

# Assessment of hirsutism among Korean women: results of a randomly selected sample of women seeking pre-employment physical check-up

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**BACKGROUND:** The objectives of this study were to define the distribution of the modified Ferriman–Gallwey (mF-G) score in a random group of Korean women and to study any association(s) between hirsutism and endocrine/metabolic markers.

**METHODS:** A single investigator assessed the mF-G score prospectively in 1010 Korean women, who consulted a health-care center as part of a group check-up for employment. Logistic regression models were utilized to test the relationships between the presence of hirsutism and levels of endocrine/metabolic markers.

**RESULTS:** Subjects had mF-G scores ranging from 0 to 19, and 505 subjects (50.0%) had an mF-G score of zero. Of the 1010 subjects, 95.1% had a score at or below six; thus, a score of six or greater represented hirsute women in our population. The most frequently affected site was the upper back, but the most densely affected area was found to be the lower abdomen. Hirsutism was significantly and positively associated with serum levels of total testosterone (T) and hemoglobin A<sub>1c</sub>, but negatively associated with those of sex hormone binding globulin (SHBG). In addition, the odds of a woman developing hirsutism were higher for increased total T and HbA<sub>1c</sub>, and lower for decreased SHBG. Hirsutism and homeostatic model assessment for insulin resistance were positively associated, but the relationship was not significant after adjusting for age and BMI.

**CONCLUSIONS:** mF-G scores greater than six represent the appropriate diagnostic cutoff for the detection of hirsutism in Korean women. Increased serum total T and HbA<sub>1c</sub>, and decreased SHBG concentrations were associated with the presence of hirsutism.

**Key words:** androgen excess / hair growth / hirsutism / polycystic ovary syndrome

## Introduction

Hirsutism is a disorder of excess growth of terminal hairs in androgen-dependent areas, which include the chin, upper lip, chest, breasts, abdomen, back and anterior thighs. Hirsutism is the most commonly used clinical indicator of hyperandrogenism. Although the causes of increased androgen production in women are diverse, polycystic ovary syndrome (PCOS) is regarded as the most common etiology of clinical hyperandrogenism in women (Azziz *et al.*, 2004; Carmina *et al.*, 2006).

Excess body and facial terminal hair growth is measured semi-quantitatively using a scoring system such as the mF-G score (Ferriman and Gallwey, 1961). Ferriman and Gallwey evaluated 9 ‘hormonal’ sites in 161 women aged 18–38 and reported that a score above 5 was found in 9.9%, above 7 in 4.3% and scores above 10 in only 1.2% of women tested. Subsequently, Hatch *et al.* (1981) indicated that only 5% of premenopausal women had a score of eight or greater in the original data collected by Ferriman and Gallwey. Thus, they concluded that a score of eight or more represented hirsute women. Using this concept of the 95th percentile of the population, various values for defining hirsutism

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have been reported by different studies. *Knochenhauer et al. (1998)* reported that 7.6, 4.6 and 1.9% of women had an mF-G score of 6 or more, 8 or more and 10 or more, respectively, without differences between unselected black and white women; thus, the prevalence of hirsutism varied from 2 to 8% depending on the chosen cutoff F-G score. The PCOS/Troglitazone Study Group defined hirsutism as a score above six on the mF-G scale (*Azziz et al., 2001*); *Chang et al. (2005)* classified hirsutism as an mF-G score of seven or greater and *DeUgarte et al. (2006)* used a score of eight or greater.

It is well known that there are racial variations in hair growth patterns (*Bernstein and Rassman, 1997*; *Sperling, 1999*; *Lee et al., 2002*). For example, Japanese women tend to have less body and facial hair than their non-Asian counterparts (*Carmina et al., 1992*), whereas European and Maori women are more likely than other ethnic groups to present with hirsutism (*Williamson et al., 2001*). The mF-G scoring system does not account for ethnic differences, and race-specific normative ranges have not been well established. Recently, *DeUgarte et al. (2006)* indicated that the prevalence and degree of facial and body terminal hair growth was similar in a randomly chosen group of black and white women. However, additional studies including other ethnic or racial groups, particularly Asians, have not yet been performed.

The objectives of this study were to define the degree and distribution of the modified Ferriman–Gallwey (mF-G) score in a random group of Korean women and study any association(s) between hirsutism and endocrine/metabolic markers. For these purposes, a single investigator obtained data prospectively in 1010 random Korean women who consulted a health-care center in our hospital as part of a group physical check-up for employment.

## Materials and Methods

### Subjects

Between March 2005 and December 2008, 4550 premenopausal women, aged 18–40, visited a health-care center in Seoul National University Hospital as a part of group physical check-up for their occupation. The women underwent medical evaluations including a medical history, physical examination, blood sampling and radiologic imaging as part of a routine health check-up and cancer screening. Subjects completed a standardized history form related to physician-diagnosed diseases (such as gynecological, internal, mental, neurological and/or urological conditions), medication (any medication taking more than once a week), cigarette smoking, alcohol intake and socio-demographic factors (such as marital, educational and economic status). Of these women, 3048 received routine cancer screening and gynecologic examinations according to their health check programs, and were randomized to two gynecologist's clinics. To eliminate inter-observer variations, the study subjects were examined by one gynecologic endocrinologist (J.J.K.) who also determined the hirsutism score. Among the 1448 women who received gynecologic examinations in the author's clinic, 438 women declined participation in the study, resulting in 1010 female enrollees. This project was approved by the review board for human research of Seoul National University Hospital and written or verbal informed consent was obtained from each participant.

### Study protocol

Information about a subject's gynecologic history, such as age at menarche, childbearing history, menstrual cycle length and regularity and the use of medication, was gathered during the examination. For

women who were receiving hormonal therapy, their menstrual history prior to treatment and the reason for treatment were recorded. Oligomenorrhea was defined as less than eight periods per year or cycles longer than 35 days, and amenorrhea was defined as the absence of menstruation for more than 3 months without pregnancy (*Norman et al., 2007*).

Hirsutism was assessed using the mF-G scoring system. Nine body areas (upper lip, chin, chest, upper and lower abdomen, upper arms, thighs and upper and lower back) were graded from 0 to 4, and the scores in each area were summed (*Practice Committee of the American Society for Reproductive Medicine, 2006*). Terminal hair was defined as pigmented, coarse and longer than 5 mm. The mF-G score was recorded in a uniform graphical form as described by *Hatch et al. (1981)*. There were 31 subjects who reported regular shaving or waxing in the forearm or leg areas, which were not hormonal sites, and 7 subjects received laser hair removal also in the forearm and leg areas. No one had received truncal or facial area laser hair removal. However, five subjects reported regular upper lip or chin shaving, and one subject received laser hair removal to the upper lip area; those subjects were instructed to point out their hair patterns prior to undergoing hair removal in the graphical form described by *Hatch et al. (1981)*.

The self-reported presence of acne was also recorded, although no specific scoring system was applied. Among 1010 women, 975 subjects received a transvaginal or transrectal ultrasound to assess for polycystic ovaries or any other pathology in the pelvis.

### Clinical and biochemical measurements

Clinical variables such as body weight, height, waist circumference (WC) and blood pressure (BP) were assessed in all subjects whereas wearing a light gown and without shoes. Body weight and height was measured by Inbody 3.0 (Biospace, Seoul, Korea), and BMI was calculated as weight (kg) divided by the square of height ( $\text{m}^2$ ). WC was measured by a trained person with the tape placed horizontally at the smallest diameter between the costal margin and iliac crest while the participant gently exhaled.

In all women, blood samples were obtained during morning fasting state, although these were obtained independent of the menstrual cycle. Serum samples were stored at  $-70^\circ\text{C}$  for subsequent hormonal analysis. Serum total testosterone (T), free T and sex hormone binding globulin (SHBG) were measured using radioimmunoassay (RIA) (Siemens, Los Angeles, CA, USA). The free androgen index (FAI) was calculated as the total T/SHBG  $\times 100$ , and the values for T were converted from ng/ml to nmol/l using the following index proposed by the manufacturer:  $1 \text{ ng/ml} = 3.467 \text{ nmol/l}$ . Serum glucose, total cholesterol, triglycerides, high-density lipoprotein (HDL)-cholesterol, low-density lipoprotein (LDL)-cholesterol and  $\text{HbA}_{1c}$  were measured using a 200FR system (Toshiba, Tokyo, Japan). Fasting insulin levels were evaluated using a commercial kit (BioSource Europe S.A., Belgium) and the homeostatic model assessment for insulin resistance (HOMA-IR) was calculated with the following equation:  $\text{glucose (mg/dl)} \times \text{insulin } (\mu\text{U/ml}) / 405$ .

### Statistical analysis

Continuous variables were compared using Student's *t*-test and the differences in frequency were tested using the  $\chi^2$  test. Deviation from the normal distribution was examined via visual inspection of quartile-normal plots and/or the Shapiro–Wilk test of normality. If the continuous variables were not in the Gaussian distribution and the normal distributions were achieved by natural logarithmic or square root transformations, then the data were displayed as geometric means and 95% confidence intervals (95% CIs).

The unadjusted and adjusted odds ratios (ORs) and 95% CIs for hirsutism were assessed using a logistic regression model. The ORs were adjusted for age and BMI. All data analyses were performed using Stata

software (version 10.2, StataCorp., College Station, TX, USA) and significance was accepted for two-sided *P*-values of <0.05.

Results

Baseline characteristics of the 1010 random Korean women

Table 1 shows the clinical and biochemical properties of all subjects. As previously stated, only premenopausal women aged 18–40 years were enrolled, and the median age was 32 years. Of the subjects studied, 15.9% had a history of oligo- and/or amenorrhea, and

10.3% had a polycystic ovary on transvaginal or transrectal ultrasound. There were 71 (7.0%) women diagnosed with PCOS by the Rotterdam criteria, and an additional 26 women (2.6%) may have had PCOS, but they had not received 17-hydroxyprogesterone or prolactin tests.

Overall, 46 subjects (4.6%) were taking hormonal medications at the time of evaluation. Among the 46 women using hormones, 16 used combined oral contraceptive pills (1.6% of the subjects studied), 21 had a levonorgestrel releasing intrauterine device (2.1% of the subjects studied), 7 had a progestin-only implant (0.7% of the subjects studied), 1 used cyclic medroxyprogesterone acetate and 1 used corticosteroids due to systemic lupus erythematosus.

Table 1 Clinical and biochemical features in hirsute, non-hirsute and the total subjects studied.

	Hirsute group (n = 102)	Non-hirsute group (n = 908)	P-values	Total (n = 1010)
Age (years)	29.8 ± 5.0 <sup>a</sup>	31.7 ± 4.7 <sup>a</sup>	<0.001 <sup>d</sup>	32 (18–40) <sup>b</sup>
BMI (kg/m <sup>2</sup> )	21.5 ± 3.5 <sup>a</sup>	20.4 ± 2.5 <sup>a</sup>	<0.001 <sup>d</sup>	20.0 (14.4–39.7) <sup>b</sup>
Waist circumference (cm) <sup>a</sup>	76.7 ± 8.8	75.6 ± 7.0	0.245 <sup>d</sup>	75.8 ± 7.2
mF-G score <sup>b</sup>	7 (6–19)	0 (0–5)	<0.001 <sup>d</sup>	0.5 (0–19)
Oligo- and/or amenorrhea (%)	42.6% (43/101)	13.9% (124/890)	<0.001 <sup>e</sup>	16.9% (167/991)
Ultrasonography				
No PCO pattern	67.7% (65/96)	88.5% (773/873)	<0.001 <sup>e</sup>	86.5% (838/969)
PCO	28.1% (27/96)	8.2% (71/873)		10.1% (98/969)
Undetermined	4.2% (4/96)	3.3% (29/873)		3.4% (33/969)
Self-reported presence of acne	40.0% (40/100)	15.2% (95/625)	<0.001 <sup>e</sup>	18.6% (135/725)
Parity <sup>b</sup>	0 (0–3)	1 (0–4)	0.003 <sup>d</sup>	1 (0–4)
Hormonal medication	7 (6.9%)	39 (4.3%)	0.216 <sup>e</sup>	46 (4.6%)
SBP (mmHg) <sup>a</sup>	106.5 ± 11.1	105.3 ± 11.0	0.277 <sup>d</sup>	105.5 ± 11.0
DBP (mmHg) <sup>a</sup>	67.0 ± 8.7	66.4 ± 8.9	0.505 <sup>d</sup>	66.5 ± 8.9
Cholesterol (mg/dl) <sup>a</sup>	175.7 ± 24.8	172.9 ± 28.8	0.333 <sup>d</sup>	173.2 ± 28.4
Triglycerides (mg/dl)	70.1 (60.2, 80.0) <sup>c</sup>	66.5 (56.4, 76.6) <sup>c</sup>	0.221 <sup>d</sup>	68.5 (57.4, 79.6) <sup>c</sup>
HDL-C (mg/dl) <sup>a</sup>	63.2 ± 13.1	62.5 ± 13.4	0.646 <sup>d</sup>	62.6 ± 13.3
LDL-C (mg/dl) <sup>a</sup>	101.5 ± 22.6 (n = 61)	96.1 ± 24.5 (n = 371)	0.111 <sup>d</sup>	96.9 ± 24.3 (n = 432)
TSH (μIU/ml) <sup>a</sup>	1.75 (0.3–5.80)	1.77 (0.05–8.54)	0.528 <sup>d</sup>	1.78 (0.05–8.54)
Free thyroxine (T4) (ng/dl) <sup>a</sup>	1.24 ± 0.20	1.24 ± 0.38	0.954 <sup>d</sup>	1.24 ± 0.01
Fasting glucose (mg/dl) <sup>a</sup>	87.3 ± 7.7	87.9 ± 9.1	0.512 <sup>d</sup>	87.8 ± 0.3
Fasting insulin (μU/ml)	9.04 (7.78, 10.3) (n = 42) <sup>c</sup>	7.34 (6.37, 8.31) (n = 310) <sup>c</sup>	0.045 <sup>d</sup>	8.10 (6.63, 9.57) (n = 352) <sup>c</sup>
HOMA-IR	1.75 (0.56–7.79) (n = 42) <sup>b</sup>	1.45 (0.04–5.57) (n = 310) <sup>b</sup>	0.038 <sup>d</sup>	1.56 (0.47–7.79) <sup>b</sup> (n = 352)
Hemoglobin A1c (%)	5.56 (5.47, 5.63) (n = 74) <sup>c</sup>	5.45 (5.43, 5.47) (n = 823) <sup>c</sup>	0.014 <sup>d</sup>	5.46 ± 0.01 (n = 897) <sup>a</sup>
Total testosterone (ng/ml)	0.42 (0.32, 0.52) (n = 14) <sup>c</sup>	0.28 (0.26, 0.30) (n = 230) <sup>c</sup>	0.007 <sup>d</sup>	
Free testosterone (pg/ml) <sup>c</sup>	0.70 (0.56, 0.84) (n = 30)	0.67 (0.62, 0.72) (n = 241)	0.757 <sup>d</sup>	
SHBG (nmol/l) <sup>c</sup>	42.1 (35.8, 48.4) (n = 26)	57.5 (53.2, 61.8) (n = 213)	<0.001 <sup>d</sup>	
FAI	3.27 (2.23, 4.31) (n = 12) <sup>c</sup>	1.89 (1.69, 2.09) (n = 198) <sup>c</sup>	0.022 <sup>d</sup>	
DHEAS (ng/ml)	2017 (1710, 2324) (n = 27) <sup>c</sup>	2120 (1945, 2295) (n = 114) <sup>c</sup>	0.603 <sup>d</sup>	

*P*-values are for the hirsute and non-hirsute groups. BMI, body mass index; DBP, diastolic blood pressure; DHEAS, dehydroepiandrosterone sulfate; FAI, free androgen index; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; mF-G score, modified Ferriman–Gallwey score; PCO, polycystic ovary; HOMA-IR, homeostatic model assessment for insulin resistance; SBP, systolic blood pressure; SHBG, sex hormone binding globulin; TSH, thyroid-stimulating hormone. Hormonal medications: combined oral contraceptive pills, levonorgestrel releasing intrauterine device, progestin-only implant, medroxyprogesterone acetate and corticosteroid.

<sup>a</sup>Data are shown as means ± SD.

<sup>b</sup>Data are shown as median (range).

<sup>c</sup>Data are shown as geometric mean and 95% CI.

<sup>d</sup>Student's *t*-test.

<sup>e</sup>χ<sup>2</sup> test.

## Distribution of the mF-G scores and defining the cutoff levels

Distribution of the mF-G scores are shown in Fig. 1, which demonstrates a skewed distribution toward the lower end of the range. Subjects had mF-G scores ranging from 0 to 19, and 505 subjects (50.0%) had an mF-G score of zero. Of the women studied, 83.2% had a score equal to or less than three, 89.9% had a score equal to or less than five, 95.1% had a score equal to or less than six and 97.3% had a score equal to or less than eight. Consequently, using a cutoff of 95% of the population as normal, a score of six or greater represented hirsutism in our population. As shown in Fig. 2, the most frequently affected site, defined by a hirsutism score of at least one, was the upper back. However, the main contributor to the total hirsutism score, and thus the most densely affected area (the mean mF-G score of those subjects who had a score of at least one in the affected area), was found to be the lower abdomen. Among 71 PCOS patients, 28 patients (39.4%) had hirsutism with a median score of 3 (0–19).

## Comparison of clinical and biochemical features between hirsute and non-hirsute groups

For further analysis, subjects were divided into two groups according to the presence of hirsutism (defined by an mF-G score of six or greater) for comparison of their clinical and biochemical features (Table I). The mean age of the hirsute group was significantly lower ( $29.8 \pm 5.0$  versus  $31.7 \pm 4.7$  years,  $P < 0.001$ ), and the mean BMI was significantly higher ( $21.5 \pm 3.5$  versus  $20.4 \pm 2.5$ ,  $P < 0.001$ ) than the non-hirsute group. As expected, the frequency of the following characteristics was significantly higher in the hirsute group than in the non-hirsute group: oligo- and/or amenorrhea (42.6 versus 13.9%,  $P < 0.001$ ), PCO by ultrasound (28.1 versus 8.2%,  $P < 0.001$ ) and self-reported acne (40.0 versus 15.2%,  $P < 0.001$ ). There were also significant differences in the serum level of total T [0.42 (95% CI 0.32–0.52) ng/ml for the hirsute group versus 0.28 (95% CI 0.26–0.30) ng/ml for the non-hirsute group,  $P = 0.007$ ], SHBG [42.1 (95% CI 35.8–48.4) for the hirsute group versus 57.5 (95% CI 53.2–61.8) for the non-hirsute group,  $P < 0.001$ ], FAI [3.27 (95% CI 2.23–4.31) for the hirsute group versus 1.89 (95% CI 1.69–

2.09) for the non-hirsute group,  $P = 0.022$ ], HOMA-IR [1.75 (95% CI 0.56–7.79) for the hirsute group versus 1.45 (95% CI 0.04–5.57) for the non-hirsute group,  $P = 0.027$ ] and even the level of HbA<sub>1c</sub> [5.56 (95% CI 5.47–5.63) for the hirsute group versus 5.45 (95% CI 5.43–5.47) for the non-hirsute group,  $P = 0.014$ ]. However, we could not find any significant differences between the two groups in other clinical or biochemical variables including WC, BP, lipid levels, thyroid-stimulating hormone levels, free thyroxine or fasting glucose.

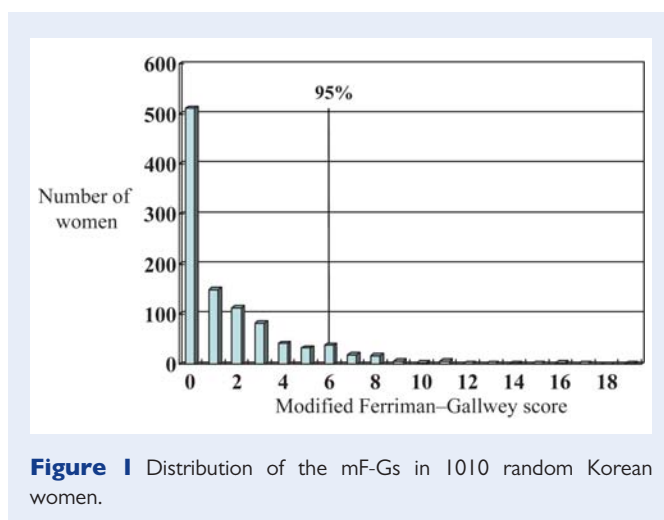
## Association of serum androgens and other biochemical variables with the presence of hirsutism

For the purpose of defining biochemical hyperandrogenism in our population, serum total T, free T and SHBG were measured in 216 non-hirsute (mF-G score less than six as defined in this study), eumenorrheic women who did not show PCO on ultrasonography and who were sampled during the early follicular phase (Days 3–5) of their menstrual cycle. These 216 women were part of the 1010 women enrolled in this study. Among women who were diagnosed with PCOS, 56 agreed to hormonal testing, and their serum total T, free T and SHBG were also measured. Together, these women comprised the 272 subjects used to construct logistic regression models to assess the relationships between hirsutism and serum androgens or other biochemical markers. In unadjusted models, there were significant associations between the presence of hirsutism and the serum total T, SHBG, HOMA-IR and HbA<sub>1c</sub> (Table II). With the exception of HOMA-IR, this relationship remained significant after adjusting for potential confounders, age and BMI. More specifically, the odds that a woman will develop hirsutism are 1.30 times higher for every 0.1 ng/ml increase in serum total T concentration (adjusted OR 1.30, CI 1.03–1.66,  $P = 0.029$ ), 2.15 times higher for every 1% increase in serum HbA<sub>1c</sub> (adjusted OR 2.15, CI 1.06–4.36,  $P = 0.035$ ) and 0.98 times lower for every 1 nmol/l increase in serum SHBG concentration (adjusted OR 0.98, CI 0.98–0.99,  $P = 0.045$ ). Details of the regression model are shown in Table II.

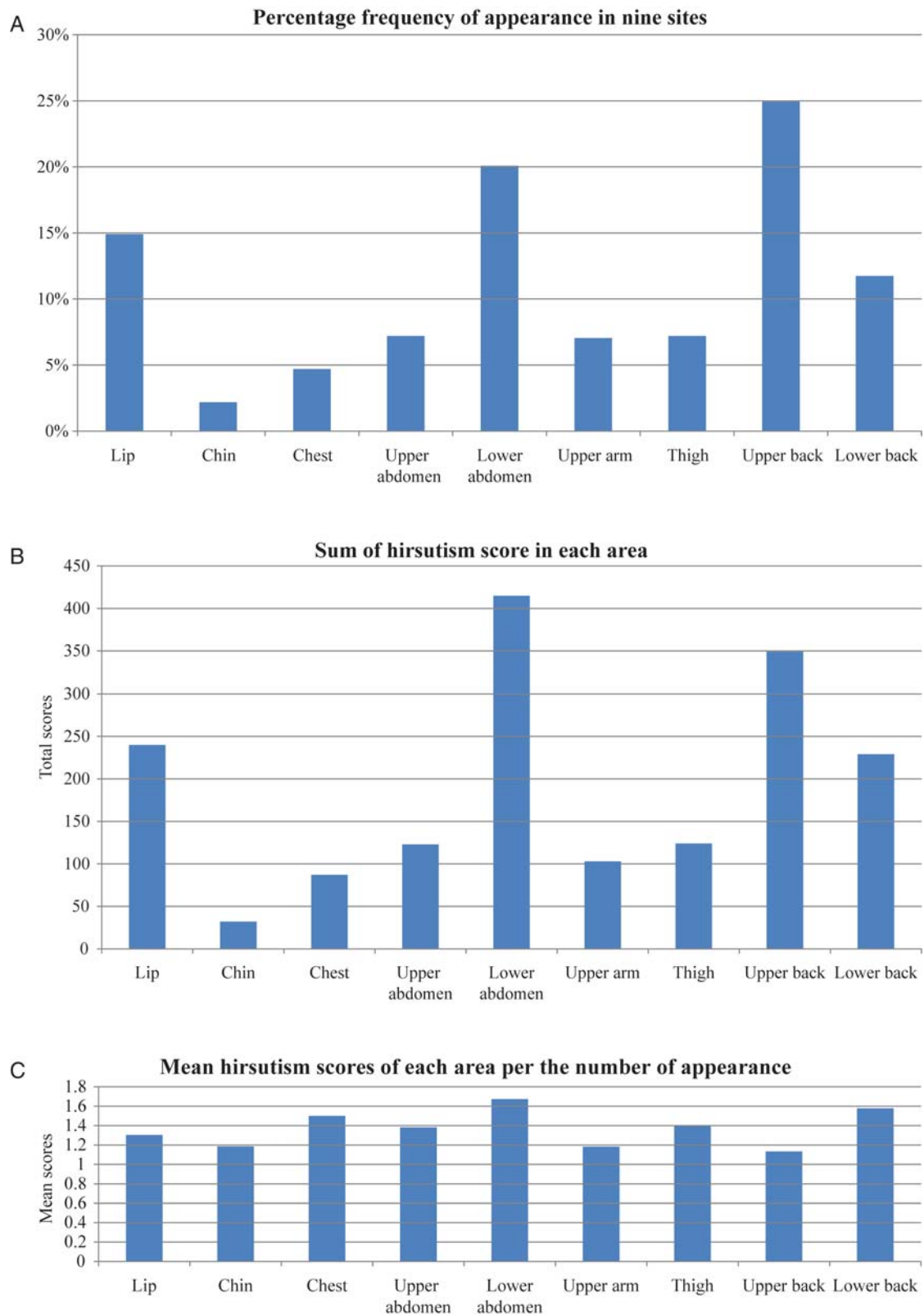
## Discussion

The aims of the present study were to investigate the degree and distribution of the mF-G score and to define the cutoff value in Korean women. In addition, we analyzed the associations between the mF-G score and hormonal or metabolic markers. For these purposes, a single investigator assessed the mF-G score prospectively and as objectively as possible to minimize observation bias. According to our data, a score of six or greater represented hirsute women in our population, and there were significant associations between serum total T, SHBG and hemoglobin A<sub>1c</sub> with the presence of hirsutism. To the best of our knowledge, this is the largest report investigating the distribution of hirsutism score by a single investigator.

It is well known that there is racial variation in hair growth patterns (Bernstein and Rassman, 1997; Sperling, 1999; Lee *et al.*, 2002). Using a cutoff of 95% of the population as normal, an abnormal hirsutism score would be equal to a score of eight in both black and white women (DeUgarte *et al.*, 2006). In the Turkish population, the 95% value of the hormonal hair score was nine (Sagsoz *et al.*, 2004). The



**Figure 1** Distribution of the mF-Gs in 1010 random Korean women.



**Figure 2** Frequency and distribution of terminal hair in nine skin areas.



**Table II** Unadjusted and adjusted ORs between hirsutism and serum androgen or metabolic markers.

Variables	Number	Unadjusted OR (95% CI) <sup>a</sup>	Adjusted OR (95% CI) <sup>b</sup>
Total testosterone (per 0.1 ng/ml increase)	244	1.36 (1.08–1.70)	1.30 (1.03–1.66)
Free testosterone (per 1 pg/ml increase)	271	0.94 (0.53–1.66)	0.65 (0.35–1.22)
SHBG (per 1 nmol/l increase)	239	0.97 (0.96–0.99)	0.98 (0.97–0.99)
FAI (per 1 increase)	208	1.07 (0.95–1.20)	1.03 (0.89–1.18)
DHEAS (per 1 ng/ml increase)	141	0.99 (0.99–1.00)	0.99 (0.99–1.00)
HOMA-IR (per 1 increase)	352	1.46 (1.10–1.92)	1.13 (0.80–1.60)
Hemoglobin A1c (per 1% increase)	897	2.55 (1.30–5.01)	2.15 (1.06–4.36)
TSH (per 1 μIU/ml increase)	1006	0.95 (0.80–1.12)	0.96 (0.80–1.13)

OR, odds ratio; CI, confidence interval; DHEAS, dehydroepiandrosterone sulfate; SHBG, sex hormone binding globulin; FAI, free androgen index; HOMA-IR, homeostatic model assessment for insulin resistance; TSH, thyroid-stimulating hormone.  
<sup>a</sup>Calculated with logistic regression models.  
<sup>b</sup>Adjusted for age and BMI.

abnormal score of six or greater in our data were lower than that observed in both white and black women, as expected, but higher than that observed in women of other Asian countries. In a study of 531 Thai women seen for their yearly cancer screening, women with a total mF-G score of zero, one and two accounted for 97.8% of all subjects (Cheewadhanaraks *et al.*, 2004). Thus, the authors proposed that the cutoff to diagnose hirsutism in Thai women is a score of three or greater. In a total of 623 Chinese women from the Shandong region, the suitable criterion for hirsutism was a score equal to or greater than two (Zhao *et al.*, 2007). However, in a Japanese study of 369 voluntary women and 308 outpatients, the criterion for hirsutism was also reported to be a score of more than six in the mF-G system, equivalent to our results (Ichikawa *et al.*, 1988). It is not yet clear whether the terminal hair pattern and the prevalence of hirsutism are substantially different between populations of Thai, Chinese, Japanese and Korean women.

In our group, the most frequently affected site with a hirsutism score of at least one was the upper back, but the main contributor to the total hirsutism score, and thus the most densely affected area, was found to be the lower abdomen. Ferriman and Gallwey also reported the bodily distribution of hair growth scores by age, and for women between 25 and 34 years, the mean score per frequency (sum of hirsutism scores of at least one in each area/the number of affected subjects in each area) was also highest in the lower abdomen (Ferriman and Gallwey, 1961).

The development and growth of terminal hairs is primarily stimulated by growth, thyroid hormones, and, depending on the body region, androgens (Greenblatt, 1983). Thus, we performed a logistic regression analysis to predict the presence of hirsutism using serum androgens and thyroid-stimulating hormone (TSH). In addition, the association between insulin resistance and hirsutism has been reported for idiopathic hirsutism (Unluhizarci *et al.*, 2004; Sarac *et al.*, 2007) and PCOS (Landay *et al.*, 2009). Thus, a separate logistic regression analysis was done using HOMA-IR and HbA1c. We observed significant associations between the presence of hirsutism and serum total T, SHBG, HOMA-IR and HbA1c, although the association with HOMA-IR was not significant after adjustment for age and BMI. Although direct measurements of total or free T by RIA are highly variable and inaccurate (Azziz *et al.*, 2009), considering the fact that insulin resistance and

hyperinsulinemia are important factors in the reduction of circulating SHBG levels (Preziosi *et al.*, 1993), our findings suggest that insulin resistance and the subsequent elevation of serum androgens may have a role in the clinical expression of hirsutism. However, whether hirsutism is a secondary effect mediated through increased androgen production or whether insulin is a direct stimulator of hair follicles at the level of the pilosebaceous unit has yet to be elucidated.

The challenges faced by the proposed visual grading systems for hirsutism are that it is subjective in nature and demonstrates significant inter and intra-observer variability (Barth, 1996; Wild *et al.*, 2005). In our study, a single investigator determined the hirsutism score, thus eliminating inter-observer variation. Of course, this cannot exclude the possibility of intra-observer variation, and we did not validate an intra-observer correlation. When evaluating the hirsutism score, we strictly adhered to the grading and definition as given by the mF-G system (Practice Committee of the American Society for Reproductive Medicine, 2006) and to the definition of terminal hair (pigmented, coarse and longer than 5 mm) to reduce intra-observer variability. Another limitation of this study is a possible selection bias by using a selected population. Results are not based on population data, but rather based on a pre-employment check-up, and there may be a bias in the selection of the sample. Lastly, we did not ask the subjects whether they felt themselves to be hirsute or not, from the start of this survey, thus we have no data about the total proportion of patient-important hirsutism. To the best of our knowledge, 43 women felt that they are hirsute with a median score of 6 (0–20). Among them, 17 women (39.5%) had hirsutism scores below 6 (median score 3).

In our study group, combined oral contraceptive pills were used by only 1.6% of all subjects, which was much lower than the 25.4% (161 among 633 women) reported in the USA (DeUgarte *et al.*, 2006). In another report about contraceptive practice and attitudes in Korea (Lee and Byeon, 2003), the most common contraceptive method was tubal ligation (23.2%), followed by condoms (21.8%), with oral contraceptives used the least (1.7%). The participants in our study also used combined oral contraceptive pills only marginally (1.6%), so separate estimates for combined oral contraceptives are not provided because they are not likely to influence our results.

In conclusion, although intra-observer variations cannot be ruled out, the main findings of our study suggest that an mF-G score of

$\geq 6$  is the appropriate diagnostic cutoff for the detection of hirsutism among Korean women. We also observed that an increased serum total T, HOMA-IR and  $\text{HbA}_{1c}$ , and decreased serum SHBG concentrations were associated with the presence of hirsutism. Although the pathophysiology of hirsutism is complex and multifactorial, including local factors at the pilosebaceous unit, these findings suggest that insulin resistance, as well as serum androgens, may have a role in the clinical expression of hirsutism.

## Authors' roles

J.J.K., S.J.C.: Analysis and interpretation of data, drafting the article. Y.M.C., S.Y.M.: Final approval of the version to be published. S.S.H.: Analysis and interpretation of data. K.R.H.: Revising the article critically for important intellectual content. S.M.K.: Substantial contributions to acquisition of data. S.H.Y.: Revising the article critically for important intellectual content.

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