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Application of the Wilson-Richmond Categorisation Tool on Three-Dimensional Facial Scans of a Population of 12-Year Old Welsh Children

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ABSTRACT

Objective: To determine the reproducibility and reliability of the Wilson-Richmond categorisation tool in the assessment of lip morphology and to demonstrate its use in a 12-year old Welsh population.

Setting and Sample Population: 50 subjects age 12 (27 male and 23 female) of Caucasian origin selected from two large comprehensive schools in South Wales (UK) as part of a growth study.

Material & Methods: Images of the subjects obtained by laser stereophoto-grammetry were assessed using the Wilson-Richmond categorisation tool in order to evaluate the perioral region from a topographical perspective.

Results: The Wilson-Richmond categorisation tool demonstrated high levels (70 -100%) of both intra and inter-examiner reliability. The lower double ver-million border and the philtrum width proved to be the most reliable and re-producible categories (85-100% agreement). The least reliable were the lower vermillion contour and lip-chin shape in both the intra and inter-examiner groups (70 -78% agreement). This study found that some morphological features in this 12-year old Welsh population differed in prevalence compared to previously reported Figure.

Conclusion: This study has shown that the Wilson-Richmond categorisation tool is both a reproducible and reliable method of lip morphology assessment. The morphological traits of a 12-year old Welsh population have been reported and further research on this population will highlight the normal morphological changes of the lips associated with growth.

Keywords: Categorisation Tool; Children; Laser Scanning; Lip Morphology; Three-Dimensions

Clinical Relevance

The lips frame the orthodontists work and it is important therefore to understand the effect that not only orthodontics has upon this structure, but also the effect of normal growth, in particular as orthodontic treatment is often undertaken in patients of pubertal age and studies suggests that facial growth continues into adult hood (Behrents, et al. [1]). The necessity to be able to predict accurately growth and the orthodontic affects upon the lips is further rein-forced by the fact that the smile is one of the key criteria by which patients judge the success of their own orthodontic treatment (Margolis, et al. [2]).

Introduction

(Rains and Nanda, et al. [3]) highlighted the scarcity of investigations in the pub-lished literature on the orthodontic effects upon the soft tissue profile before the 1950's and a similar finding was found by (Riolo, et al. [4]). In contrast, there has been a considerable amount of research on lip growth following cleft lip and palate repair and changes in lip contour following orthognathic surgery (Millard, et al. [5-7]). Surprisingly there has been a paucity of research in the prevalence of different types of lip morphology in a normal population (Wilson, et al. [8]). Studies that have looked into this area have attempted to describe and classify the traits they have found; for example the three-dimensional study undertak-en by (Mori, et al. [9]) on a small sample of five to six year old children who classi-fied the morphology of the philtrum columns into four types;

1. Triangular type,
2. Parallel type,
3. Concave type and
4. Flat type, and the work of a panel of experts for the National Human Genome Research Institute who summarised the anatomy of the oral region and defined and illustrated the terms that describe the major characteristics of the lips, mouth (Carey, et al. [10]), nose and philtrum (Hennekam, et al. [8,11]) reviewed the characteristics of lips in a normal 15-year-old Caucasian population and described the various lip traits and associa-tions present. The findings of this study were used to devise the Wilson-Richmond Categorisation Tool (WRCT), which can be utilised to aid the identifi-cation of the various morphological features of the lips. This study seeks to as-sess the reproducibility and reliability of the Wilson-Richmond categorisation tool between its developer and a new researcher in the assessment of lip mor-phology and to demonstrate its use in a 12-year old Welsh population.

Materials and Method

Subjects

The Welsh subjects are Caucasian children originally selected from two large comprehensive schools in the South Wales area of the United Kingdom as part of a growth study (Kau, et al. [12-14]) and were recruited in Year 7 (11 to 12 years of age). Ethical approval for the study design was obtained from the relevant ethics committees. This study assesses the prevalence of lip morphology traits in this population of 12-year-old Welsh children, which com-prised of fifty individuals (27 male and 23 female) and as part of the selection process; individuals with craniofacial anomalies and facial disfigurement were excluded.

Wilson Richmond Method to Record Lip Morphology

The WRCT has been used in this study to categorise morphological fea-tures of the lips and to demonstrate the reproducibility and reliability of this tool (Figures 1 & 2) in the assessment of various lip traits present in a population sample. All the facial images were aligned and registered on a common frame-work to ensure consistency in lighting using Rapidform (Zhurov, et al. [15]). Six standardised images were produced of the lips (anterior, left and right pro-file, three-quarter and inferior views) as shown in (Figure 3).

Reliability and Reproducibility

One of the authors (SH) was trained in the use of the WRCT using a random test sample of forty patients obtained from the Avon Longitudinal Study of Parents and Children (ALSPAC) (Golding, et al. [16]). Once a level of greater than 70 per cent agreement was achieved for both intra- and extra-examiner agreements the WRCT was then applied to the Welsh cohort.

Statistical Analyses

To evaluate inter- and intra-examiner agreement, the percentage agreement for each trait was evaluated.

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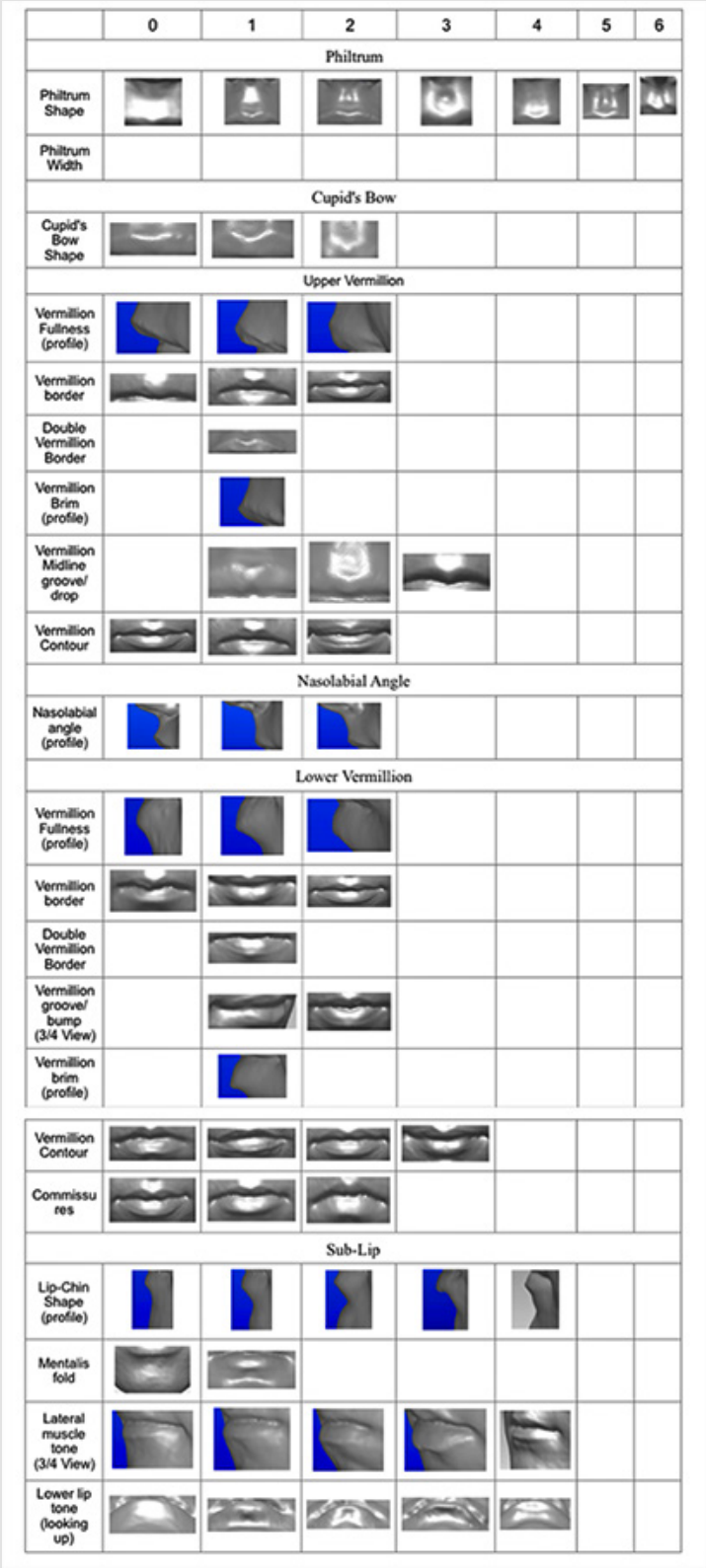

Figure 1: Wilson-Richmond Categorisation Tool for the morphological assessment of the perioral region.

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	Definition	Score
Philtrum width	Three categories based on the width of the philtrum based anywhere from the columella to the vermillion border.	0 - Narrow
		1 - Average
		2 - Wide
Philtrum shape	Progressive scoring of the surface of the philtrum in terms of the smoothness of the surface and the position of the largest indention from the columella to the vermillion border.	0 - Smooth philtrum
		1 - Normal gradient
		2 - Indentation near columella
		3 - Indentation in the middle
		4 - Indentation near the vermillion border
		5 - Deep groove running from columella to the vermillion border.
		6 – Deep groove extending through the vermillion border
Cupid's bow	Progressive scoring of the Cupid's bow the higher the score the more angulated the Cupid's bow.	0 - Flat
		1 - U-shaped
		2 – Sharp V
Upper/lower lip vermillion fullness	Progressive scoring of the fullness of the lips not extending beyond the vermillion border (viewed in profile).	0 - Thin
		1 - Medium
		2 - Thick

Upper/lower lip double vermillion border	A ribbon of soft tissue matching the vermillion border usually lying 2mm above the border.	0 - None
		1 - Present
Upper/lower vermillion brim	A small semi-circular projection at the vermillion border.	0 - None
		1 - Present
Upper/lower lip vermillion border	Identifiable vermillion lip border with variable coverage.	0 - None
		1 - Middle
		2 - Full border
Upper/lower lip vermillion midline Groove/drop	Notch: grooved area (tissue deficiency); Drop: bumped area (tissue excesss).	0 - None present
		1 - Groove in midline
		2 - Bunched mass in midline
Nasolabial Angle	Columella angle which can be 90 degrees, acute or obtuse.	0 - Acute
		1 - Normal
		2 - Obtuse
Upper lip vermillion contour	The shape of the vermillion border from the Cupid's bow peaks to the commissures.	0 - Concave
		1 - Straight
		2 - Convex
		3 – Pseudo-convex
Lower lip-chin shape	The curvature of the sub lip area, from the lower lip vermillion border to the chin.	0 - Flat
		1 - Curved concavity
		2 - Angular concavity
		3 - Marked angular concavity
		4 - Marked angular concavity, with a convex area
Pronounced mentalis fold	Presence of an obvious mental fold.	0 - Not present
		1 - Present

Commissures	Position of the commissures in relation to the general lip line.	0 - Upturned
		1 - Straight
		2 - Downturned
Lower lip vermillion contour	General curvature of the lower lip.	0 - Narrow in midline
		1 - Straight
		2 - Curved
		3 - Markedly curved
Lower lip tone	The assessment of the mentalis muscle tone.	0 - None
		1 - Convex
		2 - Slight
		3 - Marked lateral muscular tonicity
		4 - Marked tonicity with bumped areas

Figure 2: Description of morphological traits.

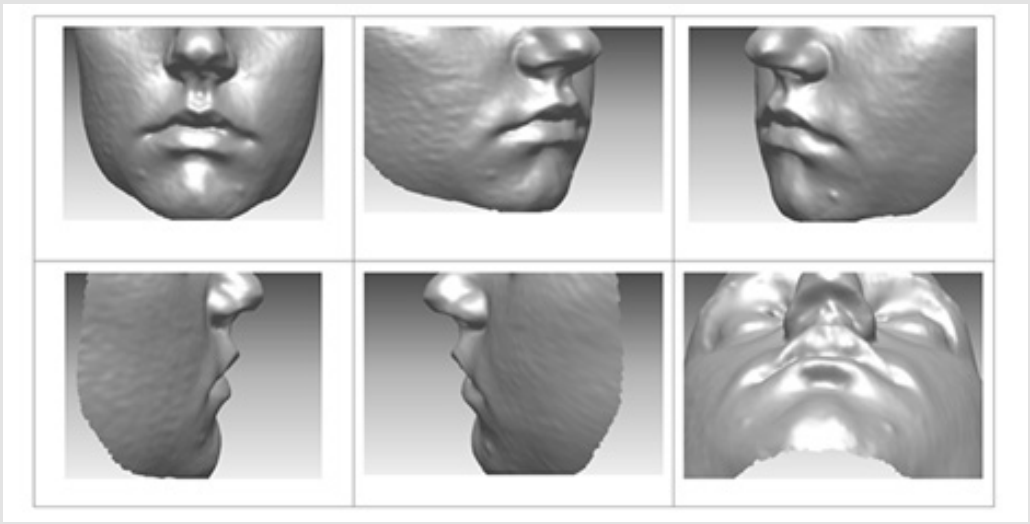

Figure 3: An example of the standardised views of the 360o laser scan used.

Results

Reliability and Reproducibility

A high level of agreement was found for both inter and intra examiner agreement. The percentage agreement ranged from 80 to 95% for intra- and 70 to 100% for inter-examiner agreement (Table 1), demonstrating that the WRCT is both reliable and reproducible.

Welsh Cohort Morphological Lip Traits

The results of the WRCT assessment of the lips of the fifty 12-year old Welsh individuals are displayed in (Table 2). Both males and females were more likely to display an average philtrum width, however females with a philtrum indentation tended to display it closer to the columella (39.13%) or the middle of the philtrum (26.09%), whereas the males tended to display it in the middle of the philtrum or closer to the vermillion border (33.33% and 18.52%). More males tended to have thinner upper lips (51.85%) and displayed a bunched mass in the midline (51.85%) than their female counterparts. An average nasolabial angle (M: 55.56%, F: 69.57%), medium lower lip fullness (M: 51.85%, F: 47.83%), a middle lower lip vermillion border (M: 85.19%, F: 69.57%) and a lower lip vermillion without a groove or drop (M: 85.19%, F: 73.91%) predominated for both males and females. The incidence of a prominent mentalis fold was similar in both male and females (M: 85.19%, F: 73.91%). However, the lower lip tone trait in males tended to be a marked lateral muscular tonicity (37.04%) compared to the females who were more likely to demonstrate a convex lower lip tone (43.48%).

Table 1: Intra- and inter-examiner percentage agreements for both upper and lower lips.

	Intra-examiner agreement%	Inter examiner agreement		Intra-examiner agreement%	Inter-examiner agreement
Upper lip			**Lower lip**		
Philtrum shape	90	85	Vermillion fulness	90	85
Philtrum width	95	95	Vermillion border	88	80
Cupid's bow	90	88	Double vermillion bored	98	100
Vermillion fulness	80	80	Vermillion brain	88	85
Vermillion border	88	83	Vermillion groove/notch	78	75
Double vermillion border	93	93	Lip-chin shape	78	85
Vermillion brim	93	83	Mentalis fold	93	73
Vermillion groove/drop	85	75	Commissures	83	85
Contour	85	83	Vermillion contour	70	83
Nasio-labial angle	93	78	Lower lip tone	78	70

Table 2: WRCT categorisation results of the 12-year old Welsh population sample.

			Males	Females	Total	%
	N	%	N	%	N	of total
Philtrum Width						
Narrow (0)	3	11.11	1	4.35	4	8
Average (1)	20	74.07	16	69.57	36	72
Wide (2)	4	14.81	6	26.09	10	20
Philtrum Shape						
Smooth (0)	3	11.11	1	4.35	4	8
Normal gradient (1)	5	18.52	7	30.43	12	24
Indentation near columella (2)	5	18.52	9	39.43	14	28
Indentation near middle (3)	9	33.33	9	39.13	15	30
Indentation near vermillion (4)	5	18.52	6	26.09	5	10
Deep groove (5)	0	0.00	0	0.00	0	0
Deep groove extending through the vermillion Border (6)	0	0.00	0	0.00	0	0

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Cupid's Bow Shape						
Flat (0)	1	3.70	8	34.78	9	18
U Shaped (1)	24	88.99	14	60.87	38	76
Sharp V-Shape (2)	2	7.41	1	4.35	3	6
Upper lip vermillion fullness						
Thin (0)	14	51.85	7	30.43	21	42
Medium (1)	11	40.74	11	47.83	22	44
Thick (2)	2	7.41	5	21.74	7	14
Upper lip double Vermillion border						
None (0)	27	100.00	23	100	50	100
Double Border (1)	0	0.00	0	100	0	0
Upper lip double brim						
None (0)	24	88.89	23	100.00	47	94
Brim present (1)	3	11.11	0	0.00	3	6
Vermillion border						
None (0)	3	11.11	3	1.04	6	12
Middle only (1)	10	37.04	12	52.17	22	44
Full border (2)	14	51.85	8	34.78	22	44
Upper lip vermillion groove/drop						
Nose present (0)	11	40.74	18	78.26	29	58
Groove in midline (1)	2	7.41	0	0.00	2	4
Bunched mass in midline (2)	14	51.85	5	21.74	19	38
Nasolabial angle						
Acute (0)	2	7.41	1	4.35	3	6
Average (1)	15	55.56	16	69.57	31	62
Obtuse (2)	10	37.04	6	26.09	16	32
Upper lip vermillion contour						
Concave (0)	9	33.33	7	30.43	16	32
Straight (1)	16	59.26	15	65.22	31	62
Convex (2)	1	3.70	1	4.35	2	4
Pseudo-convex (3)	1	3.70	0	0.00	1	2
Lower lip vermillion fullness						
Thin (0)	6	22.22	4	17.39	10	20
Medium (1)	14	51.85	11	47.83	25	50
Thick (2)	7	25.93	8	34.78	15	30
Lower lip double vermillion border						
None (0)	27	100.00	22	95.65	49	98
Double border (1)	0	0	1	4.35	1	2
Lower lip vermillion border						
None (0)	1	3.70	0	0.00	1	2
Middle only (1)	23	85.19	16	69.57	39	78
Full border (2)	3	11.11	7	30.43	10	20
Lower lip vermillion groove/drop						
None present (0)	23	85.19	17	73.91	40	80
Groove in midline (1)	2	7.41	1	4.35	3	6

Bunched mass in midline (2)	2	7.41	5	21.74	7	14
Lower lip vermillion brim						
None (0)	19	70.37	15	65.22	34	68
Brim (1)	8	29.63	8	34.78	16	32
Lip- chin shape						
Flat (0)	1	3.70	1	4.35	2	4
Curved concavity (I)	12	44.44	6	26.09	18	36
Angular concavity (2)						
	6	22.22	9	39.13	15	30
Marked angular concavity (3)	8	29.63	6	26.09	14	28
Marked angular concavity, with a convex area (4)	0	0.00	1	4.35	1	2
Mentalis fold						
None (0)	4	14.81	6	26.09	10	20
Fold present (1)	23	85.19	17	73.91	40	80
Commissures						
Upturned (0)	1	3.70	1	4.35	2	4
Straight (1)	12	44.44	17	73.91	29	58
Downturned (2)	14	51.85	5	21.74	19	38
Lower lip vermillion contour						
Narrow in midline (0)	13	48.15	9	39.13	22	44
Straight (1)	5	18.52	8	34.78	13	26
Curved (2)	5	18.52	2	8.70	7	14
Markedly curved (3)	4	14.81	4	17.39	8	16
Lower lip tone						
None (0)	2	7.41	1	4.35	3	6
Convex (1)	3	11.11	10	43.48	13	26
Slight (2)	8	29.63	7	30.43	15	30
Marked lateral muscular tonicity (3)	10	37.04	5	21.74	15	30
Very marked tonicity with bumped areas (4)	4	14.81	0	0.00	4	8

Discussion

This is an exploratory study which looked at normal lip morphology/lip traits in a 12-year-old population using the Wilson/Richmond classification (Wilson, et al. [8]). High levels of agreement between inter and intra examiner reliability with respect to most aspects of the WR (Wilson, et al. [8]) CT was reported in this previous study and they highlighted that the least reliable aspect was the assessment of the lower lip vermillion contour. In their research they found the intra and inter examiner reliability to be 79% and 33% respectively. Percent-age agreement was used rather than the Kappa statistic to ensure transparency in interpreting examiner agreement across 15 lip parameters with up to 6 sub-categories. In this study, almost all of the WRCT categories the intra-examiner reliability was greater than inter-examiner reliability. The only exceptions to this were the lower vermillion double lower border and the lower lip tone. The highest agreement in the intra-examiner group and inter-examiner group were the lower double vermillion border category and the philtrum width. The lowest categories in the intra-examiner and the inter-examiner group were the lower vermillion contour and lip-chin shape. (Wilson, et al. [8]) recommended dichotomisation of the lower lip results in order to improve reliability (90% inter-examiner and 67% intra examiner respectively), whilst in the author's (SH) experience this aspect of the WRCT did prove the most difficult aspect in which to achieve calibration, the results of this study showed that a high level of agreement (70% inter and intra-examiner agreement) could be achieved and that dichotomisation of this aspect of the WRCT was not be required. This could potentially be due to the fact that the author had a more comprehensive training package or because the use of this tool had matured since its development and consequently the author received better training from the developers in its use.

The morphological appearance, trends and associations of the test sample are not reported here as they have already been reported in the much larger study undertaken by (Wilson, et al. [8]). But more importantly this study has shown that an examiner new to the WRCT can calibrate and utilise this tool to assess a series of scanned images from a study population in order to classify the individuals according to the morphological appearance of their lips. This type of analysis would not have been possible by the more traditional land marking techniques, where the subtleties of the lip contours, grooves and indentations are ignored, with the preference for exact measurements with small margins of error. This detailed examination of the topography of the lips afforded by the WRCT provides a unique insight into lip morphology (and can be likened to a detailed Admiralty chart of the ocean bed or that of hill contours on an Ordnance survey map). This 12-year old sample of Welsh school children was a younger population group on which to utilise the WRCT when compared to the 15 year old population used in the development of the assessment tool, by (Wilson, et al. [8]). Orthodontists are fully aware that adolescence is a period of rapid physical and psychological development, which begins, with the onset of puberty. Puberty is a rapid period of sexually dimorphic development with changes in body size, shape, and composition and females enter and complete each stage of puberty earlier than boys (11 years in girls and 13 years in boys) (Tanner and Whitehouse, et al. [17,18]).

Therefore in this population sample some individuals would have been within the pubertal growth period (mainly female), some finished (female) whereas some may yet have started (mainly male). Whereas in the population utilised by (Wilson, et al. [8]) all of the females should have completed puberty as well as most (if not all) of the males. The differences in incidences of the respective morphological traits re-ported above, compared to the study undertaken by (Wilson, et al. [8]) therefore could potentially be due to changes that occur during this period of significant growth. This study found that 12-year old Welsh males tended to have medium or thin upper lip vermillion and average philtrums, in addition there was a higher proportion of males with obtuse nasolabial angles. Could these be structures that are affected in this period of growth? Meanwhile the incidences in males and females for features such as a U-shaped Cupid's bow, philtrum indentations, a vermillion brim being present (upper or lower), mentalis fold and lower lip tone were similar (despite a significant difference in population size) to the incidence described by (Wilson, et al. [8]). Could this suggest relatively static morphological architecture? Morphological and gender associations may also become more apparent as this population pass through puberty. By following this population and reviewing the perioral morphological characteristics up to 17-years of age it is hoped that a better understanding of the three dimensional changes in this region can be attained. This study is limited in comparison to that of (Wilson, et al. [8]), in describing the prevalence of traits, by its somewhat smaller sample size. But it is hoped that it may provide a gauge for population calculations and inform hypotheses in larger studies. It is also the aspiration of the authors that this tool will allow a detailed insight into the soft tissue characteristics of different ethnic populations and the potential identification of changes due to growth of a key aspect of the oral soft tissue environment for many medical specialties.

Conclusion

This study has shown that a new examiner can learn the Wilson-Richmond method of lip assessment and that the WRCT is a reproducible and reliable method of assessing the various morphological features of the lips. This tool has been developed on epidemiological data and shows both good inter and intra-examiner reliability. The WRCT can provide a standardised means of assessment, highlighted by the results of a 12-year-old Welsh population of school children reported above. In addition it is hoped that it will provide the means by which further comparisons amongst different, growing, ethnic groups may be compared with a view to identifying population associations.

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