Age and Ageing 2015; **44:** 269–274
doi: 10.1093/ageing/afu170
Published electronically 1 November 2014

Factors associated with grip strength decline in older adults

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Abstract

Background: few studies have examined associations of multi-faceted demographic, health and lifestyle factors with long-term change in grip strength performance across the adult lifespan. The aim of this study was to examine the associations of risk factors in specific parts of the adult lifespan (e.g. in early midlife, in late midlife and in old adulthood) separately for women and men.
Methods: data came from the longitudinal Swedish Adoption/Twin Study of Aging (SATSA). Grip strength performance was followed in 849 participants who were 50–88 years of age at baseline. The follow-up period with seven waves of data of grip strength was 22 years, and the risk factors were measured up to 20 years before the assessment of grip strength. Latent growth modelling was used for the longitudinal analyses.
Results: a gender difference in the type of factors associated with grip strength performance and development across the adult lifespan was found. Significant factors for the age slopes for women were stress, smoking and dementia. For men, marital status, mean arterial pressure, physical activity at work and having a chronic disorder were of importance. These factors varied in their associations with grip strength across the adult lifespan.
Conclusion: factors measured earlier in adulthood were associated with grip strength decline in late midlife and old adulthood. Gender-specific patterns of risk factors suggest that it may be worthwhile to conduct research on grip and muscle strength (and biological vitality) separately for men and women.

Keywords: *grip strength, risk factors, lifespan, longitudinal, aged, gender differences, older people*

Introduction

Loss of muscle strength in older persons may lead to several negative outcomes such as limited daily living activities [1, 2], falls resulting in injuries [3, 4] and mortality [5]. Hence, poor muscle strength in old age is an important public health issue. Grip strength is a common measure of muscle strength that is sensitive to age-related changes and to changes in biological functioning [6].

There is a clear gender difference in grip strength levels across the adult lifespan, with men having higher grip strength [7–9]. On average, grip strength performance tends to peak around 30–40 years of age [10–12] and then decreases with increasing age in both women and men [7, 9, 13]. Since men's grip strength level on average decreases faster with age than women's, the gender difference tends to narrow slightly with age [7–9, 12, 13].

Different biological mechanisms behind declining grip strength have been proposed and some risk factors have been suggested including age, gender, body size, low physical activity, smoking and morbidity [8, 9, 12, 14]. However, only a few studies, and primarily with a limited number of data points [9], have examined how several potential risk factors are associated with the long-term change in grip strength performance across the adult lifespan [9, 12].

Our aim in this study was to map factors associated with grip strength development in the second half of the adult lifespan. Data came from the Swedish Adoption/Twin Study of Aging (SATSA) [15]. Measurements of grip strength ranged over 22 years and were merged with data from the Swedish Twin Registry [16] that were collected up to 20 years before the start of SATSA. This study included the following features: (i) a population-based, long-term follow-up of grip strength changes with several measurement waves, (ii) several potential risk factors of different types, (iii) the potential risk factors covered much of the adult lifespan, (iv) separate analyses of factors associated with grip strength mean performance and rate of change and (v) separate analyses for women and men. To the best of our knowledge, no study has yet included all these important features. In addition, we used specified time periods (e.g. early adulthood, early midlife, late midlife and late adulthood) to determine whether the risk factors were associated with grip strength during the adult lifespan.

Method

Participants

The main aim of the SATSA project [15] is to study the aetiology of individual differences in ageing. The first wave of data collection (Q1) was administered in 1984. The sample consisted of same-sex twin pairs reared together and same-sex twin pairs reared apart from early age. The twin pairs who participated in Q1 and were above 50 years of age were invited to in-person testing (IPT) in 1986–88, which included a biomedical and cognitive examination [15]. IPT was repeated every 3 years (with the exception of IPT4, which was replaced with a phone interview). SATSA is an ongoing study, and at the time of the present analyses, we had access to seven different IPT waves (IPT1–IPT3, IPT5–IPT8) conducted between 1986 and 2010.

To study early factors associated with grip strength, data from the Swedish Twin Registry [16] collected in 1967, 1970 and 1973 were obtained for the SATSA participants. These questionnaires included questions about demographics, health and lifestyle factors.

All participants with at least one grip strength value during the period IPT1–IPT8 were included in this study, which resulted in a final sample of 849 persons—504 women and 345 men.

Measures

Grip strength

Grip strength was measured by a Collin hand grip dynamometer (0–70 kg) at each IPT. The participant made six attempts (three with each hand) [17], and the maximum score (in kg) was used as the participant's grip strength score. (For trajectories of grip strength scores, see Supplementary data, Figure S1a and b available in *Age and Ageing* online.) The average number of participated waves was 4.0 (SD 1.9); 76% participated in at least three waves.

Potential risk factors

Potential risk factors associated with grip strength trajectories were collected from two time points (Time I [1967–73] and Time II [1984–86]). Time I was based on data from the Swedish Twin Registry questionnaires. In Time II, data were collected from two occasions, Q1 in 1984 and IPT1 in 1986–88. Some participants ($n = 213$) did not participate at IPT1, and their corresponding measures (i.e. blood pressure, cholesterol and triglyceride levels) were instead taken from their first IPT entry [18].

We included multiple potential risk factors that have been studied separately in previous studies and found to be significantly associated with grip strength [9, 12, 14, 19, 20]. Further, we added health-related factors that have not been studied before in this context (e.g. lipids and stress). The risk factors were as follows: age, education level, socio-economic status (SES), marital status, body weight, height, self-reported health, depression, stress, mean arterial pressure (MAP), lipids, morbidity, smoking and physical activity. For a description of the independent variables structured according to the entry steps in the latent growth models, see Supplementary data, Appendix 1 available in *Age and Ageing* online.

Age group

This variable was included to examine during which period in the lifespan that potential risk factors were important. The participants were categorised into three age groups: age group 1 (born 1935–49), age group 2 (born 1919–34) and age group 3 (born 1900–18). Time I represented potential risk factors in young adulthood for age group 1, in early midlife for age group 2 and in late midlife for age group 3 (Supplementary data, Table S1 available in *Age and Ageing* online). Time II represented potential risk factors ~15 years later for each age group (i.e. early midlife for age group 1, late midlife for age group 2 and old adulthood for age group 3). A description with background data for the age groups is provided in Supplementary data, Table S2 available in *Age and Ageing* online.

Statistical analyses

For the statistical analyses section, see Supplementary data, Appendix 2 available in *Age and Ageing* online.

Results

Women

The estimated average grip strength level for women at age 67 was 21.63 kg ($P < 0.0001$) and decreased about −0.19 kg/year ($P < 0.0001$) between 50 and 67 years of age and −0.45 kg/year ($P < 0.0001$) between 67 and 96 years of age (Figure 1). Among women, higher education level, higher MAP in early midlife and old age, and more physical activity in late midlife were associated with higher grip strength levels at age 67 (Table 1). Higher depressive symptoms and perceived stress in early midlife, having a musculoskeletal disorder in late midlife or old age, and being diagnosed with

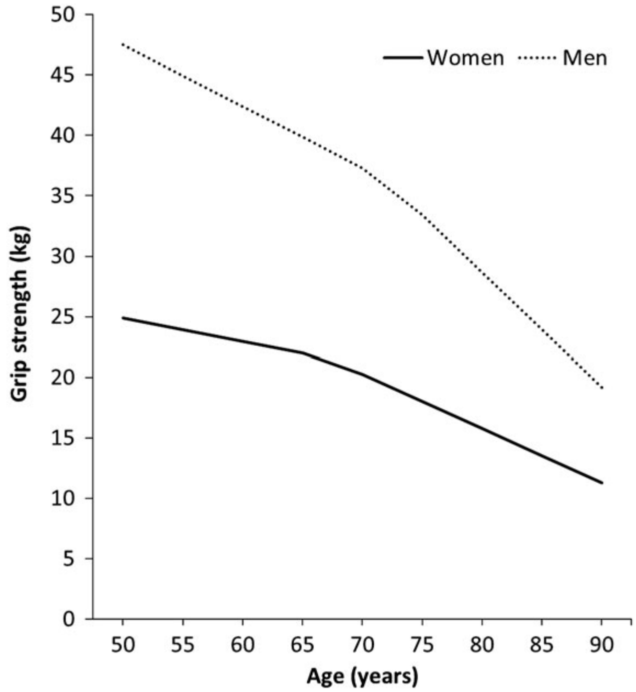

Figure 1. Grip strength trends for women and men. The fitted intercept ages were 67 years for women and 72 years for men.

dementia during the follow-up period were associated with lower grip strength levels.

A different subset of risk factors was associated with rates of change. Among women, higher perceived stress in early midlife and smoking in early and late midlife were associated with a steeper decline in late midlife (slope A). Further, being diagnosed with dementia during the follow-up period was associated with a steeper grip strength decline in old age (slope B).

Men

The estimated average grip strength level for men at age 72 was 36.28 kg ($P < 0.0001$) and the expected yearly decrease was −0.51 kg/year ($P < 0.0001$) between 50 and 72 years of age and −0.95 kg/year ($P < 0.0001$) between 72 and 96 years of age (Figure 1).

For men, being married in early midlife and old adulthood, and having higher perceived stress in old adulthood were all associated with higher grip strength levels at age 72, whereas higher SES in childhood, higher physical activity at work in young adulthood, higher MAP and having a cardiovascular disorder in early midlife, and having a chronic disorder in old adulthood were associated with lower grip strength levels (Table 2).

Among men, an occupation with more physical activity in young adulthood or being married in late midlife were both associated with a steeper decline during late midlife (slope A). To have higher MAP in early midlife was instead associated with a positive effect on slope A. To have a chronic disorder in late midlife was associated with less decline during old age (slope B).

Discussion

We followed grip strength performance from the age of 50 up to the last years of life. A gender difference in the pattern of risk factors associated with grip strength was found. We found also that factors assessed earlier in adulthood were associated with later grip strength decline, both in late midlife and in late old age.

As this study is one of the few studies that have followed grip strength longitudinally for >20 years, it is interesting to note that the model chosen to best describe the decline included two linear trends with a pivot point that differed by 5 years for men and women, at 67 and 72 years, respectively. Additionally, grip strength declined somewhat faster after the pivot point. This result is partially in line with previous research [7, 9–11, 13, 21] that indicates faster decline in older age groups. That people decline more steeply after the turning point might be indicative of the ageing process, *per se*, or of possible reductions in performing certain activities.

For women, the risk factors seem to be more lifestyle related (e.g. smoking and stress), while for men more physically related factors (e.g. MAP, physical activity and chronic disorders) were important. The different gender patterns indicate that it may be worthwhile to do research on grip and muscle strength separately for men and women, and that intervention strategies most likely need to be different for men and women.

The implications of these results suggest that to maintain biological vitality for women during late midlife and old age, they should (i) minimise stress in early midlife and (ii) avoid smoking in early and late midlife. Long-term stress is in general negative for the body [22], and the fact that stress affected women more than men could be related to gender differences in appraisal of stressors or in coping strategies [23]. Smoking was a rather strong risk factor of the grip strength slope in late midlife for women, confirming previous findings [9, 12, 24]. Smoking affects the body through, for example, increased oxidative stress, which affects the muscles negatively [25]. The other factor associated with better grip strength slope in women, (iii) avoiding dementia, is less easy to influence. Associations between dementia and grip strength have been found in previous studies [26, 27], and one reason might be that both cognitive functions and grip strength are dependent on the central nervous system that is affected in dementia patients [28]. Grip strength has mainly been interpreted as a risk factor for dementia, but it is also possible that declining grip strength is indicative of preclinical dementia processes [27].

In contrast, smaller declines in grip strength slope in late midlife for men were associated with less physically strenous work in young adulthood, confirming results from another study [9]. Physical activity is in general positively related to muscle strength [29], but too much and the wrong type of physical activity may result in poor physical functioning later in life [30]. A more physically strenuous occupation might, therefore, ultimately affect the body negatively. Less decline in grip strength for men in late midlife and old age was also

Table 1. Factors associated with grip strength for women[a]

Factors	Intercept (kg) (95% CI)	*P*	Slope A (kg/year) (95% CI)	*P*	Slope B (kg/year) (95% CI)	*P*
Age group 1 (born 1935–49; *n* = 103)						
Education level	2.20 (0.28, 4.12)	*			–	
Depression (early midlife)	−3.58 (−5.70, −1.46)	***			–	
Stress (early midlife)	−1.98 (−3.23, −0.73)	**	−0.14 (−0.27, −0.01)	*	–	
MAP (early midlife)	0.14 (0.08, 0.21)	***			–	
Smoking (early midlife)	1.58 (−0.72, 3.87)	0.178	−0.26 (−0.50, −0.02)	*	–	
Dementia	−13.25 (−22.48, −4.01)	**			–	
Age group 2 (born 1919–34; *n* = 220)						
Musculoskeletal disease (late midlife)	−1.79 (−3.16, −0.42)	*			0.12 (−0.01, 0.24)	0.064
Smoking (late midlife)	−0.81 (−2.30, 0.67)	0.285	−0.25 (−0.49, −0.01)	*		
Dementia	−0.31 (−2.31, 1.69)	0.763			−0.27 (−0.48, −0.07)	**
Age group 3 (born 1900–18; *n* = 181)						
Physical activity (late midlife)	1.89 (0.78, 3.00)	***	–			
MAP (old age)	0.07 (0.01, 0.13)	*	–			
Musculoskeletal disease (old age)	−2.41 (−4.70, −0.13)	*	–		0.02 (−0.15, 0.20)	0.783

Only coefficents that reached statistical significance are shown (and the non-significant coefficients included in the final models). Age group 1 was not analysed with regard to slope B, because they were too young; age group 3 was not analysed with regard to slope A because they were too old. The age for grip strength at the intercept was 67 for women. Slope A = 50–67 years of age; slope B = 67–96 years of age. The values shown represent the change in intercept/slope associated with 1 unit increase (e.g. 1 mmHg increase in MAP). For coding of the other variables, see Supplementary data, Appendix 1 available in *Age and Ageing* online. MAP, mean arterial pressure.

[a]Body height was controlled for in the model.

**P* < 0.05.

***P* < 0.01.

****P* < 0.001.

Table 2. Factors associated with grip strength for men[a]

Factors	Intercept (kg) (95% CI)	*P*	Slope A (kg/year) (95% CI)	*P*	Slope B (kg/year) (95% CI)	*P*
Age group 1 (born 1935–49; *n* = 102)						
SES (childhood)	−0.69 (−1.16, −0.22)	**			–	
Physical activity at work (young adulthood)	−2.10 (−4.12, −0.08)	*	−0.15 (−0.27, −0.02)	*	–	
Marital status (early midlife)	4.98 (0.62, 9.34)	*	0.24 (−0.01, 0.50)	0.063	–	
MAP (early midlife)	−0.18 (−0.31, −0.05)	**	−0.02 (−0.02, −0.01)	***	–	
Cardiovascular disorders (early midlife)	3.43 (0.19, 6.66)	*			–	
Age group 2 (born 1919–34; *n* = 153)						
Marital status (late midlife)	0.91 (−2.61, 4.43)	0.612	−0.42 (−0.73, −0.11)	**		
Chronic disorders (late midlife)	−2.60 (−5.68, 0.48)	0.098	−0.15 (−0.42, 0.11)	0.259	0.60 (0.23, 0.96)	**
Age group 3 (born 1900–18; *n* = 90)						
Perceived stress (old adulthood)	2.06 (0.40, 3.73)	*	–			
Marital status (old adulthood)	4.55 (1.06, 8.04)	*	–			
Chronic disorders (old adulthood)	−4.62 (−8.86, −0.38)	*	–		0.05 (−0.36, 0.46)	0.825

Only coefficents that reached statistical significance are shown (and the non-significant coefficients included in the final models). Age group 1 was not analysed with regard to slope B, because they were too young; age group 3 was not analysed with regard to slope A, because they were too old. The age for grip strength at the intercept was 72 for men. Slope A = 50–72 years of age; slope B = 72–96 years of age. The values shown represent the change in intercept/slope associated with 1 unit increase (e.g. 1 mmHg increase in MAP). For coding of the other variables, see Supplementary data, Appendix 1 available in *Age and Ageing* online. MAP, mean arterial pressure.

[a]Body height was controlled for in the model.

**P* < 0.05.

***P* < 0.01.

****P* < 0.001.

associated with having higher MAP in early midlife, not being married in late midlife and having a chronic disorder in late midlife. However, these associations seem intuitively to go in the wrong direction, since their effects are opposite to the effects on the intercept. In these cases, the associations with the slopes should be interpreted within the context of the intercept levels. In general, participants who are stronger at baseline have a tendency to show steeper decline in muscle strength than weaker participants [31], and even if they decline at a faster rate, they may have a higher performance. (This general tendency, however not significant, was observed for slope B in this study.) This is also the fact for men compared with women. To focus solely on the impact of the factors associated with the slopes might, therefore, be misleading in some cases. In this study, the associations with MAP might be an example of that phenomenon, since higher MAP in early midlife was negative for the intercept for men, but positive for the slope in late midlife. Marital status showed this pattern as well. In this study, it was positive for men to be married in early midlife or old age for the intercept, but negative to be married in late midlife for the slope in late midlife. The mechanism for the association between marital status and grip strength among men is not clear. Marital status is probably a proxy for something that is more closely related to grip strength, such as different activities or different coping strategies. It may also be so that men with higher performance are more likely to marry [32]. Further research is needed to see what marital status stands for in this aspect. Interestingly, marital status was not associated with grip strength for women. For men, having a chronic disorder in old age was negative for the intercept, but, surprisingly, having a chronic disorder in late midlife was positive for the grip strength slope in old age in this study. The most reasonable explanation is that men diagnosed with a chronic disorder have lower grip strength levels in general and, therefore, will not decrease so much in their slopes.

Although this study had a robust design, there are still limitations that should be considered when interpreting the results. First, since several tests were performed, a correction of the significance level could have been done. However, to not miss any real associations, alpha levels of 5 % were used, which means that some of the findings closer to the alpha level might be due to chance. Second, more women than men in the study made it easier to reach significance levels for women, especially for the oldest age group. However, no significant factors associated with the slopes in the oldest age group for either women or men were detected. Third, there might be a potential impact of sample attrition on the results. However, comparisons of the average number of measurement occasions before and after the turning points indicated no sparseness of data coverage in later ages and no gender differences in number of measurement occasions. To avoid bias due to attrition, we made use of all available grip strength data from the participants with full maximum likelihood estimation. However, individuals with some of the risk factors may be at greater risk of early death, which could reduce the apparent impact of a risk factor on grip strength decline [21]. Fourth, as some factors (e.g. SES and physical activity) were measured in different ways at the two time points, it may limit our ability to compare their influence at these two different stages of the life course. Fifth, to avoid loss of power and bias due to listwise deletion when studying several independent variables at the same time, imputation was made. However, single imputation and the relatively high percentage of imputation for a few variables (e.g. physical activity at work) are a potential limitation. Finally, differences between the results for different age groups may in part reflect cohort effects.

Conclusions

We found that risk factors earlier in adulthood were associated with grip strength decline later in life. The results suggest that interventions for better muscle strength (and biological vitality) should start early in life and should focus on different lifestyle aspects for women and men.

Key points

- Men and women differ in their pattern of risk factors associated with grip strength decline.
- Risk factors of grip strength decline vary in their associations with grip strength across the adult lifespan.
- Grip strength decline in old age is associated with risk factors measured earlier in adult life.

Conflicts of interest

None declared.

Funding

This work was supported by National Institute of Aging [AG04563, AG10175, AG08724], The MacArthur Foundation Research Network on Successful Aging, the Swedish Council for Working Life and Social Research [97:0147:1B, 2009-0795] and Swedish Research Council [825-2007-7460, 825-2009-6141]. A.K.D.A. was supported by Future Leaders of Aging Research in Europe postdoctoral grant [FORTE 2010-1852].

Supplementary data

Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

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Received 11 February 2014; accepted in revised form 24 September 2014