Anthropometric and body composition analysis of infertile women with polycystic ovary syndrome

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Abstract

Objectives: To evaluate the body composition and anthropometric profile of infertile women who have been diagnosed with polycystic ovary syndrome (PCOS) and to investigate the incidence of PCOS and to examine body fat composition as a risk factor for this disease.

Methods: This hospital-based case controlled study was conducted on a cohort of 132 patients with and without PCOS. Bioelectrical impedance analysis was used to record body composition parameters, such as total body fat, visceral fat, subcutaneous fat, skeletal muscle composition and their distribution in the trunk, legs and arms, as well as blood pressure. Anthropometric profile parameters, including body mass index (BMI), ideal body weight (IBW), waist circumference, hip circumference and waist-to-hip ratio, were also recorded.

Results: The mean age of incidence of PCOS was 29.74 ± 3.32 years (OR 1.417), and most of the cohort exhibited high to very high visceral fat with significant correlation (p < 0.001).

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significantly higher in patients with PCOS (p < 0.001). The mean BMI, waist and hip circumference of the PCOS group were 28.2 ± 6.08, 97.44 ± 15.11 cm and 109.22 ± 17.39 cm, respectively. The results also indicated significant increases in DP and MAP (OR 1.528) in patients with PCOS compared to the control group (p < 0.001).

**Conclusion:** This study exhibits higher levels of BMI, body fat distribution, waist and hip circumference, diastolic and mean blood pressure, visceral fat, and a disproportionate increase in the level of global fat and its distribution.

**Keywords:** Anthropometry; Body composition; Body mass index; Infertility; PCOS

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**Materials and Methods**

**Materials**

The study data were collected using an Omron HBF 375 Karada Scan Body Composition Monitor—Body Fat Analyser to analyse body composition; an OMRAN Digital BP apparatus was used to measure systolic pressure (SP) and diastolic pressure (DP).

**Study participants**

This case-control study examined equal numbers of infertile women diagnosed with PCOS and not diagnosed with PCOS from a total of 132 women visiting Al-Bushra Medical Specialty Complex, Muscat for infertility treatment in 2016. PCOS was defined in accordance with the Rotterdam criteria. Criteria for excluding patients from this study included women with hypothyroidism, hyperthyroidism, liver failure, hyperprolactinemia, adrenal hyperplasia and diabetes. Women receiving oral contraceptives, hypoglycaemics and anti-dyslipidaemics were also excluded from the study.

**Methods**

**Anthropometric profile**

All subjects involved in the study underwent physical examination to assess height, weight, waist and hip circumference, total body fat, total skeletal muscle, distribution of fat, body mass index (BMI) and Ideal Body weight (IBW); the parameters were calculated following standard procedures and the instructions supplied with the digital body composition analyser. Hypertension and prehypertension was defined as 140/90 mmHg and 120/80 mmHg, respectively.

**Assessment of body composition**

Body composition and weight were measured in a standardized way following the instructions supplied with the Omron Body Composition analyser. This instrument is approved by the FDA for use in research involving adults and children.

**Medical ethics**

This study was approved by the Institutional Ethics Committee and the study centre. Data were collected only from the patients who provided written consent after the objectives were specified and assurances of privacy, anonymity and confidentiality were given. Every patient was given the liberty to withdraw from the study at any time.

**Statistical analysis**

Each case was given a case number, and the information collected in this study was entered directly into SPSS version 19 (SPSS Inc. Chicago, IL, USA) and was analysed using descriptive statistics such as the mean and standard deviation for continuous numerical data; for categorical data, percentage-frequency distributions were used. Means were compared between groups using the t test, and medians were compared using the post hoc Tukey C test. Logistic

**Introduction**

Approximately 10–15% of reproductive aged females are affected by a complex endocrine disorder, polycystic ovary syndrome (PCOS).1 PCOS is associated with multiple factors and has a complex pathogenesis that adversely affecting the health of women.2 It is known to cause endocrine abnormalities, such as the release of gonadotropin-releasing hormone (GnRH), leading to increased LH secretion and decreased FSH levels. It is also known to affect the hypothalamus–pituitary–ovarian axis and ovarian stromal thecal hyperfunctioning, resulting in chronic oligo-ovulation and hyperandrogenism, leading to not only biochemical but also metabolic and reproductive dysfunction.3 Adolescents diagnosed with PCOS are also diagnosed with menstrual irregularities, increased waist circumference (WC), impaired glucose tolerance (IGT), subclinical atherosclerosis characterized by visceral fat changes and epicardial fat thickness.4,5

A retrospective cross-sectional study on the prevalence of PCOS carried out in Oman at Sultan Qaboos University Hospital (SQUH) reported a frequency of 7.0%. The overall incidence of PCOS was 2.8 per 1000 patients in 2010. The prevalence was higher among women in the age group of 25–34, especially in the Muscat region, followed by the Dhakailey and Al Batinah regions. The study concluded that the prevalence and diagnosis rate was almost similar to that in global population.6

Some studies support a higher risk of developing obesity due to impaired metabolic function in women with PCOS, and the incidence differs from country to country depending on lifestyle, environmental and dietary factors.7,8 However, the relationship between PCOS incidence and body composition, especially in infertile women, has not yet been studied. Therefore, this case-control study was designed with the aim of investigating the differences, relative risk and correlation between the incidence of PCOS and anthropometric factors, as well as body composition.
Body composition in infertile PCOS women

regression was used to correlate metabolic factors, waist circumference and PCOS diagnosis. p values of less than 0.05 were considered statistically significant.

Results

Validation of the study design

Overall, this was a very good model for predicting PCOS because the Omnibus test of model coefficients showed a highly significant chi-square value of 41.688 (p-value <0.001). In addition, the Nagelkerke R-squared value was found to be 0.682, implying that 68% of the variation in the outcome variable is explained by the predictors in the model. Altogether, as a model, we found arm subcutaneous fat, leg subcutaneous fat, mean arterial pressure, and age to be the most significant predictors of PCOS.

Body fat composition

Most of the patients (86%) in the control group exhibited normal visceral fat; in contrast, 62.9% of the PCOS population exhibited normal visceral fat, 7.69% had high visceral fat, and 22.58% had very high visceral fat. A Chi-square analysis showed significant (p = 0.004) differences in visceral fat content between the cases and the control group. Based on these results, visceral fat is elevated in the high and very high category of patients with PCOS and is significantly (p < 0.001) correlated with the incidence of PCOS (Tables 1 and 2). The results shown in Tables 1 and 2 show that the total body fat distribution in patients diagnosed with PCOS is significantly (p < 0.001) higher than that in the control group. The odds ratio showed a 36.6% increase in risk of developing PCOS in patients having higher total body fat. Highly significant (p < 0.001) correlations were recorded between the incidence of PCOS and total subcutaneous fat (r = 0.296), trunk subcutaneous fat (r = 0.244), arm subcutaneous fat (r = 0.309) and leg subcutaneous fat (r = -0.293).

Skeletal muscle composition

Based on the results shown in Table 2, there is a highly significant (p < 0.001) negative correlation (−0.339) between total skeletal muscle and the incidence of PCOS. A significant (p < 0.001) positive O (r = 0.318) correlation was found between trunk skeletal muscle and PCOS. According to Table 1, 81.42% of patients with PCOS had lower skeletal muscle distribution; this value compares with 42.18% of the population in the control group. No significant difference was found between the cases and the control group.

Anthropometric profile

As depicted in Table 1, PCOS is a common disorder in reproductive-aged women between 25 and 30 years, followed by women aged 31–35 years. These results show that there is a significant (p < 0.001) difference in the age of incidence of PCOS. Table 2 shows a 1.417-fold increase in the risk of developing PCOS compared to the control. A highly significant (p < 0.001) correlation (r = 0.355) was observed between the incidence of PCOS and BMI, with a higher mean BMI (28.2 ± 6.08 kg/m²) compared to that (24.12 ± 4.69 kg/m²) of the control group. The percentage of women with normal BMI in the PCOS group (35.48%) is approximately half that of women in the PCOS group (60.93%), and 41.93% were obese compared to 10.93% of women in the control group (Table 1), and a significantly (p = 0.002) higher number of obese and overweight women were seen in the PCOS group. The mean hip circumference in PCOS patients was 109.22 ± 17.39, a value that was significantly (p < 0.001) higher than that (99.02 ± 14.97 cm) of women in the control group. Furthermore, 9, 39, 11 and 5 had normal, medium, large and extra-large hip circumference respectively in PCOS patients compared to 30, 24, 10 and nil found to be with normal, medium, large and extra-large hip circumference respectively of women in the control group (Tables 1 and 2).

Blood pressure

Our results showed (Table 1) an insignificant difference in systolic blood pressure between the control and PCOS case groups. However, a highly significant (p < 0.001) difference was recorded for diastolic and mean blood pressure. Mean arterial pressure was higher in patients with PCOS than in patients in the control group. The odds ratio calculated for mean arterial pressure (MAP) in the PCOS patients was 1.528 times higher than that in the control group. A significant (p < 0.001) correlation was found between SP (r = 0.396) and DP (r = 0.27) (Table 2).

Discussion

This study was carried out to determine the body composition of infertile women with PCOS and to compare the relevant factors to those in women without PCOS. The results of our study are encouraging and indicate new ways of treating body fat in PCOS patients. PCOS is a common disorder in reproductive-aged women between 25 and 30 years, and the mean age of incidence of PCOS was 29.74 ± 3.32 years; this value represents a 1.417-fold higher risk of PCOS compared to the control group, similar to the results of a previous report.14

Excess abdominal adipose tissue initiates metabolic and endocrine irregularities that impair insulin action, and this interacts with the progression of hyperandrogenism, leading to impaired glucose uptake, which again increases the deposition of visceral fat, independently of body mass index.15,16 Our results are on the higher side of numbers observed in similar studies because we observed a higher percentage of women in the high to very high visceral fat category. These results are supported by the highly significant (p < 0.001) correlation between the incidence of PCOS and elevated waist (r = 0.345) and hip (r = 0.302) circumferences. More PCOS patients were in the category of having a large or extra-large hip circumference than in previous studies, which reported that increased waist and hip circumference are associated with increased incidence of PCOS.17,18

The results showed that the total body fat distribution in patients who have been diagnosed with PCOS was
significantly (p < 0.001) higher than that in the control group, and majority were in the high to very high category. Highly significant (p < 0.001) correlations were recorded between the incidence of PCOS and total subcutaneous fat, trunk subcutaneous fat, arm subcutaneous fat and leg subcutaneous fat. These results are similar but are at the higher end of the range found in studies measuring adipose tissue depots using ultrasound. Our results showed a correlation

Table 1: Stratified comparative analysis of the body composition, blood pressure and anthropometric profile of control and PCOS patients.

| Factors               | Category          | Total | Control | Case | Level of significance |
|-----------------------|-------------------|-------|---------|------|-----------------------|
| Age                   |                   |       |         |      |                       |
| 18–24                 |                   | 30    | 29      | 1    | Chi-square = 47.9     |
| 25–30                 |                   | 56    | 16      | 40   | Degrees of freedom = 4 |
| 31–35                 |                   | 31    | 9       | 22   | Probability = 0.000   |
| 36–40                 |                   | 12    | 9       | 3    |                       |
| ≥41                   |                   | 3     | 3       | -    |                       |
| Visceral fat          |                   |       |         |      |                       |
| ≤9%                   | Normal            | 94    | 55      | 39   | Chi-square = 11.0     |
| 10–14%                | High              | 17    | 3       | 14   | Degrees of freedom = 2 |
| ≥15                   | Very high         | 14    | 5       | 9    | Probability = 0.004   |
| Total body fat        |                   |       |         |      |                       |
| 21–32.9               | Normal            | 50    | 37      | 13   | Chi-square = 18.4     |
| 33–38.9               | High              | 44    | 18      | 26   | Degrees of freedom = 2 |
| ≥39                   | Very high         | 36    | 11      | 25   | Probability = 0.000   |
| Skeletal muscle       |                   |       |         |      |                       |
| ≤24.3%                | Low               | 79    | 26      | 53   |                       |
| 24.3–30%              | Normal            | 51    | 38      | 13   |                       |
| 30.4–35.3             | High              | 0     | 0       | 0    |                       |
| ≥35.4                 | Very high         | 2     | 2       | 0    |                       |
| BMI                   |                   |       |         |      |                       |
| ≤18.5%                | Underweight       | 5     | 4       | 1    | Chi-square = 15.2     |
| 18.5–25%              | Normal            | 66    | 40      | 22   | Degrees of freedom = 3 |
| 25–30                 | Overweight        | 26    | 13      | 13   | Probability = 0.002   |
| >30                   | Obese             | 35    | 9       | 26   |                       |
| Blood pressure profile|                   |       |         |      |                       |
| Systolic blood pressure mmHg |       |       |         |      |                       |
| <120                  | Normal            | 41    | 23      | 18   | Chi-square = 4.09     |
| 120–130               | Prehypertension   | 50    | 23      | 27   | Degrees of freedom = 3 |
| 131–140               | Mild hypertension | 18    | 5       | 13   | Probability = 0.251   |
| >140                  | Moderate hypertension | 12  | 6       | 6    |                       |
| Diastolic blood pressure mmHg |       |       |         |      |                       |
| <80                   | Normal            | 49    | 36      | 13   | Chi-square = 22.1     |
| 80–90                 | Prehypertension   | 69    | 25      | 42   | Degrees of freedom = 3 |
| 91–100                | Mild hypertension | 4     | 1       | 3    | Probability = 0.000   |
| >100                  | Moderate hypertension | 6  | 0       | 6    |                       |
| Mean arterial pressure mmHg |       |       |         |      |                       |
| <93                   | Normal            | 41    | 30      | 11   | Chi-square = 18.8     |
| 93–95                 | Prehypertension   | 30    | 16      | 14   | Degrees of freedom = 3 |
| 96–100                | Mild hypertension | 24    | 6       | 18   | Probability = 0.000   |
| >100                  | Moderate hypertension | 31  | 10      | 21   |                       |
| Waist circumference   |                   |       |         |      |                       |
| <80 cm                | Normal            | 23    | 21      | 2    |                       |
| >80 cm–<88 cm         | Overweight        | 36    | 17      | 19   |                       |
| ≥88 cm                | Obese             | 72    | 27      | 45   |                       |
| Hip circumference     |                   |       |         |      |                       |
| 66–96                 | Small             | 39    | 30      | 9    | Chi-square = 19.9     |
| 96–119                | Medium            | 63    | 24      | 39   | Degrees of freedom = 3 |
| 119–137               | Large             | 21    | 10      | 11   | Probability = 0.000   |
| 137–154               | Extra-large       | 5     | -       | 5    |                       |
| Waist/Hip ratio       |                   |       |         |      |                       |
| ≤0.76                 | Low risk          | 18    | 15      | 3    | Chi-square = 16.2     |
| 0.76–0.83             | Moderate risk     | 15    | 10      | 5    | Degrees of freedom = 3 |
| 0.84–0.9              | High risk         | 35    | 10      | 25   | Probability = 0.001   |
| >0.9                  | Very high risk    | 64    | 31      | 33   |                       |

The results were analysed using the chi-square test in comparison with the control group. p values of less than 0.05 were considered statistically significant.
between increased amounts of upper body fat, subcutaneous fat in the trunk, arm and legs and decreased insulin sensitivity that was higher than that reported in a recent study.\textsuperscript{16,20} Our results also showed a significantly higher trunk/peri- pheral fat ratio (p < 0.001) in infertile PCOS patients than that reported in a previous study.\textsuperscript{17}

A case control study reported a higher prevalence of androgen-related fat distribution, improved muscle strength in the biceps, and lower limb and handgrip strength in PCOS patients without improving skeletal muscle ratio.\textsuperscript{21} Our results support those of the previous study in that we found a significant (p < 0.001) negative correlation between total skeletal muscle and the incidence of PCOS and a lower total skeletal muscle percentage compared to the control group. It has also been noted that patients with PCOS were in a lower category of skeletal muscle distribution compared to the population in the control group, and these results support those of a study that found significantly lower total skeletal muscle in a PCOS group compared to a control group.\textsuperscript{22} Lower skeletal muscle distribution in the PCOS group, which is associated with infertility, can reduce insulin sensitivity, as reported in 2014.\textsuperscript{17}

Table 2: Comparative analysis of the anthropometric profile and body composition of control and PCOS patients.

| Factors                  | Study group | Mean ± Std. deviation | Level of significance (2-tailed) ‘t’ test | Exp (B) odds ratios | 95% Confidence interval of the difference | Pearson correlation |
|--------------------------|-------------|-----------------------|----------------------------------------|---------------------|------------------------------------------|---------------------|
| Age (Years)              | Control     | 28.24 ± 7.983         | 1.417                                  | 3.06               | 0.606                                     | 0.123               |
|                          | PCOS        | 29.74 ± 3.325         | 0.162                                  |                     |                                          |                     |
| Height (cm)              | Control     | 159.11 ± 6.35         | 0.414                                  |                     |                                          |                     |
|                          | PCOS        | 158.2 ± 6.4           | 0.414                                  |                     |                                          |                     |
| Weight (kg)              | Control     | 60.67 ± 12.67         | 0.001                                  |                     |                                          |                     |
|                          | PCOS        | 68.43 ± 13.45         | 0.001                                  |                     | -2.32                                    |                     |
| Waist circumference (cm) | Control     | 84.83 ± 19.23         | 0.001                                  | 1.071               | -5.56                                    | 3.927               |
|                          | PCOS        | 97.44 ± 15.11         | 0.001                                  |                     | -5.59                                    | 6.621               |
| Waist/Hip ratio          | Control     | 0.85 ± 0.2            | 0.08                                  |                     | -0.014                                   | 0.0066              |
|                          | PCOS        | 0.9 ± 0.3             | 0.08                                  |                     | -0.014                                   | 0.0066              |
| BMI                      | Control     | 24.12 ± 10.68         | 0.001                                  |                     | -6.01                                    | 2.178               |
|                          | PCOS        | 28.2 ± 6.08           | 0.001                                  |                     | -6.01                                    | 2.169               |
| Hip circumference (cm)   | Control     | 99.02 ± 14.97         | 0.001                                  |                     | -5.82                                    | 4.566               |
|                          | PCOS        | 109.22 ± 17.39        | 0.001                                  |                     | -15.83                                   | 4.579               |
| Systolic BP (mmHg)       | Control     | 124.49 ± 14.11        | 0.723                                  |                     | -5.64                                    | 3.927               |
|                          | PCOS        | 125.34 ± 13.03        | 0.723                                  |                     | -5.63                                    | 3.933               |
| Mean Arterial Pressure   | Control     | 92.77 ± 8.73          | 0.002                                  | 1.528               | 8.88                                     | 1.998               |
|                          | PCOS        | 98.2 ± 10.68          | 0.002                                  |                     | 8.87                                     | 1.998               |
| Diastolic BP (mmHg)      | Control     | 76.92 ± 7.57          | 0.001                                  | 0.991               | -11.58                                   | 3.853               |
|                          | PCOS        | 84.64 ± 13.46         | 0.001                                  |                     | -11.56                                   | 3.876               |
| Ideal Body Weight (kg)   | Control     | 55.78 ± 4.55          | 0.424                                  |                     | -0.929                                   | 2.196               |
|                          | PCOS        | 55.15 ± 4.52          | 0.424                                  |                     | -0.929                                   | 2.196               |
| Total Body fat %         | Control     | 32.53 ± 5.56          | 0.001                                  | 1.366               | -7.772                                   | 2.734               |
|                          | PCOS        | 37.78 ± 8.57          | 0.001                                  |                     | -7.819                                   | 2.686               |
| Visceral fat %           | Control     | 5.47 ± 4.23           | 0.09                                  | 5.59                | -5.55                                    | 1.721               |
|                          | PCOS        | 9.1 ± 6.5             | 0.001                                  |                     | -5.82                                    | 1.699               |
| Whole subcutaneous fat % | Control     | 27.97 ± 5.67          | 0.001                                  | 0.56                | -6.799                                   | 2.898               |
|                          | PCOS        | 32.82 ± 5.65          | 0.001                                  |                     | -6.799                                   | 2.898               |
| Trunk subcutaneous fat % | Control     | 25.08 ± 7.82          | 0.001                                  |                     | -6.568                                   | 1.847               |
|                          | PCOS        | 29.29 ± 5.72          | 0.001                                  |                     | -6.569                                   | 1.845               |
| Arm subcutaneous fat %   | Control     | 44.77 ± 11.66         | 0.005                                  | 1.154               | -8.793                                   | 1.603               |
|                          | PCOS        | 49.99 ± 8.93          | 0.005                                  |                     | -8.788                                   | 1.608               |
| Leg subcutaneous fat %   | Control     | 40.42 ± 7.66          | 0.001                                  |                     | -9.965                                   | 3.025               |
|                          | PCOS        | 46.92 ± 12.05         | 0.001                                  |                     | -9.971                                   | 3.019               |
| Whole Skeletal muscle %  | Control     | 25.6 ± 4.84           | 0.001                                  |                     | 0.992                                    | 3.574               |
|                          | PCOS        | 23.32 ± 2.17          | 0.001                                  |                     | 0.987                                    | 3.579               |
| Trunk skeletal muscle %  | Control     | 19.75 ± 3.05          | 0.001                                  |                     | 1.055                                    | 3.014               |
|                          | PCOS        | 17.71 ± 2.62          | 0.001                                  |                     | 1.055                                    | 3.014               |
| Arm skeletal muscle %    | Control     | 26.73 ± 5.1           | 0.002                                  |                     | -4.0803                                  | 7.0136              |
|                          | PCOS        | 25.26 ± 22.19         | 0.003                                  |                     | -4.122                                   | 7.055               |
| Leg skeletal muscle %    | Control     | 36.05 ± 4.54          | 0.459                                  |                     | -12.469                                  | 5.663               |
|                          | PCOS        | 39.45 ± 36.95         | 0.460                                  |                     | -12.551                                  | 5.744               |

The results were analysed using Student’s t test followed by a post-hoc Tukey C test in comparison with a control group of patients. Logistic regression analysis was used to correlate factors and the diagnosis of PCOS. p values of less than 0.05 were considered statistically significant.

**The Pearson Chi-Square test shows a very significant association at the 0.01 level (2-tailed).
We observed a highly significant ($p < 0.001$) correlation between the incidence of PCOS and BMI. The mean BMI of the PCOS group was higher than that of the control group, and the prevalences of overweight and obesity were significantly ($p = 0.002$) higher in women with PCOS, showing a similar relationship between PCOS incidence and BMI.25 In our study, the prevalences of overweight, obesity and central obesity were significantly higher in women with PCOS. These observations support the findings in several studies, which have shown that increased BMI directly and significantly increases the incidence of PCOS.16,21 A higher percentage of PCOS patients were in the category of large and extra-large circumference than was reported previously in women only having PCOS.19 These results also supports the results of previous studies reporting that increased waist and hip circumferences increase the incidence of PCOS and associated complications involving infertility.24

A cross-sectional study of 84 patients with PCOS reported higher levels of arterial stiffness, thickness of the carotid intima-media due to hyperlipidaemia and insulin resistance, thereby increasing diastolic function25 and elevated diastolic blood pressure.26 Similarly, we noted a highly significant ($p < 0.001$) increase in the diastolic and mean blood pressures of PCOS patients. The odds ratio for the mean arterial pressure of PCOS patients was 1.528-fold higher than that of a control group, supporting the findings of these studies.

A limitation of this study is that this study was carried out over a period of only six months and involved patients attending only one private hospital in Muscat. Further consideration of the influence of lifestyle factors, such as dietary intake, physical activity and sedentary behaviour, to the elevated prevalence of obesity in patients with PCOS would assist in determining the aetiology of variations in body fat composition.

Conclusions

Taken together, the results of this study indicate that infertile women with PCOS have a higher percentage of visceral fat, waist circumference, hip circumference, total body fat, total subcutaneous fat, trunk subcutaneous fat, arm subcutaneous fat, leg subcutaneous fat, trunk/peripheral fat ratio, BMI, and elevated diastolic blood pressure than do women PCOS alone, as reported in earlier studies. Similarly, we noted a lower level total skeletal muscle mass and its distribution as compared with women only having PCOS.

Recommendation

It is evident that PCOS, especially in infertile women, is a complex condition; therefore, we recommend further studies that involve more patients, hospitals and regions and extending the study period to observe concrete outcomes and their possible implementation in practice.

Conflict of interest

The authors have no conflict of interest to declare.

Authors’ contributions

Chitme conceptualized the study and analysed and interpreted the data. Eman contributed to the design and conducted the study. All other authors were involved in collecting the data and in writing the initial draft of the article. All authors have critically reviewed and approved the final draft and are responsible for the content and the similarity index of the manuscript.

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