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The influence of craniofacial to standing height proportion on perceived attractiveness

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Abstract. An idealised male image, based on *Vitruvian Man*, was created. The craniofacial height was altered from a proportion of 1/6 to 1/10 of standing height, creating 10 images shown in random order to 89 observers (74 lay people; 15 clinicians), who ranked the images from the most to the least attractive. The main outcome was the preference ranks of image attractiveness given by the observers. Linear regressions were used to assess what influences the choice for the most and the least attractive images, followed by a multivariate rank ordinal logistic regression to test the influence of age, gender, ethnicity and professional status of the observer.

A craniofacial height to standing height proportion of 1/7.5 was perceived as the most attractive (36%), followed by a proportion of 1/8 (26%). The images chosen as most attractive by more than 10% of observers had a mean proportion of 1/7.8 (min=1/7; max=1/8.5). The images perceived as most unattractive had a proportion of 1/6 and 1/10. The choice of images was not influenced by the age, gender, ethnicity or professional status of the observers.

The ideal craniofacial height to standing height proportion is in the range 1/7 to 1/8.5. This finding should be considered when planning treatment to alter craniofacial or facial height.

Keywords: craniofacial height; vertical facial proportions; perception; attractiveness.

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The assessment of facial beauty is subjective[8], but the assessment of facial proportions may be undertaken objectively. Disproportionate human faces are unattractive, whereas proportionate features are acceptable, even if not always attractive. The appropriate goal for the surgeon's clinical examination is the detection of facial disproportions. An important proportional relationship not previously described in the surgical literature but potentially significant in planning treatment is that of the craniofacial height to standing height.

The first significant known study of human proportions was undertaken in the fifth century BC by the Greek sculptor Polycleitus of Argos. The *Canon* of Polycleitus refers to the book written by him, of which no copies exist, and the Roman marble copies of his original bronze statue described as the *Canon*, otherwise known as the *Doryphorus* (Spear bearer) (Fig. 1). The 'ideal' human proportions suggested by Polycleitus may only be gleaned from examination of Roman copies of the *Doryphorus*[7].

The Roman architect Marcus Vitruvius Pollio, better known simply as Vitruvius, lived in the first century BC, and is thought

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Fig. 1. The *Doryphorus* or *Spear bearer* (Polycleitus, fifth century BC).

to have dedicated his treatise *De Architectura* (Ten Books on Architecture) to the emperor Augustus Caesar in about 25 BC. He wrote that 'the human body is so designed by nature that the face, from the chin to the top of the forehead and the lowest roots of the hair, is a tenth part of the whole height'[4].

In the late 15th century the great Renaissance artist and thinker Leonardo da Vinci (1452–1519) drew the figure of *Vitruvian man* (Fig. 2), based on guidelines described by Vitruvius, demonstrating the importance of proportions in the human form. He showed that the 'ideal' human body fitted precisely into both a circle and a square, and he illustrated the link that he believed existed between perfect geometric forms and the perfect body. The distance from the hairline to the inferior aspect of the chin is described as one-tenth of a man's height. The distance from the top of the head to the inferior aspect of the chin is one-eighth of a man's height[9]. Albrecht Durer (1471–1528), perhaps the most significant artist of the German Renaissance, wrote a treatise on human proportions[1]. The first of the *Four Books on Human Proportion*, published posthumously, described the 'ideal' man of 'Eight head-lengths' (Fig. 3).

Farkas et al[3] have undertaken a large body of research throughout the 20th/21st century into the anthropometry of the human head, providing anthropometric data for adult North American Caucasian norms. Table 1 demonstrate the craniofacial height to standing height proportion and Table 2 the vertical facial height to standing height proportion, calculated from the original anthropometric data provided by Farkas[2].

To find and validate the correct proportions with which to plan clinical treatment, two sources of information are required. Firstly, population averages, which permit comparison of an individual's facial measurements and proportions to the population norms. Such data must be age, gender and ethnicity specific. Secondly, the perceived attractiveness of the proportions must be confirmed by the judgement of the lay public and ideally compared with the judgement of treating clinicians.

The purpose of this article is to investigate the influence of the proportion of the craniofacial height to standing height on the perceived attractiveness of the lay public and clinicians involved in the management of patients with facial deformities. The proportions considered most attractive may then be compared with the classical/neoclassical canons and modern anthropometric population norms.

Subjects and method

The images

The image of *Vitruvian Man* (Fig. 2) by Leonardo da Vinci was manipulated by computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA) to produce a standardised image of a man with outstretched arms. A standardised male face was drawn, with the same computer software, with 'ideal' facial proportions based on currently accepted criteria[10], and bilateral facial symmetry. The created face and body were pasted together. Using Photoshop image-processing software the vertical craniofacial height was digitally altered from a proportion of 1/6 of standing height to 1/10 of standing height. The proportion of the equal vertical facial thirds was maintained in all the images. Nine images were created with a craniofacial height to standing height proportion of 1/6, 1/6.5, 1/7, 1/7.5, 1/8, 1/8.5, 1/9, 1/9.5 and 1/10. A

Table 1. Ratio of vertical craniofacial height (vertex–gnathion) to standing height

			Average ratio of craniofacial height to standing height		
	Standing height (cm)	Craniofacial height (cm)	Minimum	Mean	Maximum
Male	176.6 (SD: 8.1)	22.9 (SD: 0.7)	7.4 (176.6–8.1/22.9)	7.7 (176.6/22.9)	8.1 (176.6 + 8.1/22.9)
Female	162.7 (SD: 6.9)	21.5 (SD: 0.8)	7.2 (162.7–6.9/21.5)	7.6 (162.7/21.5)	7.9 (162.7 + 6.9/21.5)

Figures are calculated from original data by Farkas, based on adult North American Caucasian norms (age 19–25 years)[2]. SD = Standard Deviation; 7.7 means the craniofacial height is 1/7.7th of standing height; vertex = the highest point on the head with the head in the Frankfort horizontal plane; gnathion = the lowest point on the lower border of the chin in the midline.

Table 2. Ratio of vertical face height (trichion–gnathion) to standing height

			Average ratio of face height to standing height		
	Standing height (cm)	Face height (cm)	Minimum	Mean	Maximum
Male	176.6 (SD: 8.1)	18.7 (SD: 1.2)	9.0 (176.6–8.1/18.7)	9.4 (176.6/18.7)	9.9 (176.6 + 8.1/18.7)
Female	162.7 (SD: 6.9)	17.3 (SD: 0.8)	9.0 (162.7–6.9/17.3)	9.4 (162.7/17.3)	9.8 (162.7 + 6.9/17.3)

Figures are calculated from original data by Farkas, based on adult North American Caucasian norms (age 19–25 years)[2]. SD = standard deviation; trichion = the midpoint of the hairline; gnathion = the lowest point on the lower border of the chin in the midline.

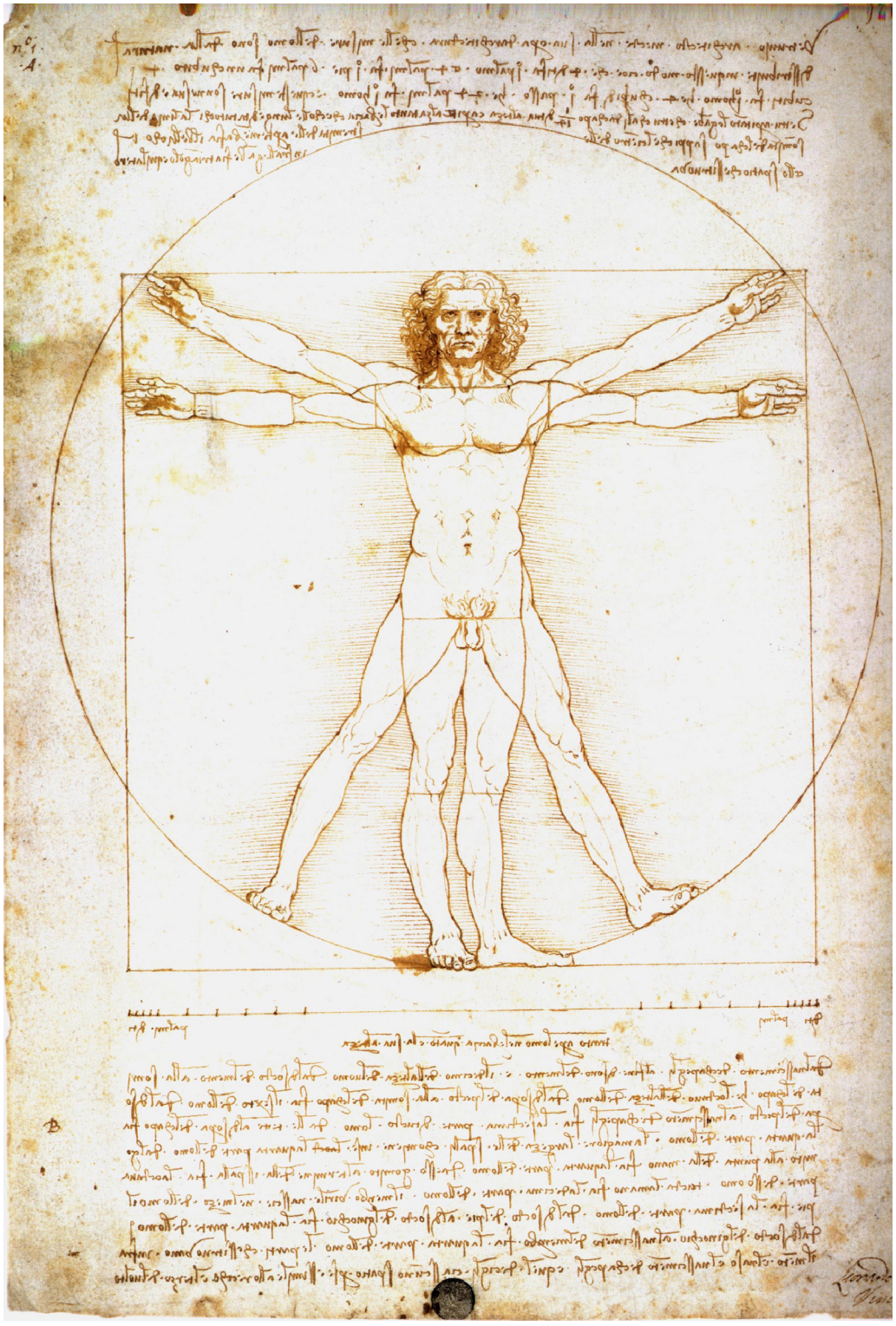

Fig. 2. Vitruvian *Man* (Leonardo da Vinci, ca. 1490).

Table 3. Observer age by ethnicity

Ethnicity	Mean Age (in years)	Std. Err.	[95% Conf.	Interval]
White	36	0.7	34.8	37.4
Black	37	1.1	35	39.6
Asian	39	1.3	36.5	41.5

duplicate of one of the images was used to assess intra-examiner reliability (Fig. 4).

Each of the ten images was printed onto a separate A4-size photographic paper with a matte finish. There were no other

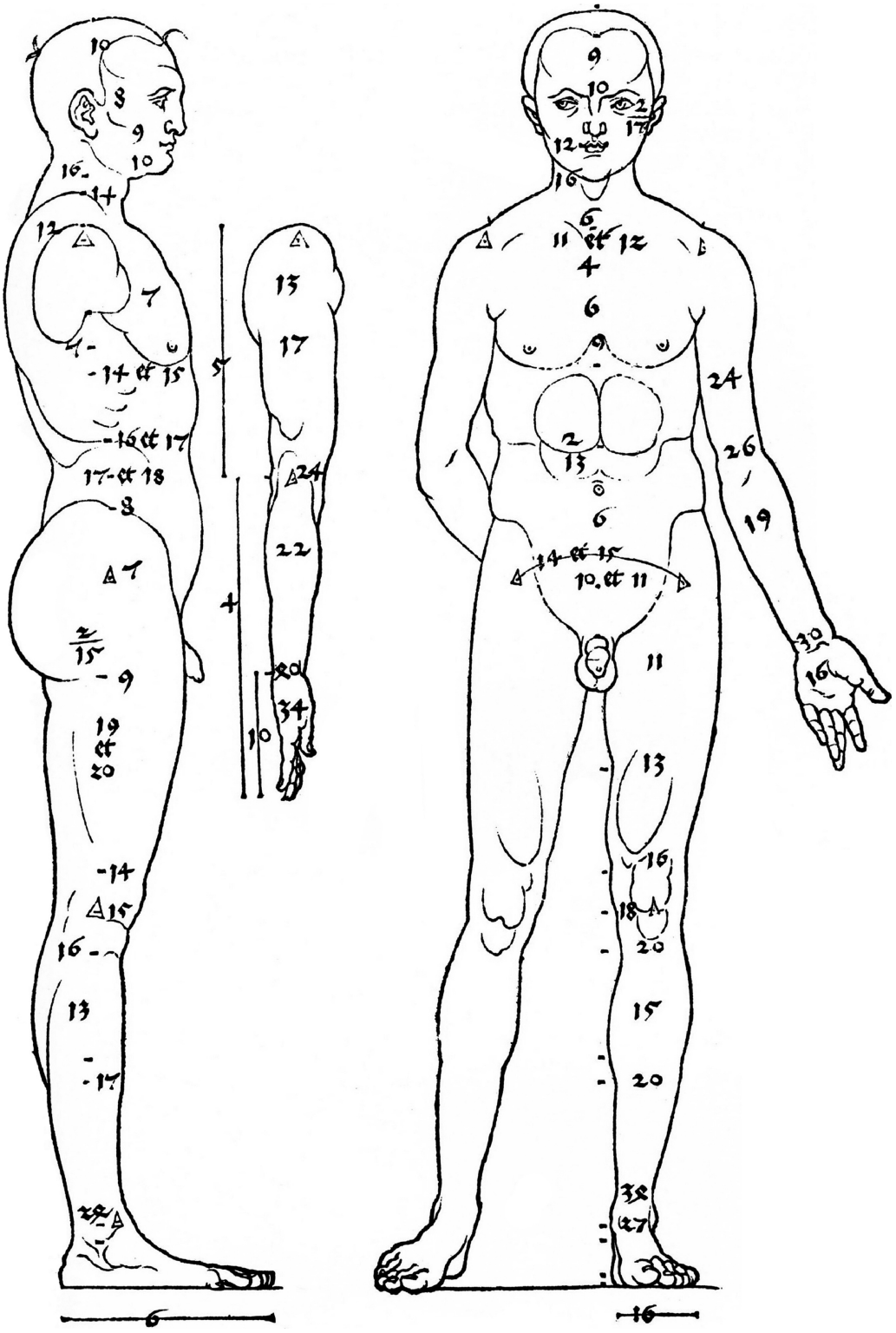

Fig. 3. Man of eight head-lengths (Albrecht Durer, ca. 1528).

identifiable marks on the paper. Each photograph was ascribed by an exclusive symbol on its posterior surface as a code for identification when tabulating the results.

The observers, questionnaire and ranking method

A total of 89 observers took part in the study. These included 74 lay people (45 female; White=43; Black=11; Asian=20) and 15 clinicians (3 female; White=12; Asian=3) involved in the management of patients with facial deformities (Table 3). Each observer was provided

with a questionnaire asking their age (in years), gender (male/female) and ethnicity (White, Black, Asian or Oriental). Observers undertook the ranking exercise individually. Each observer was shown the 10 photographic images, arranged in random order. The only difference between the images was the proportion of the craniofacial height to the standing height. The observers were asked to arrange the images in order from the most to the least attractive. The images were thereby ranked from the most to the least attractive.

Statistical analysis

The main outcome was the preference ranks of image attractiveness given by the 89 observers. One of the craniofacial height to standing height proportions was featured in two different images (Images 8

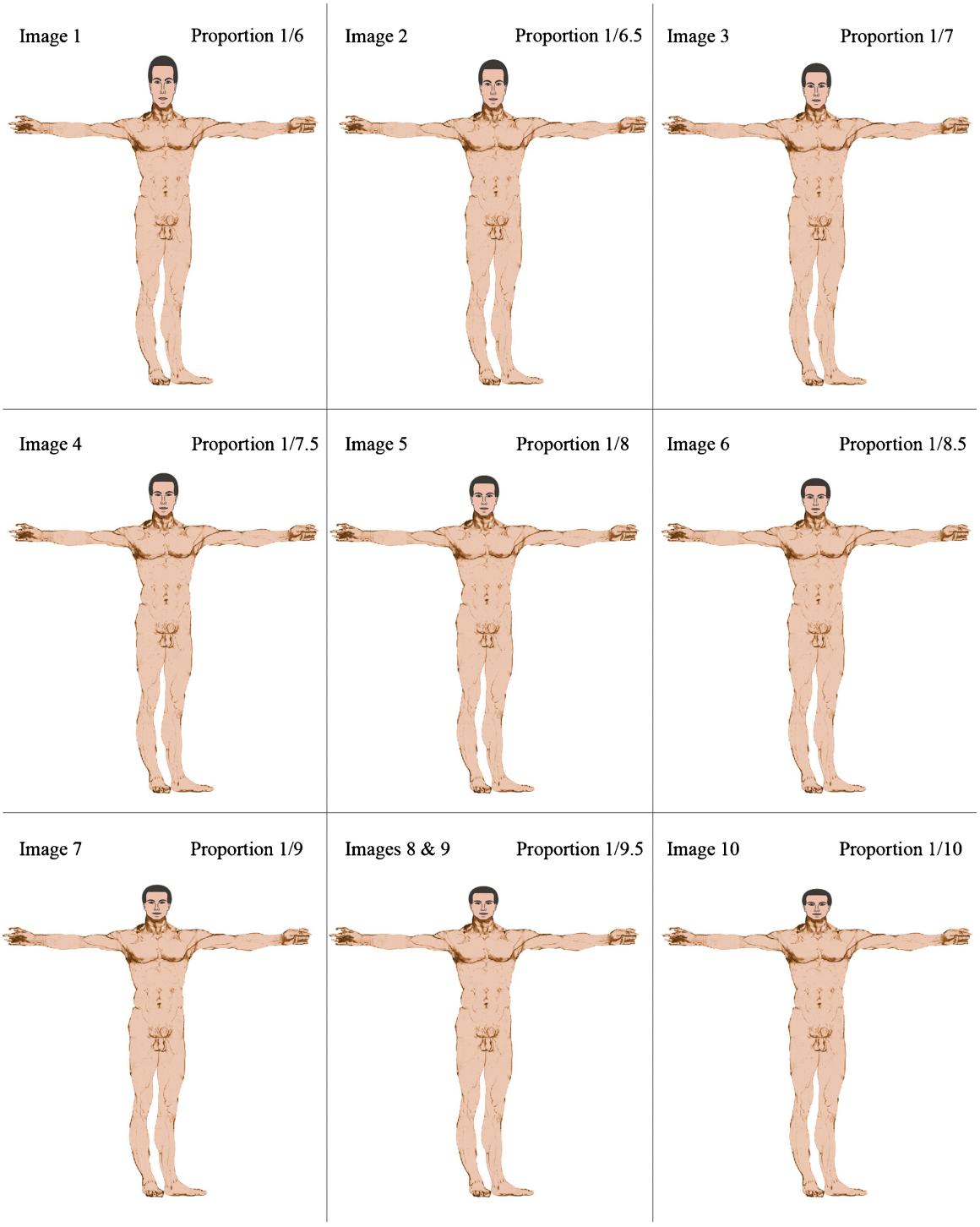

Fig. 4. The nine constructed images. An idealized male face was combined with the image of *Vitruvian Man*. Image-processing software was used to alter the vertical craniofacial height digitally from a proportion of 1/6 to 1/10 of standing height. The proportion of the equal vertical facial thirds was maintained in all the images. A duplicate of one of the images was used in order to assess intra-examiner reliability.

Table 4. Preference scores for each image

	Rank preference scores										
	1	2	3	4	5	6	7	8	9	10	Total
Image											
1	0	0	3	0	2	15	5	2	13	49	89
2	0	1	4	8	16	6	7	24	19	4	89
3	11	9	10	21	4	4	11	14	5	0	89
4	32	26	13	3	4	2	8	0	1	0	89
5	23	36	16	7	1	6	0	0	0	0	89
6	18	12	29	15	11	2	1	1	0	0	89
7	2	1	11	17	13	13	24	5	3	0	89
8	3	1	2	9	23	11	13	13	12	2	89
9	0	2	1	4	11	27	14	20	8	2	89
10	0	1	0	5	4	3	6	10	28	32	89
	89	89	89	89	89	89	89	89	89	89	890

and 9) and these constituted two replications of the measure. Bland–Altman plots and a mixed regression model were used to assess the reliability of the measure. Linear regressions were used to assess what influences the choice for the most and the least attractive images. These analyses were followed by a multivariate rank ordinal logistic regression where the independent variables were the craniofacial height to standing height proportion of the image and the age, gender, ethnicity and professional status of the observer. Data analysis was performed using the Statistical package STATA (version 9).

Results

Eighty nine observers placed each of the 10 images in rank order (most attractive = 1, least attractive = 10). Table 4 shows the number of rank preference scores given to all images. Table 5 shows the descriptive statistics of the rank preference scores by image (i.e. craniofacial height to standing height proportion).

Reliability of the Measure

The Bland–Altman plot of the two replications of the score for the proportion of 1/9.5 is shown in Fig. 5. The mixed regression model of the two scores showed that on average the difference between the two scores is 0.15 (95% confidence interval 0.01 to 0.28). This confidence interval narrowly misses zero and the *P*-value is close to the 5% cut-off for non-significance. This fact, together with the intra-class correlation of 43%, indicates a moderate agreement between the two scores[5].

The most attractive image

The images chosen as most attractive by more than 10% of observers were Images 4, 5, 6 and 3. These images had a mean craniofacial height to standing height proportion of 1/7.8 (min=1/7 and max=1/8.5).

Image 4, with a proportion of 1/7.5, was perceived as the most attractive and received a total of 32 preference scores (36%). This was followed by Image 5 (with a proportion of 1/8), which received a total of 23 preference scores (26%), Image 6 (with a proportion of 1/8.5), which received a total of 18 preference scores (20%) and Image 3 (with a proportion of 1/7), which received a total of 11 preference scores (12.4%). The multiple linear regression in Table 6 demonstrates that the choice of Image 4 (with a proportion of 1/7.5), as the most attractive was not influenced by age ($P = 0.96$), gender ($P = 0.23$), ethnicity

Table 5. Descriptive statistics of rank scores given to the 10 images

		Rank preference Score					
Image	Craniofacial proportion	Min	Max	Mean	SD	[95%	Conf.
1	6.00	3	10	8.6	1.95	*8.21*	*9.03*
2	6.50	2	10	6.9	2.04	*6.47*	*7.33*
3	7.00	1	9	4.7	2.54	*4.20*	*5.26*
4	7.50	1	9	2.6	1.97	*2.19*	*3.02*
5	8.00	1	6	2.4	1.34	*2.10*	*2.67*
6	8.50	1	8	3.0	1.51	*2.73*	*3.36*
7	9.00	1	9	5.4	1.81	*5.05*	*5.81*
8	9.50	1	10	6.2	2.05	*5.76*	*6.62*
9	9.50	2	10	6.6	1.62	*6.29*	*6.97*
10	10.00	2	10	8.5	1.87	*8.08*	*8.86*

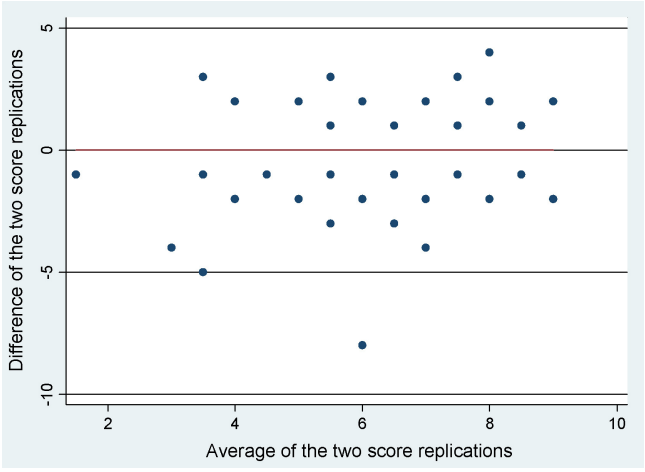

Fig. 5. Bland–Altman plot for the two scores taken at a proportion of 1/9.5 (difference is taken as first minus second replication).

Table 6. Multiple linear regression for the score given to the most attractive image (image 4)

Score 4	Coef.	[95% Conf.	Interval]	*P*-value
Age	0.00	−0.03	0.03	0.96
Sex	−0.53	−1.41	0.35	0.23
Ethnicity	−0.58	−1.45	0.29	0.19
Professional status	−0.75	−1.97	0.48	0.23

Table 7. Multiple linear regression for the score given to the most unattractive image (image 1)

Score 1	Coef.	[95% Conf.	Interval]	*P*-value
Age	0.01	−0.01	0.04	0.35
Sex	−0.42	−1.26	0.43	0.33
Ethnicity	0.17	−0.67	1.01	0.69
Professional status	1.17	−0.01	2.35	0.05

Table 8. Rank ordinal logistic regression model for score by craniofacial height to standing height proportion

Score 1	Coef.	[95% Conf.	Interval]	*P*-value
Proportion	14.9	13.43	16.29	0.0000
Proportion ∼ q	−0.92	−1.01	−0.84	0.0000

($P = 0.19$) or the professional status of the observer ($P = 0.23$).

Images 7 and 8 received only 2% and 3% preference scores. None of the Images 1, 2, 9 and 10 were selected as most attractive, which means that they received a preference score of zero.

The most unattractive image

The images that were chosen as most unattractive by more than 10% of observers were Image 1 (with a proportion of 1/6) with 49 preference scores and Image 10 (with a proportion of 1/10) with 32 preference scores. Images 2, 8 and 9 received only few choices as most unattractive and none of the Images 3, 4, 5, 6 and 7 were ever chosen as most unattractive.

The effect of craniofacial height to standing height proportion on attractiveness

The multiple linear regression in Tables 6 and 7 demonstrates that neither age, gender, ethnicity nor clinical status of the observer influenced the choice for the most (Image 4) or least attractive (Image 1) images. The results were similar across all the images. Table 5 and the plots per observer shown in Fig. 6 suggest that it is the craniofacial height to standing height proportion that determines attractiveness. The quadratic trend of the rank preference scores by craniofacial height to standing height proportion observed in the plots was confirmed by the rank ordinal logistic regression model shown in Table 8. The mean rank preference score is minimal for a craniofacial height to standing height proportion of 1/8 and increases when this proportion moves away from 1/8 in either direction.

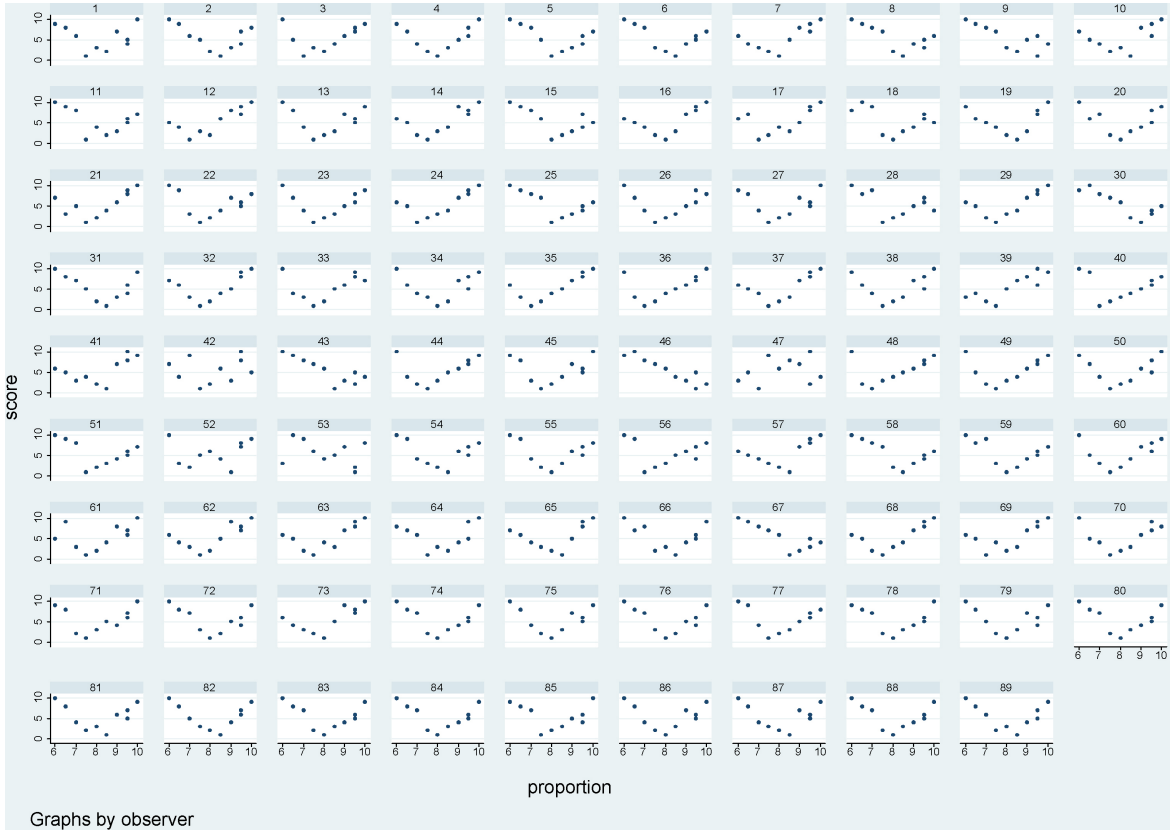

Fig. 6. Plots of rank preference score by craniofacial height to standing height proportion, per observer.

Discussion

The concept of physical beauty has been correlated with harmonious proportions throughout history. The notion is that the proportionate human face and figure is the most aesthetically pleasing. With this idea arises the question of what are ideal proportions and how does one test and validate them?

The perception of ideal proportions may vary from one individual to another, from one ethnic group to another and from one historical era to another. It is therefore vital for clinicians involved in the management of patients requiring alterations in their facial appearance to have an evidence-based approach to the guidelines they employ in planning the correction of facial disproportions.

Such evidence may be obtained from two sources. Firstly, the use of anthropometric data to obtain age, gender and ethnicity specific population averages for the proportional guideline being tested; secondly, confirmation of the perceived attractiveness by the judgement of the lay public and clinicians.

Comparison of the results with classical and neoclassical proportional canons

It is generally acknowledged that the work of Polycleitus in the fifth century BC was used by other sculptors as demonstrating the 'ideal' proportions of a man[7]. The craniofacial height to standing height proportion of the available marble copies of the *Doryphorus* is 1/7.5.

In the late fourth century BC, the prolific sculptor Lysippos is thought to have established a new canon using eight heads to standing height. This is evident from inspection of the Roman marble copy of the *Apollo Belvedere* in the Vatican Museum.

The Roman architect Vitruvius based his guidelines on the Classical Greek sculptors. He described the facial height to standing height proportion of 1/10, which corresponds to a craniofacial height to standing height proportion of 1/8[4].

The scientifically enquiring minds of the Renaissance were no longer interested in blindly following the Classical 'ideal', and began to study human anatomy and record human proportions. Adapting the work of Vitruvius with his own research, Leonardo da Vinci provided the Renaissance canons of proportion. He described the 'ideal' craniofacial height to standing height proportion as 1/8[9]. Durer later described the 'ideal' man of 'Eight head-lengths'[1].

The results of this study lend support to the use of a proportional ratio between the Classical ideal of 1/7.5 and the Renaissance ideal of 1/8.

Comparison of the results with modern anthropometric data

The craniofacial height to standing height proportion may be calculated from the original anthropometric data provided by Farkas[2]. From this original anthropometric data, the craniofacial height to standing height proportion in young adult males (age range 19–25 years) was found to be 1/7.7 (range 1/7.4 to 1/8.1), and in young adult females (age range 19–25 years) was found to be 1/7.6 (range 1/7.2 to 1/7.9) (Table 1).

The results of this study, based on lay and clinician judgements of attractiveness, generally validate the anthropometric data. In this study it was found that a proportion of 1/7.5 was perceived as the most attractive, with 1/8 a close second. The images regarded as most attractive by the participants had a mean craniofacial height to standing height proportion of 1/7.8 (min=1/7 and max=1/8.5). The mean rank preference score was found to be minimal for a craniofacial height to standing height proportion of 1/8 and increased when the craniofacial height to standing height proportion moved away from 1/8 in either direction (Table 8).

The influence of observer factors on perception of attractiveness

The multiple linear regression in Table 6 shows that choice of Image 4, with a proportion of 1/7.5, as the most attractive was not influenced by the age ($P = 0.96$), gender ($P = 0.23$) or ethnicity ($P = 0.19$) of the observer. These results support the available evidence for the universality of judgements of attractiveness[6]. The choice of Image 4 as the most attractive was not influenced by the professional status of the observer ($P = 0.23$).

Clinical implications

Patients presenting with craniofacial or dentofacial anomalies are, by definition, not average. Therefore in treatment planning, the use of mean craniofacial measurements based on population norms, though extremely important, must be used in conjunction with, and guided by a thorough understanding of facial proportional relationships.

The proportion of vertical craniofacial (head) height, and vertical facial height, to standing height has important clinical implications. If the vertical craniofacial proportions of a patient are to be altered with surgery, the treatment plan must take into account the proportion of the patient's craniofacial height to their standing height[7]. The use of absolute numeric values of measurements rather than proportions may be misleading, as the vertical craniofacial height of a patient who is 6 feet tall will be different to that of a patient 5 feet tall.

In conclusion, the understanding of proportional relationships is vital for correct treatment planning. The important proportional relationship of the craniofacial height to standing height has not been previously described or validated in the orthodontic or surgical literature.

This study has tested the validity of the classical, neoclassical and modern anthropometric-based proportional canons for the craniofacial height to standing height proportion, and compared the results with the judgement of perceived attractiveness of the lay public and clinicians.

From the results of this study it is recommended that in planning treatment to alter any aspect of craniofacial or facial height, the ideal craniofacial height to standing height proportion of 1/7.5 to 1/8, with a range from 1/7 to 1/8.5, be considered.

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