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The effect of body mass index and waist circumference on selected important seminal parameters

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Abstract

A cross sectional study was carried out in a fertility clinic of Sri Lanka in 2018 to find the relationship of body mass index and waist circumference with seminal parameters such as volume, count, motility and morphology of the male with fertility issues (n=105). The male infertility which can cause psychosocial issues, is rising in the modern society. Most of the etiologies of male infertility are unknown and could be biological in origin. Thus, the study was launched to achieve the target up to a certain extent. Every male who visited the clinic for fertility issues was personally evaluated on consent to gather the anthropometric and demographic data. Further, the semen samples of them were also collected for semen analysis. The effect of obesity (BMI and waist circumference wise) on each seminal parameter was tested separately with two statistical tests such as Spearman correlation and Wilcoxon signed rank test and found to have no significant effect from either BMI or waist circumference hence obesity on seminal parameters such as count, volume motility and morphology. Perhaps this could be due to finding of a smaller number of individuals who were in obese and extreme obese situations.

Keywords: BMI; Waist Circumference; Obesity; Seminal Parameters; Male infertility

1. Introduction

Having a baby is a dreaming event in a couple's life. Even though, certain couples are fortunate enough to make the dream a reality some are unable. This could be due to various issues such as pathological as well as physiological in origin. Increased stress levels as well as poor lifestyle habits (smoking, alcoholism, less exercise) which are most significant in the modern society, perhaps could be among the reasons of infertility with unknown origin. Though, it was believed once that the female obesity was the main contributor for the infertility, in the recent past the concept has been turned toward the male as well. According to the reputed infertile consultants, around 40% of male infertility are due to male obesity [(1)], thus the obesity in male (excess accumulation of white adipose tissues in the body) has a high impact on the infertility. According to the WHO, approximately1.6 billion adults were classed as being overweight and 400million adults were obese in 2005. Two statisticians have predicted that, in the future approximately 2.3 billion adults will be overweight and 700million will be obese.[(2)] Among the reasons of being infertile of obese men, change inn hormonal pattern is a prominent fact. In obese men altered hormone pattern such as increased level of blood estrogen and decreased level of blood testosterone, which is unfavorable for the production and maturation of spermatozoa does

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a considerable effect on the fertility issue on them. Among the other reasons, the facts such as physical Constrains for enjoying normal sex life, development of secondary chronic diseases such as hypertension and diabetes, loss of libido due to the tiredness, stress as well as the altered testosterone level could be pointed out. Anyway, it is advised for obese individuals to have a smart, body mass index (BMI < 25 Kg/m^2) even before obtaining sperm for an in-vitro fertilization test (IVF). Thus, it's obvious that the obesity plays a significant role in male fertility. Though, there was a relationship between obesity (BMI) and the quality of seminal parameters according to the foreign studies, the visible outcomes of Sri Lankan studies are a handful. Thus, the study was set up to fill the gap and discover the relationship of BMI with important seminal parameters such as volume, count, motility as well as morphology.

2. Methods and Methodology

All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

The ethical approval was obtained from the ethic review committee of the institute where the study was carried out.

2.1. Design: cross sectional study [(3)]

The cross sectional design was selected due to the reasons such as;

- Ability to access many outcomes and risk factors
- Inexpensive feature
- Less time consumption
- Possibility to generate hypothesis to build up relevant studies.

2.2. Method

The male partner of infertile couples who visited the fertility clinic of an institute of Sri Lanka during the period for fertility issues, was involved in the study. The individuals who wished to take part in the study were evaluated on exclusive and inclusive criteria on the consent.

2.2.1. Inclusive criteria

(1) All the male, who were over 18 years old.

2.2.2. Exclusive criteria [(4), (5), (6)]

- Individuals, who had been suffering from systemic diseases such as diabetes, hypertension, cancer, arthritis during the period (the conditions and the drugs used for could affect the reproductory hormones and sperm production in the testis).
- Individuals, who had been on drugs relevant to above disease conditions.
- Individuals, who had addicted to recreational drugs such as marijuana, abin and ganja (chemicals in the drug could cause negative effect on the sperms synthesis).
- Individuals, who had been on anti-gastric drugs such as cimetidine or any steroidal drugs (increase the hormone, prolactin which negatively affect on sperm production).
- Individuals, who were with pathological issues in reproductive system (varicocele, testicular problems, varicocele may raise the temperature in the area which could be unfavorable for the production of sperm).
- Individuals, who were unable to communicate (dumb, deaf and mentally handicapped).
- Individuals, who were on fertility treatment at the time (the semen quality could be changed on the ongoing treatment)
- Individuals, who were unwilling to participate in the study.

The subjects who were satisfactory according to the criteria, were selected for the study and interviewed orally to gather the data such as age, residence, lifestyle behaviors (smoking, food pattern, alcoholism, exposures to rays and heat) which could affect the synthesis of sperm indirectly. Then, the subjects were asked to provide a semen sample (3 days abstinent from ejaculation) to a given clean container. Finally, the anthropometric measurements of the subjects were taken as follows.

Measuring of height [7]

- Materials required - square flat, plane wall, measuring tape

The measuring tape was attached vertically to the plane wall. The subject was asked to remove shoes, cap/hat, etc.

Then the person was instructed to stand erect as much as possible on the flat floor, keeping his back and feet against the wall where the measuring tape was fixed. The person's position was adjusted until the tape was lined with his vertebral axis.

Furthermore, the subject was kept to the following position.

- Legs - straight
- Heels - close together
- Arms - at sides with relaxed shoulders
- Buttocks and shoulders - touching the wall

Eventually, he was asked to inhale deeply looking straight ahead without altering the position.

Finally, the square flat was kept on the crown of the head as in the picture and the person was asked to move away. The measurement was read at eye level to the nearest 0.1 cm, where the lower edge of the square intersected the measuring tape.

Measuring of weight [7]

Materials required - Scale

The calibrated scale was checked whether it was zero in reading.

The subject was advised to be free from artificial weight such as unnecessary garments, hat, watch, slippers, shoes, wallets, keys, as much as possible.

Then, he was asked to stand on the scale freely, keeping both feet on the center of the platform and looking ahead.

Finally, the weight was recorded to the nearest 100g. For the accuracy of the measurement, the same was repeated and the average reading was obtained.

2.3. Calculation and classification of BMI

The BMI of each individual was calculated according to the following common equation.

$$\text{BMI} = \frac{\text{Weight (Kg)}}{\text{Height (m}^2\text{)}}$$

The classification of individuals in to each weight groups on BMI factor was made according to the guidelines of WHO in 1990 as follows. [7]

- BMI < 18.5 = underweight
- BMI 18.5-24.9 = healthy weight
- BMI 25-30 = over weight (grade 1 obesity)
- BMI > 30-40 = obese (grade 2 obesity)
- BMI > 40 = very obese (morbid/grade 3 obesity)

Under the classification, individuals with BMI factor above 30 is considered as obese and ones with a BMI lower than the 18.5 as underweight.

2.4. The measuring of waist circumference [7]

- Materials required - Non stretching tape, Marker pen

The subject was asked to stand freely pointing feet forward and approximately 25-30 cm apart. Then the subject was instructed to hoist the upper dress (shirt) to make the abdominal area expose. The half way distance between his lower rib margin and iliac crest (in the mid axillary line) was found and marked. To improve the reproducibility of the measurement the same was done for the other side as well.

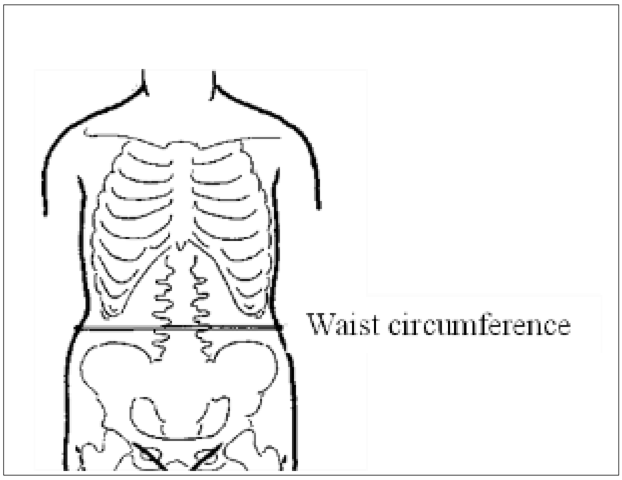

Figure 1 The midway between lower rib margin and iliac crest

Eventually, the subject was instructed to breathe out gently and the tape was applied horizontally around the subject's body.

Finally, the measurement was obtained in centimeters (to the nearest 0.1 cm) by making the tape line over the two indicated marks. Two independent measurements were obtained and an average of them was considered to ensure the reproducibility of value.

2.5. Semen analysis

The semen samples were analyzed as follows

2.5.1. Analysis of semen volume [8]

After the liquefaction was taken place, the volume of semen was measured with 10 ml of measuring cylinder.

2.5.2. Analysis of sperm count [8]

The liquefied semen mixture was gently shaken to mix the specimen and using a Sahli pipette semen was drawn up to 0.5 micro liter mark. Then the semen diluting fluid was placed up to 11 micro liter mark and placed the pipette on a rotator to mix the interior contents well.

Thereafter, the Improved Neubauer counting chamber was loaded with the mixture and allowed the sperm to settle in. Eventually, the number of sperms in four corner squares was counted.

Number of sperm/ml = $n \times 10 \times 20 \times 1000/4$

n = number of sperm counted in all four corner squares

2.5.3. Analysis of sperm motility [8]

A drop of liquefied semen (10 µl) was placed on a clean slide and covered with a coverslip and rimed the edge with petroleum jelly to prevent evaporation. It was observed the proportion of motile to non-motile sperms under high power field (× 40) in several microscopic field to obtain the average percentage of motile sperm.

2.5.4. Analysis of sperm morphology [8]

A drop of liquefied semen (10 µl) was placed on a clean slide and made a thin smear and the smear was air dried. The dried smear was washed thoroughly with semen diluting fluid to remove the mucous. Then the smear was covered around 8 mints with the diluted Leishman stain which was prepared by mixing 10 ml of stain and 20 ml of distilled water. Thereafter the stain was washed off well with buffered distilled water. Finally, the slide with stained smear was made to dry. The slide was observed for morphology under high power field and the ration of normal to abnormal spermatozoa was observed in different microscopic fields to have the final average percentage of normal spermatozoa. On the seminal analysis, individuals with normal seminal parameters were categorized as nomospermic group and ones with either one more defective seminal parameters were categorized as non nomospermic group

2.6. Data processing and statistical methods

Each and every result of seminal parameters (volume, count, motility, morphology) were subjected to normality test and non-normal distribution was indicated. Thus, non-parametric test was used in the analysis of results. The relationship between BMI and each seminal parameter was assessed under both Spearmen correlation test and Linear regression analysis. The comparison of seminal parameters in obese and control group was assessed with the Wilcoxon signed rank test. The same analytical tests were used to find the effect of waist circumference on seminal parameters. All the statistical analysis were done with the IBM SPSS 20 versions.

3. Result and discussion

3.1. The effect of obesity (BMI wise) on seminal parameters

The BMI values of the study population (n = 105) showed a normal distribution with an average value of 25.31 ± 4.89 Kg/m^2 under the normality test. The range of BMI indexes was 18.50 – 39.79 Kg/m^2. In a study (n=2469) which was carried out in the Western province of Sri Lanka to find out the average BMI values of male, found out that the value was 22.7 kg /m^2 (average age 31 years)[9]. Thus, the value is lesser than the present study. However, the age limit of the western province study was 16-72 years and the same of the current study (this study) was over 18 years. The lower average BMI of the western province study could be due to the inclusion of children. Anyway, out of all subjects, 50 were normal in weight and 31 were overweight. Thus, the number of obese individuals was 24 (obese = BMI over 30). The average BMI values of the groups of normal, overweight, and obese were 22.58 (± 1.48) Kg/m^2, 26.98 ± 1.28 Kg/m^2 and 32.55 ± 2.70 Kg/m^2 respectively, and were statistically significant each other (P < 0.05, 0.0005) under both parametric (ANOVA) and non-parametric tests (Kruscal-Wallis). As the prevalence of male obesity in Sri Lanka was 3.5% [10] during the period of study, the number of obese individuals that should be statistically investigated was 23. Thus, the all obese individuals in the study group were considered for the analysis as the test group and each average seminal parameter of them was compared with the same of the control group. In the control group it was included an age matching, normal weight individuals/subjects with normal seminal parameters (the spouse is having the fertility issue) who were selected from the same population [11]. Additionally, the relationship between BMI and each seminal parameter was also analyzed separately for the whole study group for the higher accuracy of the outcome. All the statistical analysis, relevant to the seminal parameters was performed under nonparametric assays due to the reason of their non-parametric nature. The average age of the individuals in each group of control and test was nearly similar to each other (33 years) and was statically insignificant according to the Wilcoxon signed rank test (P > 0.05). Further, the average values of BMI indexes of both group were statistically significant, according to both parametric (ANOVA) and non-parametric tests (Kruscal-Wallis) and was 22.25 (± 1.48) Kg/m^2 and 32.55 ± 2.70 Kg/m^2 respectively.

3.1.1. Effect of BMI on seminal volume

Table 1 A comparison of the average semen volumes of test (obese) and control groups with respective to the Wilcoxon signed rank test

Semen parameter	The average semen volume of the Test group (ml) (n = 24)	The average semen volume of the Control group (ml) (n = 24)	P value (Wilcoxon signed rank)
Volume (ml)	2.20 ± 0.42	2.03 ± .40	P > 0.05

Upon the result, it was clear that the average volumes of semen of the three groups were nearly equal to each other and the differences were statistically insignificant (P > 0.05) according to the Kruskal-Wallis test. Further, the average volume of obese group had been slightly higher than that of the normal group, which was able to break the concept of negative effect of obesity on the seminal quality. Anyway, this slight non-significant increase of average seminal volume in obese group could be due to the reasons such as technical errors, the well hydration or the relax mind of the subjects in the particular group at the time of collection of the semen. Further, as the all average volumes were above the normal reference value and statistically non-significant each other, the mentioned difference can't be considered as an effect of obesity. Thus, it was evident from the study population that the volume of semen was independent of BMI, which was similar to the finding of Haoi et al. in 2014 (12).

Table 2 The result of the spearman correlation between BMI and semen volume

Variables	Correlation coefficient	Significance
BMI, semen volume	0.026	P > 0.05

Further, the Spearman correlation analysis was also run to find out the relationship between BMI and semen volume and found that there was no significant relationship (P > 0.05) between the two, which was also similar to the finding of Haoi et al; 2014 (12).

Table 3 The result of the linear regression analysis between BMI and semen volume

Variables	R value	R square
BMI, semen volume	0.067	0.004

Further, a week and on significant linear relationship was found under the linear regression analysis also. The Multiple linear regression, which was run considering the age, BMI and occurrence of pus cells in the semen as independent variables against the volume of semen as the dependent variable was also shown a non-relationship between the two variables. The same analysis had been carried out in the study of Haoi et al; 2014 (12), considering the period of abstinence with age and BMI instead of pus cells and anyway found the same result. Finally, it was clear from the study that obesity under BMI wise has no significant effect on seminal volume in the individuals of the study group.

3.1.2. Effect of BMI on seminal morphology

Table 4 A comparison of the average sperm morphology of test (obese) and control groups with respective to the Wilcoxon signed rank test

Semen parameter	The average morphology percentage of the Test group (%) (n = 24)	The average morphology percentage of the Control group (%) (n = 24)	P value (Wilcoxon signed rank)
Morphology (Normal form, %)	48.06 ± 9.42	48.76 ± 8.90	P > 0.05

The average morphology of the sperm in the test group and the control group showed to be equal and statistically insignificant. Thus, it was found that there is no relationship between seminal morphology and obesity.

Table 5 The result of the Spearman correlation between BMI and semen morphology

Variables	Correlation coefficient	Significance
BMI, sperm morphology	0.013	P > 0.05

The relationship was further analyzed with the Spearman correlation analysis and found to have the same result. The same fact was proven even in the study of Haoi et al; 2014 (12).

Table 6 The result of the linear regression analysis between BMI and semen morphology

Variables	R value	R square
BMI, sperm morphology	0.018	0.001

The linear regression analysis also showed that there was no significant linearity between the two. However, according to the Multiple linear regression analysis, it was found that the combination of BMI with the age and number of pus cells in the semen (pus cell count) had a significant moderate linear relationship with the sperm morphology ($P < 0.05$, $P = 0.006$, $R = 0.40$, $R^2 = 0.16$). Thus, from the total factors which affect for the quality of sperm morphology, 16% is due to the combination of age, occurrence of pus cells in semen, and obesity. According to the result, it is clear, though there is no direct relationship of BMI wise obesity with the sperm morphology when it combines with the other factors the combination has an effect. Thus, the men with nearly over 35 years must pay their attention to controlling pyospermia (finding of the high number of pus cells in the semen) while maintaining the BMI at the same time.

3.1.3. Effect of BMI on semen count

Table 7 A comparison of the average sperm count of test (obese) and control groups with respective to the Wilcoxon signed rank test

Semen parameter	The average sperm count of the test group (10^6/ml) (n = 24)	The average sperm count of the control group (10^6/ml) (n = 24)	P value (Wilcoxon signed rank)
Sperm count (10^6/ml)	66.71 ± 12.42	90. 76 ± 16.40	P > 0.05

The number of spermatozoa finding in a semen sample is considered as a vitally important factor regarding male fertility. According to the result, every three category (normal, overweight and obese) of the study group had possessed a satisfactory average count of spermatozoa, which was higher than the normal reference value of 20 million/ml.

When it came in the comparison of average semen count of the test group (obese group) with that of the control group, it was seen that though the semen count of the test group was lesser than the control (the difference was 24 million nearly), the difference was statistically non-significant. Additionally the average count of both groups was retained over the reference level as well.

Table 8 The result of the spearman correlation between BMI and semen count

Variables	Correlation coefficient	Significance
BMI, sperm count	- 0.186	P > 0.05

Moreover, the relationship between BMI (independent variable) and semen count was analyzed with the Spearman correlation analysis and found to have the same result. Though, there was a negative relationship of BMI (obesity) with semen count, the relationship was no statistically significant. The same results had been observed even in the study of Haoi et al; 2014 [(12)] as well.

Table 9 The result of the linear regression analysis between BMI and semen count

variables	R value	R square
BMI, sperm count	0.103	0.011

In the analysis of the strength of the relationship between BMI (independent variable) and particular semen count (linear regression analysis), it was found to have weak relationship between the two (statically non-significant).

Anyway, in the Multiple linear regression analysis, it was found that the combination of BMI with the age and number of pus cells in semen/pus cell count, had a significant moderate linear relationship with the sperm count ($P < 0.05$, $P = 0.04$, $R = 0.33$, $R^2 = 0.11$). Thus, from the total factors which affect the sperm morphology, 11% is due to the combination effect of age, seminal pus cells and obesity. In the result, it is clear, though there is no direct relationship of BMI with the sperm count, when it combines with the other factors the combination has an effect. However, according to the point of view of scientists, the increased obesity could have an effect on sperm count as follows [(13)]. The enzyme aromatase cytochrome p 45 and leptin are mainly secreted by the fat cells of white adipose tissue, which represents 20% of the male body weight. Thus, in the male with higher BMI, contains higher levels of mentioned enzymes in plasma relatively. As the aromatase favors the formation of estrogen from androgen which acts as an indirect inhibitor for testosterone via inhibiting the secretion of GNRH (gonadotropin releasing hormone) from hypothalamus, high aromatase reduces the level of testosterone hence the generation and maturation of spermatozoa. Leptin also reduces the secretion of testosterone from Leydig cells of testis. Thus, the count of sperm and volume of semen may be decreased. The blood insulin, which is relatively higher in obese individuals is also a negative factor for the production of testosterone and its transport protein. [14] Further, insulin may damage the spermatozoon and mitochondrial DNA, which could alter the function as well as the morphology of sperm. When above issues are considered, higher level of leptin, insulin and aromatase could be threatened factors only in highly obese individuals (BMI with higher than 30) who have higher white adipose layers. The other issue with higher fatty layer is the deposition of environmental toxin and pollutant, which can be toxic to sperm. Sleep apnoea, which is common among obese can also have an effect on sperm production via the reduction of available oxygen in blood which is required to maintain proper sperm nullification. Reactive oxygen species, which is comparatively high in obese men can also attack sperm membrane and mitochondrial membrane, which can cause to have poor sperm. Though, the concept is theoretically true, under the present study it was collapsed. This could be due to the finding of the lower number of obese subjects and un-finding of subjects who are in the obesity grade 3 level, where the density of white adipocyte is severely higher than the others. It is obvious that the unfavorable effect made by the adipocyte is proportionate to the density of it. Anyway, the less number of obese and extremely obese males in Sri Lanka, compared to the other countries is quite interesting and a better trend of a healthy future. This could be due to the effect of figure maintaining desire, which is thought of by most of the males.

3.1.4. Effect of BMI on sperm motility

Table 10 A comparison of the average sperm motility indexes of test (obese) and control groups with respective to the Wilcoxon signed rank test

Semen parameter	The average sperm motility of the Test group (%) (n = 24)	The average sperm motility of the Control group (%) (n = 24)	P value (Wilcoxon signed rank)
Motility (%)	67.25 ± 11.42	70.94 ± 12 .40	P > 0.05

The other most important seminal parameter which decides the quality of semen is, the motility of spermatozoa. When the average motility indexes of both groups (test and control) were compared statically it was seen that though there was a slight decrease of motility in the test (obese) group, it was statistically insignificant (P > 0.05).

Table 11 The result of the Spearman correlation between BMI and sperm motility

Variables	Correlation coefficient	Significance
BMI, sperm motility	- 0.013	P > 0.05

Analysis with the Spearman correlation test also indicated that though there was a slight negative relationship of BMI with sperm motility, it was non-significant.

Table 12 The result of the linear regression analysis between BMI and sperm motility

Variables	R value	R square
BMI, sperm motility	0.009	0.001

However, though there was a week linear relationship between the two variables, a moderate linear relationship was observed with the combined effect of BMI, age, and pus cells of semen with sperm motility at Multiple linear regression analysis ($P < 0.05$, $P = 0.01$, $R = 0.34$, $R^2 = 0.14$). Thus, from the total factors which affect the sperm morphology, 14% is due to the combination of age, seminal pus cells and obesity (BMI wise). Finlay, under the study it was clear that the obesity (BMI wise), had no direct relationship with the seminal parameters such as volume, count, motility and morphology.

3.2. The effect of obesity on seminal parameter (waist circumference wise)

Table 13 Average values of seminal parameters of the individuals in the two groups of normal and over normal waist circumferences

Semen parameter	Test group (the group with over normal waist circumference (n=35)	Control group (the group with normal waist circumference) (n=35)	P value (Wilcoxon signed rank)
Volume (ml)	2.10 ± 00.42	2.40 ± 00.43	P > 0.05
Count (10^6cells/ml)	63.33 ± 12.13	73.58 ± 13.11	P > 0.05
Morphology (normal form %)	44.00 ± 8.60	45.33 ± 8.90	P > 0.05
Motility (%)	62.20 ± 12.38	63.66 ± 12.74	P > 0.05

Table 14 The total result of the Spearman correlation analysis between waist circumference and each seminal parameter

Variables	Correlation coefficient	Significance
Waist circumference, semen volume	0.031	P > 0.05
Waist circumference, sperm count	-0.152	P > 0.05
Waist circumference, sperm motility	-0.043	P > 0.05
Waist circumference, sperm morphology	0.149	P > 0.05

Table 15 The total result of the linear regression analysis between waist circumference and each seminal parameter

Variables	R value	R square
Waist circumference, semen volume	0.04	0.003
Waist circumference, semen count	0.128	0.016
Waist circumference, sperm motility	0.143	0.020
Waist circumference, sperm morphology	0.066	0.004

In the study the value of 90 cm was considered as the cutoff value to differentiate the over normal waist circumference from the normal waist circumference as it was the WHO recognized value for the South Asians. Thus, the individuals with 90 cm or above were considered as the over normal waist circumference bearers. The average waist circumference of the total study group (n=105) was 90 (± 9.25) cm. A study, which had been carried with 4532 Sri Lankan men had found that the average waist circumference of them was 78 cm (77.5-786) [15]. However, the average BMI of the present study had been higher than the particular study [15] and it could be due to the fact of having a lot of middle aged subjects in the present study (subjects with age around 35 years).

The subjects with waist circumference over 90 cm were included in the test group (n=35) and the average value of them was 92.03 (±10.81) cm. The similar number of age matching subjects who were with normal waist circumferences and seminal parameters were admitted to the control group and the average waist circumference of them was 75.06 (± 7.25) cm. When the values of both were compared with the Wilcoxon signed rank test, it was clear that there was a statically significant difference between the two (P < 0.05 (P = 0.003). Meanwhile, the average age of both groups was 33 years. However, in the comparison of average seminal parameters of both groups (Table 12) it was obvious, though there was a slight decrease of each seminal parameter in the test group the differences were statically insignificant under the (Wilcoxon signed rank) (P > 0.05). The strength of association between the waist circumference and each seminal parameter was also analyzed separately with the Spearman correlation test and found to have no significant association between the two (Table 13). The same result was found when the two variables (waist circumference and each seminal parameter) were analyzed with linear regression analysis (Table 14). However, an interesting finding was observed when multiple linear regression analysis was run considering each seminal parameter as dependent variables and the combination of waist circumference and seminal pus cells as the independent variable. Thus, the combination had a significant moderate linear association with the sperm motility, sperm count as well as sperm morphology separately. Under the linear regression analysis, 13% of the motility, 11% of the sperm count and 11% of the sperm morphology were dependent on seminal pus as well as the waist circumference of male. Thus, according to the study either BMI no waist circumference showed a relationship / effect with seminal parameters. This could be due to the strong positive significant linear relationship of waist circumference with BMI (Correlation coefficient = 0.724 (P = 0.001), R = 0.586, $R^2 = 0.344$) which reflect that the waist circumference is relatively proportionate to the BMI value and wise versa. Anyway, the waist circumference is which measures the abdominal distribution of fat is closely relevant to the seminal production than the BMI via temperature based mechanism described previously. However, in the study group finding of less amount of higher over normal waist circumference bearers might also have affected on the outcome as it was seen in the BMI. A several studies had been carried out in abroad to analyze the effect of BMI as well as waist circumference on semen parameters and had obtained different outcomes. According to the result of the study of Eisenberg et al.[16], which was carried out in the USA (United States America), there had been a negative linear association of BMI as well as waist circumference with the semen volume. In addition, the waist circumference had a negative relationship with sperm count as well. Thus, the result had got deviated from the outcome of the current Sri Lankan study, where neither BMI no waist circumference had showed any association with the semen parameters. Thus, the variation could be due to the differences of BMI as well as waist circumference categories and physical activities of the two study groups. In the USA study the majority of the cohort were overweight and obese with high waist circumferences (82%), which was low in the Sri Lankan group. Moreover, the average physical activity of the majority was less in the USA study, which was higher (according to the collected data) in the present Sri Lankan study. However, the average age of both studies was nearly similar. In the studies carried out by Alshahrani et al; 2016, (Middle east) [17] and Chavarro 2012 (USA) [18] it was concluded that the BMI was significantly and negatively correlated to the semen count (P < 0.05) which was dissimilar to the present Sri Lankan study. However, the prevalence of obesity and mean BMI value were higher in the study group of Alshahrani et al;2016 [17], such as 83% and 29.67± 5.89 Kg/m^2 respectively, which were low in the current study (22% and 25.31 ± 4.89 Kg/m^2 respectively). Further, the grade of the obesity of the individuals in the particular studies might also have increased relative to the Sri Lankan study to create a negative effect at least on the semen count. Anyway, all studies encountered a population which was more than 100. Again, a negative correlation had been observed between the obesity and sperm count as well as sperm motility in a study carried out by Jesitus et al; 2008 [19] and Håkonsen et al; 2011 [20]. Additionally, in the Håkonsen et al; 2011 (n = 43) [20], the BMI was negatively associated with the morphology and serum testosterone level as well. In the particular study the BMI range of population had been much higher (33 - 61 kg/m^2) than that of the present Sri Lankan study, which was 15.00 – 39.79 kg/m^2. Thus, the finding of the lower number of obese people and their obesity grade might have affected on the final result of the Sri Lankan study as mentioned previously. Sperm motility again had been affected negatively by the obesity in the outcomes of the studies carried out with more than 100 men by Kort et al; 2006. [21] Findings which were similar to the present Sri Lankan study had been found in four previous foreign studies. In the studies carried out with infertile men in the USA (Ali et al; 2014) [22] and China (Lu et al., 2015) [23] had found that all four semen parameters such as sperm count, motility, morphology and volume were independent of BMI. Further, in the Chinese study it had been mentioned that not only with BMI, but also with the waist circumference there was no any relationship of seminal parameters which was similar to the current study. This could be due to finding of individuals with a low abdominal circumference in the Chinese study. If they had an adequate number of individuals with a high waist / abdominal circumference the result would have been changed due to the higher sensitivity nature of waist circumference for fat distribution than that of BMI. In the study of Jensen et al; 2013.[24] It had been further concluded that the BMI had not any significant relationship with the common four semen parameters which is similar to the finding of the current study. Further, in the Jensen et al; 2013[24], which was carried out with Danish men, had mentioned that both high as well as low BMI were associated negatively with semen parameters. Anyway, in the particular study, the average age was 19 years, which was the stage of onset of sperm production in the testis. This could be the reason for having, such as controversial result. However, all four studies had included more than 100 men as the population. Finally, according to the findings of the current study it was found that there was no significant effect of obesity (BMI wise as well as waist circumference wise) on the sperm count. It is recognized usually that the waist circumference is better than BMI in determining obesity.[25] However, the waist circumference measures the distribution of fat in the abdominal and thigh areas which are close to the testis of the male reproductive system. The Body Mass Index (BMI) measures the total body fat. Thus, the waist circumference could be more sensitive than the BMI regarding the sperm production and a slight increase of it could affect the quality of sperms rather than BMI, via the heat mechanism basically. Anyway, the phenomenon was not seen in the study. Furthermore, in the current study, the average BMI of the obese group was 32.55 ± 2.70, which was within grade 2 obesity (BMI > 30-40). As it was mentioned previously, to have a considerable effect on the quality of sperm by the BMI, there should be a dense white adipocyte tissue. [25] Thus, in the study group the effect of adipocyte might have been less. Hence, the grade of the obesity could also have affected for the outcome of the present study. Additionally, the way of action of obesity on seminal parameter could also be different from the population to population. This could also have affected on the outcome of the study. Anyway, in other foreign studies such as Herning et al; 2015, and Hakonsen et al; 2011[20,25], almost all obese individuals were at the grade three level of obesity and with high waist circumferences which were less and low in the present study.

4. Conclusion

It was found that the BMI factor as well as waist circumference has no significant effect on the seminal parameters such as count, volume motility and morphology. Hence, the seminal parameters are independent of obesity. This could be due to the reason of non-finding or rare finding of class 2 obese (BMI = 35 - 39.99 Kg/m^2) or extreme obese subjects (BMI over 40 Kg/m^2) in the study group (either BMI wise or waist circumference wise). Anyway, almost all of the subjects of the present study were within the class 1 obesity level (average BMI of obese individuals = 32.25 Kg/m^2). Thus, the effect of obesity, such as alteration of blood testosterone and other unfavorable conditions which are likely to decrease the production of semen might be less in the subjects of the study group. However, the finding of less obese individuals in the study group could be a better indicator of the health of the Sri Lankans. Further, almost all subjects in the study were physically active and were on healthy dietary patterns. This has also might affected on the individual to have less obese body mass. Anyway, it is important to carry out the similar study in various provinces of Sri Lanka to confirm the concept.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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