

## ORIGINAL RESEARCH

# Comparison of self-reported signs of facial ageing among Caucasian women in Australia versus those in the USA, the UK and Canada

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### ABSTRACT

**Background/Objectives:** Australians are more exposed to higher solar UV radiation levels that accelerate signs of facial ageing than individuals who live in temperate northern countries. The severity and course of self-reported facial ageing among fair-skinned Australian women were compared with those living in Canada, the UK and the USA.

**Methods:** Women voluntarily recruited into a proprietary opt-in survey panel completed an internet-based questionnaire about their facial ageing. Participants aged 18–75 years compared their features against photonumeric rating scales depicting degrees of severity for forehead, crow's feet and glabellar lines, tear troughs, midface volume loss, nasolabial folds, oral commissures and perioral lines. Data from Caucasian and Asian women with Fitzpatrick skin types I–III were analysed by linear regression for the impact of country (Australia versus Canada, the UK and the USA) on ageing severity for each feature, after controlling for age and race.

**Results:** Among 1472 women, Australians reported higher rates of change and significantly more severe facial lines ( $P \leq 0.040$ ) and volume-related features like tear troughs and nasolabial folds ( $P \leq 0.05$ ) than women from the other countries. More Australians

also reported moderate to severe ageing for all features one to two decades earlier than US women.

**Conclusions:** Australian women reported more severe signs of facial ageing sooner than other women and volume-related changes up to 20 years earlier than those in the USA, which may suggest that environmental factors also impact volume-related ageing. These findings have implications for managing their facial aesthetic concerns.

**Key words:** Caucasian, facial ageing, facial lines, Fitzpatrick phototype, mid-face ageing, photoageing, volume-related ageing.

### INTRODUCTION

Australia's large land mass that approaches the equator, the high sun elevation and generally clear atmospheric conditions mean that people living here can experience higher levels of UV radiation than those in Europe and North America.<sup>1,2</sup> These high UV levels put Australians at particular risk of photoageing, especially when combined with Australian's traditionally outdoor, sun-seeking lifestyle and a predominately fair-skinned population.

Facial ageing signs include wrinkles, loss of volume and sagging, and vascular disorders.<sup>3</sup> The appearance and structure of skin changes with age due to intrinsic (chronological) processes, extrinsic factors that include sun and UV exposure, gravity, pollution, and lifestyle factors such as diet, smoking, illness or stress.<sup>3</sup> Solar UV irradiation is the primary extrinsic factor causing human skin ageing.<sup>4</sup> The cumulative process of photoageing depends primarily on the degree of sun exposure and amount of skin pigment. Skin wrinkling and sagging are observed at a younger age among people with lighter skin, whereas hyperpigmentation and an uneven skin tone is the initial indicator of skin ageing in Asian and darker skin.<sup>5,6</sup>

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Volume loss also plays an essential role in facial ageing, particularly in the midface.<sup>7</sup> Facial fat is distributed above and below the facial muscles in several independent compartments.<sup>8</sup> Individual fat compartments age independently, with fat loss and ptosis in deep compartments leading to changes in facial shape, contour and anterior projection, while folds (e.g. the nasolabial fold) develop at transition points between thick and thinner superficial fat compartments.<sup>9</sup> Gravity also plays a role but in a non-uniform manner, impacted by underlying ligaments.<sup>10</sup> In addition, maxillary retrusion occurs with increasing age along with a decrease in orbital rim anterior projection and in mandibular length and height.<sup>11</sup> This loss of craniofacial skeletal support for the overlying midfacial soft tissue contributes significantly to the volume changes observed here.<sup>12</sup>

Although studies have shown that photodamage is more prevalent in younger Australians than their age-matched counterparts in Europe,<sup>13,14</sup> data are limited on the differences in the extent and course of skin and volume-related facial ageing between women living in Australia and those living in the northern hemisphere. This sub-analysis of a large cross-sectional, multinational, internet-based study was conducted to compare the differences in the patterns of static facial wrinkles and volume loss reported by Australian and non-Australian women. As the Australian cohort primarily comprised Caucasians and Asians with Fitzpatrick skin phototypes I, II and III, the comparator groups from Canada, the UK and the USA were restricted to women matching these characteristics.

## METHODS

### Study design and participants

Between December 2013 and February 2014, a cross-sectional, internet-based questionnaire was administered to members of the YouGov (YouGov plc, London, UK) Polling-Point Panel, a proprietary opt-in study panel. The Polling-Point Panel comprises over 2.5 million respondents in 11 countries, among whom are 500 000 active panellists each in Australia, Canada, the UK, and the USA. Panel members were recruited by several methods to help ensure diversity in the panel population. Recruitment methods included Web advertising campaigns that target respondents based on their keyword searches (the primary method), permission-based email campaigns, partner-sponsored solicitations; telephone-to-Web recruitment (random digit dialling-based sampling), and mail-to-Web recruitment (voter registration-based sampling).

Women aged 18–75 years living in Australia, Canada, the UK and the USA, who had pre-consented to complete health-related internet surveys by answering ‘Yes’ to the question, ‘Would you be willing to occasionally complete polls in the future?’ were recruited from the panel via an email invitation. The pre-specified sampling framework was designed to select a study cohort comprising an approximately equal number of participants in age and racial or ethnic groups from each country. Approval from the appropriate accredited central institutional review board and ethics committee was obtained prior to study

initiation. Participants provided their informed consent before entering the study.

To best capture the natural course of facial ageing, participants were excluded if they had significant facial trauma or burns that altered the appearance of their facial skin or if they had previously undergone facial plastic surgery, treatment with botulinum toxins or injectable fillers, facial skin resurfacing, or laser treatments. Participants were also excluded if they had used a prescription oral or topical retinoid at any time prior to study enrolment, or were using prescription or over-the-counter facial products containing growth factors or hormones.

The study included questions about sociodemographic characteristics (e.g., country of residence, race or ethnicity, age, Fitzpatrick skin phototype), clinical characteristics (height, weight, skin characteristics, sun exposure history, and alcohol and tobacco use), and clinical characteristics of facial ageing. For data quality assurance, YouGov delivered only cases where the respondent’s age and sex matched that of the existing profile data. The data were also checked for repetitive response patterns and response times that indicated that the respondent was not sufficiently engaged in making an active response.

To understand how the Australian sample compared to the other countries, we aimed to match the Australian cohort demographics as closely as possible. Hence for this sub-analysis, only Caucasian and Asian women with Fitzpatrick skin phototypes I, II, or III<sup>15</sup> were included.

### Study objective and measures

The study objective was to compare the severity of facial ageing and the time course of its clinical characteristics between fair-skinned Australian women and those living in the USA, UK and Canada.

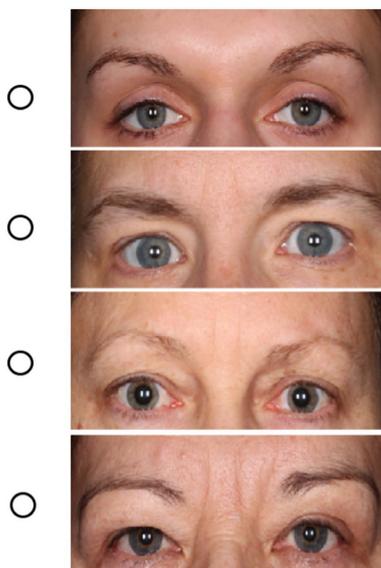
Race was categorised as Caucasian/white (including Arab/Middle Eastern) or Asian (including South Asian [Indian, Pakistani, Bangladeshi] and Melanesian/Native Hawaiian/Pacific Islander). The Fitzpatrick skin phototype scale was used to classify participants’ skin colour based on its typical response to UV light on a scale from Type I (very fair skin that always burns and never tans) to VI (dark brown skin that never burns and always tans).<sup>15</sup>

Using a mirror, participants compared their facial features against photometric rating scales (Fig. 1) illustrating progressive severity of ageing (none to severe) for eight facial characteristics: static forehead, crow’s feet and glabellar lines; tear troughs; midface volume loss; nasolabial folds; oral commissures; and perioral lines. They were asked to select one image out of four to six (depending on the feature) that most represented their current facial features in the absence of facial expression.

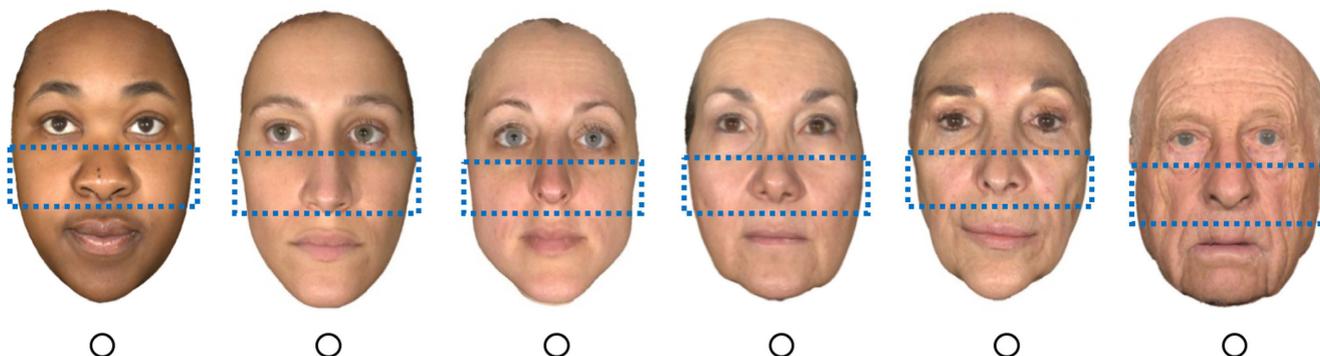
### Statistical analyses

Descriptive statistics were summarised for sociodemographic and clinical characteristics (means and standard deviations or percentages were calculated for each variable). For continuous variables, analysis of variance was

(a) Select the picture below that most closely represents your frown lines (vertical lines between your eyebrows) when you are **not** frowning.



(b) Select the picture below that best represents the **fullness of your mid-face** (area below the temple and above the jaw as indicated within the blue dotted area).



**Figure 1** Examples of photonumeric scales used to self-evaluate severity of ageing with respect to facial lines and volume loss. (a) Glabellar lines; (b) Mid-face volume.

used for comparisons between the participants’ countries of residence. For categorical variables, intercountry comparisons were made using the Pearson’s  $\chi^2$  test.

For characteristics related to facial ageing, mean respondent ratings for the severity of each facial feature were plotted in descriptive line graphs by 10-year age cohorts stratified by country. Data on facial ageing characteristics were also analysed by linear regression to assess the impact of country (Australia versus Canada, the UK and the USA) on ageing severity for each feature, after controlling for age, race and smoking status (current or ex-smoker versus never-smoker). Alcohol use, Fitzpatrick skin phototype (I–III), body mass index (BMI), and the sun exposure variables were not included as covariates in the linear regressions because bivariate linear regression analyses showed that there were no significant associations with ageing severity of most facial features.

To compare the time course of facial ageing among women from different countries, the proportions who reported moderate or severe ageing for each facial feature were analysed and compared using descriptive bar graphs to show the decade during which  $\geq 50\%$  of the women in each country rated each facial feature as having moderate or severe signs of ageing. This cut-off was chosen to yield the best sensitivity in detecting differences in facial ageing severity among countries.

Statistical analyses were carried out using SPSS Statistics vers. 23 (IBM, Armonk, NY, USA).

**RESULTS**

A total of 3267 eligible women of all races and ethnicities completed the study in four countries (Australia, Canada, the UK and the USA), and 1472 Caucasian and Asian women

with Fitzpatrick skin types I, II and III were included in this sub-analysis. Most of the Australians lived in coastal cities, but in the other countries, more respondents lived inland (Figure S1). Their demographic data are summarised in Table 1. In all, 75% of these respondents were Caucasian and the remainder were Asian (Table 1). The mean BMI was greater in Australian women than in women from other countries, most likely because the BMI ranges differed between countries (Table 1), and because five Australian participants had a BMI >50 kg/m<sup>2</sup>, versus only one in the UK and two in Canada and the USA. The proportion of Asians was lower in Australia than in the other countries. The proportions of women who had ever smoked and who drank alcohol were lowest in the USA. Australia and the USA had

the lowest proportion of women whose household income was lower than the median country income.

When asked about their history of sun exposure during the 6 months preceding the study, most respondents reported that they spent an hour or less per day outside during peak sun hours and did not have sunburns that lasted longer than a day. Most sun exposure variables differed significantly among countries (Table 1). The only sun exposure variable that did not significantly vary among the countries was the frequency with which sunblock was worn, with most participants wearing it sometimes, often or always.

Increasing age was significantly associated with more severe signs of ageing for all facial features (all  $P < 0.0001$ ; Table 2). Asian ethnicity was significantly associated with

**Table 1** Participants' characteristics, including self-reported exposure to extrinsic facial ageing factors

Characteristic	Country					Intergroup comparison	
	All women	Australia	USA	UK	Canada	Statistical value	<i>P</i> value
<i>N</i> (%) <sup>†</sup>	1472 (100)	447 (30)	524 (22)	505 (21)	596 (27)		
Age in years, mean ± SD	47.5 ± 16.1	47.4 ± 16.1	49.5 ± 16.2	47.7 ± 16.3	45.8 ± 15.9	3.2 <sup>‡</sup>	0.025
BMI in kg/m <sup>2</sup> , mean ± SD (range)	26.5 ± 6.8 (8.7–66.1)	27.9 ± 7.4 (16.9–66.1)	25.8 ± 6.5 (8.7–56.7)	25.2 ± 5.7 (13.7–55.9)	25.7 ± 6.6 (16.3–62.3)	11.0 <sup>‡</sup>	<0.001
Race/ethnicity, <i>n</i> (%)							
Caucasian	1101 (75)	401 (90)	199 (61)	251 (76)	270 (68)	92.8 <sup>§</sup>	<0.001
Asian	371 (25)	46 (10)	125 (39)	74 (24)	126 (32)		
Fitzpatrick skin phototype, <i>n</i> (%)							
Type I <sup>††</sup>	161 (11)	55 (12)	36 (11)	35 (12)	35 (9)	19.5 <sup>§</sup>	0.004
Type II <sup>†††</sup>	595 (40)	211 (47)	120 (37)	108 (35)	156 (39)		
Type III <sup>††††</sup>	716 (49)	181 (41)	168 (52)	162 (55)	205 (52)		
Smoking status, <i>n</i> (%)							
Current or former smoker	559 (38)	184 (41)	95 (29)	115 (38)	165 (42)	14.5 <sup>§</sup>	0.002
Never smoked	915 (62)	263 (59)	229 (71)	190 (62)	231 (58)		
Drinks alcohol, <i>n</i> (%)	869 (59)	288 (64)	151 (47)	205 (67)	225 (57)	35.5 <sup>§</sup>	<0.001
Household income, <i>n</i> (%)							
≤Median country income	775 (55)	181 (41)	138 (43)	175 (57)	279 (71)	125.7 <sup>§</sup>	<0.001
>Median country income	448 (30)	185 (41)	124 (38)	54 (18)	87 (22)		
Prefer not to answer	251 (17)	85 (19)	62 (19)	76 (25)	30 (7)		
Time outside in the sun on average per day during peak sun hours over past 6 months, <i>n</i> (%)							
<30 min	625 (43)	225 (50)	166 (51)	85 (27)	153 (39)	57.8 <sup>§</sup>	<0.001
30–60 min	418 (28)	119 (27)	85 (55)	106 (35)	110 (28)		
>1–2 h	249 (17)	67 (15)	43 (13)	62 (20)	77 (19)		
>2	180 (12)	58 (9)	32 (10)	54 (18)	56 (14)		
Number of sunburns during past 6 months that lasted ≥1 day, <i>n</i> (%)							
0	975 (66)	269 (60)	236 (73)	232 (76)	236 (60)	44.0 <sup>§</sup>	<0.001
1	317 (22)	124 (28)	60 (19)	40 (15)	95 (24)		
2	120 (8)	58 (9)	16 (5)	21 (7)	45 (11)		
≥3	62 (4)	16 (4)	12 (4)	12 (4)	22 (6)		
How often participant wears sunblock on her face, <i>n</i> (%)							
Never	151 (9)	32 (7)	37 (11)	22 (7)	40 (10)	20.1 <sup>§</sup>	0.065
Rarely	264 (18)	75 (16)	60 (19)	48 (16)	85 (21)		
Sometimes	495 (34)	156 (35)	89 (28)	115 (37)	135 (34)		
Often	345 (25)	117 (26)	76 (24)	75 (24)	77 (19)		
Always	241 (16)	69 (15)	62 (19)	49 (16)	61 (15)		
How often participant wears a hat when outside, <i>n</i> (%)							
Never	344 (25)	65 (15)	95 (29)	84 (28)	100 (25)	60.2 <sup>§</sup>	<0.001
Rarely	401 (27)	107 (24)	88 (27)	89 (29)	117 (30)		
Sometimes	394 (27)	130 (29)	75 (23)	85 (28)	104 (26)		
Often	229 (16)	95 (21)	50 (15)	34 (11)	50 (13)		
Always	104 (7)	50 (11)	16 (5)	15 (4)	25 (6)		

<sup>†</sup>Percentages are rounded; some categories may not equal 100%; <sup>‡</sup>*F* value for analysis of variance analysis; <sup>§</sup> $\chi^2$  value for Pearson  $\chi^2$  test; <sup>††</sup>Very fair skin that always burns and never tans; <sup>†††</sup>Fair skin that always burns and sometimes tans; <sup>††††</sup>Medium skin that sometimes burns and always tans. BMI, body mass index.

**Table 2** Impact of country<sup>†</sup> on facial aging characteristics controlling for age, race and smoking status using linear regression

Model/Variable	Model summary <i>R</i> <sup>2</sup>	Coefficients <sup>‡</sup>				
		Unstandardised coefficients		95% CI for <i>B</i>		<i>P</i> value
		<i>B</i>	Std error	Lower	Upper	
<b>Facial lines</b>						
Static forehead lines	0.240					
Age		0.022	0.001	0.019	0.024	<0.001
Asian		-0.166	0.048	-0.260	-0.072	0.001
Smoker (current or former) <sup>§</sup>		0.145	0.041	0.063	0.224	0.001
Canada		-0.028	0.051	-0.128	0.075	0.591
UK		-0.126	0.054	-0.252	-0.019	0.021
USA		-0.191	0.055	-0.298	-0.085	0.001
Static glabellar lines	0.410					
Age		0.056	.001	.054	.039	<0.001
Asian		-0.117	0.051	-0.216	-0.017	0.022
Smoker (current or former) <sup>§</sup>		0.205	0.044	0.119	0.291	<0.001
Canada		-0.206	0.054	-0.312	-0.099	<0.001
UK		-0.128	0.058	-0.242	-0.015	0.027
USA		-0.196	0.058	-0.310	-0.081	0.001
Static crow's feet	0.489					
Age		0.059	0.001	0.056	0.041	<0.001
Asian		-0.182	0.047	-0.272	-0.095	<0.001
Smoker (current or former) <sup>§</sup>		0.135	0.059	0.058	0.213	0.001
Canada		-0.211	0.049	-0.306	-0.115	<0.001
UK		-0.217	0.052	-0.319	-0.115	<0.001
USA		-0.253	0.053	-0.356	-0.150	<0.001
Perioral lines	0.358					
Age		0.050	0.001	0.028	0.035	<0.001
Asian		-0.125	0.047	-0.217	-0.035	0.008
Smoker (current or former) <sup>§</sup>		0.140	0.040	0.061	0.219	0.001
Canada		-0.122	0.050	-0.220	-0.024	0.015
UK		-0.109	0.055	-0.214	-0.005	0.040
USA		-0.146	0.054	-0.252	-0.041	0.007
<b>Volume-related features</b>						
Tear troughs	0.507					
Age		0.053	0.001	0.050	0.056	<0.001
Asian		-0.113	0.057	-0.225	-0.001	0.047
Smoker (current or former) <sup>§</sup>		0.094	0.049	-0.002	.190	0.055
Canada		-0.295	.061	-0.415	-0.176	<0.001
UK		-0.225	.065	-0.352	-0.098	0.001
USA		-0.553	0.065	-0.481	-0.224	<0.001
Midface volume	0.255					
Age		0.052	0.002	0.029	0.056	<0.001
Asian		-0.177	0.066	-0.306	-0.047	0.007
Smoker (current or former) <sup>§</sup>		0.053	0.057	-0.079	0.144	0.567
Canada		-0.035	0.071	-0.174	0.105	0.617
UK		-0.024	0.075	-0.171	0.125	0.751
USA		-0.170	0.076	-0.319	-0.021	0.025
Nasolabial folds	0.565					
Age		0.041	0.002	0.038	0.044	<0.001
Asian		-0.002	0.060	-0.002	0.060	0.968
Smoker (current or former) <sup>§</sup>		0.181	0.052	0.080	0.285	<0.001
Canada		-0.174	0.064	-0.300	-0.048	0.007
UK		-0.146	0.068	-0.280	-0.012	0.033
USA		-0.247	0.069	-0.382	-0.112	<0.001
Oral commissures	0.428					
Age		0.058	0.001	0.055	0.040	<0.001
Asian		-0.170	0.051	-0.269	-0.070	0.001
Smoker (current or former) <sup>§</sup>		0.174	0.044	0.088	0.260	<0.001
Canada		-0.167	0.054	-0.274	-0.061	0.002
UK		-0.105	0.058	-0.218	0.008	0.070
USA		-0.114	0.058	-0.228	0.000	0.050

<sup>†</sup>Using Australia as the reference country; <sup>‡</sup>Dependent variables: listed facial feature; <sup>§</sup>Using 'non-smoker' as the reference variable.

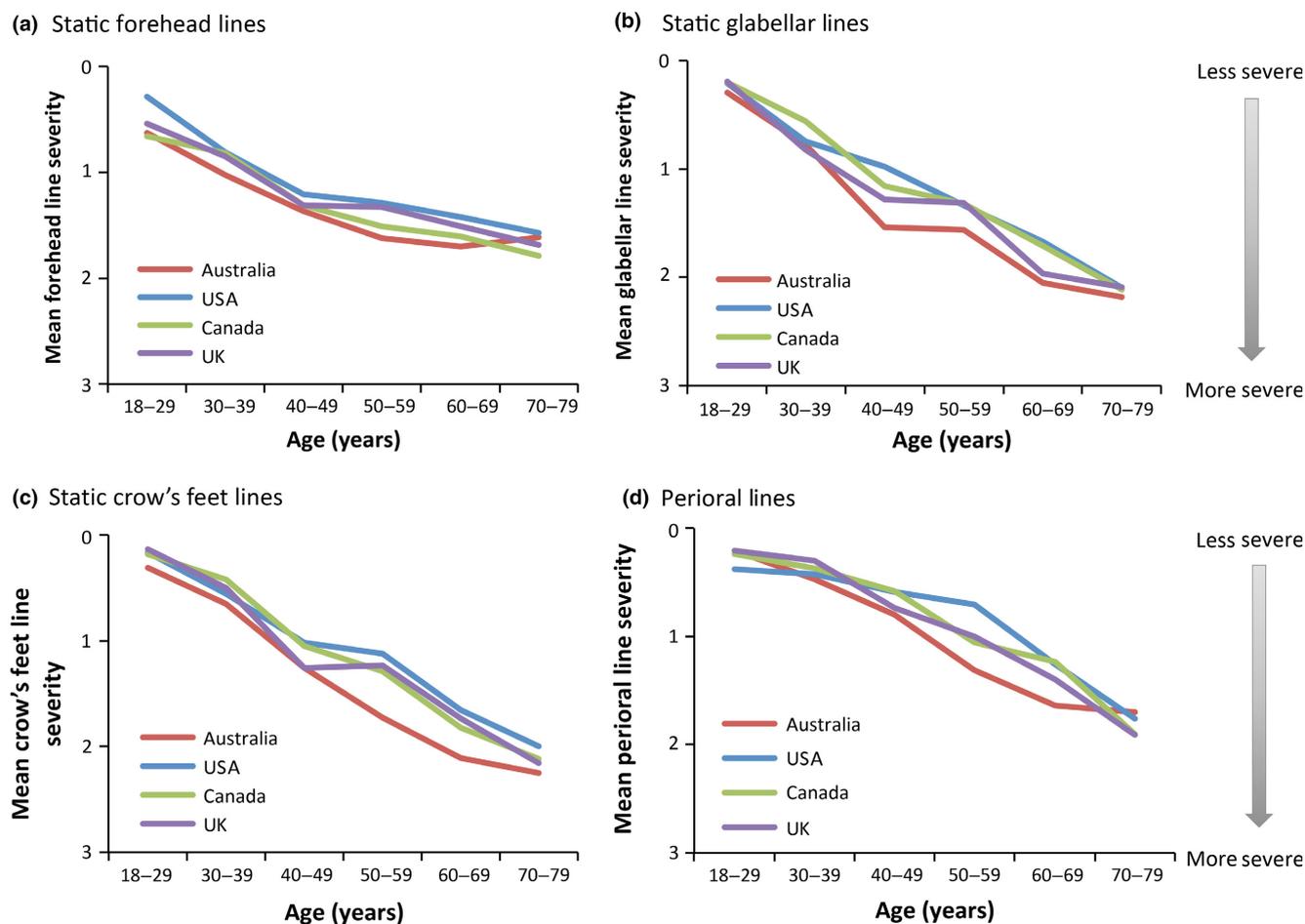
less severe ageing for most facial features ( $P \leq 0.05$ ) except for nasolabial folds, for which differences were not statistically significant (Table 2). Current or former smoking was significantly associated with more severe ageing for all features except tear troughs and midface volume loss ( $P \leq 0.001$ ; Table 2). BMI was not included as a cofactor in the linear regressions because in bivariate analyses with the facial features, it was not a significant factor for any feature, including midface volume loss (data not shown).

Australian women reported more severe facial lines and higher rates of change with age than women from the other countries, particularly compared to those from the USA (Fig. 2). The severity of facial lines reported by women from other countries was significantly less than in Australians for all line types ( $P \leq 0.04$ ; Table 2) except for static forehead lines in Canadian women, where the differences were not statistically significant. In Australian women, the steepest increases in severity occurred between the ages of 30–59 years for forehead lines, 18–49 years for glabellar lines, 30–69 years for crow's feet lines and 40–69 years for perioral lines (Fig. 2). The mean severity of static forehead, glabellar and crow's feet lines

was greater among Australians aged 18–29 years than among women of this age from some of the other countries. Among women in their seventies, the mean severity of facial lines was generally similar among the countries, with more severe glabellar and crow's feet lines being reported by Australians (Fig. 2).

With regard to volume-related facial features, even though their mean BMI was greater than those of women from the other countries (Table 1), Australian women showed significantly greater severity and higher rates of change for tear troughs and nasolabial folds than women from all other countries ( $P \leq 0.035$ ; see Table 2 and Fig. 3). Oral commissures were also more severe in Australian women, but only the differences from Canadian women were statistically significant ( $P = 0.002$ ; Table 2). Loss of midface volume with ageing was similar between women from the different countries (Fig. 3b), and only women from the USA had statistically significant differences from Australians ( $P = 0.025$ ; Table 2).

Mean tear trough severity was greater among the youngest Australians (18–29 years) than the other countries; the oldest Australian women also reported the



**Figure 2** Mean self-reported severity of facial lines by age. (a) Static forehead lines; (b) Static glabellar lines; (c) Static crow's feet lines; (d) Perioral lines.

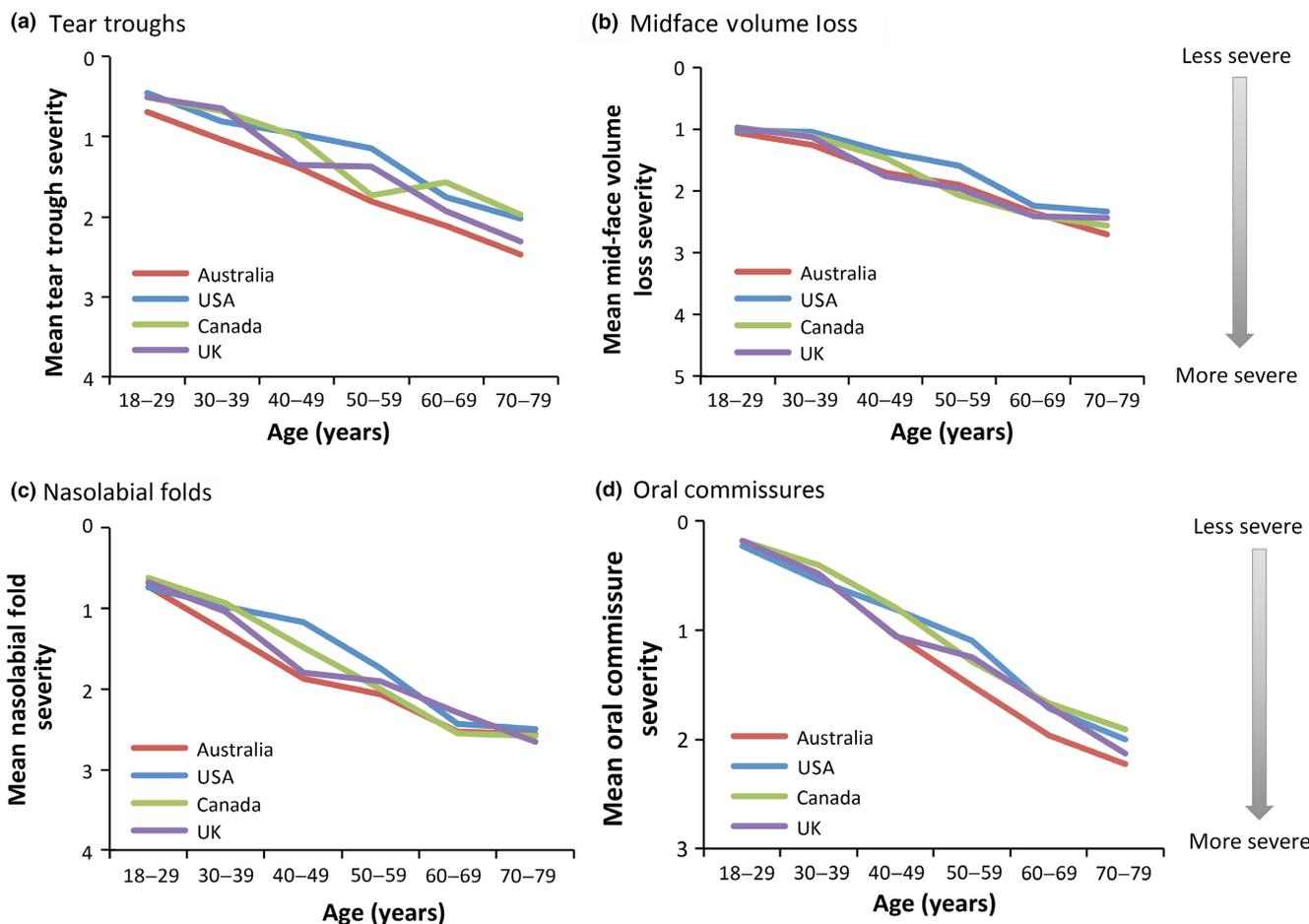


Figure 5 Mean self-reported severity of volume-related features by age. (a) Tear troughs; (b) Midface volume loss; (c) Nasolabial folds; (d) Oral commissures.

greatest mean severity of tear troughs, midface volume loss and oral commissures (Fig. 5). The increase in severity of most volume-related features was generally constant as the Australians aged except for nasolabial folds, where the greatest increase in severity occurred between the ages of 18 and 49 years. Among women from the other countries, increases in severity varied more with ageing (Fig. 5).

When the proportions of women who reported moderate to severe ageing of each facial feature were compared among countries by decade of age using a cut-off of  $\geq 30\%$ , the greatest differences were seen between Australian and US women. Over 30% or more of Australian women reported moderate or severe signs of facial ageing for all features from the ages of 30–59 years (40–49 years for four of eight features), but this proportion of US women did not report this level of severity until the ages of 40–69 years (60–69 years for five of eight features; Fig. 4).

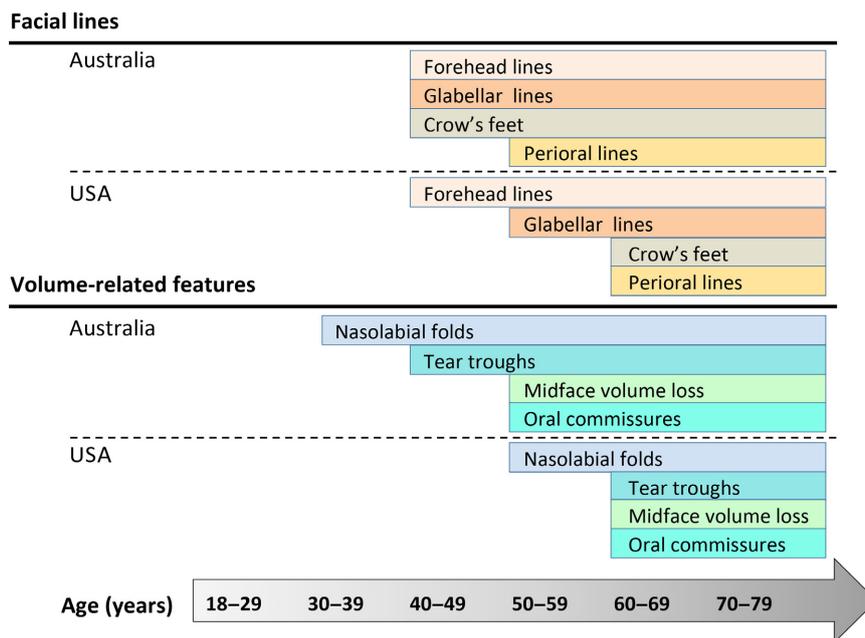
With regard to the course of facial ageing, nasolabial folds preceded other features in Australians, with advanced severity reported by  $\geq 30\%$  of those aged 30–39 years (Fig. 4). By contrast, this level of nasolabial fold severity

was reported two decades later by the same proportion of US women and a decade later in the other two countries (data not shown). By the age of 40–49 years,  $\geq 30\%$  of Australians reported advanced severity for all upper face lines and tear troughs (Fig. 4). In American women, moderate to severe static forehead lines appeared first, being the only feature reported by this proportion of women in their forties; glabellar lines of this severity were reported in their fifties and crow’s feet, perioral lines, tear troughs, midface volume loss and oral commissures were reported as moderate or severe during their sixties.

### DISCUSSION

This sub-analysis was carried out to compare the severity and course of facial ageing among Australians with age-matched and skin phototype-matched women of a similar heritage who lived in the northern hemisphere.

Australian women reported significantly more severe signs of ageing at younger ages and a greater degree of change with age for most features than women from the other countries, particularly those from the USA. The



**Figure 4** Signs of facial aging: decade at which  $\geq 30\%$  of women reported moderate to severe ageing for facial lines and volume-related features (Australia versus USA).

greatest differences in mean severity of ageing between Australia and the other countries were seen for glabellar and crow's feet lines, and for volume-related tear troughs and nasolabial folds. Based on these findings, it might be expected that a greater proportion of fair-skinned Australian women might seek facial aesthetic treatment at earlier ages than US women<sup>16</sup> to address these signs of ageing.

Different courses of facial ageing were also seen among the women living in these countries (Fig. 4). The clinical implications are that fair-skinned Australian women's facial areas of treatment priority may differ from those of women living in the northern hemisphere.<sup>16</sup>

Our finding that advanced signs of photoageing were reported by relatively young Australian women is in agreement with a previous study of skin ageing in Queensland. Of 1400 participants aged 27–47 years, 85% had moderate to severe photoageing shown by skin microtopography, and every year of age after 30 years up to 54 years significantly increased the odds of photoaged skin.<sup>15</sup> Other community-based studies of Australian adults have also shown photoageing prevalence rates that are substantially higher than in European adults.<sup>14</sup> In a hospital-based study in The Netherlands, only 7% of 24–49-year olds had moderate to severe clinically assessed elastosis, compared with 35% of Australians in the same age group.<sup>14</sup>

We found it surprising that the greatest differences in facial ageing were observed between Australian and US women, and as such, we explored possible reasons for this. Australians did not have the highest levels of sun exposure or severe sunburns during the 6 months preceding the study, and they were more likely to wear a hat (Table 1). Bivariate linear regression analyses showed that neither alcohol nor the other sun exposure variables significantly

impacted facial ageing (data not shown). Although the USA, Canada and the UK had higher proportions of Asian respondents and Asians experience skin wrinkling later than Caucasians<sup>6,17–19</sup>, variability due to race was controlled for in the linear regressions. We also controlled for differences in smoking habits, as smoking is positively associated with skin ageing<sup>15,20,21</sup>. Of the survey respondents who were excluded because they had used cosmetic treatments to alter the effect of aging to their face, 43% were from the USA, 27% from Canada, 22% from Australia, and 8% from the UK. This suggests that cosmetic treatments are more common in the USA than in Australia, so even if the exclusion of participants who had received cosmetic treatments or procedures resulted in the selection of women with more severe facial ageing, this should have been more apparent among US than Australian women.

Therefore, the main reason for greater aging severity observed in Australians may be childhood and cumulative sun and UV exposure, particularly given these participants' mainly coastal location (Figure S1) and traditionally outdoor lifestyle. Large differences in latitude-dependent solar UV indices<sup>1,2,22</sup> and reduced exposure during long, often cloudy, northern hemisphere winters may mean that the women from Canada, the UK and northern USA experienced substantially less UV during their lifetimes than the Australians. These aspects were not evaluated in this study because of the potential for inaccuracy when asking respondents to recall and estimate their own childhood sun exposure and sunburn history,<sup>25</sup> and because calculating lifetime sun and UV exposure requires average yearly sunlight hours combined with ambient UV light.<sup>24</sup> Nevertheless, a non-linear relationship between lifetime sun exposure and skin ageing has been demonstrated: the skin

of younger individuals is more sensitive to sun exposure than the skin of individuals older than 50 years.<sup>24</sup> This is aggravated by the fact that sun exposure during childhood and early adulthood exceeds that in middle adulthood.<sup>14</sup> Findings that the prevalence rates of mild skin damage among children aged 15–15 years in Scotland was 35% compared with 40–70% in Queensland<sup>14</sup> may support this theory, as does the above mentioned photoageing observed in 85% of 27–47-year-olds from Queensland.<sup>14</sup> Even though education campaigns and legislation on the dangers of sun exposure were introduced in Australia in the 1970s,<sup>25</sup> these may have come too late for the respondents older than 45 years.

Midface volume loss differences were not as large as for the other features among the different countries (Fig. 3), possibly because it can be more difficult for people to understand and self-assess volume loss in this area of the face using a photo-numeric scale, compared to other facial features. However, the substantially earlier appearance of volume-related ageing signs like nasolabial folds, oral commissures and tear troughs in Australian women than in those from the USA (Fig. 4) was again surprising. UV exposure would not necessarily have been expected to impact facial fat loss or redistribution. A possible explanation is that greater loss of skin elasticity in Australians resulting from greater photodamage during childhood and adolescence results in less external support for the underlying tissue structure, so that it reveals tissue sagging and fat loss in the form of nasolabial folds and tear troughs at a younger age. In addition, the full spectrum of the sun's light output comprises not only UV, but also visible, infrared and longer wavelengths. It is possible that volume-related damage may result from the deeper penetration of longer light wavelengths. Indeed, fat removal is now being achieved by non-invasive techniques that include low level light and infrared technologies,<sup>26,27</sup> and perhaps chronic low-dose exposure to these may contribute to the volume changes observed.

The study strengths are that the internet-based approach used for data collection in this study enabled access to a large, globally distributed population with a relatively wide range of socioeconomic status. The YouGov panel of respondents is accustomed to filling in questionnaires, making errors less likely, and the study design favoured complete participant responses. However, electronic data collection and accuracy of self-reported information also pose limitations. Self-reported data without formal objective assessments by physician evaluators can be affected by response bias (and may have been responsible for the midface volume loss findings we observed). Nevertheless, response bias in this study may have also been mitigated by the relatively large sample size and the socioeconomic status range of the respondents. Another study limitation is that data were not collected on childhood sun exposure, which might have provided more insight into the reasons for the differences in facial ageing between Australians and women from other countries. However, self-reporting childhood data from memory also has substantial limitations regarding accuracy.<sup>25</sup>

In conclusion, fair-skinned Caucasian and Asian women in Australia reported more severe signs of facial ageing at earlier ages than those living in the USA, UK and Canada.

Generally, the greatest differences were seen between Australian and US women, with Australian women reporting some signs of advanced ageing approximately 20 years earlier than those from the USA. These outcomes may be the result of extrinsic factors more prevalent in Australia, such as childhood and cumulative UV exposure. Volume-related changes (oral commissures, tear troughs, nasolabial folds) usually assumed to be caused by intrinsic ageing were also reported at earlier ages in Australian women, suggesting that environmental influences may also impact volume-related ageing. These findings may have implications for the understanding and management of Australian women's facial aesthetic concerns, particularly with regard to their prioritisation of facial areas that require anti-ageing treatment compared with those of US women.<sup>16</sup>

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## Supporting Information

Additional Supporting Information may be found online in Supporting Information:

**Figure S1.** Location within the surveyed countries of 1472 respondents included in this subanalysis (depicted as yellow dots).