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Indoor mobility-related fatigue and muscle strength in nonagenarians: a prospective longitudinal study

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Abstract

Background and aims—Mobility-related fatigue is an important indicator of functional decline in old age, however, very little is known about fatigue in the oldest old population segment. The aim of this study was to examine the association between indoor mobility-related fatigue and muscle strength decline in nonagenarians.

Methods—The study is based on a prospective longitudinal study of all Danes born in 1905 and assessed in 1998, 2000 and 2003, and includes 92- to 93-year-old persons who were independent of help in basic indoor mobility at baseline ($n = 1,353$). Fatigue was assessed at baseline and defined as a subjective feeling of fatigue when transferring or walking indoors. The outcome measure, maximum grip strength, was measured at each measurement point.

Results—Grip strength declined throughout the study in participants with and without fatigue, but those reporting fatigue had significantly ($P < .001$) lower muscle strength during the entire study period. Longitudinal analyses indicated slightly slower decline in muscle strength among participants with fatigue compared to those without; however, observed selective dropout of participants with fatigue and poor performance at baseline needs to be considered when interpreting the results. Accordingly, participants without fatigue had significantly higher chances of being alive and having muscle strength above gender-specific median at first (RR 1.32, 95 % CI 1.07–1.58), second (RR 1.51, 1.06–1.96) and third (RR 1.39, 1.01–1.97) measurement points.

Conclusions—Indoor mobility-related fatigue in advanced later life should not merely be considered as an unpleasant symptom, but rather an indicator of physical impairment, and consequently declined physiological reserve.

Keywords

Aging; Nonagenarians; Fatigue; Muscle strength

Introduction

The oldest old, those aged 85 years and older, is the fastest growing segment of the older population in the western world, mainly due to a reduction in mortality rates in this population [1]. Physical functioning declines with increasing age, and studies including the oldest old have suggested that, for the individual, long life brings an increasing risk of declining physical abilities and loss of independence [2]. A widely observed change in human ageing is a progressive decline in skeletal muscle strength [2, 3]. For example, hand grip strength, a marker of physiological reserve during aging [4, 5], has been reported to have an approximate annual decline rate of 0.5–1 % after midlife [3, 6]. Poor muscle strength, in turn, hinders the ability to manage basic tasks of daily life, eventually leading to a greater risk of losing independence [4] and of mortality [5, 7]. Although the information on physical functioning of the oldest old is gradually accumulating, longitudinal studies describing changes in muscle strength in this population segment are still scarce [2, 3].

Fatigue is considered to be an important indicator of functional decline in old age [8, 9]. General feelings of fatigue among older adults have been associated with many adverse health outcomes, such as various chronic conditions [10], poor physical functioning [11], and increased mortality [12]. In contrast to general fatigue, mobility-related fatigue is considered as a phenotype characterized by the relationship between self-reported fatigue and the specific activities with which the fatigue is associated [9, 13]. Activity-related fatigue has benefits of providing more comparable basis for evaluating differences between individuals, changes over time and effects of interventions, compared to general fatigue without specific context. Furthermore, measuring mobility-related fatigue is clinically useful because it provides means to identify the functional areas in which fatigue is activity-limiting [9].

Previous cross-sectional and longitudinal observational studies in general older populations have indicated that self-reported fatigue in daily mobility tasks is associated with poor health [14], low physical performance [15–17], more use of social and health services [18], and mortality [19]. Activity-related fatigue in older adults with osteoarthritis [20] or chronic heart failure [21] has been further associated with various clinical and psychological characteristics, such as disease severity and depressive symptoms. In addition, perceived fatigue after a standardized objectively measured physical activity has been shown to correlate significantly with lower levels of energy expenditure, poor physical functioning and greater frailty [13, 22]. However, very little is known about mobility-related fatigue in older adults aged 90 years or older [23] and its predictive value on physical functioning in

this population segment has not been investigated before. Given that individuals in the oldest old population segment have an increased risk of disability for each additional year of life [2] and that the nature of physical disabilities may differ from that in younger age groups [24], it is crucial to understand and identify risk factors for declining physical abilities in this oldest old population segment, and thereby help to elucidate the aging process and develop potential preventive interventions appropriate for this age group [24].

In this prospective longitudinal study, we examine the association between self-reported indoor mobility-related fatigue and grip strength decline among nonagenarians aged 92–93 years at baseline. Grip strength has been shown to discriminate functioning in all adult age groups, even among nonagenarians [2, 3] and it has shown to correlate with daily functioning [25] and survival [26] in the cohort of oldest old used in this current study. Therefore, the results of this paper can provide important insight into physiological basis of self-reported mobility-related fatigue among nonagenarians.

Methods

Study population

This longitudinal observational study is based on data of the nationwide Danish 1905 cohort study [27]. The cohort members were identified through the Danish Civil Registration System and the whole Danish 1905 cohort was contacted in 1998. Three thousand six hundred persons aged 92–93 were alive at the beginning of the survey, and 2,262 (63 %) of these participated in the baseline data collection. In the present study, 1,814 participants with nonproxy interviews on indoor mobility-related fatigue were included; 271 of these were unable to transfer or walk indoors independently, and 190 did not have full information on all variables used, leaving 1,353 participants for the final baseline population. Around two-thirds of the selected sample lived independently in a house or an apartment and one-third in sheltered housing, for example in supportive housing or nursing home. The follow-up data collection was carried out during 2000 and 2003. The regional Scientific Ethical Committees of Denmark approved the study (19980073PMC).

Data collection and methods

Face-to-face interviews were conducted at participants' homes and included structured questions on mobility-related fatigue and other health factors. In addition, maximum handgrip strength was measured during the interviews.

Fatigue—Mobility-related fatigue was assessed at baseline and defined as “a subjective feeling of fatigue in basic indoor mobility tasks”. It was measured using two items from the Avlund Mobility-Tiredness Scale (MOB-T) [28]. Participants were first asked whether they were able to (1) transfer from a chair or a bed and (2) walk indoors without help of another person. Participants who were able to manage both tasks independently were further asked whether they felt fatigued after performing them. Individuals reporting fatigue in transferring ($n = 257$, 19 %) or walking indoors ($n = 284$, 21 %) were categorized as having fatigue in basic indoor mobility ($n = 366$, 27 %). Participants who were unable to manage the tasks independently ($n = 271$) were excluded from the current study.

The scale has been validated and used with younger-older populations and has shown good reliability, validity, and predictive value [8, 28]. Because of the high prevalence of inability in the more-advanced tasks of the scale, that is, climbing stairs and walking outdoors, a modified scale was used in the current study. Ability to transfer and walk indoors are essential tasks for independent daily functioning, and therefore we consider these two tasks as a sound basis for measuring indoor mobility-related fatigue in this population. The Rasch

model [28] for item analysis has shown that the separate items in the scale are expressions of the same underlying unidimensional scale. The MOB-T scale thus fulfills the demands for construct validity and scalability in terms of objectivity, sufficiency, and strongly homogeneous items. It is therefore acceptable to remove items from the original scale, even though a full-item scale is preferred.

Grip strength and follow-up profile—Maximum isometric grip strength was measured at each measurement point using a handheld dynamometer. The best performance of three measurements with the preferred hand was used as a measure of grip strength [27]. In the main analyses grip strength was used as a continuous variable (kg) and for ancillary analyses good grip strength was defined separately for each measurement point as being alive, completing the measurement and having grip strength above gender-specific median.

The study population ($n = 1,353$) was divided into three subgroups according to number of grip strength assessments completed: (1) individuals who completed the test only at the first measurement point (year 1998, $n = 704$), (2) individuals who completed the test at the first and second measurement points (years 1998 and 2000, $n = 403$), and (3) individuals who completed the test at first, second and third measurement points (years 1998, 2000 and 2003, $n = 246$).

Covariates—The most important factors that could confound the associations between mobility-related fatigue and grip strength were identified a priori. Information on self-reported physician diagnosed diseases and prescription medication at baseline was collected during the face-to-face interview. A physician coded medicine use according to the Anatomical Therapeutic Chemical (ATC) classification system, and the total number of medications and diseases was used in this study. Depressive symptoms were assessed using the depression section from the Cambridge Mental Disorders of the Elderly Examination (CAMDEX) diagnostic interview [29], comprising 17 items (range 0–34), with higher scores indicating higher levels of depressive symptoms. Information on body height (in meters) and weight (in kilograms) were used as indicators for body size in the main analyses, and for descriptive purposes, body mass index (BMI, kg/m^2) was calculated. Physical activity was evaluated with a single question about the frequency of participation in light exercise, for example, in light gardening, short walks or bicycle rides. The responses were categorized into sedentary (less than once a week) or active (weekly or more often).

Statistical analyses

Comparisons between groups with and without mobility-related fatigue were examined with Chi-square test for categorical variables, Kruskal–Wallis test for skewed continuous variables, and t test for normally distributed continuous variables.

The association between fatigue and decline in grip strength (kg) was calculated using random coefficient models. The analyses were completed with the MIXED procedure in SAS. Group (effect of fatigue on grip strength), time (effect of follow-up time on grip strength) and group $\times$ time (interaction effect of fatigue $\times$ follow-up time on grip strength) effects were estimated. The results on rate of change are presented as beta estimates (β) indicating the annual change in grip strength (kg per year). To examine whether participants with or without fatigue have different effect on physical performance decline in men and women, and those living independently or in sheltered housing, the interaction terms gender $\times$ fatigue and housing $\times$ fatigue were entered in the models. We did not stratify analyses as all interaction terms were nonsignificant. To estimate chances of staying alive and having good grip strength, measurement point specific relative risks (RRs) were calculated using the NLMIXED procedure with Poisson regression [30].

The SAS 9.1 Statistical Package was used for all analyses (SAS Institute Inc., Cary, NC, USA).

Results

Baseline descriptive data are presented in Table 1. In total, around one-third (27 %) of participants reported fatigue when transferring or walking indoors, one-third (32 %) lived in sheltered housing and the majority (72 %) was female. A larger proportion of those with fatigue lived in sheltered housing were women and physically sedentary, and they had more chronic conditions, medications and depressive symptoms as compared to participants without fatigue (Table 1).

Table 2 and Fig. 1 show longitudinal assessment of grip strength according to follow-up profile and fatigue at baseline. In total, participants' grip strength at baseline was higher and the rate of decline slower when more assessments were completed. Consequently, participants who remained in the study for the longest time had the highest grip strength at baseline and the slowest rate of decline (Table 2; Fig. 1).

Mobility-related fatigue had a significant adjusted group effect on grip strength during the entire study period and in total, nonagenarians reporting fatigue at baseline had on average 1.62 kg lower adjusted grip strength ($\beta -1.62$, $P < .001$) compared to those without fatigue (Table 2; Fig. 1). Grip strength declined in participants with and without fatigue throughout the study with a total average decline of 0.57 kg per year ($\beta -0.57$, $P < .001$). The rate of change tended to be slightly slower among those reporting fatigue ($\beta 0.23$, $P = .052$) with a significant adjusted group-by-time effect among those who took part in all three measurement points ($\beta 0.33$, $P = .028$) (Table 2). However, those with fatigue had significantly lower participation rate in both follow-up points, mainly due to higher rate of mortality as compared to those without fatigue (Fig. 1). Further, Table 3 shows a consistent and significant declining pattern of baseline muscle strength according to participation status in the second and third measurement points; participants had the highest, and those who died before the subsequent measurement point, the lowest performance at baseline. Taken these observations together, comparisons in the rate of decline must be considered with caution and interpreted only together with information on nonparticipation.

To be able to combine the observed differences in the participation rate and the level of grip strength between the fatigue groups, we performed ancillary analyses to calculate the chances of having good grip strength at different stages of the study, that is, being alive, completing the measurement and having grip strength in the better half of the gender- and measurement point specific strength spectrum (Table 4). Participants without fatigue at baseline had 30–50 % higher chances of being alive and having good grip strength at the first, second and third measurement points (RR 1.32, 95 % CI 1.07–1.58; RR 1.51, 95 % CI 1.06–1.96 and RR 1.39, 95 % CI 1.01–1.97, respectively) when adjusting for gender, housing and years of education. Further adjustments with body size, chronic diseases, medications and physical activity attenuated the risks at each measurement point (Table 4).

Discussion

This longitudinal study showed that in initially nondisabled nonagenarians, fatigue in basic indoor mobility is consistently associated with lower level of grip strength, and that nonagenarians without fatigue at baseline have better changes to survive with good grip strength during follow-up. Taken together, the results suggest that fatigue in advanced later life should not merely be considered as an unpleasant symptom, but rather an indicator of physical impairment, and consequently declined physiological reserve.

This is the first longitudinal study addressing the association between fatigue and objectively measured performance in the oldest old population. The observed differences in the level of muscle strength between participants with and without fatigue are comparable with those reported earlier in studies including younger older populations [16, 17], demonstrating that perceived fatigue has a measurable physiological basis also among the oldest old. As lower level of muscle strength is known to be associated with higher risk of functional decline and mortality among younger older adults [4, 5, 7] as well as the oldest old [25, 26], the results of our study may indicate potential clinical significance. It is highly possible that due to their lower muscle strength, nonagenarians reporting mobility-related fatigue have a greater risk for accelerated overall functional decline compared to those without fatigue. However, the aim of this current paper was first to study the longitudinal associations between mobility-related fatigue and muscle strength, and the associations with further functional decline need to be addressed with future studies.

We observed that the rate of strength decline tended to be lower in participants with fatigue than those without. However, these results may be affected by selective dropout in this study population, and need to be interpreted only side by side with information on nonparticipation. The proportion of individuals completing the tests at second and third measurement points was substantially smaller in the group with fatigue than without, especially due to higher mortality among those with fatigue (Fig. 1), and in general, those who remained in the study for the longest time had the highest grip strength at the first measurement point and the slowest rate of decline during the follow-up (Tables 2, 3). This selective dropout has been described also in previous longitudinal studies including nonagenarians [2, 3] and in this current study, it may have potentially caused underestimation in the rate of muscle strength decline among those reporting fatigue. In addition, a previous study [3] has suggested that although the decline in grip strength is almost linear in the age span of 50–85 years, a horizontal plateau in the decline was observed among the oldest old women, possibly due to floor effect combined with horizontal or even declining course of mortality in the oldest ages [1]. As the proportion of women in our study was substantially higher in those with fatigue than those without (82 vs. 69 % and 93 vs. 72 % among those participating in the second and third measurement points, respectively, data not shown), it is possible that this phenomenon may also partly contribute to the slower decline grip strength in participants reporting fatigue. All in all, these observations underline the challenges of evaluating the effect of fatigue on change in specific physical function in the oldest old populations due to high and selective drop-out rate among those with the poorest function at baseline [2, 3].

To be able to combine the observed differences in the participation rate and the level of grip strength between the fatigue groups, we performed ancillary analyses to calculate the chances of having good grip strength at different stages of the study, that is, being alive, completing the measurement and having grip strength in the better half of the gender- and measurement point specific strength spectrum. Participants without fatigue had up to 50 % higher chances of surviving and having good measured grip strength at different stages of the study (Table 3), consequently indicating significantly poorer outcome for participants reporting fatigue at baseline. Previous studies have shown that subjective feelings of fatigue predict mortality in younger-older populations [12, 19]; however, the associations between fatigue, attrition and mortality need to be examined in more detail in future studies including participants from the oldest old population segment.

We chose to use grip strength as a measure of muscular strength in this study. Although the measurement of grip strength involves only upper extremity musculature, it is highly correlated with strength of other muscle groups [31] and has been widely used as a measure of total body strength and a marker of physiological reserve during aging [4, 5, 7]. The

instrument, the hand held dynamometer, is inexpensive, easily portable, simple and quick to use, and is thus feasible also in home-based settings, which is crucial for response rates in studies of the elderly. Unlike many performance-based measures, grip strength measure does not require specific mobility skills and is thus not inherently limited to better-functioning individuals. Therefore, it has been used successfully with high participation rates even among nonagenarians [2, 3, 25], making the measure very feasible for the purposes of this current study. Furthermore, as grip strength has been shown to correlate with daily functioning [25] and survival [26] in the current cohort of the oldest old, the results of this paper provide important insight into physiological basis of self-reported fatigue among nonagenarians. Given that the nature of physical disabilities in the oldest old may differ from that in younger age groups [24], it is critical to understand and identify indicators and risk factors for declining physical abilities in this population segment, and thereby help to elucidate the aging process and develop potential preventive interventions appropriate for this age group [24].

When interpreting the results, some limitations and strengths of the study should be considered. First, although the prospective longitudinal design with repeated grip strength measurement in a sample of oldest old is a major strength of this current study, longitudinal follow-up in this population segment has natural limitations. As has been observed before in studies including nonagenarians [2, 3], attrition during the follow-up was high, specifically among those with the poorest performance and fatigue at baseline. Thus, the level of grip strength and rate of decline among participants reporting fatigue may be underestimated. However, we presented information on the attrition side by side with our main results, allowing the reader to estimate possible effects of the nonparticipation on the outcome of this study. Furthermore, the study would have benefited from more frequent follow-ups because of high mortality rate in this population segment. In addition, we used fatigue measured dichotomously at a single time point as a predictor of grip strength. Future studies need to address possible dose–response relationships between fatigue and various health outcomes, and clarify how trajectories of fatigue during the follow-up relate to changes in grip strength. One more limitation of this study is that due to our main variables, we did not include participants who completed only proxy interview or those who were not able to manage basic mobility tasks independently. These exclusions may have affected our results slightly and restricted the generalizability only to somewhat better-functioning nonagenarians. In addition to the longitudinal design, a well-characterized nationwide cohort with standardized measures of fatigue and medical history is strength of this study.

Conclusions

The results of this prospective longitudinal study demonstrated that self-reported mobility-related fatigue has a measurable physiological basis also among the oldest old individuals, and that fatigue in advanced later life should not merely be considered as an unpleasant symptom, but rather an indicator of physical impairment, and consequently declined physiological reserve.

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Fig. 1.
Mean grip strength (kilograms, kg) by follow-up profile and fatigue at baseline ($n = 1,353$)

Table 1

Baseline characteristics of the study population by fatigue

	All (<i>n</i> = 1,353)	Fatigue		<i>P</i>
		No (<i>n</i> = 987)	Yes (<i>n</i> = 366)	
Living in sheltered housing	436 (32)	289 (29)	147 (40)	< .001
Women	977 (72)	682 (69)	295 (81)	< .001
Formal education 7 years	1,043 (77)	780 (79)	263 (72)	.005
Sedentary	715 (53)	445 (45)	270 (74)	< .001
Number of diseases	3.4 ± 2.4	3.2 ± 2.2	4.1 ± 2.6	< .001
Number of medications	3.2 ± 2.5	2.9 ± 2.4	4.0 ± 2.8	< .001
BMI (kg/m ²)	23.3 ± 3.5	23.3 ± 3.5	23.1 ± 3.6	.669
CAMDEX score	7.7 ± 5.8	6.6 ± 5.2	10.7 ± 6.2	< .001

N (%) or mean ± SD shown*SD* standard deviation, *BMI* body mass index, *CAMDEX* Modified Cambridge Mental Disorders of the Elderly Examination score, range 0–29

Table 2

Longitudinal assessment of grip strength by number of assessments completed and fatigue at baseline (1998)

Study sample	<i>n</i>	β Estimate (SE) ^a Annual change	β Estimate (SE) <i>P</i> value	Time ^c	Group $\times$ time ^d
Only baseline					
Without fatigue	487	–	–	–	–
With fatigue	217	–	–1.26 (0.37) .001	–	–
Baseline + one follow-up					
Without fatigue	308	–0.89 (0.11)			
With fatigue	95	–0.78 (0.19)	–1.46 (0.56) .010	–0.88 (0.09) < .001	0.11 (0.22) .619
Baseline + two follow-ups					
Without fatigue	192	–0.71 (0.07)			
With fatigue	54	–0.38 (0.13)	–1.99 (0.72) .006	–0.63 (0.06) < .001	0.33 (0.15) .028
Total for two follow-ups					
Without fatigue	987	–0.63 (0.06)			
With fatigue	366	–0.40 (0.10)	–1.62 (0.29) < .001	–0.57 (0.05) < .001	0.23 (0.12) .052

^a Beta estimates and standard errors (SE) for different groups are derived from gender, housing, education, weight and height adjusted random coefficient models and they indicate the average annual change in grip strength (kg)

^b Effect of fatigue on grip strength adjusted for gender, housing weight and height

^c Effect of follow-up time on grip strength (annual change) adjusted for gender, housing, weight and height

^d Interaction effect of fatigue $\times$ follow-up time on grip strength adjusted for gender, housing, weight and height

Table 3

Baseline grip strength stratified by participation status at first, second and third follow-up points ($n = 1,353$)

	1998		2000		2003	
	<i>n</i>	kg (SE)	<i>n</i>	kg (SE)	<i>n</i>	kg (SE)
Participants	1,353	16.7 (0.2)	649	19.5 (0.2)	246	20.2 (0.3)
Lost to follow-up	–	–	316	18.0 (0.3)	346	18.7 (0.3)
Dead	–	–	388	17.5 (0.2)	761	17.9 (0.2)
<i>P</i> value				< .001		< .001

Proportions and adjusted risk ratios (RRs) for having measured grip strength above the median at specific measurement point in participants without versus with fatigue at baseline (1998)

Table 4

Proportion with outcome %		Model 1 ^a RR (95 % CI)	Model 2 ^b RR (95 % CI)	Model 3 ^c RR (95 % CI)	Model 4 ^d RR (95 % CI)	Model 5 ^e RR (95 % CI)
1998						
With fatigue	37	Ref.	Ref.	Ref.	Ref.	Ref.
Without fatigue	52	1.39 (1.12–1.65)	1.32 (1.07–1.58)	1.34 (1.09–1.60)	1.32 (1.06–1.58)	1.24 (1.02–1.45)
2000						
With fatigue	15	Ref.	Ref.	Ref.	Ref.	Ref.
Without fatigue	24	1.62 (1.15–2.10)	1.51 (1.06–1.96)	1.52 (1.07–1.97)	1.47 (1.03–1.90)	1.23 (0.89–1.58)
2003						
With fatigue	10	Ref.	Ref.	Ref.	Ref.	Ref.
Without fatigue	15	1.47 (1.02–2.07)	1.39 (1.01–1.97)	1.41 (0.89–1.93)	1.28 (0.80–1.77)	1.07 (0.68–1.46)

^aUnadjusted

^bAdjusted for gender, housing and years of education

^cModel 2 + weight and height at baseline

^dModel 3 + number of medications and number of chronic diseases at baseline

^eModel 4 + physical activity at baseline