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Original Research

Is the penile golden ratio an indicator of normal sperm count and normal hormonal status? A prospective-observational study

Fatih Demir[1,*], Gokhan Sonmez[2], Murat Keske[1], Mert Ali Karadag[1]

[1]Kayseri City Hospital, Department of Urology, Kayseri, Turkey
[2]Erciyes University, Department of Urology, Kayseri, Turkey

***Correspondence:** fatihdemir1975@gmail.com (Fatih Demir)

Abstract

Background and Objective: The constant phi number (1.618...) is accepted as the indicator of esthetic beauty and harmony in numerous fields of natural sciences and is also known to be effective in various biological systems in the human body such as skeletal system and facial anatomy, respiratory system, and cardiovascular system. In this study, we aimed to compare the anthropometric proportions obtained from penile measurements and the phi-value and to investigate whether this number could be an indicator of fertility.

Material and Methods: This study included 200 infertile male patients. Penile ratio (PR) was calculated by dividing the corpus penis length by the glans penis length. Patients were divided into two equal groups: Group-I included patients with a PR that was closest to the constant phi-value (n = 100) and Group-II included patients with a PR that was the most distant to the phi-value (n = 100). Spermiogram findings, and serum hormone levels were compared between the two groups.

Results: Mean age was 27.37 $\pm$ 3.45 years, median penile length was 9.1 (7.1-10.2) cm, and median PR was 2.06 (1.65-2.64). In group I and II, an abnormal spermiogram was detected in 41% and 48% (*P* = 0.319) and hormonal dysfunction was present in 28% and 26% of the patients (*P* = 0.750), respectively. Overall sperm counts and sperm concentrations were significantly higher in group I compared to group II.

Conclusion: Although PR may not be an indicator of normal spermiogram or hormone status, patients with a closer PR to the phi value are likely to have more favorable spermiogram values.

Keywords

Penis; Golden ratio; Phi number; Fertility; Penile ratio

1. Introduction

The golden ratio is an irrational number accepted as the indicator of aesthetic beauty and harmony in numerous fields of art and natural sciences [1]. This number is expressed as a mathematical constant phi (φ) of approximately 1.618 and is calculated by first sectioning the circumference of a circle (c) into two arcs including a larger arc (a) and a smaller arc (b) and then dividing the length of (a) by the length of (b) (i.e. a/b) or by dividing the length of (c) by the length of (a) (i.e. c/a) [2].

Researchers have indicated that the φ-value also represents biological harmony and that numerous anatomical regions in human body have ratios equal to the φ-value. Of note, a previous study evaluated the relationship between the cardiac system and the φ-value and revealed that some echocardiographic measurements of healthy individuals accorded with the φ-value [2]. Some other studies found that some facial landmarks and symmetry as well as some obstetric organs accorded with the φ-value [2–6]. Interestingly, even human DNA has been found to accord with the φ-value [1].

Anthropometric proportions of the urogenital tract in adults are a result of the perfect hormonal balance developing during the childhood and adolescence [7]. Previous studies found a relationship between anthropometric proportions and the wellbeing of the urogenital tract or fertility [8–10]. One of the best known anthropometric proportions is the anogenital distance whose relationship with fertility is attributed to embryonic development [8]. In addition, digit lengths and some ratios calculated based on these lengths have been found to be associated with fertility as well [9, 10]. The remaining question, then, is whether the φ-value could be a marker of fertility and the wellbeing of the reproductive system.

In this study, we aimed to investigate the effect of the relationship between the proportions obtained from penile measurements and the φ-value on male fertility.

2. Materials and methods

2.1 Patient selection

The study included 200 infertile male patients aged 20-35 years who presented to Kayseri City Hospital Urology-Infertility outpatient clinic between January and September 2020. Infertility was defined as the failure to achieve a clinical pregnancy for a minimum period of 12 months' despite regularly unprotected sexual intercourse [11]. Exclusion criteria were as follow: abnormal urogenital examination (testicular volume $<$ 14 mL, non-palpable ductus deferens, presence of varicocele, and congenital anomalies such as epispadias and hypospadias), prior scrotal surgery, presence or history of cryptorchidism, known chromosomal anomalies, known endocrinological disorders such as hypogonadotropic hypogonadism, use of drugs known to affect sex hormone levels or spermiogram parameters (chemotherapeutic and anabolic drugs and hormone replacement drugs), and a previous diagnosis of idiopathic male infertility or non-obstructive azoospermia.

2.2 Data collection

In addition to standard urogenital examination and spermiogram, follicle-stimulating hormone (FSH), luteinizing hormone (LH), total testosterone (TT), estradiol (E2), sex hormone-binding globulin (SHBG), and serum albumin level were measured in each patient. Ten millilitres of venous blood were taken from the control group between 08.00 and 10.00 o'clock after 6 to 8 hours of fasting and the samples were examined. The levels of hormones were determined by means of ADVIA Centaur XP Immunoassay Systems (SIEMENS, Berlin, USA). Free testosterone (FT) and bioavailable testosterone (BT) were calculated using previously described formulas [12, 13].

Semen samples were obtained from each patient in specially designed rooms following a three-day sexual abstinence.

In urogenital examination, testicular volume was measured with Prader orchidometer [14]. Flaccid penile length was measured from the dorsal surface of penis to the pubis-glans (x) and from the glans penis-corpus penis junction to the external meatus (y) by the same urologist (F.D.) for maximum standardization. Penile ratio (PR) was calculated by dividing the longer distance (x) by the shorter distance (y) (i.e. x/y). See the Fig. 1 for description of measurement of PR.

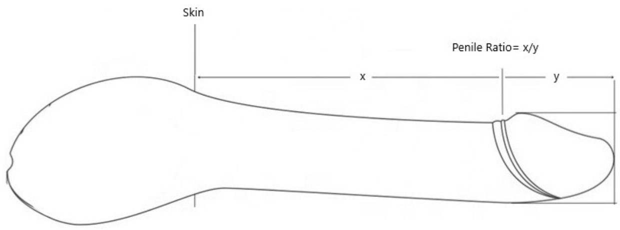

FIG. 1. Description of measurement of Penile Ratio. Penile ratio was calculated by dividing the longer distance (x) by the shorter distance (y) (i.e. x/y).

In addition to penile length and PR, age, body mass index (BMI), testicular volume, FSH, LH, TT, E2, SHBG, BT, FT, and spermiogram findings (overall sperm count, ejaculate volume, sperm concentration, sperm motility) were recorded for each patient.

Hormonal dysfunction was defined as the presence of abnormality in any of the five parameters including FSH (reference range [rr], 1.5-12.4 IU/L), LH (rr, 1.7-8.6 IU/L), TT (rr, 2.49-8.36 μg/L), FT (rr, 0.003-0.2 μg/L), and BT (rr, 1.3-6.8 μg/L) and an abnormal spermiogram was defined as the presence of abnormality in any of the five parameters including overall sperm count ($<$ 39 M), sperm concentration ($<$ 15 M/mL), ejaculate volume ($<$ 1.5 mL), sperm motility rate (a + b $<$ 32%), and Kruger's strict criteria (normal $<$ 4%).

2.3 Statistical analysis

Data were analyzed using SPPS 22.0 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). Normal distribution of data was analyzed using histogram plots and Shapiro-Wilk test. Continuous variables with normal distribution were expressed as mean $\pm$ standard deviation (SD), continuous variables with non-normal distribution were expressed as median (1^{st}-3^{rd} quartile), and categorical variables were expressed as frequencies (%). In independent groups, continuous variables with normal distribution (such as age and semen morphology) were compared using Independent Samples t-test, continuous variables with non-normal distribution (such as BMI, testicular size, penile measurements, hormone levels and semen parameters) were compared using Mann-Whitney U test, and categorical variables (such as infertility rates) were compared using Pearson's Chi-square test. Binary logistic regression analysis was used for evaluation the relationship between PR-hormonal status and PR-semen status. In order to evaluate the correlation between semen parameters and PR, "Scatter-Dot" graphs were examined at the first step and the R^2 values were determined. Then Spearman's Correlation Analysis was used to evaluate the correlation between

TABLE 1. Demographic characteristics and urogenital measurements of the patients

Parameter	Group I (n = 100)	Group II (n = 100)	*P*
Age (years)	27.62 ± 3.80	27.11 ± 3.05	0.297
BMI (kg/m^2)	26.35 (23.60-28.10)	26.45 (23.40-28.50)	0.777
Testicular size (mL)			
Right	20.0 (18.0-24.0)	20.0 (18.0-22.0)	0.151
Left	20.0 (18.0-23.5)	20.0 (18.0-22.0)	0.091
Penile length (cm)			
Glans	2.7 (2.5-3.1)	2.7 (2.5-3.0)	0.629
Corpus	5.5 (4.0-6.1)	7.5 (6.6-8.1)	$<$ 0.001
Penile ratio (corpus/glans)	1.66 (1.50-1.85)	2.64 (2.47-3.15)	$<$ 0.001

Data are expressed as mean ± standard deviation or median (1-3rd quartile).
BMI, Body mass index.

values found to be significant in Scatter-Dot. A *P* value of $<$ 0.05 was considered significant.

2.4 Ethical considerations

The study was approved by Kayseri City Hospital Ethics Committee (Approval No.: 1192020). A verbal and written consent was obtained from each patient prior to the study.

3. Results

The study included 200 patients with a mean age of 27.37 ± 3.45 years and a median BMI of 26.35 (range, 23.45-28.17) kg/m^2. Median flaccid penile length was 9.1 (range, 7.1-10.2) cm and the median PR was 2.06 (range, 1.65-2.64). Of all patients, 20 (10.0%) patients had hormonal dysfunction, 65 (32.5%) patients had an abnormal spermiogram (abnormal morphology: 15, abnormal sperm counts or motility: 32, both of them: 18), and 34 (17.0%) patients had both. Based on these rates, the overall number of male with the abnormal findings was found to be 59.5% (119/200).

Patients were divided into two equal groups: group I included patients with a PR that was closest to the constant φ-value (patients between 1.438 and 1.829) (n = 100) and group II included patients with a PR that was the most distant to the φ-value (patients below 1,438 or above 1,829) (n = 100). The two groups were similar with regard to age and BMI values. Similarly, no significant difference was found between the groups with regard to the right and left testicular volumes and the corpus penis length (x). However, glans penis length (y) was significantly higher in group II compared to group I (Table 1).

No significant difference was found between the patients with normal and abnormal spermiogram findings and hormone levels (Fig. 2A,B). Similarly, no significant difference was found between the median TT levels in group I (3.6 [range, 3.2-5.5] μg/L) and group II (3.5 [range, 3.2-4.9] μg/L) (P = 0.738). Although the E2 levels were slightly higher in Group II compared to Group I, no significant difference was found between the two groups with regard to FSH, LH, FT, and BT values (Table 2).

Moreover, there was no significant difference between the two groups with regard to sperm motility (P = 0.155), whereas overall sperm counts and sperm concentrations were significantly higher in Group I compared to Group II ($P < 0.05$) (Table 3).

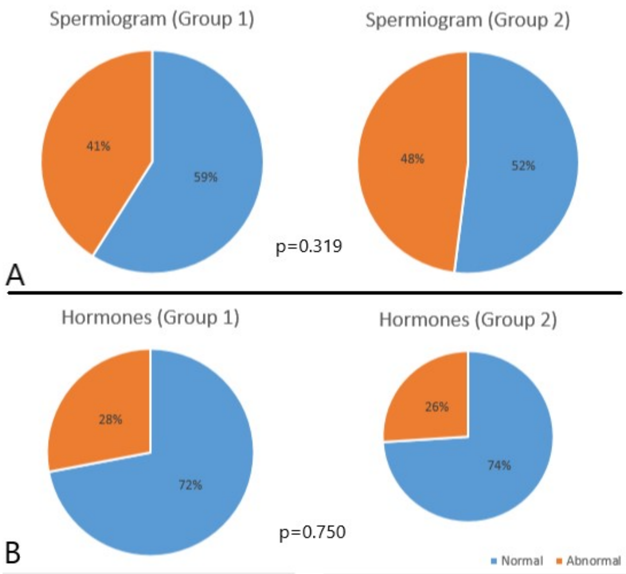

FIG. 2. Comparison of the spermiogram and hormone parameters of groups. (A) Normal and abnormal spermiogram rates of groups. (B) Normal and abnormal hormonal status rates of groups.

In regression analysis, there were no significant relationship between normal/abnormal spermiogram status-PR and normal/abnormal hormonal status-PR (P = 0.322 and P = 0.076, respectively). When the correlation between sperm count and sperm concentration and PR was evaluated, it was seen that there was a correlation between PR value and sperm concentration and PR (R^2 = 0.047, P = 0.020). However, there was no correlation between total sperm count and PR (Fig. 3).

4. Discussion

The Fibonacci sequence and the φ-value are the most aesthetically pleasing indicators commonly used in art and natural sciences, and their relationship with the human anatomy and biological structures has become a growing concern [15]. In the present study, we evaluated the effect of the relationship between the golden ratio and the penis, a urological

TABLE 2. Comparison of the hormone levels of the groups

	Group I (n = 100)	Group II (n = 100)	*P*
Total testosterone (μg/L)	3.6 (3.2-5.5)	3.5 (3.2-4.9)	0.738
Estradiol (pg/mL)	13.4 (8.1-25.0)	19.2 (5.9-22.5)	0.029
FSH (IU/L)	3.2 (2.4-4.7)	4.0 (2.2-6.5)	0.256
LH (IU/L)	5.4 (4.6-7.6)	5.2 (4.1-6.7)	0.870
Bioavailable Testosterone (μg/L)	1.60 (1.45-2.10)	1.92 (1.51-2.24)	0.056
Free Testosterone (μg/L)	0.062 (0.060-0.081)	0.074 (0.058-0.087)	0.108

Data are given as median (1-3^{rd} quartile).

FSH, Follicle-stimulating hormone; **LH,** Luteinizing hormone; **SHBG,** Sex hormone-binding protein.

TABLE 3. Comparison of the spermiogram parameters of the groups

	Group I (n = 100)	Group II (n = 100)	*P*
Ejaculate volume (mL)	3.0 (2.0-3.5)	3.2 (2.0-5.0)	0.080
Overall sperm count (M)	90.00 (18.00-147.50)	63.00 (40.12-83.75)	0.045
Sperm concentration (M/mL)	25.00 (5.50-61.26)	17.90 (10.95-28.00)	0.039
Normal morphology (%)	4.0 ± 1.1	4.3 ± 1.0	0.364
Sperm motility (%)			
a + b	38.0 (21.0-51.0)	36.0 (10.0-54.0)	0.155

Data are expressed as mean ± standard deviation or median (1-3^{rd} quartile).

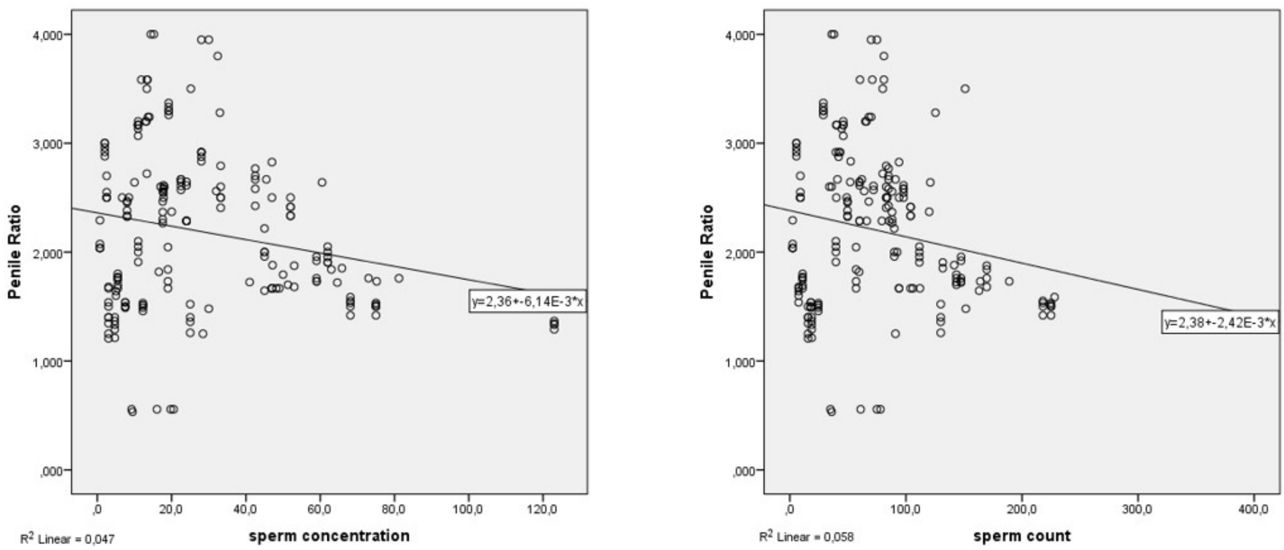

FIG. 3. Evaluation of the correlation between semen parameters and penile ratio. Scatter-Dot graphs show that there is a significant relationship between sperm concentration and PR (left side), but not between sperm count and PR (right side).

organ that consists of two different anatomical regions and distances and is highly appropriate for the measurements of length, on spermiogram and hormonal parameters. The results indicated that PR (i.e. proportion of corpus penis to glans penis) is not an indicator of abnormal spermiogram. Additionally, no significant difference was found between patients with a PR that was the closest to the φ-value and patients with a PR that was the most distant to the φ-value with regard to hormonal levels. However, interestingly, overall sperm counts and sperm concentrations were both higher in patients with a closer PR (i.e. in patients with a near-ideal ratio) than in patients with a more distant PR. These findings implicate that although PR may not be an indicator of normal spermiogram or hormone status, patients with a closer PR to the φ-value are likely to have more favourable spermiogram values. Correlation and regression analysis results also supported these results. Although there was no relationship between PR and semen status/hormonal status in regression analysis, there was a significant relationship between sperm concentration and PR according to correlation analysis.

To date, there have been numerous studies investigating examples of the golden ratio in various biological systems in the human body [15–23]. Among these, Petekkaya *et al.* evaluated the relationship between the anatomy of nasal concha and the golden ratio [15]. Additionally, a recent systematic review investigated the association between the golden ratio and the cardiovascular system by measuring some electrocardiographic distances and wavelengths as well as the vertical-to-transverse diameters ratio and some arterial blood pressure ratios. The authors revealed that these ratios were consistent with the golden ratio and could be indicators of a healthy cardiovascular system [16]. Another study evaluated the relationship between cardiovascular surgery and the golden ratio by performing various echocardiographic measurements in 41 patients and reported that a healthy mitral valve was associated with the golden ratio [17]. Iosa *et al.* examined the relationship between anthropometry and gait harmony and found that anthropometric proportions were associated with a walking that was in harmony with the golden ratio [18]. Some other studies reported on a relationship between the golden ratio and other body parts including bone structures, liver, lungs and retina [19–22]. However, a literature search performed on Pubmed, EMBASE, and Cochrane Central Trials Registry revealed that there has been only one study that investigated the relationship between urogenital organs and the φ-value. In that study, da Silva *et al.* evaluated the associated between penile curvature and golden ratio in five patients with penile curvature (three patients with congenital curvature and two patients with acquired curvature) and reported that the φ-value was consistent with all the cases of congenital penile curvature while there was no relationship with acquired penile curvature. Based on these findings, the authors suggested that the golden ratio could be used in penile curvature surgery, regenerative medicine, and tissue engineering [23].

Literature indicates that infertility affects almost 15% of the reproductive age range population and the male factor accounts for up to 40-60% of these cases [24]. In our study, almost 59% of the patients had either hormonal dysfunction or an abnormal spermiogram or both. Although our study had several exclusion criteria and this rate did not include the female factor, the male factor infertility rates found in our study were consistent with those reported in the literature. However, it should be kept in mind that the patients included in our study and the patients described in the literature are not homogeneous.

The ideal sperm concentration level in healthy and young men is controversial. In a study with 5252 healthy men, the mean sperm concentration was reported to be around 50 million [25]. In a 2001 study conducted among healthy and young Japanese men, it was reported that the total sperm count and sperm concentration of the population was approximately 70 million and 25 million/mL, respectively [26]. Sperm concentrations of our cohort appear to be lower than the literature and this may be due to ethnicity. In addition, it should be kept in mind that the men included in our study were not completely healthy men and consisted of men who applied to us because of inability to conceive.

Our study had several important limitations. First, the study had a limited number of patients. Second, the study was conducted with patients that had already been diagnosed with infertility rather than with the general population. Third, no information was available regarding the fertility potential of patients' wives. Finally, in accordance with world health organization (WHO) guideline recommendations, 2 consecutive semen analysis should be performed. According to the results of a recent study, after finding normozoospermia on the initial analysis, 27% of the second semen analyses were pathological. Following a first pathological semen analysis 23% of the second analyses were normal [27]. A single semen and hormone analysis were performed in this study and this is another important limitation.

5. Conclusions

These results indicated that overall sperm counts were higher in patients with a closer PR than in patients with a more distant PR to the φ-value. Although these findings do not provide clear evidence on the effect of the relationship between PR and the golden ratio on fertility, it can be asserted that the anthropometric compatibility in the penis is effective on sperm count. Further studies involving larger numbers of volunteers and encompassing the majority of the general population are needed to substantiate the effect of this growingly popular ratio on urogenital organs.

Author contributions

Study Design: FD, MAK, Data Collection: GS, Statistical Analysis: MK, Data Interpretation: FD, Manuscript Preparation: FD, MK, Literature Search: FD, MAK

Ethics approval and consent to participate

The study was approved by Kayseri City Hospital Ethics Committee (Approval No.: 1192020). A verbal and written consent was obtained from each patient prior to the study.

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Conflict of interest

The authors declare no conflict of interest.

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