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Original article

Associations of childhood socioeconomic position and health with trajectories of grip strength from middle to older ages in populations from China and England

Mphatso Chisala [a,*], Rebecca Hardy [b], Rachel Cooper [c,d], Leah Li [a,*]

[a] Population, Policy and Practice Research and Teaching Department, University College London Great Ormond Street Institute of Child Health, UK
[b] School of Sport, Exercise and Health Sciences, Loughborough University, UK
[c] AGE Research Group, Translational and Clinical Research Institute, Faculty of Medical Sciences, Newcastle University, UK
[d] NIHR Newcastle Biomedical Research Centre, Newcastle University, Newcastle upon Tyne Hospitals NHS Foundation Trust and Cumbria, Northumberland, Tyne and Wear NHS Foundation Trust, Newcastle upon Tyne, UK

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ABSTRACT

Background: We investigated associations of childhood socioeconomic position and health with trajectories of grip strength from middle to older ages in two distinct populations.
Methods: We used data from the China Health and Retirement Longitudinal Study (CHARLS, $n = 16{,}701$) and English Longitudinal Study of Ageing (ELSA, $n = 12{,}695$). Hand grip strength was measured at three timepoints in CHARLS (2011–2015) and four in ELSA (2001−2020). Random-effects growth models were applied to assess associations between each childhood factor and age trajectories of grip strength.
Findings: Lower parental education was associated with weaker grip strength, by 0·36 kg(95 % CI:0·17,0·56) for participants of illiterate (vs literate) parents in CHARLS and 1·88 kg(0·43,3·33) for participants of parents without education (vs ≥ high school) in ELSA, after adjusting for parental occupation and own adult socioeconomic position. Low parental occupation was associated with weaker grip strength, although the difference diminished after adjustment for adult socioeconomic position. Financial hardship was associated with weaker grip strength only in CHARLS, by 0·19 kg(0·01,0·38) after adjustment. Self-rated poor childhood health and school absenteeism were associated with weaker grip strength (both studies). Being confined to bed and hospitalised for more than a month due to health were associated with weaker grip strength only in CHARLS. Each additional childhood illness (only reported in ELSA) was associated with 0·52 kg(0·28,0·81) lower mean grip strength. Reported poor childhood health (CHARLS), low parental education and school absenteeism (ELSA) were associated with grip strength decline.
Interpretation: Lower socioeconomic position and poor health in childhood were associated with weaker grip strength in later life in both Chinese and English populations. Addressing socioeconomic disparities and promoting health of children may enhance life-course physical capacity, promote healthy ageing and reduce age-related adversities.

1. Introduction

Muscle weakness, which is highly prevalent in older age, is an important indicator of physical frailty and sarcopenia, age-related syndromes associated with adverse health outcomes [1]. Maintaining optimal muscle strength can delay the onset of weakness and functional decline and is a key component of healthy ageing [2]. Hand grip strength (HGS) is a simple measure of muscle strength that peaks in early adulthood, maintains through midlife, and declines in old age for both sexes [3–6]. Low HGS in older adults is associated with disability [7], chronic illnesses [8], poor mental health [9,10], cognitive decline [10,11], and premature mortality [12,13]. Rapid decline in HGS in old age is also associated with increased mortality [14,15] and morbidity [16–18].

Until recently, studies of determinants of HGS in older adults largely focused on adult factors, such as poor health [19,20], disadvantaged

* Corresponding authors.
E-mail addresses: mphatso.chisala.22@ucl.ac.uk (M. Chisala), leah.li@ucl.ac.uk (L. Li).

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socioeconomic position (SEP) [21,22], and lower levels of participation in physical activity [23]. However, there is increasing evidence that disadvantaged SEP in early-life has long-lasting effects on health outcomes, including HGS, across the life course. A meta-analysis showed that indicators of disadvantaged childhood SEP were modestly associated with reduced HGS in later life, although most studies included were from British populations [24]. Similar relationships have since been reported in ageing studies from high-income settings with adjustment for adult SEP and health [25–28].

Poor childhood health may also be associated with HGS as it is associated with poor adult health [29,30]. It has been suggested that illness in critical periods including childhood may result in biological alteration that puts people at increased risk of chronic diseases [31]. There is also increasing evidence suggesting the effect of childhood health on later health outcomes is likely through a chain of risk of adverse of exposures across the life course [32]. However, whether and how child health is associated with muscle strength is less clear.

Studies that have examined the associations between early-life factors and HGS suggest that a life course approach is required to identify both protective and risk factors for maintaining strength as people age [24,25,33–35]. However, there are important evidence gaps: (1) limited studies have examined childhood health in relation to HGS across older ages and (2) it is unclear how associations between SEP across life and HGS present in populations at different stages of economic development. The existing evidence on childhood factors associated with adult HGS is largely based on populations in high income countries such as the UK. While there are a growing number of studies of ageing from low- and middle-income countries [35–38], there remains a need to undertake more research in countries experiencing marked changes in socioeconomic circumstances and healthcare. As measures of early-life circumstances may differ substantially between populations, understanding their long-term relationships with HGS is crucial in providing insight into the potential contextual influences and mechanisms of the relationships. It is therefore important to better understand these gaps to inform wider-scale early interventions to reduce and prevent early-onset morbidity and mortality and improve quality of life in ageing populations [13–15].

The UK and China both have ageing populations, but have distinct social, cultural and economic contexts. China has experienced rapid changes in demographics and healthcare, and the growth of the older population. There is also increasing interest in research in ageing-related outcomes and the associated factors. Recent studies in China have reported links between sociodemographic factors (e.g. female sex, lower education, rural residence, less earning/coverage in medical insurance) and functional limitations, poor physical and mental health amongst older adults [39–41].

This study investigated (1) whether disadvantaged SEP and poor health in childhood were associated with reduced mean grip strength and rapid decline decades later in middle-to-older adulthood in England and China and (2) whether the associations were independent of own adult SEP.

2. Methods

We used data from the China Health and Retirement Longitudinal Study (CHARLS) and English Longitudinal Study of Ageing (ELSA), which are designed to be nationally representative of adults and similar in many aspects of their design. Both studies collected detailed longitudinal data on demographic, socioeconomic and health characteristics, conducted physical assessments, and collected biological samples.

2.1. Data

CHARLS started in 2011 and recruited adults aged ≥45y from 150 counties/districts from 28 provinces across China (N = 17,708). Participants were followed up in 2013, 2015, 2018 and 2020 (total 5 waves). Refreshment samples were added to subsequent waves to maintain the representation of the study sample. In 2014, a special life history survey was conducted to collect details about participants' childhood experiences before 17y (15,579 from wave 1 and 3033 as refreshment samples). Physical assessments were conducted in waves 1–3 (2011–15). A total of 16701 participants had a life history assessment (eligible sample for this study) and at least one HGS assessment done over the 3 waves. Details of data collection and procedures were reported elsewhere [42]. The CHARLS was approved by the Ethical Review Committee at the Peking University.

ELSA started in 2002/3 and recruited adults aged ≥50y living in private households in England, who had participated in the 1998, 1999 or 2001 Health Survey for England (N = 12,099). Participants were followed up biennially to 2020 (10 waves). Refreshment samples were added to waves 3, 4, 6, 7, 9 and 10. In 2006/7, a life history survey was conducted to collect information on important childhood and life events. Physical assessments were conducted in waves 2, 4, 6 (for all), 8 and 9 (exclusive subsamples). A total of 12,695 participants had data on childhood experiences from life history survey or main questionnaires and at least one HGS assessment done over the 10 waves. Details of data collection were reported elsewhere [43]. Ethical approval and written informed consent were obtained for all waves of ELSA. In both studies, we define enrolment as the first time of entry of each participant in the study.

2.2. Measures

2.2.1. Hand grip strength

In both studies HGS (kg) was measured in a standing position for participants who were judged to be safe to be assessed and understood the instruction. In CHARLS, HGS was measured in waves 1–3 using a standard hand dynamometer (WL-1000, Nantong, China). Four measurements (two in each hand) were taken at each wave. In ELSA, HGS was measured in waves 2, 4, 6, and 8/9 using a Smedley dynamometer (Stoelting Co., Wood Dale, IL, USA). Six measurements (three in each hand) were taken at each wave. The maximum of the measurements recorded was used for both studies.

2.2.2. Childhood socioeconomic position

Childhood SEP was measured by parental education and occupation (reported in life history survey in CHARLS and main surveys in ELSA), and financial hardship (life history survey for both). Parental education was based on father's education (or mother's if missing), categorised as ‘illiterate/no formal education’ or ‘primary school or higher’ in CHARLS, and ‘no education’, ‘less than high school’, and ‘high school or higher’ in ELSA.

Parental occupation in CHARLS was based on father's occupation (mother's if missing), classified as ‘agricultural’ or ‘non-agricultural’ job, and in ELSA on father's (main carer's if absent) occupation, categorised according to the Registrar General's Social Classification (RGSC) as classes ‘I/II’(professional/managerial), ‘III/IV’ (skilled/semi-skilled), and ‘V’ (unskilled including unemployed). Experience of financial hardship in CHARLS was defined as ‘family financial situation being worse than average family in the same community/village before 17y’ (vs same/better off), and in ELSA, as ‘ever experienced severe financial hardship’ before 17y (vs never).

2.2.3. Childhood health

Indicators of childhood health were reported during the life history surveys, including self-rated health (SRH), being “hospitalised”, “confined to bed”, and “missing school” for ≥one month because of health reasons before 15y. A participant was classified as ‘poor childhood health’ if SRH was less healthy than others (vs average or somewhat/much healthier) in CHARLS, and fair/poor (vs excellent/very good/good) in ELSA. In ELSA (not CHARLS), participants reported childhood illnesses (asthma, severe headache, chronic ear problems,

epilepsy, emotional/psychiatric problems, diabetes, heart problems, leukaemia, cancer). A total score of self-reported illnesses was also derived for ELSA.

2.2.4. Adult Socioeconomic position and height

Adult SEP was considered as a potential mediator for the association between early life factors and grip strength. The highest educational level of participants in CHARLS was categorised as 'no education', 'up to middle school', 'high school to vocational school', and 'degree-level' and as 'no education', 'up to high school', 'college/vocational', and 'degree-level' in ELSA. Occupation in CHARLS was classified as 'agricultural' and 'non-agricultural' job and as classes 'I/II', 'III/V' and 'V/unemployed' in ELSA. Adult height (cm) which is associated with HGS and early-life circumstances [44,45] was measured at Waves 1–3 in CHARLS and Waves 2/4/6 in ELSA. Details of measures for childhood SEP and health and adult factors are provided in Supplementary Table S1.

2.3. Statistical analyses

We applied random effects models to repeated measures for HGS to examine the associations of each childhood SEP and health indicator with trajectories of HGS in each study. We adopted a quadratic function of age, with a random intercept and random slope to account for the within individual correlations.

Baseline models (Model 1) included age at enrolment, sex, adult height, and each childhood SEP or health indicator. Each model was then adjusted for parental education and occupation (mutually adjusted for each other) (Model 2). To assess whether associations were independent of participants' own SEP, models were further adjusted for adult occupation and educational attainment (Model 3).

To establish whether childhood factors were associated with decline in HGS, we tested their interactions with age in all models. Only age-interactions with self-rated poor childhood health in CHARLS, parental education, and missing school in ELSA were significant ($p < 0.05$). Thus we present the estimated difference in mean HGS by each childhood factor in Tables 2 and 3, and illustrated the difference in rate of decline in Figs. 2 and 3. We tested the interactions of each childhood factor with sex. Only sex-interactions with missing school and being hospitalised due to health in CHARLS and experiencing financial difficulty in ELSA were significant. Therefore we present results estimated from models for sexes combined, with adjustment for sex in the main text. Sex stratified results are shown in Supplementary Tables S2 and S3.

We conducted sensitivity analyses: we repeated analyses (i) for participants who remained in the study and those lost to follow-up separately and (ii) for participants who had a HGS at all waves (n = 6321 in CHARLS and n = 2666 in ELSA) and those had missing record at any wave (irrespective of when they joined the study).

3. Results

There were slightly more females (CHARLS: 51·4 %; ELSA: 54·6 %) than males in both studies. The mean age at enrolment was younger in CHARLS (57·9±9·6 years) than ELSA (61·4y±9·4 years) (Table 1). Compared with females, males had a higher mean trajectory for grip strength at all ages, but a faster rate of decline (Fig. 1). The distributions of childhood factors differed between studies. In CHARLS, the majority of parents had an agricultural job (80·5 %) and were illiterate or had no formal education (60·8 %). In ELSA, 23·8 % of parents had unskilled manual jobs and only 1 % of parents had no education. For childhood health, fewer reported missing school (3·8 %), being confined in bed (5·6 %), and being hospitalised (2·1 %) for ≥one month in CHARLS than ELSA (22 %, 16·6 % and 10·5 %, respectively). Self-rated poor childhood health did not substantially differ between studies (13·1 % and 11·8 %) (Table 1).

Table 1
Summary statistics for measures of grip strength, childhood socioeconomic position (SEP) and health, and adult SEP in CHARLS (N = 16,701) and ELSA (N = 12,695).

	CHARLS	N	ELSA	N
Female (%)	51·4 %	16,698	54·6 %	12,695
Age at enrolment (year) – mean (SD)	57·9 (9·6)	16,630	61·4 (9·4)	12,695
Grip strength at enrolment (kg) – mean (SD)				
Males	39·5 (9·3)	8103	41·6 (9·8)	5255
Females	26·5 (7·4)	8594	24·9 (6·6)	6321
Height (cm) - mean (SD)				
Males	164·7 (6·6)	8078	173·4 (7·0)	5245
Females	153·5 (6·4)	8569	160·0 (6·8)	6277
Measures of childhood SEP				
Parental education[a] (%)		15,837		9217
Illiterate/no formal education	60·8 %			
Primary school or higher	39·2 %			
No education			1 %	
Less than high school			78·9 %	
High school or higher			20·1 %	
Parental occupation[a] (%)		16,444		12,619
Agricultural job	80·5 %			
Non-agricultural job	19·5 %			
Classes I/II			32·8 %	
Classes III/IV			43·4 %	
Classes V			23·8 %	
Financial hardship[b] (%)	39·9 %	16,479	2·8 %	5328
Measures of childhood health before 15y[b]				
Self-rated poor child health (%)	13·1 %	16,472	11·8 %	6620
Missed school ≥ a month (%)	3·8 %	16,501	22 %	6631
Confined in bed ≥ a month (%)	5·6 %	16,422	16·6 %	6634
Hospitalised ≥ a month (%)	2·1 %	16,429	10·5 %	6632
Chronic illness (%)				6636
0			5·5 %	
1			83·5 %	
2–7 illnesses			11 %	
Measures of adult SEP				
Occupation (%)		16,668		12,682
Non-agricultural	54·1 %			
Agricultural	42·6 %			
Unemployed	3·3 %			
Class I/II			18·5 %	
Class III/IV			19·6 %	
Class V/unemployed			61·9 %	
Education (%)		16,700		12,695
Degree/high level education	3·4 %		49·3 %	
Medium-level education	26 %		22·2 %	
Low-level education	43·7 %		20·8 %	
No education	26·9 %		7·7 %	

[a] Reported in life history survey in CHARLS and in main surveys in ELSA.
[b] Reported in life history survey in both studies.

3.1. Childhood SEP and HGS from middle-to-older adulthood

All measures of disadvantaged childhood SEP were associated with lower grip strength, but only parental education in ELSA was associated with rate of decline in HGS (i.e. difference in mean HGS diminished with age, Fig. 1B). In CHARLS, grip strength was lower on average at all ages, by 0·68 kg (95 % CI:0·44,0·82) for participants whose parents were illiterate/no education (vs ≥ primary school) and by 0·42 kg(0·23,0·60) for participants who experienced financial hardship in childhood (Table 2). Differences attenuated but remained at 0·36 kg (0·17,0·56) and 0·19 kg (0·01,0·38) respectively after adjusting for other childhood and adult SEP measures. For parental occupation, grip strength was

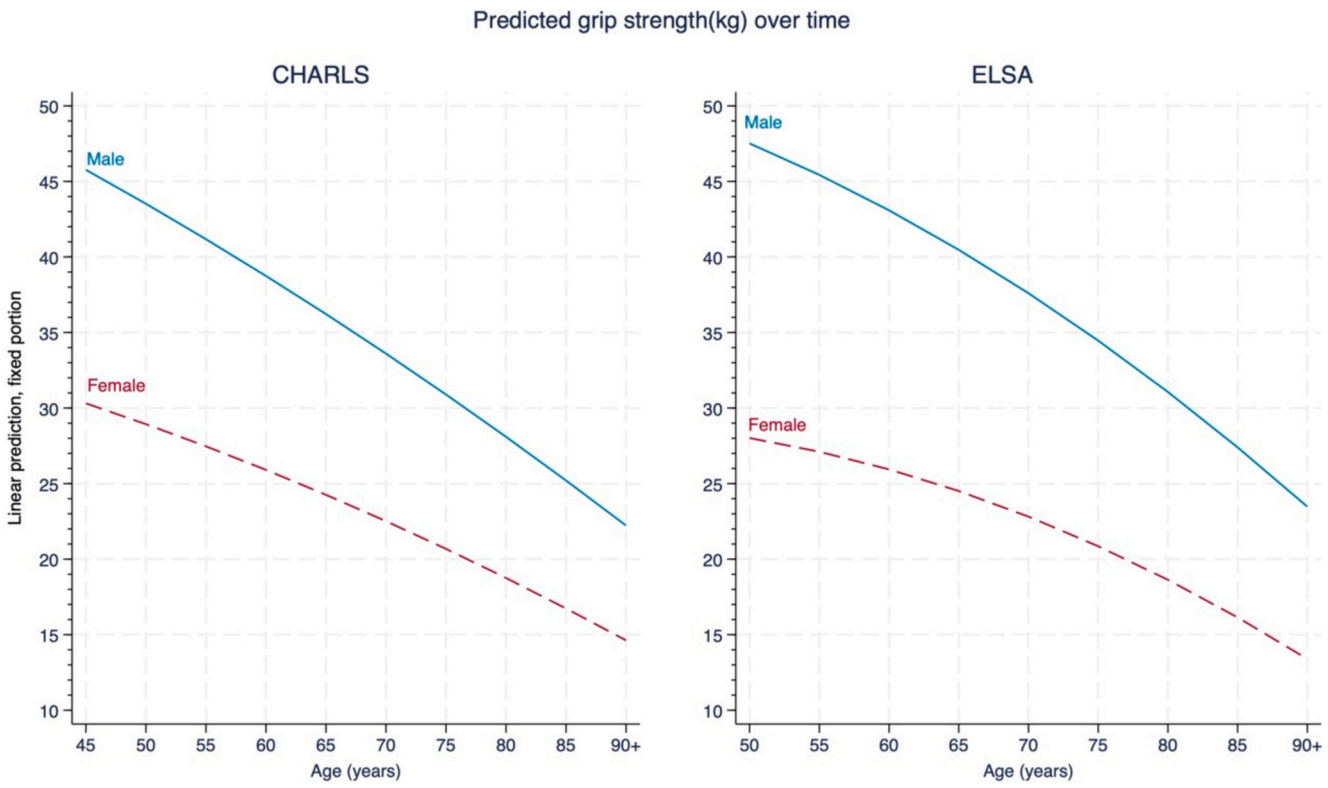

Fig. 1. Mean age-trajectories for grip strength(kg) estimated using growth models with random effects for (a) CHARLS b) ELSA.

lower by 0·77 kg (0·54,1·01) for participants whose parents had an agricultural (vs non-agricultural) job. The difference remained when adjusting for other childhood SEP measures, but was non-significant when further controlling for adult SEP (Table 2).

In ELSA, grip strength was lower on average by 2·80 kg (1·38,4·21) for participants whose parents had 'no education' (vs '≥high school'). The difference was greatest at 50y (~5 kg), decreased with age (i.e. 'no education' group had a slower rate of decline, Fig. 1B), and this age-dependent pattern remained after adjusting for other childhood and adult SEP measures. There was little difference in mean grip strength for those of parents with <high school education (vs '≥high school'). For parental occupation, grip strength was lower on average by 0·50 kg (0·20,0·80) for 'class V' and by 0·31 kg (0·05,0·56) for 'classes III/IV' (vs 'I/II'), and differences diminished when further adjusted for adult SEP. There was no overall association between financial hardship and HGS (Table 2), but amongst females, it was associated with lower HGS by 1·31 kg(0.17, 2·44) and amongst males, with higher HGS by 2.01 kg (0.25,3.76), after adjusting for childhood and adult SEP (Supplementary Table S2). The inconsistency in the association might be due to the fact that only few (<3 %) in ELSA reported financial hardship in childhood.

3.2. Childhood health and HGS from middle-to-older adulthood

Poor childhood SRH and 'missing school' were associated with lower grip strength trajectories in both studies, irrespective of childhood and adult SEP. In CHARLS, grip strength was on average lower by 1·04 kg (0·77,1·30) for those reporting poor health and by 0·78 kg(0·31,1·25) for those reporting 'missing school'. Similarly, in ELSA, grip strength was on average lower by 0·89 kg (0·41,1·36) for worse SRH and by 0·44 kg(0·07,0·82) for 'missing school' after the adjustment (Table 3). This association however decreased with age for poor SRH (in CHARLS) and missing school (in ELSA) (Fig. 3). 'Being confined to bed' and 'being hospitalised' were also associated with an average lower grip strength in CHARLS, but not in ELSA, by 0·76 kg(0·40,1·75) and 1·07 kg (0·40,1·75), respectively, and remained after the adjustment. In ELSA, each additional illness was associated with a lower mean grip strength of 0·52 kg (0·28,0·81) after adjusting for childhood and adult SEP (Table 3).

3.3. Sensitivity analysis

For both studies, there was consistency in the direction and strength of the associations of early-life factors with HGS (i) amongst participants who had grip measures at all waves and those with fewer measures and (ii) amongst those who remained in the studies and those who were lost to follow-up (Supplementary Table S4).

4. Discussion

We found that most indicators of disadvantaged childhood SEP were associated with lower grip strength from middle-to-older adulthood in CHARLS and ELSA, but not with the rate of decline (i.e. difference in mean HGS persisted across age). The associations for parental education (both cohorts) and financial hardship (CHARLS) were independent of childhood and adult SEP. Poor childhood SRH, missing school, and being confined to bed for ≥one month (CHARLS), and childhood illness (ELSA) were associated with lower grip strength, independent of childhood and adult SEP. Poor SRH (CHARLS), lower parental education and missing school (ELSA) were also associated with slower rate of decline in grip strength.

4.1. Childhood SEP and grip strength

The associations of parental occupation and education with HGS in later life in both settings are consistent with other studies [24,25,46]. In CHARLS, differences by SEP indicators ranged from 0·42 kg to 0·77 kg. In ELSA, having parents with no education was associated with an average ~2·8 kg lower HGS, while parental occupation and financial hardship were associated with <0·5 kg lower HGS. While different classifications were applied to SEP indicators in the two settings, overall

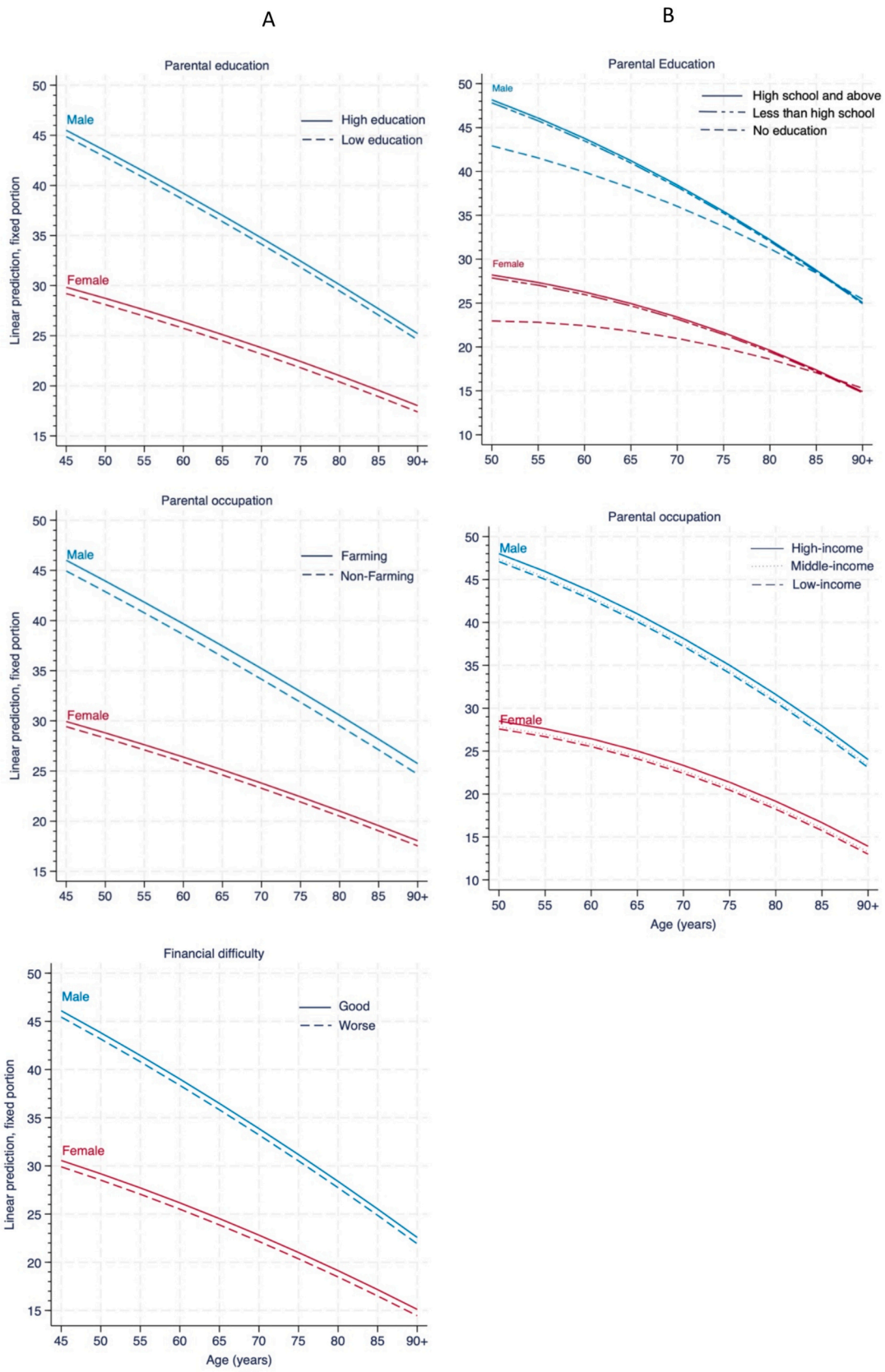

Fig. 2. Mean age-trajectories for grip strength (kg) by childhood SEP groups estimated using growth models with random effects for (A) CHARLS and (B) ELSA.

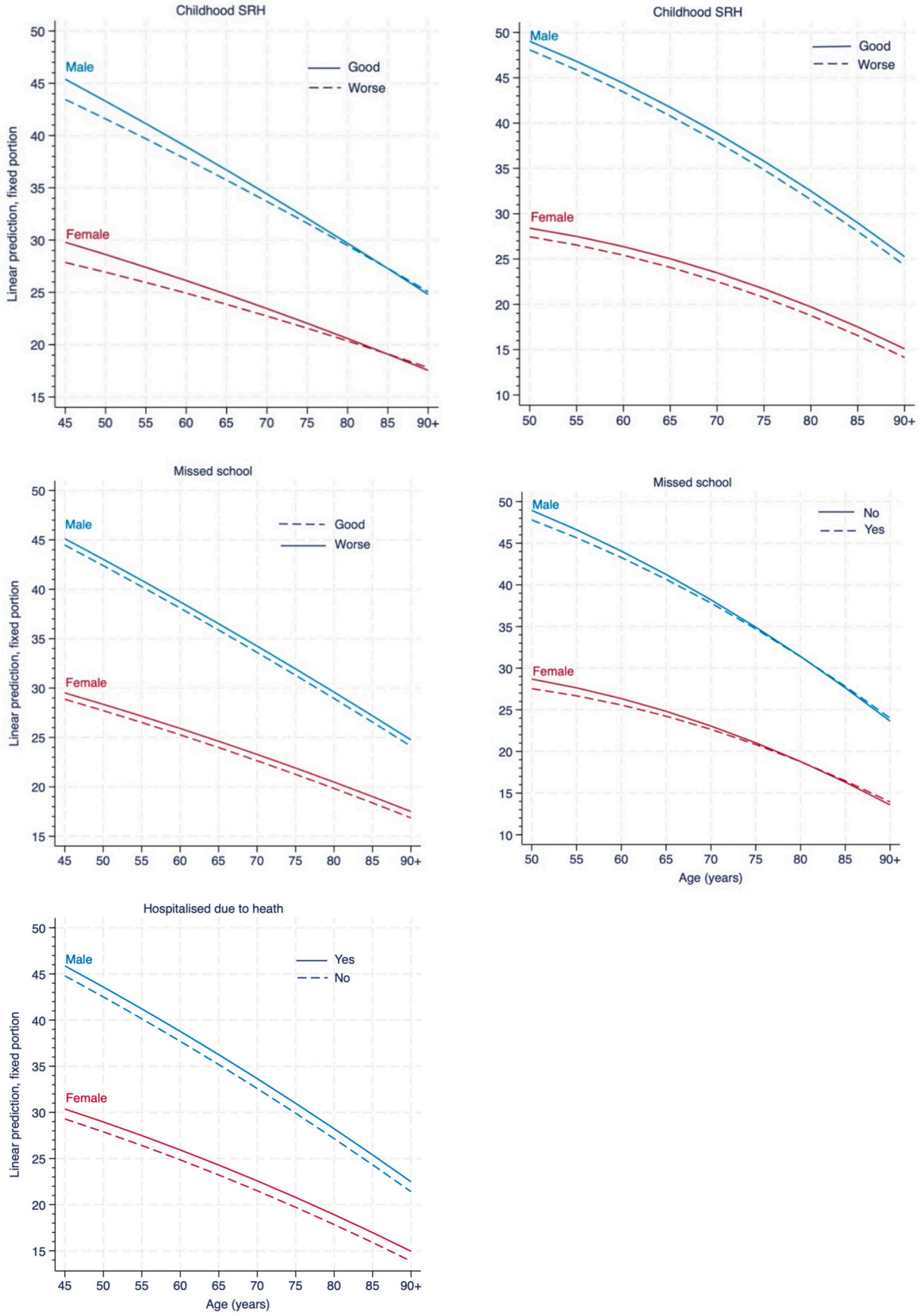

Fig. 3. Mean age-trajectories for grip stength(kg) by childhood health indicators estimated using growth models with random effects for (A) CHARLS and (B) ELSA.

Table 2
Differences in mean grip strength (kg) by indicators of childhood socioeconomic position (SEP) in CHARLS and ELSA, estimated using random effects growth models (N = 16,643 for CHARLS and *N* = 11,454 for ELSA for baseline models)[a].

	Model 1	Model 2	Model 3
CHARLS			
Parental education (baseline: ≥primary school)			
Illiterate/no education	**−0·68(−0·82,-0·44)**	**-0·56(−0·76,-0·37)**	**-0·36(−0·56,-0·17)**
Parental occupation (baseline: non-agricultural)			
Agricultural occupation[b]	**-0·77(−1·01,-0·54)**	**-0·58 (−0·83,0·34)**	-0·12 (−0·37,0·13)
Financial hardship	**-0·42(−0·60,-0·23)**	**-0·32(−0·51,-0·13)**	**-0·19(−0·38,-0·01)**
ELSA			
Parental education[c] (baseline: ≥high school)			
≤High school	**-0·39(−0·71,-0·06)**	-0·24 (−0·59,0·11)	0·11 (−0·24,0·47)
No education	**−2·80(−4·21,-1·38)**	**−2·65 (−4·11,−1·19)**	**-1·88 (−3·33,−0·43)**
Parental occupation (baseline classes I/II)			
Classes III/IV	**−0·31 (−0·56,−0·05)**	−0·16 (−0·46,0·14)	0·10 (−0·20,0·40)
Class V	**−0·50(−0·80,−0·20)**	**-0·45(−0·80,-0·10)**	-0·07 (−0·43,0·28)
Financial hardship	0·06 (−0·85,0·98)	0·22 (−0·76,1·25)	0·22 (−0·78,1·23)

[a] Genders combined. Estimates that reached significance at $p \leq 0{\cdot}05$ were bold-faced. **Model 1** included age, height and gender. **Model 2** included model 1 factors, plus parental education and occupation. **Model 3** included model 2 factors, plus adult SEP indicators (i.e. occupation and education).
[b] Including unemployed.
[c] Significant age interaction with parental education (no education) in ELSA.

Table 3
Differences in mean grip strength (kg) by indicators of child health in CHARLS and ELSA, estimated using random effects growth models[a].

Measures of child health	Model 1	Model 2	Model 3
CHARLS			
Self-rated poor child health[b]	**−1·19(−1·45,-0·92)**	**−1·12(−1·39,-0·85)**	**−1·04 (−1·30,−0·77)**
Missed school ≥ a month	**−0·59 (1·05,−0·11)**	**−0·66 (−1·13,−0·18)**	**−0·78(−1·25,-0·31)**
Confined to bed ≥ a month	**-0·76(−1·75,-0·40)**	**-0·69(−1·00,-0·21**	**-0·61(−1·13,-0·36)**
Hospitalised ≥ a month	**−1·07 (−1·75,−0·40)**	**−0·60 (−1·23,−0·04)**	**−0·64 (−1·29,0·01)**
ELSA			
Self-rated poor child health	**−0·98 (−1·41,−0·55)**	**−0·99 (−1·46,−0·51)**	**0·89 (−1·36,−0·41)**
Missed school ≥ a month[b]	**−0·50 (−0·84,−0·16)**	**−0·46 (−0·83,−0·08)**	**−0·44 (−0·82,−0·07)**
Confined to bed ≥ a month	−0·18 (−0·55,0·19)	−0·13 (−0·54,0·28)	−0·18 (−0·59,0·23)
Hospitalised ≥ a month	−0·39 (−0·88,0·13)	−0·37 (−0·81,0·20)	−0·31 (−0·81,0·20)
Childhood illness	**−0·51 (−0·75,-0·27)**	**−0·51 (−0·79,-0·25)**	**−0·52(−0·81,-0·28)**

[a] Genders combined. Estimates that reached significance at $p < 0{\cdot}05$ were bold-faced. **Model 1** included age, height and gender. **Model 2** included model 1 factors, plus parental education and occupation. **Model 3** included model 2 factors, plus adult SEP indicators (i.e. occupation and education).
[b] significant age interactions with poor child health in CHARLS and with missing school in ELSA.

disadvantaged childhood SEP was associated with a lower grip strength throughout middle-to-older ages. Although the associations were generally similar, the interpretation and generalisation of the results require caution because of the diverse demographic and geographical settings of England and China. For example, childhood SEP was more homogenous in CHARLS than ELSA population, e.g., amongst parents who were illiterate in CHARLS, the majority (88 %) also had an agricultural job, which could underestimate the association between early life factors and health. Contrary, although infrequent, participants with uneducated parents had a much weaker grip strength compared to their counterparts in ELSA which also highlights the possibility of contextual differences in these associations. Other multi-site cohort studies have also found the impact of childhood SEP to have a stronger association with physical functioning in high (vs low) income settings and suggested that the discrepancy is likely because of the variations in determinants of health outcomes [24,47]. The differences in the classification of the measures between the two settings however make it difficult to make statistical comparisons. For most early life factors we found no sex differences in the association between childhood SEP and HGS, consistent with some studies [12,33,48,49]. However, there are other studies that have identified sex disparities in the association between childhood SEP and grip strength, although these were not uniform and mostly from high income settings. [25,27,28,50]

4.2. Childhood health and grip strength

For both settings, poor childhood SRH and school absenteeism were associated with lower grip strength, independent of childhood and adult SEP. Several studies have found associations between childhood SRH with other measures of physical function, such as time required to get up from a chair [30], walking speed [32], and frailty [34,51]. Most childhood health factors in CHARLS and increasing number of illnesses in ELSA were also associated with weaker HGS, independent of childhood and adult SEP. Prolonged exposure to ill health may lead to altered musculoskeletal systems, resulting in weak HGS in adulthood. In our study, the associations between childhood health and HGS were attenuated further after adjusting for adult health (i.e. self-reported poor health and chronic condition) (Supplementary Tables S2 and S3), suggesting that some of the associations observed were explained by poor adult health. In addition, the association may also be attributable to the indirect impact of poor early growth and nutrition (including during fetal development) as mediators on later health outcomes [33].

4.3. Early-life factors and decline in grip strength

We found few associations between early-life factors and rate of decline in HGS in CHARLS and ELSA. The lack of association has also been reported in other studies, although findings were inconsistent [27,28,33]. It is thought that early-life factors are associated with attainment of peak muscle mass and strength but not decline of HGS [13]. Individuals with a lower peak would also have a low HGS as they age. It is also also plausible that a faster decline in physical function (including HGS) is more affected by adult factors compared to early-life factors [46].

Parental education and missing school in ELSA and self-rated childhood health in CHARLS were however associated with the rate of decline in grip strength in this analysis. These early-life factors had a marked effect in midlife, but the difference lessened in older participants. It has been suggested that early-life factors have a greater impact on HGS in midlife (vs later life) [27,46,52]. Another plausible explanation for this weakening association is related to survival bias. Individuals who have lower SEP and have survived to older ages may possess certain resilience or protective factors that contribute to better

physical health as they age [51]. We noted that the difference in HGS for a small number of individuals (1 %) whose parents had no education compared to high school education diminished with age in ELSA. Other studies that have reported a diminished educational inequality on health outcomes as people age have suggested that 1) unlike other SEP indicators, education which is attained earlier in life may be more important in preventing onset and not progression of diseases [53] and that 2) improving social security and welfare services for ageing populations (particularly in high income countries) may slow down the decline in health outcomes in those with low education [54]. This phenomenon is however still yet to be explored.

4.4. Strengths and limitations

Our study has several strengths. Firstly, to our knowledge, this is the first study to examine the long-term associations of a range of childhood health indicators on HGS in two distinctly different ageing populations. Secondly, CHARLS and ELSA are nationally representative surveys with repeated measures of HGS over time, allowing us to study the associations of early-life factors with age-related trajectories of HGS from middle-to-older ages. Thirdly, we used objective measures of muscle strength, which are associated with increased risk of morbidity and premature mortality.

However, limitations exist. Firstly, data on childhood were retrospectively reported and thus, subject to recall bias. However, early-life factors collected retrospectively have been validated through comparison to prospectively collected data in high income settings [29,55]. Secondly, as in most longitudinal ageing studies, there is a high risk of attrition and missing data which results in biases including survival bias. Although those lost to follow up were more likely to be in poor health and socioeconomically disadvantaged, the direction and magnitude of associations between early-life factors and HGS differed little from those who remained in the study. Thirdly, the association between early-life factors and HGS may be underestimated, as individuals who were unable to perform a HGS test were excluded. Although these participants were also likely to have had poor health in childhood, the numbers were small (<1 %) in both studies, and thus are unlikely to have large impact on the estimates.

5. Conclusion

Socioeconomic factors and health in early-life were associated with grip strength in later life in two demographically different ageing populations. These results highlight the importance of addressing socioeconomic disparities and promoting health of children, to enhance physical capacity and well-being in later life in both high and low/middle-income countries. Additionally, with China as an example, developing countries which are already facing an increase in ageing population may need to further develop sustainable and long-term policies aimed at reducing socioeconomic and health inequalities in these settings, across the life-course therefore optimising healthy ageing.

Contributors

Mphatso Chisala conceived the study, designed the analysis, analysed the data, and wrote the first draft of the manuscript.

Rebecca Hardy provided critical feedback regarding the analyses, the interpretation of data and the manuscript.

Rachel Cooper provided critical feedback regarding the analyses, the interpretation of data and the manuscript.

Leah Li conceived the study, designed the analysis, provided critical feedback regarding the analyses and the interpretation of data, and revised the manuscript.

Mphatso Chisala and Leah Li are the guarantors of this work.

All authors saw and approved the final version and no other person made a substantial contribution to the paper.

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Ethical approval

This study was approved by the University College London Research Ethics Committee (25327.001).

Provenance and peer review

This article was not commissioned and was externally peer reviewed.

Data sharing and collaboration

There are no linked research data sets for this paper. Data will be made available on request.

Declaration of competing interest

The authors declare that they have no competing interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.maturitas.2024.108154.

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