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Hair Loss Among Elderly Men: Etiology and Impact on Perceived Age

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Background. Androgenetic alopecia is the most common type of hair loss in men, but little is known about the etiology of androgenetic alopecia in elderly men and its impact on perceived age. Here we used a population-based twin study of men aged 70+ to assess the magnitude of the genetic component affecting hair loss and to examine the association between baldness and perceived age.

Methods. In the fourth wave of The Longitudinal Study of Aging Danish Twins we obtained digital photos of the face and photos of the vertex area of 739 elderly male twins, including 148 intact twin pairs. The degree of baldness and perceived age were assessed in each twin by five and nine nurses, respectively. The heritability of balding was estimated using structural-equation analysis, and it was tested whether baldness was associated with estimations of age.

Results. The intrapair correlation of degree of balding was consistently higher for monozygotic than for dizygotic twin pairs regardless of the baldness categorization used, and structural-equation analysis revealed a heritability of 79% (95% confidence interval, 0.40–0.85) for the mean baldness index. The remaining variation could be attributed to nonshared environmental effects. There was only a very weak and statistically nonsignificant association between baldness and overestimation of age.

Conclusions. The majority of the variation in baldness in elderly men can be explained by genetic factors, and hair quantity has little impact on perceived age in elderly men.

ANDROGENETIC alopecia (AGA) is the most common type of hair loss in men. It is characterized by visible loss of hair over areas of the scalp due to progressive miniaturization of hair follicles (1–3). It is distinct (i.e., cosmetically significant) in more than 45% Caucasian men by the age of 49, and in 70% by the age of 79 (4). In Asian, Native American, and African-American men the prevalence is lower and AGA is less severe (5).

It is generally assumed that male balding tends to run in families, but data documenting this are sparse, and the nature of any underlying genetic predisposition and the mode of inheritance are unknown. The frequency of balding in fathers of bald persons is very high in individuals younger than 30 years, but decreases with age to approach the general population frequency (6). This finding suggests a strong genetic component to early-onset baldness with an attenuation of the genetic component with age.

Among the family studies, twin studies are particularly valuable as they are able to disentangle the influence of common environment and genes. Twin literature on hair loss is, however, very scarce. Three small studies (7–9) indicate an influence of genetic factors on various aging signs including hair loss, but include too few dizygotic twin pairs to reliably estimate the heritability. The only large-scale twin study estimating the magnitude of a genetic component affecting baldness and hair loss is a recent Australian twin register study of 25- to 36-year-old males (10). The results from this study indicate a heritability of approximately 80% of early-onset AGA. To our knowledge, there are no heritability estimates available for AGA at older ages.

Hair is an important part of a person's physical appearance. The present cultural emphasis on youthful appearance has further strengthened the value of abundant hair. Some studies have associated balding with overestimations of age (11–14). In the study by Butler and colleagues 1998 (14), 96 students graded computer-morphing photographs. The study showed that the same 30-year-old individual was rated significantly more dominant, dynamic, and masculine, and was perceived to be significantly younger with "full cranial hair" than he was when in a bald condition. This most likely is why most men experience hair loss as a moderately stressful process, causing loss of self-esteem and impaired quality of life (15,16). The available studies on baldness and perceived age have been conducted in younger and middle-aged men. As men age, the probability of visible AGA increases. Accordingly, baldness is a more normative part of the physical appearance in elderly men and could hence be expected to affect perceived age to a lesser degree at older ages. However, no studies have attempted to discern how balding affects perceived age in elderly men.

By using the Longitudinal Study of Aging Danish Twins (LSADT), which comprises digital pictures of the face and vertex of male participants aged 70+, the aims of this study were (a) to assess the magnitude of the genetic component affecting hair loss in elderly men, and (b) to investigate the association between baldness and perceived age in elderly men.

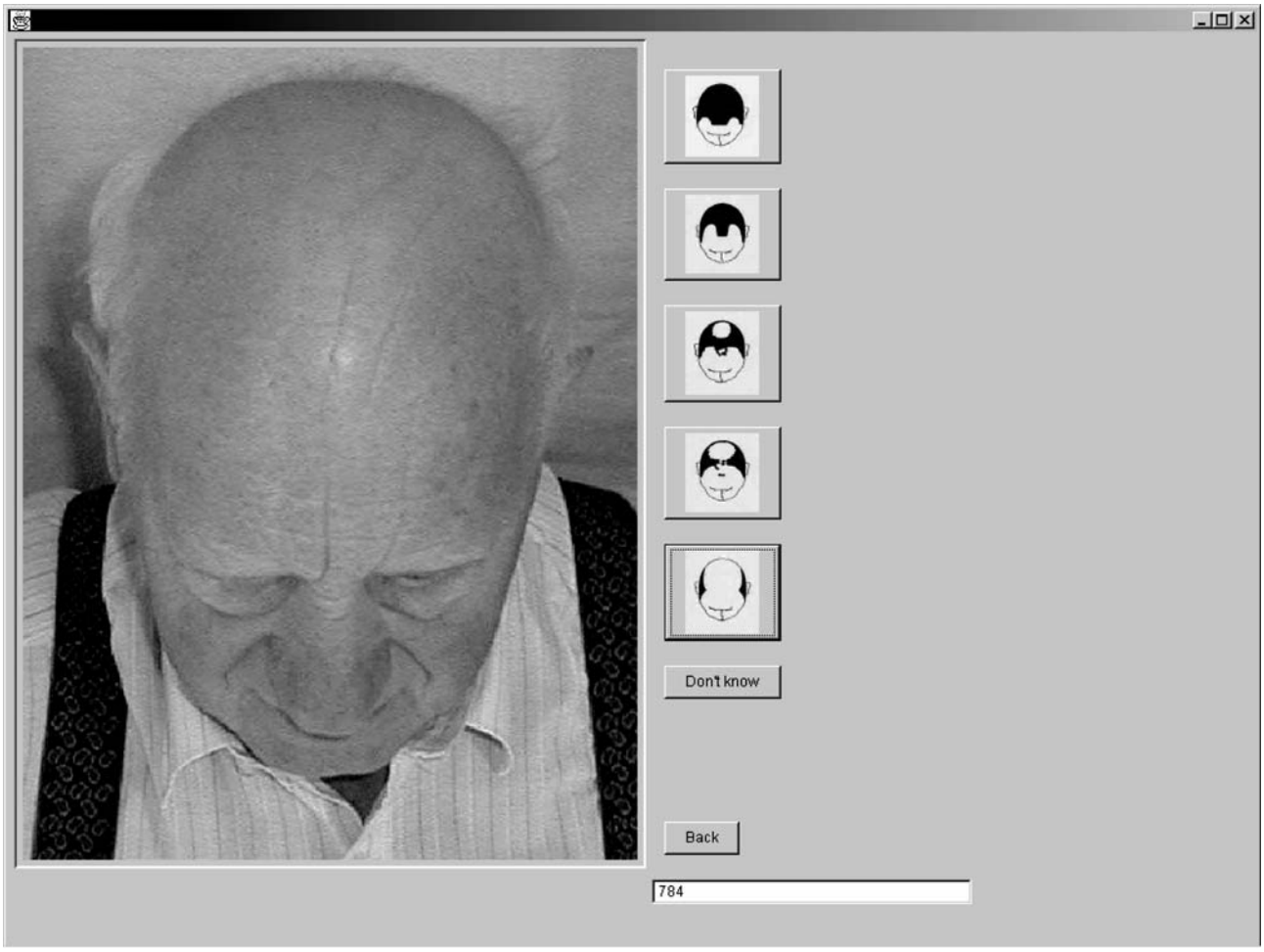

Figure 1. Grading scale.

Methods

Survey Population

The population-based nationwide LSADT comprises elderly Caucasian twins (17). As part of the fourth wave (the 2001 LSADT survey), 91% of the cognitively intact participants, aged 70–91 years, consented to have their face photographed. A digital camera was used at a distance of 0.6 meters, person en face, head held straight with a neutral background, if possible. In addition, male participants had a picture of their scalp taken (same standard plus head bent forward in an angle of ca. 45°). For 866 male twins, we had a high quality scalp photo; of these, 739 twins also had a high quality face photo taken providing a sample size sufficient for the proposed analyses.

Baldness Index

Five female nurses (31–47 years) were engaged to assess the degree of baldness from the vertex photo of each male twin. A computer was programmed to allow the digital scalp photos to be shown one at the time together with the grading scale (Figure 1). By using the Hamilton scale (18) as modified by Norwood (4) and by Lotufo and colleagues (19), the photos were classified according to a five point scale: 0) no hair loss (Hamilton-Norwood [HN] scale I), 1) frontal baldness only (HN scale II–IIIa), 2) frontal hair loss with mild vertex baldness (HN scale III–vertex V), 3) frontal hair loss with moderate vertex baldness (HN scale VI), and 4) frontal hair loss with severe vertex baldness (HN scale VII). In addition, the scale included an extra category "non-classifiable" allowing the nurses not to assess the degree of baldness if in doubt.

For the analyses of twin similarity, only twin pairs in which both twins provided a high quality scalp picture were used. Of the 866 scalp photos, 29 were graded as "non-classifiable" by one or more graders. These were subtracted from the data, leaving 837 scalp photos: 541 single twins who had a dead or nonparticipating co-twin, 66 intact monozygotic twin pairs, and 82 intact dizygotic twin pairs. Cronbach's Coefficient Alpha ($\alpha = 0.97$) showed a very high consistency of the graders; therefore, we did not use nine graders as in the assessment of perceived age. The Baldness Index, defined as the mean of the five gradings, was calculated.

Perceived Age

Nine female nurses (25–46 years) were engaged to assess the visual age of each twin from the face photo. The mean of

Table 1. Hair Loss Among Elderly Danish Twins

Age	70–74 Years	75–79 Years	80–84 Years	85+ Years	All
N (individuals)	369	262	121	85	837
Mean age (*SD*)	72.3 (1.4)	77.4 (1.5)	82.0 (1.4)	88.8 (2.7)	77.0 (5.5)
Mean perceived age (*SD*)	75.9 (3.6) ($n = 330$)	78.4 (2.7) ($n = 222$)	78.7 (3.7) ($n = 108$)	80.7 (3.0) ($n = 79$)	77.6 (3.7) ($n = 739$)
Mean of Baldness Index (*SD*)*	1.95 (1.12)	2.26 (1.17)	2.22 (1.21)	2.52 (1.16)	2.15 (1.17)
% Who are almost bald†	26.0	37.8	37.2	47.1	33.5
% With almost all hair intact‡	33.6	22.9	28.1	18.8	28.0

Notes: *See text for details.
†Baldness index ≥ 3.
‡Baldness index ≤ 1.
SD = standard deviation.

the nurses' age estimates for each twin was used as the twin's perceived age. The reliability of the mean age rating was estimated to be 0.84 using analysis of variance, and $\alpha = 0.90$ using Cronbach's Coefficient Alpha.

Analyses of Twin Similarity

Standard biometric models (20) were used to estimate the heritability of male baldness in elderly twins. It is assumed that the total variance in a trait can be composed as $V = A + D + C + E$, where A refers to the variance contribution of additive genetic effects, D refers to the variance contribution of genetic effects due to dominance, C refers to the variance contribution of shared environmental effects (effects due to the shared environment of reared-together twins), and E refers to the variance contribution of nonshared environmental effects (unique effects not shared by reared-together twins). We fitted separate ADE and ACE models to the data because in the standard biometric model the parameters C and D cannot be estimated simultaneously). Also, simpler models (AE, CE, DE, and E models) were fitted to the data.

Each model was evaluated in terms of whether it fitted the data (i.e., had a nonsignificant chi-square goodness-of-fit test statistic) and was parsimonious (i.e., none of the parameters could be deleted without a significant increase in the chi-square test statistic). For a comparison of non-nested models, the Akaike Information Criterion ($AIC = \chi^2 - 2 \times df$) was used. Models with the lowest AIC were preferred. Because of significant age effects on the outcome measures, models were fitted to the data in which linear effects of age had been regressed out.

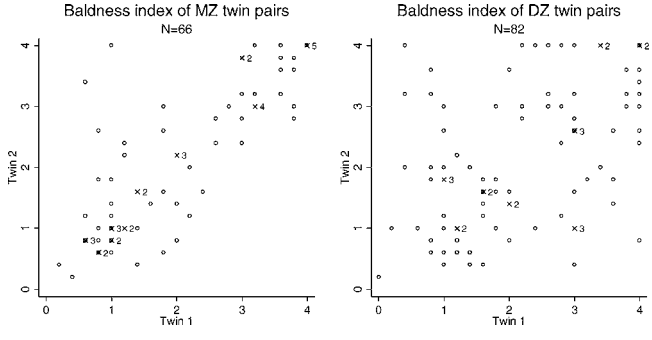

Figure 2. Unadjusted Baldness Index according to zygosity.

Results

Baldness Index

Summary statistics stratified by age are shown in Table 1. The fraction of individuals having little hair (Baldness Index ≥ 3) increases with age, whereas the fraction having almost all hair intact (Baldness Index ≤ 1) declines.

Figure 2 shows the unadjusted Baldness Index for twin 1 and twin 2 by zygosity. The corresponding twin correlations are given in Table 2 for the Baldness Index and in Table 3 for various dichotomizations of the Baldness Index. These data show that the monozygotic twin correlations are high and about twice the dizygotic twin correlations, indicating the presence of large genetic effects on male baldness.

The heritability of male baldness was computed by using the Mx software package (21). The biometric models for the age-adjusted Baldness Index are shown in Table 4. The best fitting model is the AE. According to this model, 79% (95% confidence interval [CI], 69%–85%) of the observed variation in the Baldness Index could be explained by additive genetic effects, and 21% (95% CI, 15%–31%) by nonshared environmental effects. To test whether the results were sensitive to our baldness grading we repeated the biometrical models using different gradings and groups: median of the five ratings; division of the individuals into groups with almost all hair intact versus the rest; individuals almost completely bald versus the rest. As seen in Table 5, all gradings and groups give similar results.

Perceived Age

The association between the Baldness Index and the difference between perceived and actual age is shown in

Table 2. Intraclass Correlation Coefficients and 95% Confidence Intervals (CIs) for Baldness Index

Age, Years	Zygosity	*N**	Correlation (95% CI)
70–74	MZ	33	0.74 (0.56–0.85)
75–79	MZ	20	0.88 (0.76–0.94)
80+	MZ	13	0.75 (0.42–0.89)
70–74	DZ	45	0.46 (0.20–0.65)
75–79	DZ	28	0.41 (0.06–0.65)
80+	DZ	9	0.17 (0–0.66)†
All	MZ	66	0.78 (0.68–0.85)
All	DZ	82	0.42 (0.22–0.57)

Notes: *Number of intact twin pairs.
†Truncated at zero.
MZ = monozygotic; DZ = dizygotic.

Table 3. Twin Intrapair Correlations for Baldness Measures

Twin Zygosity	MZ	DZ
N (twin pairs)	66	82
Intraclass correlation coefficient of median (95% CI)	0.87 (0.77–0.92)	0.39 (0.17–0.57)
Tetrachoric correlation coefficient of almost bald (95% CI)*	0.93 (0.77–0.99)	0.27 (0–0.57)‡
Tetrachoric correlation coefficient of almost all hair intact (95% CI)†	0.76 (0.48–0.92)	0.30 (0–0.62)‡

Notes: *Baldness Index $\geq$ 3.
†Baldness Index $\leq$ 1.
‡Truncated at zero.
MZ = monozygotic; DZ = dizygotic; CI = confidence interval. CI values are calculated assuming equal thresholds within twin pairs and zygosity.

Figure 3. The estimate of the slope of the best fitting regression line is –0.10 (95% CI, –0.45–0.26), which is not statistically significant. However, as previously described (22) and as seen in Table 1, perceived ages regress toward a mean of 78 years; therefore, we stratified the analyses for age (Figure 3). For the two age groups, 70–79 years and 80+ years, there is a small statistically nonsignificant positive slope (0.41 and 0.17, respectively), indicating a slightly increasing estimation of age by increasing baldness in both cohorts: Going from having all hair intact to being completely bald increases the estimation of age by 0.7 and 1.6 years, respectively, in the two cohorts.

Discussion

From our population-based study comprising elderly twins we have two main findings:

a) The majority of the variation in hair loss among elderly men can be attributed to genetic factors.
b) There is only a very weak and statistically nonsignificant association between perceived age and baldness in elderly men.

Our study shows a very strong genetic component to hair loss in elderly men. Contrary to our expectations based on previous intergenerational studies (6) we found a genetic component to balding among elderly men of similar size as in younger males. Both our study of 70+-year-olds and the study by Nyholt and colleagues of 25- to 36-year-old men (10) revealed heritability around 80%.

Table 4. Biometrical Models for Baldness Index in 148 Pairs of Elderly Danish Male Twins (LSADT 2001)

Model	χ^2	*df*	*p*	AIC
ADE	6.8	9	.66	−11.2
ACE	6.8	9	.66	−11.2
AE	**0.1**	**1**	**.79**	**−1.9**
CE	17.8	1	.00	15.8
E	78.6	1	.00	76.6

Notes: Best fitting model according to AIC (Akaike's Information Criterion = $\chi^2 - 2 \times df$) is given in bold.
A = additive genetic effects; D = genetic effects due to dominance; C = shared environmental effects; E = nonshared environmental effects.

Table 5. Biometric Models for Various Baldness Indices in Elderly Danish Twins

Variance Component	Additive Genetic Effects (95% CI)	Nonshared Environmental Effects (95% CI)
Baldness Index	0.79 (0.69–0.85)	0.21 (0.15–0.31)
Median of ratings	0.86 (0.76–0.92)	0.14 (0.08–0.24)
Almost bald vs the rest*	0.92 (0.74–0.98)	0.08 (0.02–0.26)
Almost all hair intact vs the rest†	0.75 (0.48–0.91)	0.25 (0.09–0.52)

Notes: *Baldness Index $\geq$ 3.
†Baldness Index $\leq$ 1.
CI = confidence interval.

Our study had a number of strengths. We used five graders to assess baldness from vertex photos, whereas the only previous sizeable twin study (10) was based on self-assessment. The fact that the photos were digital enabled the use of a computer set-up where the scale was continuously visible next to the picture during the grading of baldness. The fact that the pictures were taken as part of a survey in which the interviewers were visiting the participants in their homes ensured the inclusion of the more frail participants; this is usually not the case when participants have to attend a clinical survey located at a research institution.

The weakness of our study was that the photos could not be taken as standardized as in a clinical setting due to the various conditions in the participants' residences. However, the very high Cronbach's Coefficient Alpha value (0.97) showed that the baldness scoring was very reliable. Furthermore, any random misclassification would lead to an underestimation of the genetic component. Hence our result showing a very strong genetic component is likely to be conservative.

Although our study suggests that genetic variants for hair loss are present, it does not reveal which genetic variants are of importance. The few available family data suggest that AGA has a complex polygenic mode of inheritance. Based on the current understanding of hair follicle biology and the hair growth cycle, there are a number of candidate genes to explore: 5 alpha-reductase, the insulin gene, the androgen receptor, aromatase, growth factors, the Y chromosome, and estrogen receptors (23). Furthermore, the human hairless gene is a good candidate gene because, after cloning of this gene, mutation has been reported in families with autosomal recessive universal congenital alopecia and papular atrichia (24). However, an initial small association and family study of AGA failed to detect any involvement of the human hairless gene (25). Among the few positive findings is the androgen receptor gene, which in an association study was found to be significantly more frequent in young bald males than in older males with no baldness (26).

Our study suggests that the main causes for the differences in hair loss among elderly men are to be found in genetic differences. The prospect for identifying specific genetic factors influencing male baldness depends of course on the number and the size of the effects of these genetic factors as well as their interactions. However, the combination of a very

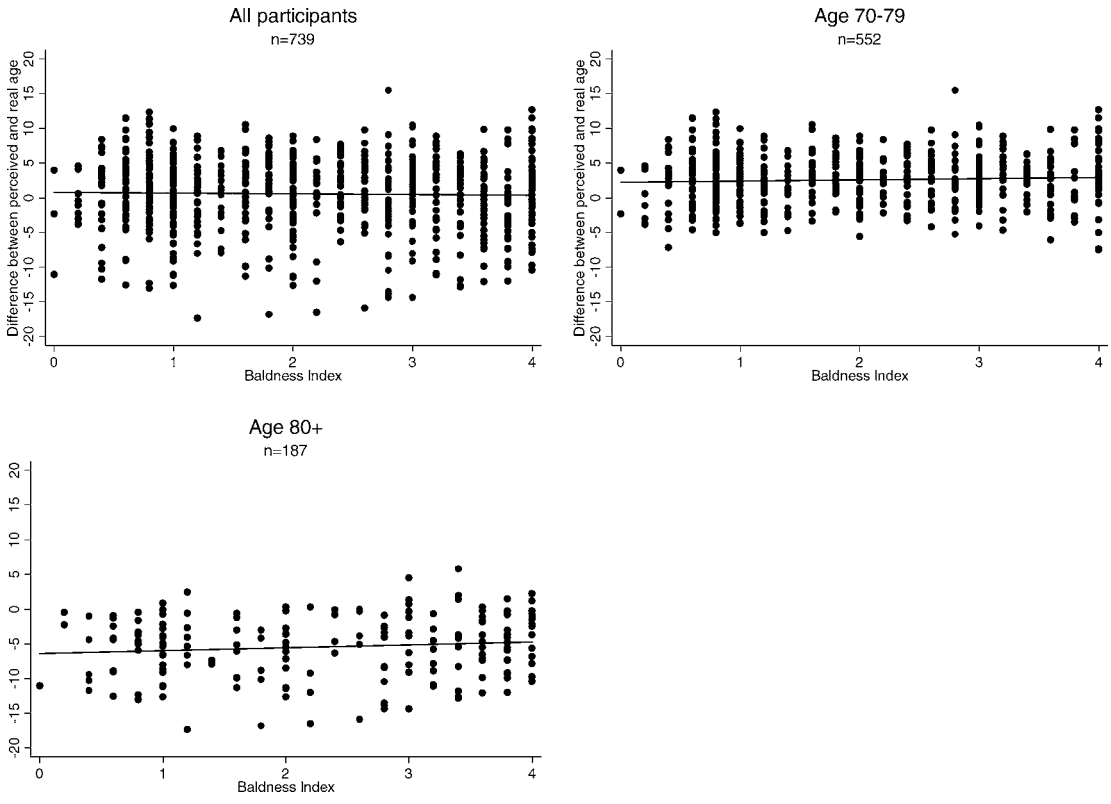

Figure 3. Relation between perceived age and Baldness Index in all participants as well as in two age strata. The line shows the best fitting straight line.

high heritability, a prevalent condition which can be measured quantitatively, and a number of good candidate genes is promising for the efforts to identify genetic variants affecting hair loss. A promising design for identifying new candidate genes is the use of extremely concordant or extremely discordant pairs (27) based on the notion that a region on the genome harboring a gene variant important for male baldness will tend to be shared more often than the expected 50% in sibling pairs (and dizygotic twin pairs) extremely concordant for hair loss and, correspondingly, less often than the expected 50% in extremely discordant sibling pairs (dizygotic twins).

Identification of such gene variants could be the first step toward understanding the etiology of hair loss and potentially how to reduce it. Whether such an undertaking is worthwhile from a health perspective is dubious, as a reduction in hair loss is unlikely to directly affect health. Nonetheless, arresting hair loss might have significant psychological benefits for many individuals, as psychological studies have consistently associated increasing degrees of hair loss with loss of self-esteem, introversion, neuroticism, and feelings of diminished attractiveness at all ages, but especially pronounced in men with early onset of balding (15,16).

As expected, we found only a weak and statistically nonsignificant association between overestimations of age and baldness in men older than 70 years. As the incidence and degree of balding increases with age, balding becomes a more typical, and less noticeable, part of appearance in elderly men. Hence, baldness does not "age" the old man as it "ages" the younger man.

Our culture is preoccupied with physical appearance and youth. Loss of cranial hair is a common feature of age, but still induces many men to spend a great deal of effort, time, and money to enhance their appearance. Our study suggests that also at older ages the etiology of baldness is mainly to be found in genetic factors, and that hair quantity has no impact on perceived age. So there may be a time to let it go.

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References

1. Olsen EA, ed. *Disorders of Hair Growth.* New York: McGraw-Hill; 1993:321–362.
2. Whiting DA. Diagnostic and predictive value of horizontal sections of scalp biopsy specimens in male pattern androgenetic alopecia. *J Am Acad Dermatol.* 1993;28:755–763.
3. Sinclair R. Male pattern androgenetic alopecia. *BMJ.* 1998;317:865–869.
4. Norwood OT. Male pattern baldness: classification and incidence. *South Med J.* 1975;68:1359–1365.
5. Hoffmann R. Male androgenetic alopecia. *Clin Exp Dermatol.* 2002; 27:373–382.

6. Birch MP, Messenger AG. Genetic factors predispose to balding and non-balding in men. *Eur J Dermatol.* 2001;11:309–314.
7. Nishimura H, Shumuzi S. Studies on various ageing phenomena in Japanese twins and siblings. *Acta Genet Med Gemellol (Roma).* 1963;12:22–49.
8. Niermann H. *Zwillingedermatologie*. Berlin, Germany: Springer-Verlag; 1964.
9. Hayakawa K, Shimizu T, Ohaba Y, et al. Intrapair differences of physical aging and longivity in identical twins. *Acta Genet Med Gemellol (Roma).* 1992;41:177–185.
10. Nyholt DR, Gillespie NA, Heath AC, Martin NG. Genetic basis of male pattern baldness. *J Invest Dermatol.* 2003;121:1561–1564.
11. Wogalter MS, Hosie JA. Effects of cranial and facial hair on perception of age and person. *J Soc Psychol.* 1991;131:589–591.
12. Cash TF. Losing Hair, Losing Points?: The Effects of Male Pattern Baldness on Social Impression Formation. *J Appl Soc Psychol.* 1990;20:154–167.
13. Muscarella F, Cunningham MR. The evolutionary significance and social perception of male pattern baldness and facial hair. *Ethology and Sociobiology.* 1996;17:99–117.
14. Butler J, Pryor B, Grieder M. Impression formation as a function of male baldness. *Percepy Mot Skills.* 1998;86:347–350.
15. Cash TF. The psychological effects of androgenetic alopecia in men. *J Am Acad Dermatol.* 1992;26:926–931.
16. Wells P, Willmoth T, Russell RJH. Does fortune favour the bald? Psychological correlates of hair loss in males. *Br J Psychol.* 1995; 86:337–344.
17. Christensen K, Gaist D, Vaupel JW, McGue M. Genetic contribution to rate of change in functional abilities among Danish twins aged 75 or more. *Am J Epidemiol.* 2002;155:132–139.
18. Hamilton JB. Patterned loss of hair in man: types and incidence. *Ann N Y Acad Sci.* 1951;53:708–728.
19. Lotufo PA, Chae CU, Ajani UA, Hennekens CH, Manson JE. Male pattern baldness and coronary heart disease. The Physicians' Health Study. *Arch Intern Med.* 2000;160:165–171.
20. Neale MC, Cardon LR. *Methodology for Genetic Studies of Twins and Families.* Dordrecht: Kluwer Academic Publisher; 1992.
21. Neale MC. *Mx: Statistical Modeling.* 4th ed. Richmond, VA: Department of Psychiatry, Medical College of Virginia; 1999.
22. Christensen K, Iachine M, Rexbye H, et al. "Looking old for your age" – a genetically influenced condition associated with mortality. *Epidemiology.* 2004;15:251–252.
23. Ellis J, Harrap S. The genetics of androgenetic alopecia. *Clin Dermatol.* 2001;19:149–154.
24. Kruse R, Cichon S, Anker M, et al. Novel hairless mutations in two kindreds with autosomal recessive papular atrichia. *J Invest Dermatol.* 1999;113:954–959.
25. Hillmer AM, Kruse R, Macciardi F, et al. The hairless gene in androgenetic alopecia: results of a systematic mutation screening and family-based association approach. *Br J Dermatol.* 2002;146:601–608.
26. Ellis JA, Stebbing M, Harrap S. Polymorphism of the androgen receptor gene is associated with male pattern baldness. *J Invest Dermatol.* 2001;116:452–455.
27. Risch N, Zhang H. Extreme discordant sib pairs for mapping quantitative trait loci in humans. *Science.* 1995;268:1584–1589.

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