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Physical capability in midlife and risk of disability pension and long-term sickness absence: prospective cohort study with register follow-up

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Objective The aim of this study was to determine the association of physical capability with health-related labor market outcomes among older workers.

Methods The prospective risk of disability pension and long-term sickness absence (LTSA) of ≥6 weeks was estimated from physical capability on 5076 older workers (age 49–63 years) from the Copenhagen Aging and Midlife Biobank (CAMB). Physical capability was objectively measured through nine different tests (jump performance, postural balance, chair-rise, explosive muscle strength, maximal strength of the hand, back and abdominal muscles, lung capacity, and aerobic fitness) and linked to a high-quality register on social transfer payments among all Danish residents. Cox-regression analyses estimated the association of physical capability with risk of disability pension and LTSA.

Results For all measures, low physical capability [≥1 standard deviation (SD) below the mean for each gender] was associated with increased risk of disability pension and/or LTSA, whereas high physical capability (≥1 SD above the mean for each gender) was not. A capability−response association was observed between the number of tests with low capability and disability pension and LTSA (P<0.0001) – with the risk-estimate for disability pension being 8.52 (95% confidence interval 3.98–18.25) when low capability was present in ≥5 physical tests. Population attributable risks analyses indicate that 42% of the disability pension cases were attributable to low physical capability whereas this was the case for 12% of the LTSA cases.

Conclusions Using objective measures of predictors and outcomes, our study shows that low physical capability in midlife was associated with increased risk of disability pension and LTSA. The results indicate that increasing physical capability to an average level among older workers with low capability could potentially contribute to preventing >40% of premature exits from the labor market.

Key terms aerobic fitness; exercise; labor market; lung capacity; maximal oxygen uptake; muscle strength; older worker; physical capacity.

Due to the demographic changes observed during the last decades, keeping older workers in the labor market is a political priority. However, this is not without challenges considering the age-associated decline in health (1–3). This encompasses a decline in physical capacity that sets in around the age of 30 years (2) and a decline in cognitive ability that becomes apparent around the age of 50 after which it accelerates (3). For example, muscle strength decreases by an average of 1–2% per year from the age of 30 (2). Consequently, workers aged 50–60 years of age will on average have lost over a third of their muscle strength. Importantly, also the number of coexisting health problems increases with age (4). Even though physical work demands will likely show a

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small decrease in many industries due to implementation of new technology (5, 6), the age-associated decline in physical capability could lead to a significant proportion of older workers lacking the resources to cope with the physical demands at work (7). This can lead to reduced work ability, poor health, and challenging labor market attachment at an older age.

Physical capability measured by easily administrable tests such as grip strength and walking speed has been proposed as candidate biomarkers of the aging process and indicators of current and future health (8, 9). Specifically, low physical capabilities could reflect both diagnosed and undiagnosed disease and aging processes and have been associated with higher rates of mortality in the older population (8, 10). However, to capture individuals at earlier stages of the disablement process there is a need to investigate the development and consequence of functional decline and limitations prior to older age (11, 12). Elucidating the association of physical capability in midlife with health-related labor market endpoints – eg, long-term sickness absence (LTSA) and disability pension – could help to develop screening tools to identify workers at risk of premature exit from the labor market. Identifying individuals who are more vulnerable to premature exit may help to target future preventive interventions and slow down or postpone the onset of early aging processes in midlife (11).

Previous studies employing both self-rated and objectively measured physical capability have observed an association between low physical capability and poor health (13). Borch-Supan et al (14) observed a significant deterioration of self-assessed health among older participants from the SHARE study who just started to receive disability benefits. However, this deterioration was less pronounced when health was obtained more objectively by hand-grip strength, which indicates justification bias in self-assessed health (14). This is in agreement with Kalwij et al (15) emphasizing the need for objective health indicators when analyzing the association between health status and labor market participation. To our knowledge, only one study has previously examined the association between objectively measured physical capability and labor market participation. That study, by Stafford et al (16), found that better physical capability (ie, grip strength, chair-rise time, one-legged balance test) was associated with a greater likelihood of participating in bridge or voluntary employment after retirement from main occupation (self-reported). However, they found no association with a performance-based physical capability score and retiring for negative reasons (16).

The aim was to determine the association of nine objective measures of physical capability in midlife with register-based disability pension and LTSA among participants from the Copenhagen Aging and Midlife Biobank (CAMB) cohort. It was hypothesized that low physical capability [≥1 standard deviation (SD) below the mean for each gender] would increase the risk for future disability pension and LTSA, whereas high physical capability (≥1 SD above mean for each gender) would decrease this risk.

Methods

Study design

This prospective cohort study merges data on physical capability from CAMB with a national register containing information on sickness absence and disability benefits. The study follow-up period was 4–6 years and the average time of follow-up was 4.62 years. When reporting on the study, the STROBE checklist was followed to ensure transparent and standardized reporting (17). The methods and design have previously been described (18).

Study population

The CAMB cohort was established from 2009–2011 by inviting 17 937 persons (age 49–63 years) from three existing Danish cohorts [the Metropolit Cohort (19), the Danish Longitudinal Study on Work, Unemployment, and Health (20), and the Copenhagen Perinatal Cohort (21)]. In total 7190 (40%) completed a survey questionnaire and 5575 further participated in a clinical examination (31%) (22). The clinical examination consisted of a health examination and different physical capability tests and took place from 2009–2011. The following exclusion criteria were test-specific: dizziness in regard to the standing balance test; disc herniation and extensive hip-, knee-, and ankle-pain in regard to the jump height test; high blood pressure (BP) (ie, systolic BP >160 mmHg and/or diastolic BP >100 mmHg) in regard to the chair rise test, strength tests for back and abdominal muscles, and the aerobic fitness test. Individuals not affiliated with the labor market at the point of data collection were excluded from the present study. After exclusion, the study population consisted of 5076 workers (age 49–63 years at baseline). Because not all participants performed all the physical capability tests, the exact number of participants for each of the analyses varied.

Physical capability

Maximal handgrip strength and explosive muscle force [ie, rate of force development (RFD)] were measured with a Jamar dynamometer (model G100, Biometrics Ltd, Newport, UK) wired to a computer's signal conditioning interface (11). The attempt with the highest

force value (kg) of three to five attempts was used for further analysis. In addition, the test with the highest RFD (kg/s) was used for further analysis.

Maximal muscle strength of the abdominal- (trunk flexion) and back muscles (trunk extension) were measured in a standing position in a custom-made dynamometer setting (23). The attempt with the highest force value (kg) of 3–5 attempts was used to determine maximal strength.

Functional lower limb capability was measured as the number of chair-rises performed during a 30-second sit-to-stand test (24). The test was performed using a chair (height 45 cm) with a mechanical contact in the seat, enabling automatic recording of the number of chair-rises completed (25).

Postural balance was assessed by three one-legged balance tests performed for 30 seconds on an instrumented force plate (AMTI OR6, Watertown, MA, USA) (11). The attempt with the lowest sway area of the center of pressure was selected for further analysis. Maximal vertical jump height was assessed during countermovement jumping on the same force plate (26). The attempt with the highest jump height (cm) of 3–5 attempts was used for further analysis.

Aerobic fitness was estimated from a submaximal cycle ergometer test as previously described by Åstrand & Ryhming (27). Aerobic fitness (ml/kg/min) was then calculated as maximal oxygen uptake (l/min) / bodyweight (kg) × 1000.

Lung capacity was assessed by the forced expiratory volume in the first second (FEV_1) during a spirometry test (28). The attempt with the highest FEV_1 (% of predicted FEV_1) of 3–5 attempts was used for further analysis.

Physical capability composite score

A physical capability composite score was created by summing the number of tests with low capability for each participant (ie, ≥1 SD below the mean for each gender). The aerobic fitness test was introduced late within the baseline measurement period and data were therefore obtained from a sub-group consisting of 1313 participants. The analyses with aerobic fitness as predictor were therefore exploratory by nature and not included in the physical capability composite score. Thus, the composite score ranged from 0–8 and a data-driven categorization to ensure an adequate number of persons in each category was employed to further divide the score into the following 4 categories: (i) "0" test with low capability, (ii) "1–2" tests with low capability, (iii) "3–4" tests with low capability, and (iv) "≥5" tests with low capability. Because few individuals had 7 and 8 tests with low capacity, the upper limit was set to ≥5.

Outcome variables

Information on disability pension and LTSA was derived from the Danish Register for Evaluation of Marginalization (DREAM), containing information on all social transfer payments on all Danish residents (29) and linked to the CAMB cohort via the unique Danish personal identification number. In the DREAM register, sickness absence is recorded on a weekly basis when the employer is entitled to reimbursement of the sickness absence pay (30). During the study follow-up, the period during which the employer received no reimbursement changed from 21 days to 30 days of sickness absence (January 2012). Since 30 calendar days represents >4 weeks, ie, it goes into the 5th week, and given that sickness absence is recorded on a weekly basis in DREAM, ≥6 consecutive weeks was used as a measure of sickness absence of >30 calendar days. To define LTSA consistently throughout the follow-up period, it was therefore defined as ≥6 consecutive weeks in DREAM (31, 32).

Covariates

Age is considered a confounder since physical capacity decreases over time and the number of health problems increases with age thus influencing the likelihood of health-related labor market outcomes such as LTSA and disability pension.

Height and weight are strongly correlated with physical capability (33), and body mass index (BMI) has been associated with poor health and mortality (34). Height and weight of participants were measured by the clinical personnel and BMI was calculated as BMI (kg/m^2)=body weight/(height)^2.

Smoking status is associated with poor health, mortality and physical capability (35). Smoking was evaluated by a question from the CAMB questionnaire: "Do you smoke?" With the response categories: (i) yes, daily; (ii) yes, but not daily; (iii) no, but I have smoked previously; (iv) no, I have never smoked. For the analyses, the response categories i–iii were collapsed into "smoking" while response category iv represented "no smoking".

Education is associated with physical fitness and health and could therefore also be considered a confounder (36). Level of education was categorized into five groups; unskilled, skilled, and short-, medium-, and long-term education (37). For further analyses, a variable was generated corresponding to the educational level, with 1 representing the lowest level of education (ie, unskilled) and 5 representing the highest level of education (ie, long-term education).

Factors within the physical and psychosocial work environment have been associated with both health-related labor market outcomes and physical capabil-

ity (25, 31). For instance, higher physical exposures throughout working life have been associated with slightly poorer chair-rise performance in midlife (25). Psychosocial work environment was assessed by seven dimensions from the Copenhagen Psychosocial Questionnaire (38) that was modified to retrospectively cover the participants' entire working life: (i) quantitative demands, (ii) influence/decision authority, (iii) emotional demands, (iv) time pressure, (v) role conflicts, (vi) possibilities for development, and (vii) rewards/appreciation. Physical work environment was assessed by number of years during working life with (i) mostly sedentary work without physical strain, (ii) mostly standing or walking work without major physical strain, (iii) mostly standing or walking work with some lifting and carrying, (iv) mostly heavy, fast or physically demanding work (31). The data on exposure years in each of the four categories were transformed into a number between 0 and 100 and categorized into low (0–24.99), moderate (25–49.99), high (50–74.99), and very high (75–100) physical work demands.

Poor health is an important determinant of transition into disability pension and sickness absence and musculoskeletal disorders, cardiovascular diseases, depression and anxiety have been shown to predict the risk of these health-related outcomes (39–41). Persons with decreased physical capability are more likely to experience poor health (ie, one or more diseases), which could be the cause of disability pension and LTSA. Further, poor physical capability can be a consequence of several chronic diseases that could also be the main causes of disability pension and LTSA. Thus, chronic diseases could influence both the level of physical capability and the different health-related labor market outcomes. Chronic diseases were assessed by the following question: "Do you have or have you had any of the following diseases?" with the response options "yes, have now", "yes, previously" or "no" to the following diseases: back disease, cancer including leukemia, chronic anxiety or depression, stroke, hypertension, myocardial infarction, and angina pectoris. For each chronic disease, a binary variable was generated: 1 representing that the participant has or had the specific disease, and 2 representing that the participant never had the specific disease.

Previous LTSA is a strong predictor of future LTSA, disability pension, and low physical capability. Previous LTSA (ie, ≥6 consecutive weeks) was assessed from the DREAM register two years prior to the baseline measurements.

Statistical methods

The Cox proportional hazard model was used to test the associations of each of the nine measures of physical capability and the capability composite score with register-based LTSA and disability pension during the 4–6 year follow-up period (ie, baseline measurements were assessed from 2009–2011 and register follow-up were in 2015). When individuals had an onset of LTSA and disability pension within the follow-up period, the survival times were non-censored and referred to as event times. The analyses were censored for all events of permanent drop-out from the labor market within the follow-up period (ie, early retirement, emigration, and death). The different models in the analyses were adjusted as follows: the minimally adjusted model 1 was adjusted for age and gender; the fully adjusted model 2 was additionally adjusted for education, lifestyle factors (smoking, BMI), physical work environment, psychosocial work environment, chronic diseases (back disease, cancer including leukemia, chronic anxiety or depression, stroke, hypertension, myocardial infarction, and angina pectoris) and previous LTSA. In addition, a sensitivity analysis was performed by additionally adjusting model 2 for self-rated health. Self-rated health was operationalized as a continuous variable ranging from 1 (excellent) to 5 (poor). To test for the existence of capability−response relationships between the number of physical tests with low capability and LTSA and disability pension statistically, trend tests were performed by including the capability composite score as continuous variables in the Cox proportional hazard model. Population attributable risks from low physical capability were calculated for both disability pension and LTSA. This analysis was based on the hazard ratios (HR) and proportions exposed from model 2 in the analysis employing the physical capability composite score (42). Additionally, the interaction for gender was tested for the association between the different physical capacity measures and LTSA. Unless otherwise stated, the estimation method was maximum likelihood and the results are reported as HR with 95% confidence intervals (CI). The significance level was set at an alpha level of $P<0.05$.

Results

The characteristics of the study population are presented in table 1. Mean age of the study sample was 54.3 (SD 3.8) years, and the proportion of men was 70% since the Metropolit Cohort included only male participants. During the follow-up period, the following number of outcome events occurred: 970 participants (19.3%) had at least one episode of LTSA and 85 participants (1.7%) were granted a disability pension. The number of censored participants in the analyses was: 538 participants (10.7%) due to early retirement; 529 participants (10.4%) due to granted state pension;

Table 1. Baseline characteristics of the study sample. [SD=standard deviation.]

	Study sample				Men				Women			
	N	%	Mean	SD	N	%	Mean	SD	N	%	Mean	SD
Age, years	5076		54.3	3.8	3537		55.2	3.3	1539		52.0	4.0
Education												
Unskilled manual worker	366	7			243	7			122	8		
Skilled manual worker	1869	38			1364	39			506	33		
Short-educated non-manual worker	509	10			329	10			179	12		
Medium educated non-manual worker	1330	27			822	24			508	33		
Long-educated non-manual worker	902	18			697	20			206	14		
Lifestyle												
Body mass index (kg/m^2)	5076		26.0	4.1	3505		26.4	3.7	1533		25.1	4.6
Smoking (yes and ex-smoker)	1102	22			746	22			329	22		
Smoking (no)	3922	78			2720	78			1191	78		
Physical work environment during working life												
Sedentary work	2618	53			1810	53			809	54		
Moderate physical work	1072	22			713	21			360	24		
Hard physical work	827	17			589	17			238	16		
Very hard physical work	414	8			325	9			89	6		
Psychosocial working conditions (1–5)												
Quantitative demands (low-high)	4967		3.4	1.0	3449		3.4	1.0	1518		3.3	1.0
Influence (high - low)	4972		2.2	0.8	3456		2.1	0.8	1516		2.3	0.8
Emotional demands (low-high)	4970		3.2	1.2	3457		3.2	1.2	1513		3.2	1.2
Time pressure (low-high)	4975		2.6	0.9	3458		2.7	0.8	1517		2.6	0.8
Role conflicts (high-low)	4945		3.6	0.9	3441		3.6	0.9	1504		3.7	0.9
Possibilities for development (high-low)	4972		1.9	0.8	3457		1.9	0.8	1515		1.9	0.8
Appreciation (high-low)	4914		2.4	0.9	3409		2.4	0.9	1505		2.4	0.9
Chronic diseases												
Back disease (have or have had)	1306	26			949	27			342	23		
No back disease	3705	74			2508	73			1174	77		
Cancer inclusive leukemia (have or have had)	212	4			125	4			84	6		
No cancer inclusive leukemia	4799	96			3332	96			1432	94		
Hypertension (have or have had)	1198	24			910	26			288	19		
No hypertension	3775	76			2545	74			1230	81		
Myocardial infarction or angina pectoris (have or had)	103	2			87	3			16	1		
No myocardial infarction or angina pectoris	4896	98			3370	97			1499	99		
Stroke (have or had)	71	1			55	2			16	1		
No stroke	4908	99			3405	98			1503	99		
Chronic depression or anxiety (have or had)	516	10			282	8			217	14		
No chronic depression or anxiety	4497	90			3173	92			1303	86		

and 60 participants (1.2%) due to death. Average time to follow-up (ie, time to event or censoring) for the analyses with disability pension and LTSA as outcome was 4.62 (SD 0.96) and 4.62 (SD 0.95) years, respectively. A significantly higher proportion of the women had an episode of LTSA in the follow-up period compared to the men (P<0.0001), whereas no statistical difference, was observed for disability pension (P=0.46). In regard to LTSA, 367 events (23.9%) were observed among the women and 603 events among the men (17.2%). In regard to disability pension, 29 events (1.9%) were observed among the women and 56 events among the men (1.6%).

Physical capability

Table 2 shows the mean level and SD of physical capability for each of the nine tests stratified by gender. Table 3 shows the result of the association of the nine measures of physical capability with risk of disability pension and LTSA. Low capability, ie, capability that was ≥1 SD below the mean, was associated with increased risk of disability pension in the fully adjusted model in eight tests: jump performance, chair-rise performance, grip strength, explosive muscle force, back strength, abdominal strength, aerobic fitness, and lung capacity.

Low capability was associated with increased risk of LTSA in the fully adjusted model in six tests: jump performance, grip strength, back strength, abdominal strength, postural balance, and lung capacity.

High capability, ie, capability that was ≥1 SD above the mean, was only associated with increased risk of LTSA in the fully adjusted model for the lung capacity test. High physical capability was not associated with disability pension or LTSA in any of the remaining eight tests.

The interaction for gender in the association between each physical capability test and LTSA yielded the following results: grip strength (P=0.23), jump height (P=0.28), aerobic fitness (P=0.29), back muscle strength (P=0.39), abdominal muscle strength (P=0.60), chair-rise (P=0.35), explosive muscle force (P=0.043), postural balance (P=0.46), lung capacity (P=0.15) (results not shown in tables).

Table 2. Physical capability of the nine objective measures among women and men. [SD=standard deviation; FVC_1=forced expiratory volume in one second.]

Physical test	Women			Men		
	N	Mean	SD	N	Mean	SD
Jump height (cm)	1326	14.8	4.0	3108	22.0	4.9
Chair-rise (number in 30 sec)	1455	21.6	5.5	3136	22.3	5.5
Grip strength (kg)	1528	31.7	5.2	3501	50.0	8.3
Explosive muscle force (kg/s)	1528	220.6	50.7	3501	348.5	77.0
Back muscle strength (kg)	1349	41.4	11.3	2868	66.2	16.4
Abdominal muscle strength (kg)	1359	42.9	10.1	2898	67.7	13.3
Postural balance (mm^2)	1509	810	775	3393	1136	1489
Aerobic fitness (mlO^2/kg/min)	733	33.0	8.1	580	34.6	9.0
Lung capacity (% predicted FVC_1)	1530	94.1	13.5	3496	93.6	14.6

Physical capability composite score

Table 4 and figure 1 shows the association of the number of physical tests with low capability with risk of disability pension and LTSA. In the fully adjusted model, low capability in 3–4 tests and ≥5 tests were associated with increased risk of disability pension and LTSA when compared with respondents with no results reflecting low physical capability. Highly statistically significant capability−response associations were observed between the number of physical tests with low capability (continuous variable) and disability pension (P<0.0001) and LTSA (P<0.0001) (results not shown in tables).

Population attributable risks

All population attributable risks (PAR) were estimated using the estimates from the fully adjusted model 2 depicted in table 4. The PAR analysis indicates that 42% of the disability pension cases were attributable to low physical capability whereas 12% of the LTSA cases were attributable to low physical capability (results not shown in tables).

Discussion

Overall, low physical capability (ie, ≥1 SD below mean for each gender) was associated with increased risk of disability pension and LTSA, whereas high physical capability (ie, ≥1 SD above mean for each gender) was not associated with these health-related outcomes. A capability–response association was observed between the number of physical tests with low capability and disability pension and LTSA. PAR analyses indicate that 42% of the disability pension cases were attributable to low physical capability whereas this was the case for 12% of the LTSA cases.

Strengths and weaknesses of the study

Determining physical capability by nine different objective measures in a large heterogeneous sample of older workers is a strength of the study. Obtaining objective measures of physical capability is more challenging than using questionnaires alone, but the measurements are more precise. As an example, there is only a weak-to-moderate correlation between self-reported muscle strength and objectively measured muscle strength (r =0.30−0.51, ie, explained the variation of 9−26%) (43, 44). In addition, reporting bias was reduced where individuals answering questions about their own physical capabilities may be related to other variables (eg, mental health) that may affect the risk of disability pension and sickness absence.

Another strength of the study is the use of objective (ie, register-based) data on disability pension and LTSA. The DREAM register has high validity as it contains weekly information on all social transfer payments for all Danish residents (30). Even though the participants were active at the labor market and the analyses were controlled for several known chronic diseases, the observed associations between low physical capability and labor market outcome may to some extent be caused by an undiagnosed underlying disease. Due to Danish law, the DREAM register holds no information on diagnoses for LTSA and disability pension and the issue of reverse causality could, therefore, be a limitation to the present study. Thus, unmeasured confounding may have been a problem even though an extensive amount of variables were included in the final and fully adjusted model. A sensitivity analysis was, therefore, performed by additionally adjusting the final model 2 for self-rated health (not shown in the tables). Self-rated health has previously been used to capture perceived health and is a major independent predictor of objective health, morbidity, and mortality (45). The sensitivity analysis did not change the overall results, and only changed the hazard ratio estimates for the 9 different tests slightly (0.001−0.003 points). This was somewhat expected since the fully adjusted model was already adjusted for previous LTSA and several diseases (ie, back disease, cancer including leukemia, chronic anxiety or depression, stroke, hypertension, myocardial infarction, and angina pectoris). However, it can't be ruled out that low physical capability in the present study may in some cases be an indicator of yet undiagnosed disease that per se may cause LTSA and disability pension. Because sickness absence may be on the causal pathway from low physical capability (exposure) to disability pension (outcome) it could be argued that controlling for previous LTSA (model 2) in the analysis with disability pension as endpoint is an over-adjustment. However, the fully adjusted model 2 will form the base for both

Table 3. The association of the nine measures of physical capability with risk of disability pension and long-term sickness absence (LTSA). [HR=hazard ratio; 95% CI=95% confidence intervals]. Significant associations in the fully adjusted model 2 are **marked in bold** (P<0.05).

Physical test	Capability	N	%	Disability pension				LTSA			
				Model 1 [a]		Model 2 [b]		Model 1 [a]		Model 2 [b]	
				HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Jump height	Mean	3096	69.8	1		1		1		1	
	High	656	14.8	0.73	0.25–2.10	1.28	0.42–3.91	0.71	0.56–0.89	0.79	0.62–1.01
	Low	682	15.4	4.63	2.62–8.17	**2.66**	**1.37–5.18**	1.69	1.41–2.02	**1.33**	**1.09–1.63**
Chair-rise	Mean	3063	66.7	1		1		1		1	
	High	768	16.7	0.42	0.15–1.19	0.29	0.07–1.22	0.83	0.68–1.01	0.94	0.76–1.16
	Low	760	16.6	4.33	2.71–6.91	**2.24**	**1.32–3.79**	1.39	1.18–1.65	1.08	0.90–1.30
Grip strength	Mean	3517	69.9	1		1		1		1	
	High	756	15.0	0.87	0.43–1.79	1.03	0.47–2.24	0.93	0.77–1.12	0.88	0.72–1.08
	Low	756	15.0	2.82	1.76–4.50	**2.00**	**1.19–3.35**	1.34	1.14–1.59	**1.21**	**1.01–1.44**
Explosive muscle force	Mean	3500	69.6	1		1		1		1	
	High	767	15.3	0.61	0.28–1.35	0.57	0.22–1.47	0.91	0.75–109	0.91	0.75–1.10
	Low	762	15.2	2.40	1.49–3.87	**1.88**	**1.13–3.13**	1.15	0.97–136	1.04	0.87–1.25
Back strength	Mean	2914	69.1	1		1		1		1	
	High	654	15.5	0.95	0.42–214	0.75	0.28–1.97	1.08	0.89–1.31	1.01	0.82–1.24
	Low	649	15.4	3.80	2.26–639	**2.81**	**1.59–4.98**	1.44	1.20–1.74	**1.32**	**1.08–1.61**
Abdominal strength	Mean	2976	69.9	1		1		1		1	
	High	660	15.5	0.86	0.38–1.94	0.65	0.26–1.62	1.19	0.98–1.45	0.94	0.76–1.16
	Low	621	14.6	3.43	2.04–5.76	**3.39**	**1.88–6.09**	1.51	1.25–1.82	**1.47**	**1.19–1.80**
Postural balance	Mean	3854	78.6	1		1		1		1	
	High	512	10.4	0.38	0.12–1.21	0.60	0.17–1.82	0.85	0.68–1.07	1.02	0.81–1.28
	Low	536	10.9	2.05	1.13–3.70	1.52	0.77–3.00	1.42	1.16–1.73	**1.30**	**1.05–1.60**
Aerobic fitness	Mean	913	69.5	1		1		1		1	
	High	196	14.9	1.26	0.35–4.52	1.32	0.30–5.74	1.04	0.75–1.44	0.98	0.68–1.41
	Low	204	15.5	4.23	1.80–9.98	**6.24**	**2.16–18.02**	1.12	0.81–1.55	1.13	0.78–1.63
Lung capacity	Mean	3568	71.0	1		1		1		1	
	High	741	14.7	0.37	0.13–1.01	0.39	0.12–1.25	0.77	0.63–0.94	**0.80**	**0.65–0.99**
	Low	717	14.3	2.85	1.81–4.49	**2.09**	**1.26–3.46**	1.60	1.36–1.88	**1.30**	**1.09–1.55**

[a] Adjusted for age and gender.
[b] Model 1 + education, lifestyle (body mass index, smoking), chronic diseases, physical and psychosocial work environment, previous LTSA.

Table 4. The association of the number of physical tests with low capability with risk of disability pension and long-term sickness absence (LTSA). [HR=hazard ratio; 95% CI=95% confidence intervals]. Significant associations in the fully adjusted model 2 are **marked in bold** (P<0.05).

Sum	N	Disability pension				LTSA			
		Model 1[a]		Model 2[b]		Model 1[a]		Model 2[b]	
		HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
0	2135	1		1		1		1	
1–2	2244	1.58	0.85–2.90	1.55	0.80–3.01	1.21	1.05–1.39	**1.20**	**1.03–1.39**
3–4	539	5.15	2.75–9.68	**3.16**	**1.56–6.43**	1.74	1.44–2.10	**1.39**	**1.14–1.70**
≥5	165	18.21	9.40–35.26	**8.52**	**3.98–18.25**	2.14	1.56–2.93	**1.42**	**1.01–2.01**

[a] Adjusted for age and gender.
[b] Model 1 + education, lifestyle (body mass index, smoking), chronic diseases, physical and psychosocial work environment, previous LTSA.

health-related outcomes for the discussion, in spite of the possible bias associated with over-adjustment in the analyses with disability pension as outcome.

A weakness of the study is the low response rate to the CAMB survey which could have introduced selection bias. Previous findings from the CAMB study found that respondents who filled in the questionnaire (31% of the invited 17 937 persons) and non-responders were comparable in regard to educational level and general health, whereas a larger proportion of respondents were employed (22). Further, Møller et al (37) showed that participants attending the physical examination (ie, the study sample for the present study) had significantly higher education, were more likely to be employed, whereas no statistically significant difference existed in use of the health care system compared to the non-responders/non-participants.

A weakness of the study is that psychosocial work environment was retrospectively evaluated to cover the whole working life and could, therefore, be prone to potential bias, in particular, recall bias. Asking participants to combine exposures during their working life in a single number for their average level of quantitative demands, decision authority, emotional demands, time pressure, role conflicts, possibilities for development, and appreciation is a very limited step towards a life course perspective (46). Hence, it is not possible to evaluate the influence of current psychosocial work environment (ie, at the point

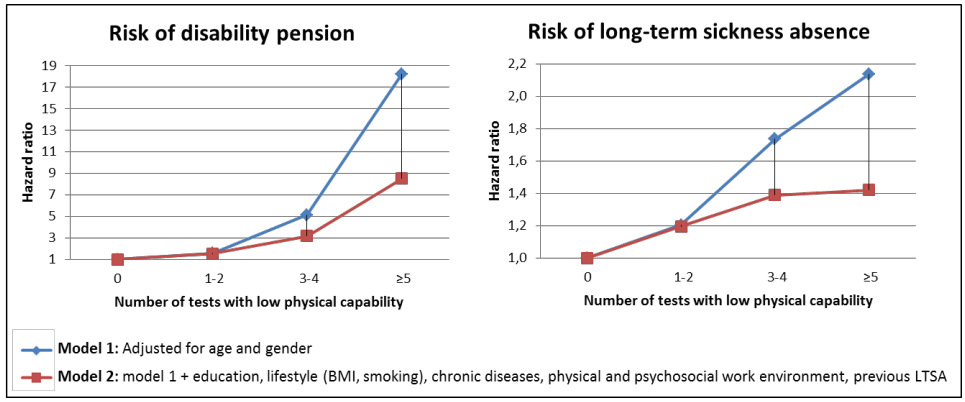

Figure 1. The association of the number of physical tests with low capability with risk of disability pension (left) and long-term sickness absence (right).

of data collection) on the association between physical capability and health-related labor market outcomes. In addition, cognitive ability (not related to psychosocial work environment) may influence the association between physical capability and health-related outcomes (16, 47). Thus, we controlled the analyses for educational attainment to provide a proxy for cognitive ability (cognitive ability in youth likely determines educational attainment). Unfortunately, we did not have a measure to cover age-related changes in cognitive ability which theoretically could have influenced the present results.

The low number of cases for disability pension is an important weakness to the study and could have introduced insufficient statistical power, thus increasing the risk of non-significant findings. Thus, wide confidence intervals for the risk estimates were observed in the analyses with disability pension as outcome measure (see table 3 and 4). Importantly, new reforms have made it more difficult to be granted a disability pension in Denmark and the average age to obtain a disability pension has increased from 45.8 years in 2011 to 48.1 years in 2015. Hence, there is a tendency for municipalities in Denmark to recognize fewer disability pensions after the introduction of the new reforms in 2012. However, highly statistically significant associations were still found between low capability and disability pension, indicating the existence of a true association. Nevertheless, this degree of uncertainty in regard to the risk estimates in the analyses with disability pension as outcome could still have influenced the overall results and may explain some of the observed difference in risk estimate-size and PAR between the analyses with disability pension and LTSA as outcome measures.

Interpretation of results

The study showed that low capability in the nine objective physical measures was associated with an increased risk of permanently or temporarily leaving the workforce due to poor health (ie, disability pension and LTSA, respectively). Previous studies employing both self-rated and objectively measured physical capability have observed an association between low physical capability and poor health. Rice et al (13) found that older workers from the English Longitudinal Study of Ageing with impaired self-rated physical mobility (ie, difficulty walking a quarter mile) were at increased risk of early work exit. Further, in a cross-sectional design, Borch-Supan et al (14) observed a significant deterioration of self-assessed health among older participants from the SHARE study who just started to receive disability benefits. However, this deterioration was much less pronounced when health was obtained more objectively by hand-grip strength, which indicates justification bias in self-assessed health (14). This is in agreement with Kalwij et al (15) emphasizing the need for objective health indicators when analyzing the relationship between health status and labor force participation. A study employing objectively measured physical capability showed that aerobic fitness (ergometer bicycle test) and handgrip muscle strength in late adolescence were independently and jointly associated with long-term risk of poor health such as vascular disease and arrhythmia (48). Additionally, Stafford et al (16) found that better physical capability (objectively measured by grip strength, chair-rise time, and one-legged balance test) was associated with greater likelihood of participating in bridge or voluntary employment after retirement from main occupation (self-reported). However, they found no association with performance-based physical capability score and retiring for negative reasons (ie, own health, partner's health, becoming a carer, bereavement, made redundant, unhappy with job or with working, work problems) (16). The present study elaborates on these previous findings by showing that low objectively measured physical capability increases

the risk for register-based disability pension and LTSA, whereas high capability was not associated with these health-related outcomes. Specifically, low jump performance, low abdominal muscle strength, low back muscle strength, and low aerobic fitness showed the highest risks estimates of disability pension.

To assess the combined effect of low capability in multiple tests, a physical capability composite score was created. The analyses showed a capability–response relationship between the number of physical tests with low capability and disability pension and LTSA ie, increased risk from exposure to a higher number of physical tests with low capability (table 4 and figure 1). Even though the time for physical capability assessment is limited in research and clinical settings, our results indicate a value of conducting a range of different capability tests (8, 16).

In general, we observed higher risk estimates in the analyses with disability pension as endpoint compared to LTSA. This was also reflected in the PAR analyses showing that 42% of the disability pension cases were attributable to low physical capability whereas this was the case for 12% of the LTSA cases. Both LTSA and disability pension reflects a complex interaction of health and work characteristics and can be a consequence of the scenario where requirements at work exceed individual resources. Even though both LTSA and disability pension is considered health-related labor market outcomes, differences may still exist that could assist the interpretation of the present results. Poor health is an established risk factor for leaving the labor market and disability pension seems to be preceded by sickness absence. However, sickness absence could to a larger extent be entitled to other causes than poor health such as social factors. Hence, health-related factors, such as physical capability, may influence the transition into disability pension (permanently unable to work due to ill health) and LTSA (temporarily unable to work due to ill health) differently. In line with this, a proportion of workers on LTSA will later return to work whereas disability pension is a social benefit for people with a significant and permanent loss of work ability (ie, with more severe and long lasting health problems). It should also be mentioned that the low number of cases and the accompanied wide CI could have introduced a degree of uncertainty in regard to the accuracy of the risk estimates in the analyses with disability pension as outcome.

The results show that low physical capability is associated with increased risk of LTSA and disability pension irrespectively of level of physical activity level at work. Hence, low physical capability may lead to an imbalance between individual capacity and work demands thereby challenging health and labor market participation among both workers engaged in physical and sedentary job tasks. In the present study sample, 53% reported sedentary job tasks, whereas the remaining reported moderate, hard or very hard physical work (see table 1). A previous study on the CAMB population showed that physical work during working life increased the risk of both LTSA and disability pension when compared to sedentary work (31). Even though physical work demands will likely show a small decrease in many industries (6–8), low physical capability may especially make it difficult for employees engaged in hard physical work to cope with the physical demands at work by challenging the physical reserve capacity (ie, the difference between physical work demands and physical capacity of the worker). Overall, the present study suggests that promoting physical capability among older workers with low capability may contribute to extend working lives. The PAR analyses indicated that >40% of all cases of disability pension in this study were attributable to low physical capability. Hence, a large proportion of disability pensions could theoretically be reduced by increasing physical capability in midlife or earlier. This could, for example, be achieved by promoting physical activity in the workplace, such as strength training. Previous research has shown that strength training in the elderly can increase muscle mass, strength, and functional performance (49). In addition, strength training at the workplace for 10–12 weeks has been shown effective for increasing physical capability in middle-aged workers, including grip strength, back strength and jump performance (50, 51). However, knowledge is lacking in physical activity interventions at the workplace specifically targeting older workers. Future longitudinal studies should investigate the effect of physical activity at the workplace for retaining older workers in the labor market.

Concluding remarks

Low physical capability was associated with increased risk of disability pension and LTSA whereas high capability was not associated with these health-related outcomes. Importantly, a capability–response association was observed between the number of physical tests with low capability and disability pension and LTSA. The results indicated that 42% of the disability pension cases were attributable to low physical capability whereas this was the case for 12% of the LTSA cases. Promoting physical capability among older workers with low capability may contribute to prolonged working careers.

Ethical approval

The Danish Data Protection Agency approved this study (j.nr. 2015-41-4232). The local ethical committee and the Danish Data Protection Agency have previously approved the CAMB as a database combining three cohorts: approval No. H-A-2008-126 and No. 2013-41-1814, respectively (22). Participants were informed

about the content and purpose of the CAMB study and gave their written informed consent to participate (22).

Availability of data and materials

The dataset that supports the findings of this study are available from the CAMB steering committee but restrictions apply to the availability of these data, which were used under license for the current study and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the CAMB steering committee.

Competing interests

None declared.

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