infertility in 20-49 years women in Yazd, 2014-2015: A cross-sectional study. International Journal of Reproductive Biomedicine. 2018;16(11):683.

6. Poddar S, Sanyal N, Mukherjee U. Psychological profile of women with infertility: A comparative study. Industrial psychiatry journal. 2014;23(2):117.
7. Tabong PTN, Adongo PB. Infertility and childlessness: a qualitative study of the experiences of infertile couples in Northern Ghana. BMC pregnancy and childbirth. 2013;13(1):72.
8. Larsen, U. Primary and secondary infertility in sub-Saharan Africa. International Journal of Epidemiology. 2000; 29(2):285-291.
9. Hasanpoor- Azghdy SB, Simbar M, Vedadhir A. The emotional-psychological consequences of infertility among infertile women seeking treatment: results of a qualitative study. Iran Journal of Reproductive medicine. 2014;12(2):131-138
10. Jordan CB, Ferguson RJ. Infertility-related concerns in two family practice sites. Families, Systems, & Health. 2006;24(1):28.
11. Tarleton HP, Smith LV, Zhang ZF, Kuo T. Utility of anthropometric measures in a multiethnic population: their association with prevalent diabetes, hypertension and other chronic disease comorbidities. J Community Health. 2014;39(3): 471-9.
12. Casadei K, Kiel J. Anthropometric measurement. "In StatPearls [Internet). StatPearls Publishing. 2019.
13. Ashtary-Larky D, Daneghian S, Alipour M, et al. Waist Circumference to Height Ratio: Better Correlation with Fat Mass than Other Anthropometric Indices during Dietary Weight Loss in Different Rates. International journal of endocrinology and metabolism. 2018;16(4).
14. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. Obesity Reviews. 2011;13(3):275-286.
15. Henneberg M, Ulijaszek SJ. Body frame dimensions are related to obesity and fatness: Lean trunk size, skinfolds, and body mass index. American Journal of Human Biology. 2010;22(1):83-91.
16. Öztürk A, Çiçek B, Mazıcıoğlu MM, et al. Wrist circumference and frame size percentiles in 6-17-year-old turkish children and adolescents in Kayseri. Journal of clinical research in pediatric endocrinology. 2017;9(4):329.
17. Hingorjo MR, Qureshi MA, Mehdi A. Neck circumference as a useful marker of obesity: a comparison with body mass index and waist circumference. JPMA-Journal of the Pakistan Medical Association. 2012;62(1):36.
18. Rosner, B. Fundamentals of biostatistics 5th ed. Pacific Grove, Calif: Duxbury, 2000;308.
19. Marfell MJ, Olds T, Stewart A, Carter L. Girth measurement. In International Standards for Anthropometric Assessment. International Society for the Advancement of Kinanthropometry Publication. 2006; Revised edition.
20. WHO: Physical status: the use and interpretation of anthropometry. WHO Technical report. 1995.
21. Talmor A, Dunphy B. Female obesity and infertility. Best Practice & Research Clinical Obstetrics & Gynaecology. 2015; 29(4):498-506.
22. Seth B, Arora S, Singh R. Association of obesity with hormonal imbalance in infertility: a cross-sectional study in north Indian women. Indian Journal of Clinical Biochemistry. 2013; 28(4):342-347.
23. Dag, ZO.,& Dilbaz, B. Impact of obesity on infertility in women. Journal of the Turkish German Gynecological Association, 2015; 16(2):111.
24. Pasquali R. Obesity and androgens: facts and perspectives. Fertility and sterility. 2006;85(5): 1319-1340.
25. Kirchengast S, Huber J. Body composition characteristics and fat distribution patterns in young infertile women. Fertility and sterility. 2004;81(3): 539-544.
26. Nelson LR, Bulun SE. Estrogen production and action. Journal of the American Academy of Dermatology. 2001; 45(3):S116-S124.
27. Sharma R, Biedenharn KR, Fedor JM, Agarwal A. Lifestyle factors and reproductive health: taking control of your fertility. Reproductive Biology and Endocrinology. 2013;11(1): 66.
28. Rachoń D, Teede H. Ovarian function and obesity-interrelationship, impact on women's reproductive lifespan and treatment options. Molecular and cellular endocrinology. 2010;316(2):172-179.
29. Moran LJ, Norman RJ, Teede HJ. Metabolic risk in PCOS: phenotype and adiposity impact. Trends in Endocrinology & Metabolism. 2015; 26(3):136-143.
30. Escobar-Morreale HF. Surgical management of metabolic dysfunction in PCOS. Steroids. 2012; 77(4):312-316.
31. Yildiz BO, Knochenhauer ES, Azziz R. Impact of obesity on the risk for polycystic ovary syndrome. The Journal of Clinical Endocrinology & Metabolism. 2008; 93(1):162-168.
32. Aladashvilli-Chikvaidze N, Kristesashvili J, Gegechkori M. Types of reproductive disorders in underweight and overweight young females and correlations of respective hormonal changes in BMI. Iranian journal of reproductive medicine. 2015; 13(3):135-140.
33. Kakarla N, Bradshaw K, Glob. libr. women's med., (ISSN: 1756-2228) 2008; DOI 10.3843/GLOWM.10321.
34. Gnoth C, Godehardt E, Frank-Herrmann P, et al. Definition and prevalence of subfertility and infertility. Human reproduction. 2005: 20(5):1144-1147.
35. Akther N, Jebunnaher S. Evaluation of female infertility. Journal of Medicine. 2012;13(2):200-209.