Age and Ageing 2009; **38:** 553–558
doi: 10.1093/ageing/afp098
Published electronically 25 June 2009

Older men with higher self-rated socioeconomic status have shorter telomeres

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Abstract

Background: previous studies examining the relationship between socioeconomic status and telomere length showed conflicting results, one study finding shorter telomere length in subjects with lower socioeconomic status and one showing no relationship.
Design: cross-sectional study.
Setting: community-living elderly Chinese in Hong Kong.
Objective: this study examines the relationship between self-rated social economic status and telomere length in Hong Kong Chinese men and women aged 65 years and over living in the community.
Subjects and method: information was collected from 958 men and 978 women regarding possible confounding factors such as the presence of chronic diseases, smoking, physical activity level, dietary intake and body mass index. Telomere length was measured by quantitative PCR.
Result: in men only, after adjustment for age and other confounding factors, a higher ranking in community standing was associated with shorter telomere length.
Conclusion: men with higher self-rated socioeconomic status have shorter telomeres, possibly mediated through psychosocial rather than lifestyle factors or the presence of chronic disease. There may be cultural ethnic and age-related differences in social determinants of health.

Keywords: *telomere length, socioeconomic status, elderly Chinese, elderly*

Introduction

A social gradient of morbidity and mortality has been well documented, with those at the bottom in terms of income, occupation or education having poorer health than those at the top [1]. Recent research has also documented the importance of the psychosocial environment and the increased production of inflammatory cytokines as one of the mediating mechanisms [2]. Adverse socioeconomic factors may result in telomere shortening, through lifestyle or psychological factors affecting oxidative stress or chronic inflammatory damage, particularly in the early childhood phase when the rate of telomere attrition is greatest [3, 4].

Recent studies suggest that there may be an association between psychological stress and telomere length [5], and an accelerated telomere erosion has been observed with declining immune function and an increase in inflammatory cytokines in caregivers of Alzheimer's disease patients [6]. Telomere length in white blood cells was found to be shorter in those with lower socioeconomic status in a cross-sectional study of 1,552 female twins of a mean age 45 years [7], independent of confounding factors such as smoking, obesity and lack of exercise. However, in a smaller study of unrelated people (average age 50 years), telomere length was not associated with early or adult life socioeconomic indicators [8]. These discrepant results may be due to different methods for measuring socioeconomic position, method of measuring telomere length and reflecting inadequate power in the smaller studies. Findings are currently limited to western populations. Examining the association between

socioeconomic position and telomere length in a Chinese population where the meaning of socioeconomic position and its correlates with health behaviours and risk factors differ may prove to be informative. In a health survey of almost 2,000 community living elderly Chinese men and women of age 65 years and over in whom telomere length had been measured, we examined the hypothesis that lower socioeconomic position would be associated with shorter telomere length.

Subjects and methods

A sample of 4,000 men and women aged 65 years and over living in the community were invited to attend a health check carried out in the School of Public Health of the Chinese University of Hong Kong by placing recruitment notices in community centres for the elderly and housing estates. Several talks were also given at these centres explaining the purpose, procedures and investigations to be carried out. Subjects were volunteers, and the aim was to recruit a stratified sample so that ~33% were in each of these age groups: 65–69, 70–74 and 75+. The study was approved by the Clinical Research Ethics Committee of the Chinese University of Hong Kong, which requires informed consent to be obtained.

A questionnaire containing information regarding demographics, medical history, smoking habit, alcohol intake and physical activity level was administered by an interviewer. The presence or absence of disease was based on subjects' report of diagnosis by their doctors. Self-rated socioeconomic status was assessed by asking subjects to place a mark on an upright ladder with ten rungs, with the lowest rung being the most undesirable and the highest the most desirable state with respect to their standing in the community (community ladder). Participants placing themselves on the lower rungs of the ladder indicate that they regard themselves as having a lower status in the community. This is a subjective measure of social status developed by the John D and Catherine T. MacArthur Research Network on Socioeconomic Status and Health and has been found to be associated with key health outcomes in various population surveys of different cultural and ethnic groups [9]. They were also asked to rate themselves by placing a mark on another ladder, the top rung representing people who rated themselves as having the most money, the most education and the most respected jobs, and the bottom rung representing people at the other extreme (Hong Kong Ladder). The ladders represent a measure of self-rated socioeconomic status. The use of this self-rated measure had been discussed elsewhere [10].

Physical activity level was assessed using the Physical Activity Scale of the Elderly (PASE). This is a 12-item scale measuring the average number of hours per day spent in leisure, household and occupational physical activities over the previous 7-day period. A summary score of all the items reflect the daily physical activity level [11]. Dietary intake was assessed using a food frequency questionnaire, and mean nutrient quantitation per day was calculated using food tables derived from McCance and Widdowson and the Chinese Medical Sciences Institute [12] for the following: total calories, total fat, per cent of total calories as fat, saturated, monosaturated and polyunsaturated fatty acid, cholesterol and vitamin C.

Body weight was measured with subjects wearing a light gown, by the Physician Balance Beam Scale (Healthometer, IL, USA). Height was measured by the Holtain Harpenden standiometer (Holtain Ltd, Crosswell, UK). Body mass index was calculated by dividing the weight in kg by the height in metres [2].

Laboratory measurements

DNA samples were available from 976 men and 1,030 women. The quantitative PCR method was used to determine telomere length and has been reported elsewhere [13]. In brief, DNA was extracted in the peripheral blood by the phenol–chloroform method and stored at −80°C with concentration >100 ng/μl. Measurement of telomere length of DNA samples follows the method published by Cawthon [14] with modification [15], using a Roche LightCycler 480 (Roche, Mannheim, Germany). The threshold cycle numbers (C_t) of the DNA samples were recorded. This number is inversely proportional to log (amount of DNA templates) [16]. A standard curve of C_t versus concentration was plotted to get the efficiency for each PCR reaction. This efficiency (E) can be obtained by the formula $10^{-(1/\text{slope})}$, acceptable range 1.5–2.2. The relative T/S ratio (second derivative of the T/S ratio or $\Delta\Delta C_t$) was obtained by the formula $\{E_{(\text{tel})}\hat{}[C_{t\,(\text{reference tel})} - C_{t\,(\text{sample tel})}]\}/\{E_{(36B4)}\hat{}[C_{t\,(\text{reference 36B4})} - C_{t\,(\text{sample 36B4})}]\}$. Among the batches of reaction we performed, the PCR efficiency for the telomere primers ranged from 1.54 to 1.73 (mean ± SD: 1.63 ± 0.06), while that of the reference gene primers ranged from 1.99 to 2.17 (mean ± SD: 2.10 ± 0.06).

In addition, calibration curve of telomere length versus $\Delta\Delta C_t$ was plotted using four additional reference samples with known telomere length, that has been previously measured by terminal restriction fragment length polymorphism (TRFLP) and Southern blot. Thus, by comparing the raw sample $\Delta\Delta C_t$ to this calibration curve, the telomere length was also estimated for each sample. The average coefficient of correlation between the two parameters was $r^2 = 0.63$ which is not different from that reported in the original paper by Cawthon, $r^2 = 0.68$ [12]. The coefficients of variation (CV) of the telomere and reference gene assay (36 B4) were 1.93% and 1.27%, respectively. These values were comparable to the values from two other studies using comparable methods: 0.9% and 2.4% [17] and 2.46% and 2.26% [18]. Within a batch and between batches, analytical imprecision were determined using two control samples with known telomere length by TRFLP (long QC, TL = 11.3 kbp and short QC, TL = 8.2 kbp) using results obtained from over 20 batches of assays. The within-batch and between-batch CV per cent of calibrated TL was 8.5% and 7.5% for the long QC

sample. For the short QC sample, they were 6.3% and 6.1%, respectively.

Statistical analysis

Associations between telomere length and potential confounding factors such as body mass index, history of chronic diseases and lifestyle factors (physical activity, smoking, alcohol intake, dietary intake) were first examined using Student's *t*-test and analysis of variance. The scores for the two ladders were grouped into three, according to the distribution of the scores: <5, 5–6 and ≥7. Association between telomere length and ladder scores was examined using ANCOVA adjusted for all factors found to have association with telomere length.

Results

A total of 86.3% of the cohort had already retired, and 91.4% of women have had an occupation (other than being a housewife). The Spearman correlation coefficient between the two ladder scores was 0.43 for men and 0.29 for women, $P < 0.0001$. There were more men and more current smokers in the lower ranks of the community status ladder Table 1(a). There were also more current smokers among those with lower ranking in the Hong Kong ladder Table 1(b). Table 2 shows telomere length values in men and women, according to age, lifestyle variables and presence of diseases where associations with telomere length have been noted. The distribution of telomere length followed a normal distribution. The mean ages (SD) of the men and women were 72.8 (5.0) and 72.0 (5.2) years, respectively. Telomeres were longer in women than men (9.3 ± 2.3 vs. 8.8 ± 1.6 kbps, $P < 0.001$), although this was not significant when analysed by age subgroups. Telomere length was negatively correlated with age in men only ($r = -0.069$; $P = 0.032$). There was no association between telomere length and body mass index, physical activity level, smoking habit or alcohol intake, tea consumption, fruits and vegetable consumption and history of chronic diseases in either men or women. In men, for the community ladder measure of self-rated socioeconomic status, higher rankings were associated with shorter telomere length after adjusting for age Table 3(a). No significant relationship for women was observed. For the Hong Kong ladder, in men, only the trend was significant, while no association was observed in women Table 3(b).

Discussion

This study of an older population did not find any association between telomere length and lifestyle factors, body mass index or the presence of chronic diseases. The findings of longer telomere length in women and inverse correlation with age are compatible with previous studies [19, 20], although associations with age were not seen among the oldest old [21].

Table 1. Associations of sample characteristics with a level of (a) community ladder ranking and (b) Hong Kong ladder ranking

	1–4	5–6	7–10	*P*-values*
	(a) Community ladder ranking			
Men (%)	66.8%	51.3%	44.7%	<0.0001
Age				0.3912
65–69	31.7%	35.3%	34.8%	
70–74	32.7%	36.1%	34.0%	
75 or above	35.6%	28.6%	31.2%	
PASE				0.3376
<Median	45.2%	51.0%	49.9%	
>Median	54.8%	49.0%	50.1%	
Body mass index				0.9043
<25 kg/m^2	65.9%	66.9%	65.9%	
>25.1 kg/m^2	34.1%	33.1%	34.2%	
Total calorie intake				0.0135
<1,500 kcal/day	24.0%	28.2%	32.9%	
>1,501 kcal/day	76.0%	71.8%	67.1%	
Smoking				<0.0001
Never	48.1%	63.7%	69.0%	
Ex-smoker	41.4%	27.9%	25.5%	
Current	10.6%	8.4%	5.5%	
Alcohol use in past 12 months				0.8371
No	86.5%	88.0%	87.3%	
Yes	13.5%	12.0%	12.7%	
Tea drinking (g/week)				0.1383
<Median	44.7%	52.1%	51.9%	
>Median	55.3%	47.9%	48.1%	
Cataract				0.6163
No	61.5%	60.5%	58.6%	
Yes	38.5%	39.5%	41.4%	
Coronary heart disease				0.072
No	76.9%	82.4%	83.6%	
Yes	23.1%	17.6%	16.4%	
Osteoporosis				0.3494
No	74.0%	70.0%	69.0%	
Yes	26.0%	30.0%	31.0%	
	(b) Hong Kong ladder ranking			
Men (%)	50.9%	50.0%	50.4%	0.9395
Age				0.0701
65–69	33.2%	35.6%	36.9%	
70–74	34.1%	37.1%	29.9%	
75 or above	32.7%	27.4%	33.2%	
PASE				0.9889
<Median	49.1%	49.1%	49.6%	
>Median	50.9%	51.0%	50.4%	
Body mass index				0.7019
<25 kg/m^2	67.3%	65.4%	65.6%	
>25.1 kg/m^2	32.7%	34.6%	34.4%	
Total calorie intake				0.4183
<1,500 kcal/day	30.8%	28.3%	31.7%	
>1,501 kcal/day	69.2%	71.7%	68.3%	
Smoking				0.0057
Never	60.0%	67.9%	64.8%	
Ex-smoker	31.0%	26.2%	29.9%	
Current	9.1%	5.9%	5.3%	
Alcohol use in past 12 months				0.4865
No	87.4%	86.5%	89.3%	
Yes	12.6%	13.5%	10.7%	
Tea drinking (g/week)				0.5801
<Median	49.8%	52.3%	51.9%	
>Median	50.3%	47.7%	48.2%	
Cataract				0.56
No	58.3%	60.9%	60.3%	
Yes	41.7%	39.1%	39.8%	
Coronary heart disease				0.2308
No	82.0%	83.4%	78.7%	
Yes	18.0%	16.6%	21.3%	
Osteoporosis				0.5707
No	70.2%	71.5%	68.0%	
Yes	29.9%	28.6%	32.0%	

* *P*-value of chi-square.

Table 2. Telomere length (kpbs) by characteristics of men and women

	Men	*P*-values*	Women	*P*-values*	Overall	*P*-values*
Age		0.0318		0.7722		0.0628
65–69	8.97 (1.65)		9.29 (2.24)		9.15 (2.02)	
70–74	8.80 (1.63)		9.45 (2.21)		9.12 (1.97)	
75 or above	8.70 (1.58)		9.30 (2.35)		8.98 (2.00)	
PASE		0.1444		0.3134		0.1751
<Median	8.73 (1.59)		9.28 (2.37)		9.03 (2.06)	
>Median	8.89 (1.65)		9.42 (2.14)		9.15 (1.93)	
Body mass index		0.3258		0.8795		0.6812
<25 kg/m^2	8.85 (1.65)		9.36 (2.25)		9.10 (1.98)	
>25.1 kg/m^2	8.74 (1.56)		9.33 (2.30)		9.06 (2.02)	
Total calorie intake		0.4377		0.5381		0.2774
<1,500 kcal/day	8.72 (1.60)		9.30 (2.34)		9.16 (2.20)	
>1,501 kcal/day	8.83 (1.63)		9.39 (2.20)		9.05 (1.90)	
Smoking		0.2648		0.5370		0.0071
Never	8.79 (1.63)		9.37 (2.27)		9.20 (2.13)	
Ex-smoker	8.78 (1.60)		9.10 (1.98)		8.82 (1.65)	
Current	9.04 (1.68)		9.34 (2.80)		9.09 (1.89)	
Alcohol use in past 12 months		0.8377		0.5414		0.0340
No	8.81 (1.63)		9.36 (2.27)		9.12 (2.03)	
Yes	8.83 (1.61)		9.11 (2.19)		8.87 (1.69)	
Tea drinking (g/week)		0.3467		0.5368		0.3377
<Median	8.76 (1.51)		9.38 (2.21)		9.13 (1.98)	
>Median	8.86 (1.70)		9.29 (2.35)		9.04 (2.01)	
Cataract		0.7200		0.4608		0.2570
No	8.83 (1.61)		9.30 (2.18)		9.05 (1.91)	
Yes	8.79 (1.65)		9.40 (2.36)		9.15 (2.12)	
Coronary heart disease		0.4327		0.1956		0.6526
No	8.83 (1.61)		9.31 (2.27)		9.08 (1.99)	
Yes	8.73 (1.68)		9.55 (2.21)		9.13 (2.00)	
Osteoporosis		0.5965		0.9114		0.0642
No	8.82 (1.62)		9.36 (2.31)		9.03 (1.93)	
Yes	8.74 (1.64)		9.34 (2.22)		9.22 (2.12)	

* *P*-value of *t*-test or ANOVA.

Table 3. Estimated mean (SE) of telomere length (kpbs) by community and Hong Kong ladder rankings and ANCOVA adjusted for age

Variable	Estimated mean (SE)			*P*-value of difference	*P*-value of trend
	1–4	5–6	7–10		
			(a) Community ladder		
Male					
N	139	362	457		
Telomere length	9.20 (0.14)	8.82 (0.08)	8.68 (0.08)	0.0046	0.0011
Female					
N	69	344	565		
Telomere length	9.71 (0.27)	9.49 (0.12)	9.24 (0.09)	0.1156	0.1023
			(b) Hong Kong ladder		
Male					
N	409	422	123		
Telomere length	8.91 (0.08)	8.80 (0.08)	8.52 (0.15)	0.0559	0.0166
Female					
N	395	422	121		
Telomere length	9.46 (0.11)	9.38 (0.11)	9.06 (0.20)	0.2214	0.0829

However, this study shows that a higher rank in self-rated social standing in the community is associated with shorter telomere length in men only, a finding in contrast to previous studies examining the relationship between telomere length and the traditional objective measures of socioeconomic status in Caucasian middle-aged populations, where one study showed that telomere length is shorter in those with lower socioeconomic status [7], while one study did not show any

associations [8]. In the study of 1,552 female twins in whom shorter telomeres were found in the lower socioeconomic groups [7], the difference in mean telomere length between nonmanual and manual occupational classes was 0.15 kb, compared with the value of 0.52 kb between the groups in the lower self ranking [1–4] compared with the higher rankings [7–10], with longer telomeres in the lower ranking group. It is possible that among the Hong Kong Chinese population, those with higher socioeconomic status have less healthy lifestyles in terms of smoking, physical activity, alcohol and anti-oxidant intake. However, this is unlikely since there was no clear relationship between lifestyle and the ladder ranking in this population.

A possible explanation is that self-rated status may be a reflection of men in the higher ranks in this society being subjected to greater stress arising from changes after retirement. It has been pointed out that unlike work stress, there is relatively little data on stress in older men leaving the workforce [1]. It is possible that there may be adaptation problems from the transition from important work roles to retirement, with changes in social network and perhaps family structure. There are studies supporting an association between shorter telomere length and stress [5, 6, 22, 23]. Psychological stress in elderly men may operate in the opposite direction to the middle-age population. The effect of psychological stress may be mediated via the inflammatory cytokine pathway [24, 25], resulting in inflammatory and oxidative stress giving rise to telomere attrition.

The absence of any association in women may be explained by the absence of such psychological factors in that women had lower educational levels and income and lower level occupations or were housewives, such that leaving the workforce may not represent such a major change. Another possible explanation is the protective effect of oestrogens [26]. The lack of association is in contrast to the study in Caucasian middle-age women and men, where individuals with lower socioeconomic status measured objectively (occupational class) had shorter telomeres [7]. It is possible that psychosocial stress operate differently at different stages in life, from work to retirement.

In this study, self-rated rather than objective measures of socioeconomic status such as education, income and employment was used. It has been pointed out that in rich countries, psychosocial factors are also important in addition to material conditions, [27] such that the relationship between poverty and health is not straightforward [28]. Therefore, in 'developed' countries, an indicator that takes into account this dimension in addition to the traditional measures may be more powerful in examining social determinants of health [9, 29–32]. The self-rated ladders take into account the psychological dimension [28, 33]. Psychosocial factors, incorporated into the measurement of self-rated community status, may be more important than objective socioeconomic status *per se*, in relation to health and ageing [34].

There are limitations in this study. The data are cross-sectional in nature and consists of an older population. Hence, there may be survivor bias. We did not include a questionnaire to assess stress, to be able to test the hypothesis that the relationship between higher self-rated status and shorter telomeres is mediated via increased stress. The strength of the study lies in the sufficiently large sample size for both men and women, allowing observations related to gender differences to be made. Furthermore, an assessment of socioeconomic status incorporating psychosocial factors was used. The study also documented in a comprehensive manner many other confounding factors, which could be adjusted for if necessary in examining the link between socioeconomic status and telomere length. In conclusion, this study shows that older Chinese men who rated their socioeconomic status highly have shorter telomeres and that the relationship is possibly mediated via psychosocial stress rather than lifestyle factors or associated chronic diseases. This finding underscores the importance for further studies into the relationship between social determinants of health in the post-retirement age and the cultural and ethnic differences that may exist for this relationship.

Key points

- In middle-aged UK women, shorter telomere length was found among those in the lower socioeconomic class.
- Among Chinese men aged 65 years and over, shorter telomere length was found in those with higher self-rated economic status.
- There may be cultural- and age-related differences in the social determinants of health.

Conflicts of interest

None declared.

Funding

This study received support from the Jockey Club Charities Trust, the Research Grants Council of Hong Kong CUHK 4101/02M, National Institutes of Health Grant 5R01 AR049439-02 and the SH Ho Centre for Gerontology & Geriatrics, the Chinese University of Hong Kong.

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Received 21 May 2008; accepted in revised form 12 April 2009