Validated Assessment Scales for the Female Asian Calf

Kyle Seo, MD, PhD,* Thorin L. Geister, PhD,† Yates Yen Yu Chao, MD,‡ Chiranjiv Chhabra, MD,§ Niamh Corduff, MD,‖ Sabrina G. Fabi, MD,¶ Carl S. Hornfeldt, PhD,# Martina Kerscher, MD,** Stephanie Lam, MD,†† Tatjana Pavicic, MD,‡‡ Peter H.L. Peng, MD,§§ Berthold Rzany, MD,‖‖ Atchima Suwanchinda, MD,¶¶ Fang-Wen Tseng, MD,## and Rainer Pooth, MD, PhD†

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BACKGROUND Clinical photonumeric scales have been developed and validated to objectively measure the effectiveness of aesthetic treatments in specific anatomical areas; however, these are based on the typical features of Caucasian patients. No clinical scale for Asian calf appearance currently exists.

OBJECTIVE To develop and validate a calf assessment scale for use in the female Asian patient population.

METHODS AND MATERIALS During 2 validation sessions, 13 raters assessed calf images of female Asian subjects ($N = 35$) viewed from behind with feet flat on the floor (at rest) and on tiptoes (dynamic). Images were rated from 0 (very slim, linear profile) to 4 (very severe convex profile).

RESULTS Inter-rater and intra-rater reliability were "substantial" (≥0.6, intraclass correlation coefficient [ICC] and weighted kappa) for the calf—at rest, calf—dynamic, and calf summary score. Reliability was "substantial" for calf—at rest and calf–dynamic (≥0.6, ICC and weighted kappa) and "almost perfect" (0.85) for the calf summary score. BMI and calf circumference were highly correlated with scale ratings, and calf circumference was a significant predictor.

CONCLUSION This new photonumeric assessment scale has value for assessing the female Asian calf, providing a standardized measure of calf appearance in clinical practice and clinical research settings.

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Physical attractiveness is important for everyone's emotional well-being. With respect to the legs, the calf may be a source of unattractiveness among female Asians because they are too thin because of a lack muscle mass, too large because of muscle hypertrophy, or asymmetrical because of neuromuscular illness or trauma.[1] Calves that are too narrow can be augmented with silicone implants[2–4] or fat grafting,[2,5,6] whereas hypertrophic gastrocnemius muscles can be reshaped by surgical resection,[7] neurectomy,[8–10] or botulinum toxin.[11,12] Excess adipose tissue can be removed by liposuction,[2] laser lipolysis,[13] or radiofrequency.[14] Mild or moderate calf asymmetry, defined as a >2.0 cm difference between calves, has been treated with botulinum toxin[11] or combined selective neurectomy with or without liposuction on the hypertrophic calf, whereas the hypotrophic calf was treated with fat injection or silicone implantation.[15,16]

**Department of Dermatology, Modelo Clinic, Seoul National University College of Medicine, Seoul, Korea; †Merz Pharmaceuticals GmbH, Frankfurt, Germany; ‡Cosmetic Surgery and Laser Center, Taipei, Taiwan; §Skin Alive, Delhi, India; ‖Aesthetic Breast Surgery Centre, Corduff, Australia; ¶Goldman Butterwick Fitzpatrick Groff & Fabi, Cosmetic Laser Dermatology, San Diego, California; #Apothekon, Inc. Woodbury, Minnesota; **University of Hamburg, Hamburg, Germany; ††Central Health Medical Practice, Hong Kong, China; ‡‡Private Practice for Dermatology and Aesthetics, Munich, Germany; §§P-Skin Professional Clinic, Taipei, Taiwan; ‖‖RZANY& HUND Privatpraxis, Berlin, Germany; ¶¶International Training Center in Laser Surgery, Ramathibodi University Hospital, Bankok, Thailand; ##Taoyuan Milano Aesthetic Clinic, Taipei, Taiwan*

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Because aesthetically attractive legs is an important part of overall attractiveness within the Asian population,[1] several recent reports have specifically targeted this patient group with an emphasis on decreasing female calf size.[8–12,15,17] Numerous aesthetic scales have been developed for assessing the appearance of other anatomical areas, such as the face,[18] neck,[19] and décolleté[20]; however, no previous standardized scales exist for assessing calf appearance. The objective of the following work was to develop the first scales for the objective assessment of calf appearance in Asian women—specifically, "calf—at rest" and "calf—dynamic"—and to validate it for use in clinical and research settings.

Materials and Methods

Subject Selection

Participating subjects for lower limb photography ($N = 35$) were women originating from East or Southeast Asia, 18 to 39 years old with nearly symmetrical legs covering the range of possible leg width. Of special interest was calf contour as viewed from the rear and the right lateral side. Subjects with scarring, skin disease, irregular skin tone, or tattoos in the target area were excluded. No significant hair on the legs was allowed, and subjects were required to shave their legs, if necessary. Each subject provided informed consent before participation. Demographic information and baseline characteristics were collected, and risk factors were assessed before inclusion.

Standardized Photography

Two-dimensional color photographs were obtained using professional, high-resolution photography equipment. Subjects were photographed in highly standardized positions and always with the same angles and standardized background and lighting conditions. For the dynamic position, subjects stood on tiptoes to achieve leg presentation based on calf muscle (gastrocnemius) contraction. Raw image files were converted to

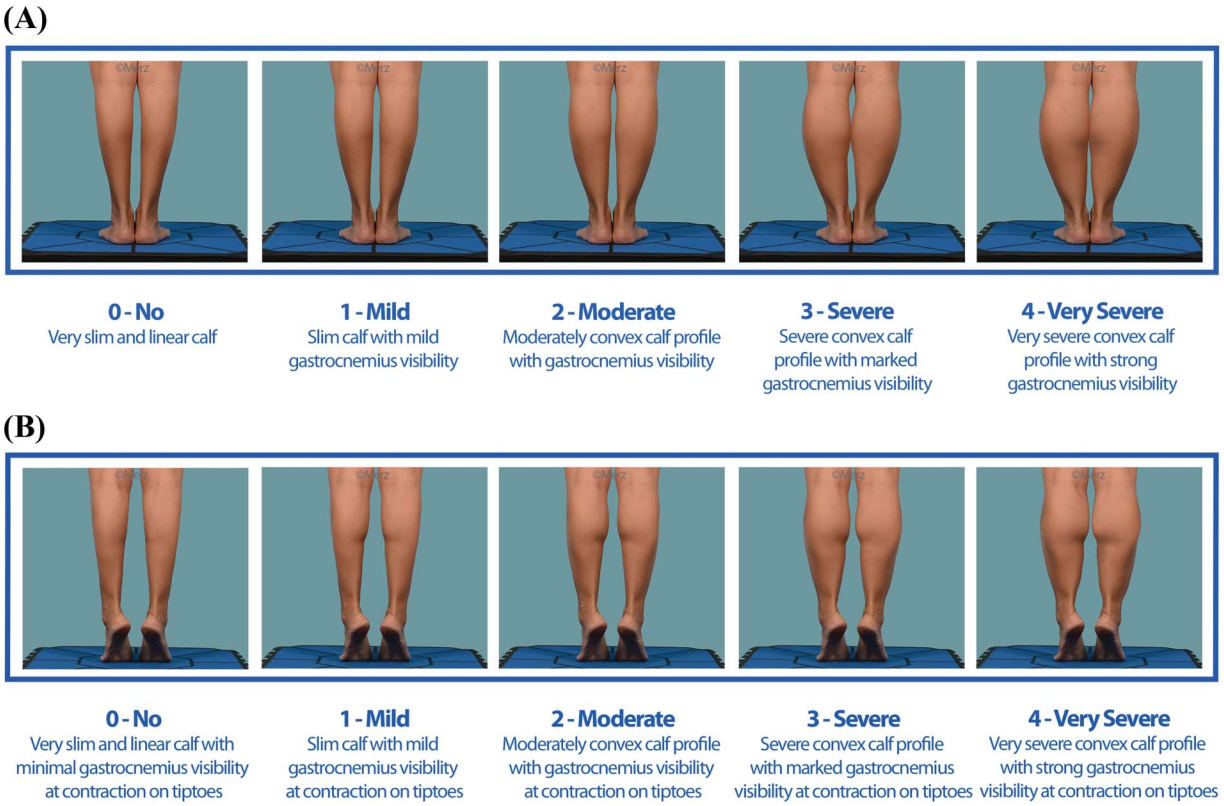

Figure 1. (A and B) Final scales for (A) calf—at rest and (B) calf—dynamic.

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TABLE 1. Subject Demographics and Baseline Characteristics

Characteristic (N = *35*)	
Mean age, yrs (SD)	26.3 (3.8)
Median age, yrs (min–max)	25 (21–38)
Sex, *n* (%)	
Male	0
Female	35 (100.0)
Mean BMI, kg/m^2 (SD)	20.9 (3.3)
Median BMI, kg/m^2 (min–max)	20.0 (16–33)
Race	
Asian	35 (100.0)
Country of origin	
China	6 (17.1)
Hong Kong	3 (8.6)
Korea	1 (2.9)
Macau	0
South Korea	3 (8.6)
Taiwan	0
USA	22 (62.9)
Vietnam	0
Subject ethnicity	
Chinese	24 (68.6)
Korean	4 (11.4)
South Korean	2 (5.7)
Taiwanese	2 (5.7)
Taiwanese/Chinese	0
Vietnamese	2 (5.7)
Vietnamese/Chinese	0
Korean/Vietnamese/Chinese	1 (2.9)
Smoker status	
Nonsmoker	34 (97.1)
Past smoker	1 (2.9)
Sunlight exposure, *n* (%)	
Never	0
Rarely	4 (11.4)
Sometimes	17 (48.6)
Often	14 (40.0)
Very often	0
Fitzpatrick skin type, *n* (%)	
I	1 (2.9)
II	5 (14.3)
III	14 (14.3)
IV	15 (42.9)
V	0
VI	0
Mean calf length, cm (SD)	37.8 (2.7)
Median calf length, cm (min–max)	37.0 (34–49)
Mean calf circumference, cm (SD)	34.8 (2.5)
Median calf circumference, cm (min–max)	34.5 (30–41)

BMI, body mass index.

high-resolution JPEG files for use in the photographic database.

Scale Creation

The process of scale creation generally followed the method described elsewhere for creating other Merz Aesthetics Scales.[18,19,21–24] Briefly, subjects were all screened by an experienced team, and 1 subject was selected whose image was representative of the general calf appearance. Additional images were then selected from the photographic database to superimpose varying degrees of calf appearance onto the base image to create composite computer-generated images for the 2 calf scales (Figure 1A,B). Photographs of subjects used as base images were not used again in the scale validation process. Each image was rated on a scale ranging from 0 (very slim, linear calf profile) to 4 (very severe convex calf profile; strong gastrocnemius

TABLE 2. Calf Scale Ratings by Validation Session

Scale Score, n *(%)*	*Session 1,* (n = *455*)	*Session 2,* (n = *455*)
Calf at rest		
0, optimal	47 (10.3)	46 (10.1)
1, mild	146 (32.1)	149 (32.7)
2, moderate	164 (36.0)	177 (38.9)
3, severe	69 (15.2)	63 (13.8)
4, very severe	29 (6.4)	19 (4.2)
Missing	0	1 (0.2)
Calf dynamic		
0, optimal	98 (21.5)	78 (17.1)
1, mild	160 (35.2)	161 (35.4)
2, moderate	140 (30.8)	136 (29.2)
3, severe	46 (10.1)	67 (14.7)
4, very severe	11 (2.4)	12 (2.6)
Missing	0	1 (0.2)
Summary score		
0	28 (6.2)	22 (4.8)
1	64 (14.1)	62 (13.6)
2	93 (20.4)	86 (18.9)
3	91 (20.0)	102 (22.4)
4	84 (18.5)	79 (17.4)
5	41 (9.0)	47 (10.3)
6	31 (6.8)	37 (8.1)
7	15 (3.3)	9 (2.0)
8	8 (1.8)	9 (2.0)
Missing	0	2 (0.4)

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TABLE 3. Calf Scale Scores by Validation Session

Session	*Statistic*	*Calf at Rest Validation Scale*	*Calf Dynamic Validation Scale*	*Summary Score*
1, *N* = 455	Mean (SD)	1.75 (1.01)	1.37 (1.01)	3.12 (1.85)
	Median (min–max)	2.0 (0–4)	1.0 (0–4)	3.0 (0–8)
	Q25–Q75	1.0–2.0	1.0–2.0	2.0–4.0
2, *N* = 455	Mean (SD)	1.69 (0.97)*	1.50 (1.02)*	3.20 (1.81)†
	Median (min–max)	2.0 (0–4)	1.0 (0–4)	3.0 (0–8)
	Q25–Q75	1.0–2.0	1.0–2.0	2.0–4.0

*n = 454.
†n = 453.

visibility). A calf summary score was calculated by combining the 2 calf scores, which ranged from 0 to 8.

Procedure

Dermatologists, plastic surgeons, and other physicians with experience in aesthetic medicine participated as raters in 2 validation sessions performed 4 weeks apart. During each session, raters were provided with 2 booklets containing images of the 35 subjects. One booklet was the calf—at rest, showing 1 subject per page with a view of the calf from behind with feet flat on the floor. The other booklet was calf—dynamic, showing 1 subject per page with a view of the calf from behind while standing on tiptoes. Raters generally completed their booklets at home and were blinded with respect any subject identifiers or characteristics. Booklets with 2 different randomization sequences were used for the 2 validation sessions.

Statistical Analysis

Categorical data were described by their absolute and relative frequencies. Scale ratings (range, 0–4) and metric data were summarized by total number (*n*), arithmetic mean, SD, median, 25% and 75% quantile, minimum, and maximum. In addition, a calf summary score was calculated by adding the 2 ratings (range, 0–8) to provide a combined assessment score for both of the 2 assessment modalities. Validation session and rater, subject, sex, and ethnicity were summarized. Estimated aesthetic treatment effort was summarized with absolute and relative frequencies by validation session and by subject and validation session. Estimated effort

TABLE 4. Inter-rater Reliability by Validation Session, Calf Scores

		Mean Weighted Kappa (CI)
	ICC 2,1	*Fleiss–Cohen*
Validation session 1		
Calf—at rest	0.65 (substantial)	0.63 (0.61–0.66)
Calf—dynamic	0.71 (substantial)	0.71 (0.69–0.73)
Summary score	0.77 (substantial)	0.76 (0.74–0.78)
Validation session 2		
Calf—at rest	0.57 (moderate)	0.57 (0.55–0.60)
Calf—dynamic	0.69 (substantial)	0.69 (0.66–0.71)
Summary score	0.71 (substantial)	0.72 (0.70–0.75)

CI, confidence interval; ICC 2,1, intraclass correlation coefficient with 2-way random single measures.

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TABLE 5. Intra-Rater Reliability: ICC 2,1 and Kappa Values for the Asian Calf Scale

		Mean Weighted Kappa (CI)
Scale	*ICC 2,1*	*Fleiss–Cohen*
Calf—At rest	0.73 (substantial)	0.69 (0.61–0.77)
Calf—Dynamic	0.80 (substantial)	0.79 (0.74–0.83)
Calf summary score	0.85 (almost perfect)	0.83 (0.80–0.87)

CI, confidence interval; ICC 2,1, intraclass correlation coefficient with 2-way random single measures.

of aesthetic treatment and estimated age were further summarized by *n*, arithmetic mean, SD, median, 25% and 75% quantile, minimum, and maximum by validation session and by subject and validation session.

Inter-rater reliability was assessed by using the intraclass correlation coefficient (ICC) with 2-way random single measures (ICC 2,1) of Shrout and Fleiss[25] and kappa values using Fleiss–Cohen weights.[26] The following ranges of ICC 2,1 were used for interpretation of results, with "substantial" being regarded as the minimum target to achieve[27,28]:

- 0.00 to 0.20, slight
- 0.21 to 0.40, fair
- 0.41 to 0.60, moderate
- 0.61 to 0.80, substantial
- ≥0.81, almost perfect

Intra-rater reliability between the first and second validation ratings was also evaluated using the weighted ICC 2,1. The statistics were calculated for each rater and pooled. For the pooled ICC 2,1, the 2 identifiers for subject and rater were first combined into one single subject-rater identifier. The intra-rater ICC 2,1 was then calculated as the ratio of the between-subject rater variance and the total variance. The same ICC 2,1 ranges were used for interpreting the results.

To explore validity of the assessment scales, correlations between the scale scores and subject demographic variables were performed (Pearson and Spearman correlation) using data from the first validation session. The first validation session was preferred because it reflects an initial unbiased use of the scale. For interpretation of the Pearson and Spearman coefficients, a mean coefficient >0.6 was considered high.

In addition, a mixed-effect regression model for the scale and additional question as dependent variables and subject demographic variables as possible predictors were implemented. Subject and rater were considered as random effects, and all other possible predictors as fixed effects. Model selection was based on stepwise backward selection with a *p*-value of 0.3 required for a variable to stay in the model.

Results

The raters consisted of a panel of male ($n = 7$) and female ($n = 6$) dermatologists ($n = 9$), plastic surgeons ($n = 2$), and other physicians ($n = 2$). For each validation session, there were 455 planned ratings (13 raters × 35 subjects). The 35 rated subjects had a mean (SD) age of 26.3 (3.8) years (range, 21–38 years). Demographic information and baseline characteristics are shown in Table 1.

Calf Scale Ratings

The scores for the calf—at rest scale are summarized in Table 2. Most subjects had scores of 0 to 2 in Session 1 (79%) and Session 2 (82%), whereas a few subjects had scores as high as 4 in Session 1 (6.4%) and Session 2 (4.2%). The overall mean (SD) score was 1.75 (1.04) for Session 1 and 1.69 (0.97) for Session 2.

The scores for the calf—dynamic scale are summarized in Table 2. Similar to the calf—at rest scores, most subjects had scores of 0 to 2 in Session 1 (88%) and Session 2

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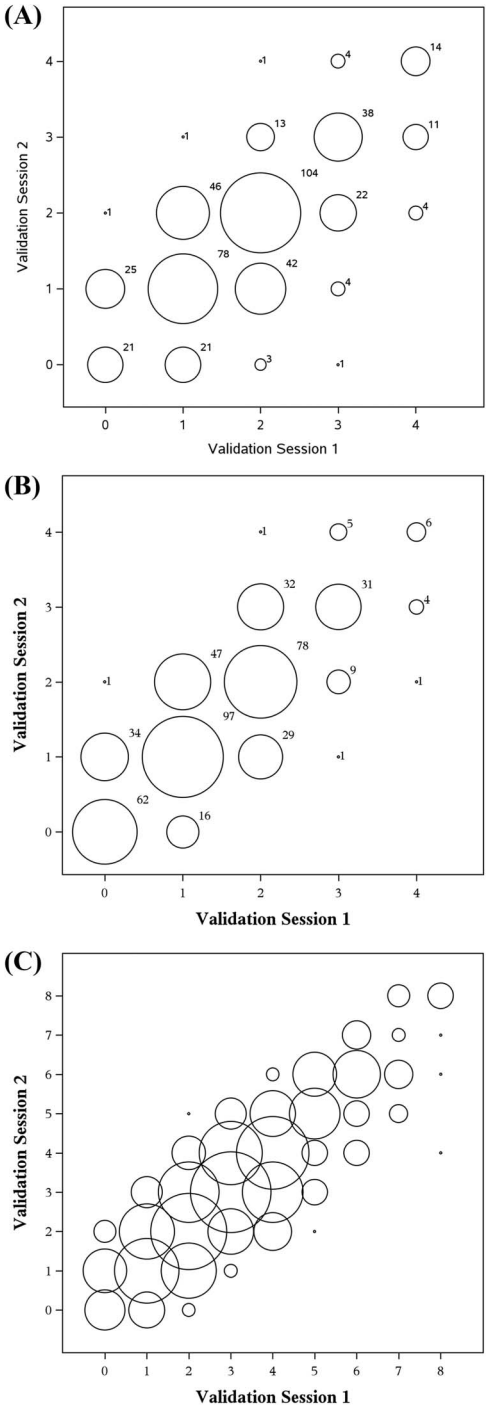

Figure 2. (A–C) Bubble plots. Bubble plots for rating combinations between the first and second validation sessions. (A) Calf at rest: first versus second validation session, pooled raters. (B) Calf–dynamic: first versus second validation session, pooled raters. (C) Calf summary score: first versus second validation session, pooled raters. High reliability is evident if the bubbles are located along the diagonal line; hence, the plots illustrate high intra-rater reliability. Low reliability is evident if the bubbles are scattered randomly on the plot. The scale from zero to 4 on both axes represents the appearance grades of the calf scales.

(82%), and few subjects had scores of 4 in Session 1 (2.4%) and Session 2 (2.6%). The overall mean scores were 1.37 (1.01) for Session 1 and 1.50 (1.02) for Session 2.

Calf summary scores are provided in Table 2. Most scores (82%) ranged from 1 to 5 with the greatest percentage being 2 (20.4%) and 3 (20.0%) in Sessions 1 and 2 (18.9%) and 3 (22.4%) in Session 2. The overall mean scores were 3.12 (1.85) in Session 1 and 3.20 (1.81) in Session 2. Calf scale scores by validation session are summarized in Table 3.

Inter-rater Reliability

The ICC and weighted kappa coefficients for inter-rater reliability of the calf scales are provided for each validation session in Table 4. Inter-rater reliability based on ICC for the calf—at rest, calf–dynamic, and calf summary score was substantial in Session 1, with scores all being ≥0.6. Inter-rater reliability was "modest" for calf—at rest in Session 2 but remained "substantial" for calf—dynamic and the calf summary score. The mean weighted kappa with Fleiss–Cohen weighted values for inter-rater reliability was very similar to the ICC values and showed the same qualitative results (Table 4).

Intra-rater Reliability

The ICC and kappa estimates for intra-rater reliability of the 3 calf scales are presented in Table 5. Based on ICC, intra-rater reliability was "substantial" for calf—at rest and calf—dynamic (≥0.6) and "almost perfect" (0.85) for the calf summary score. The mean weighted kappa was essentially the same results as the ICC values for intra-rater reliability. Bubble plots for the different assessment scales, which visualize the frequency of rating combinations of the first and second validation sessions, are shown in Figure 2A–C.

Validity of Scales

The Pearson and Spearman correlation coefficients were similar and showed only small differences. Spearman correlations are presented in Table 6, and the final regression model of the stepwise regression for the summary score of calf scales is shown in Table 7. Body

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TABLE 6. Spearman Correlation Coefficient for Calf Scale

	Calf at Rest	*Calf Dynamic*	*Summary Score*	*BMI*	*Calf Circumference*
Calf—At rest	1	—	—	—	—
Calf—Dynamic	0.62	1	—	—	—
Summary score	0.9	0.9	1	—	—
BMI	0.67	0.67	0.75	1	—
Calf circumference	0.68	0.57	0.69	0.71	1

BMI, body mass index.

mass index (BMI) and calf circumference were highly correlated, and calf circumference was a significant predictor in the final summary score model. BMI also showed substantial relationships with the scale ratings. From the other variables that entered the different models, some show a relationship trend to the 3 calf scales (data on file). These predictors were Fitzpatrick classifications (Types I–III), rater sex (women), and smoker status (never smoked).

Discussion

A part of the overall attractiveness among female Asians is an aesthetically pleasing appearance of the lower leg.[1] This seems to be very important based on the number of reports describing techniques for treating calves that are too thin or too large.[8–12,15,17] To date, scales for objectively assessing aesthetic attributes have focused on Caucasian features. Therefore, the objective of this study was to develop and validate a new Merz scale for objectively assessing calf appearance in Asian women and to validate its use in clinical and research settings. This scale is validated for photographic assessment and not for live assessment.

TABLE 7. Final Model of Stepwise Mixed Effects Regression for Calf Scale

Covariate	*Category*	*Regression Coefficient*	p
Intercept	—	−14.377	<.001
Calf circumference	—	0.484	<.001
Fitzpatrick skin type	Type 1	−0.570	.075
	Type II	−1.790	<.001
	Type III	−0.622	.058
	Type IV	0.000	—
Rater sex	Female	0.293	.205
	Male	0.000	—
Smoker status	Never	1.108	.202
	Previously	0.000	—

Most of the women evaluated in the study (~70%) presented with mild or moderately hypertrophic calves, but the range included optimal to very severely hypertrophic. For both calf scales, the combined summary score was substantial with ICC estimates ≥0.60 in both sessions. The individual calf scales scores were also substantial except for the calf—dynamic for Session 2, which was moderate.

Intra-rater reliability was also substantial for the individual assessments and almost perfect for the combined assessment, indicating generally consistent use of both of the outcomes by the single raters.

Regarding scale validity, Pearson and Spearman correlation coefficients were similar. The ratings were moderately correlated with calf circumference and with the BMI, which were also confirmed within the respective regression models as significant predictors. Based on the concept of a scale with slim to convex calves, such a relationship would be expected and support the convergent validity of these outcomes.

This 5-point scale is a reliable assessment for both the calf at rest and during dynamic flexure, which can be combined as a summary score. Similar to aesthetic scales that have been developed and validated for assessing changes in the appearance of the face,[18,21–23] neck,[19,24] chest,[20] and hands,[29] the Merz Calf Scale will likely become a valuable tool for treating the female Asian population.

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Conclusion

This study has demonstrated the value of this new photonumeric assessment scale for assessing the appearance of the female Asian calf based on the high degree of intra-rater and inter-rater reliability. This new assessment scale is another important addition to the range of validated aesthetic scales currently available for other anatomical areas. This new scale will provide an standardized measure of calf appearance in female Asian patients in clinical practice and clinical research settings.

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Address correspondence and reprint requests to: Kyle Seo, MD, PhD, Department of Dermatology, Seoul National University College of Medicine, 101 Daehak-Ro Jongno-Gu, Seoul, Korea, or e-mail: doctorseo@hotmail.com

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