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The simple task of lifting five kilograms serves as a predictor of age-related disorders in old adults

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Muscle weakness is a risk factor for multiple diseases. However, most protocols to assess muscle weakness require clinical settings. A difficulty lifting 5 kg may be a simple measure of muscle weakness in domestic settings. However, no relevant study on assessing muscle weakness has been reported. We investigated the associations of difficulty lifting 5 kg with various musculoskeletal, cardiovascular, metabolic, and neurological diseases in geriatric adults aged 50 or above from 15 countries (n = 51,536) over five years. The data was collected by the Survey of Health, Ageing, and Retirement in Europe (SHARE) conducted between 2013 and 2020. Overall, 10,025 (19.5%) respondents exhibited difficulty lifting 5 kg at baseline in 2013. Over the next four years, these respondents exhibited higher risks for developing a low quality of life (QoL) (9.42%), depression (8.14%), low handgrip strength (7.38%), and osteoarthritis (6.98%) after adjusting for age and gender. Additionally, these respondents exhibited mild to moderate risks for developing rheumatoid arthritis, heart attack, diabetes mellitus, hypertension, Alzheimer's disease, stroke, or hip fracture (all p < 0.05). After adjusting for age and country, the risks of developing various diseases were higher in men than in women. Collectively, difficulty lifting 5 kg can herald the onset of several cardiovascular, neurological, and musculoskeletal disorders along with a reduced QoL. We suggest that difficulty lifting 5 kg may be a valuable indicator of muscle weakness and poor health in domestic settings.

Physiological aging is associated with a progressive loss of muscle strength in both genders[1]. It is generally recognized that muscle weakness in these patients is associated with an increased risk of several age-related diseases[2]. Muscle weakness in old age exhibits significant prognostic potential for cardiovascular, nervous, gastrointestinal, renal, skeletal, and respiratory diseases[3]. Consequently, muscle weakness increases the risk of hospitalization, functional disability, and mortality. A bidirectional interface is proposed so muscle weakness increases disease severity and vice versa[4]. Thus, a timely identification of individuals with muscle weakness may be imperative to improve desirable patient outcomes.

In most diseases, muscle weakness may precede muscle atrophy, establishing its efficacy in predicting and monitoring disease outcomes[5]. In addition, muscle weakness appears superior to muscle wasting in predicting survival and disability in older adults[6]. Due to its prognostic potential, muscle weakness is considered a preliminary sign of sarcopenia or age-related muscle decline by the European Working Group on Sarcopenia in Older People (EWGSOP2)[7]. Handgrip strength (HGS) measurement is a simple test to investigate muscle weakness. The measurement involves squeezing a hand-held dynamometer with the maximal possible strength. A low HGS may help predict several age-related diseases, such as cancer, stroke, metabolic disorders, osteoporosis, and cardiac failure[8].

Normative values for HGS are described for various countries[9]. However, significant differences exist in the HGS values across regions. For example, the average HGS values for men aged 61–70 are 42 kg among Europeans but only 27 kg among South Asians[9]. The variations in socioeconomic status, ethnicities, dietary patterns, and lifestyles may partly account for these differences in HGS. In addition, the instruments for measuring HGS may

vary across countries. Most relevant studies involve four types of HGS dynamometers, including hydraulic, pneumostatic, spring-type, and strain hand dynamometers[10]. However, the comparative studies report inconsistencies among their readings, questioning the reliability and validity of these dynamometers[10,11]. In addition, variable prices, limited access to purchase channels, and constant maintenance and calibration may hinder the suitability of these dynamometers for domestic usage.

Thus, it may be imperative to perform a simple and preliminary evaluation of muscle strength before standardized testing, including HGS measurements and laboratory investigations. An ability to lift 5 kg of weight may be a simple and transparent measure of muscle strength in most domestic and clinical settings. This test is inexpensive and can be performed with multiple household objects. It is plausible that this test may be associated with muscle weakness and various age-associated diseases similar to HGS measurement. However, such an investigation has never been reported before.

This study aimed to evaluate the associations of muscle weakness, as determined by difficulty lifting 5 kg of weight, with the future development of various health conditions. The 5-kg threshold was selected due to its relevance to everyday household objects, such as a standard bag of sugar or all-purpose flour, an average house cat, an air fryer, a portable slow cooker, and the cast iron Dutch oven. Thus, the study provides a practical and accessible measure of muscle strength and overall health within the domestic environment. We used a longitudinal cohort study design to investigate the prognostic value of self-reported difficulty lifting 5 kg of weight for several age-related diseases and quality of life (QoL) among older adults from 15 countries.

This study used the standardized Survey of Health, Ageing, and Retirement in Europe (SHARE) dataset[12]. Participants aged 50 and older were recruited due to their relevance to age-related disorders. Fifteen geographically proximate countries with relatively homogenous racial, cultural, and ethnic profiles were selected for inclusion. This selection was further supported by our prior research indicating a similar prevalence of muscle weakness among older adults in these countries[13]. We hypothesized that difficulty lifting 5 kg of weight will be associated with a significantly higher risk of developing several age-related degenerative, metabolic, and proliferative diseases in an age- and gender-specific manner in the geriatric population of 15 countries from Europe and the Middle East.

Materials and methods

The SHARE dataset comprises a harmonized longitudinal panel survey conducted on individuals aged 50 years and older across multiple European countries and Israel[14]. Data collection occurred through computer-assisted personal interviews (CAPI), covering various domains, such as demographic characteristics, socioeconomic indicators, living conditions, and physical and mental health. For this analysis, the baseline dataset utilized was derived from the fifth wave of SHARE conducted in 2013. Follow-up information on the participants' health was provided in subsequent SHARE waves (6, 7, and 8) conducted in 2015, 2017, and 2019/2020, respectively, as described on the SHARE website[15]. The sample encompasses 15 countries: Austria, Germany, Sweden, Netherlands, Spain, Italy, France, Denmark, Switzerland, Belgium, Israel, Czech Republic, Luxembourg, Slovenia, and Estonia.

The experimental protocols described in this study were approved by the ethics board of Max-Planck-Society (Germany). Information and documentation on the ethics approval is available on the SHARE website (see FAQ Sect. 3.11 https://share-eric.eu/data/faqs-support. All experiments were carried out in accordance with relevant guidelines and regulations. A written informed consent was obtained from all study participants.

The detailed exclusion criteria are previously described[14]. Briefly, individuals were excluded if they were incarcerated, hospitalized, or out of the country for the entire survey period, unable to speak the country's language(s), or had moved to an unknown address. All SHARE respondents previously interviewed in the longitudinal study were traced and re-interviewed if they moved within the country[14].

Respondents were asked to report if they had any difficulty doing various everyday activities. Difficulties that were expected to last less than three months at the time of responses were excluded. One of the activities was "lifting or carrying weights over 5 kilos", which is the central indicator in this analysis. Difficulties in lifting 5 kg, age (10 years intervals), gender, and country of residence were the baseline information obtained from wave 5.

The evaluation of HGS was conducted utilizing a hand-held dynamometer. Participants were directed to press the dynamometer using their left and right hands, with each repetition performed twice. The highest recorded value from the four measurements were utilized for subsequent analysis. Low HGS was categorized according to gender-specific thresholds as defined by the guidelines established by the EWGSOP2, with a threshold of 27 kg for men and 16 kg for women[7].

The quality of life (QoL) was assessed using the CASP-12 index, which covers four dimensions (Control, Autonomy, Self-realization, and Pleasure), each with 3 questions[12]. The sample questions are: (1) How often do you think your age prevents you from doing the things you would like to do? (2) How often do you think that shortage of money stops you from doing the things you want to do? (3) How often do you feel that the future looks good for you? Participants were instructed to assess the frequency of specific feelings or thoughts using response categories "often," "sometimes," "rarely," or "never." Based on numerical scores of 1 (often) to 4 (never), the CASP-12 index was generated by the sum of the scores from the 12 indicators. Consequently, the index ranged from 12 (indicating minimum well-being) to 48 (maximum well-being). For the present study, an indicator for low well-being was generated, defined by scores less than or equal to 29.

Depressive symptoms were assessed utilizing the Euro-D depression scale[16]. Euro-D is an additive index based on the number of reported depressive symptoms. A total of 12 symptoms were asked, including sadness, having no hopes for the future, sleep disturbances, feelings of guilt, irritability, and loss of appetite. The Euro-D scale scores ranged from 0 to 12, with higher scores indicating more significant depressive symptoms. For the present study, an indicator for high depression level was generated, defined by scores greater than or equal to 6.

All other medical conditions were collected through a list of diseases presented to the respondents, who indicated whether they had these conditions or if they had received a doctor's diagnosis: heart attack (including myocardial infarction or coronary thrombosis or any other heart problem including congestive heart failure); chronic lung diseases; hip fracture; rheumatoid arthritis; high blood pressure or hypertension; high blood cholesterol; diabetes or high blood sugar; cancer or malignant tumours (including leukaemia or lymphoma, but excluding minor skin cancers); Alzheimer's disease, dementia, organic brain syndrome, senility or any other serious memory impairment; stroke or cerebral vascular disease; osteoarthritis or other rheumatism.

The gross sample size was 51,536, with demographic details about gender and age. However, we found missing information about various diseases and conditions, either because the respondent could not answer, or did not want to answer, or simply did not know the answer. The number of missing observations varied for various diseases and ranged from 687 (Alzheimer's disease) to 20,557 (high blood pressure). The respondents with missing information were excluded in relevant analysis as is evident by the varying displayed sample sizes for individual diseases or conditions in Table 1.

Statistical analysis

Multiple regression analyses were employed to identify the associations of the difficulty of lifting 5 kg on the risk of future medical conditions. To ease the interpretation of estimated parameters, we apply a linear probability model[17] with robust standard errors, as described by the following regression equation:

$$\pi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \epsilon$$

Here, π represents the risk of a medical condition, for example, high blood pressure. The variables $X_1, X_2, \ldots, X_k$ represent baseline characteristics (gender, age, and difficulties lifting 5 kg, etc.) influencing the medical condition, while $\beta_1, \beta_2, \ldots, \beta_k$ denote the corresponding effects. The symbol ϵ accounts for the error term. Estimated parameters are presented as percentage points change (fraction) in the risk of a given condition. The relative risk ratio (RRR) was measured as RRR = (estimate + average risk) / (average risk) = $\left(\hat{\beta} + \overline{\pi}\right)/\overline{\pi}$. An alternative is to use the probit or logit models, but their estimated parameters are not easily interpretable without a transformation into probabilities. Statistical analyses were performed using STATA software package version 18.0 (StataCorp LLC, College Station, TX).

	All			Can lift 5kg			Can not lift 5 kg		
	%	SD	n	%	SD	n	%	SD	n
Female	56.1	0.496	51,536	51.5	0.500	41,511	75.1	0.432	10,025
Age									
50–59	11.3	0.317	51,536	12.5	0.331	41,511	6.4	0.244	10,025
60–69	35.4	0.478	51,536	38.1	0.486	41,511	24.1	0.428	10,025
70–79	31.8	0.466	51,536	32.5	0.468	41,511	28.9	0.453	10,025
80–89	17.5	0.380	51,536	14.5	0.353	41,511	30.0	0.458	10,025
90 +	4.0	0.195	51,536	2.3	0.151	41,511	10.7	0.309	10,025
Difficulty lifting 5 kg	19.5	0.396	51,536	0.0	0	41,511	100	0	10,025
Handgrip strength, low	6.4	0.245	43,481	4.8	0.213	37,002	15.7	0.363	6479
Quality of life, low	7.5	0.263	43,234	5.6	0.231	36,675	17.6	0.381	6559
Euro depression scale, high	7.5	0.264	33,326	5.9	0.236	28,348	16.6	0.372	4978
Heart attack	7.2	0.259	43,161	6.5	0.246	36,158	10.9	0.312	7003
Chronic lung diseases	4.1	0.199	48,519	3.6	0.187	39,592	6.4	0.244	8927
Hip fracture	1.8	0.134	49,864	1.5	0.120	40,580	3.5	0.183	9284
Rheumatoid arthritis	6.8	0.252	46,773	5.6	0.231	38,884	12.6	0.332	7889
High blood pressure	21.5	0.411	30,979	20.6	0.405	26,176	26.2	0.440	4803
High blood cholesterol	14.6	0.353	39,288	13.9	0.346	32,399	17.9	0.384	6889
Diabetes or high blood sugar	5.8	0.233	45,007	5.3	0.225	36,954	7.9	0.269	8053
Cancer	4.6	0.210	47,129	4.6	0.210	38,292	4.7	0.212	8837
Alzheimer's disease	3.1	0.172	50,849	2.3	0.149	41,258	6.5	0.247	9591
Stroke	3.3	0.179	48,554	2.9	0.167	39,818	5.2	0.223	8736
Osteoarthritis	14.4	0.351	42,170	13.1	0.337	35,311	21.2	0.409	6859

Table 1. Summary statistics for all variables from all respondents and statistics based on the presence or absence of difficulty lifting 5 kg in the baseline year. All variables are binary and take either the value 0 or 1, and thus, any average for the variable will be between 0 and 1 and can be interpreted as the percentage with a given characteristic. The data for gender, age, and difficulty lifting 5 kg is taken from the base year 2013 (SHARE wave 5). All the other variables representing mental health or disease are from the subsequent years, 2014–2020 (SHARE waves 5–8).

Results

The essential characteristics of the study population are described in Table 1. Information on gender, age, and lifting 5 kg was obtained from the baseline year 2013. A total of 51,536 respondents were included in the study, of which 41,511 (80.5%) respondents had no difficulty lifting 5 kg at the baseline year in 2013, while 10,025 (19.5%) respondents exhibited difficulty lifting 5 kg. Women represented 56.1% of the study population. The youngest age group, aged 50–59 years, represented 11.3%, while the oldest age group, 90 or above, represented 4% of the study population (Table 1). For a given disease, we excluded the participants who already had the disease at the baseline year of 2013. Thus, the sample sizes varied for various diseases. For example, 30,979 out of the 51,536 participants did not suffer from high blood pressure in 2013. However, 21.5% of respondents developed high blood pressure between 2014 and 2020. Among those with difficulty lifting 5 kg in 2013, 26.2% of participants developed high blood pressure in the subsequent years. Conversely, among those with no difficulty lifting 5 kg in 2013, 20.6% of the respondents developed high blood pressure in subsequent years (Table 1). Further, 49,864 respondents had no hip fracture in 2013. However, 1.8% of them developed hip fractures during subsequent years. Among those with difficulty lifting 5 kg, 3.5% of respondents developed hip fractures. Conversely, among those with no difficulty lifting 5 kg, 1.5% of respondents developed hip fractures in subsequent years (Table 1).

Figure 1 represents the estimated higher risks for developing a given disease in 2014–2020 for the respondents with difficulty lifting 5 kg in 2013 after controlling for gender, age, and country of residence. The most significant effect was observed for developing a low QoL, where the risk increased by 9.42% points (95% C.I = 8.47–10.37% points). We also observed significant increased risks of developing depression (8.14% points, 95% CI = 7.05–9.23%), low HGS (7.38% points, 95% CI = 6.52–8.24%), and osteoarthritis (6.98% points, 95% CI = 5.93–8.03%) (Fig. 1). Conversely, the increased risk of developing stroke (1.78% points, 95% CI = 1.27–2.29%) and hip fracture (1.16% points, 95% CI = 0.77–1.55%) were low among respondents with difficulty lifting 5 kg (Fig. 1).

We next investigated the risks of developing given diseases among participants with difficulty lifting 5 kg in the baseline year, based on age and gender (Tables 2–5). We divided the men and women into two age groups, including 50–65 years and 66 and above. Among men aged 50–65, difficulty lifting 5 kg was associated with a significantly higher risk of developing all investigated diseases except cancer (Table 2). The highest relative risk ratio (RRR) was observed for developing depression (RRR = 3.42) among respondents with difficulty lifting 5 kg. We also observed significantly higher risks for developing low QoL (RRR = 3.16), low HGS (RRR = 2.69), and Alzheimer's disease (RRR = 2.59) (Table 2).

Among women aged 50–65, difficulty lifting 5 kg was associated with significantly higher risks of developing all diseases except cancer and hip fracture (Table 3). The highest RRR was obtained for a low HGS (RRR = 2.81), followed by poor QoL (RRR = 2.28), Alzheimer's disease (RRR = 2.06), and high depression (RRR = 2.03) (Table 3). Similarly, among men aged 66 or above, difficulty lifting 5 kg increased the risk of developing all investigated
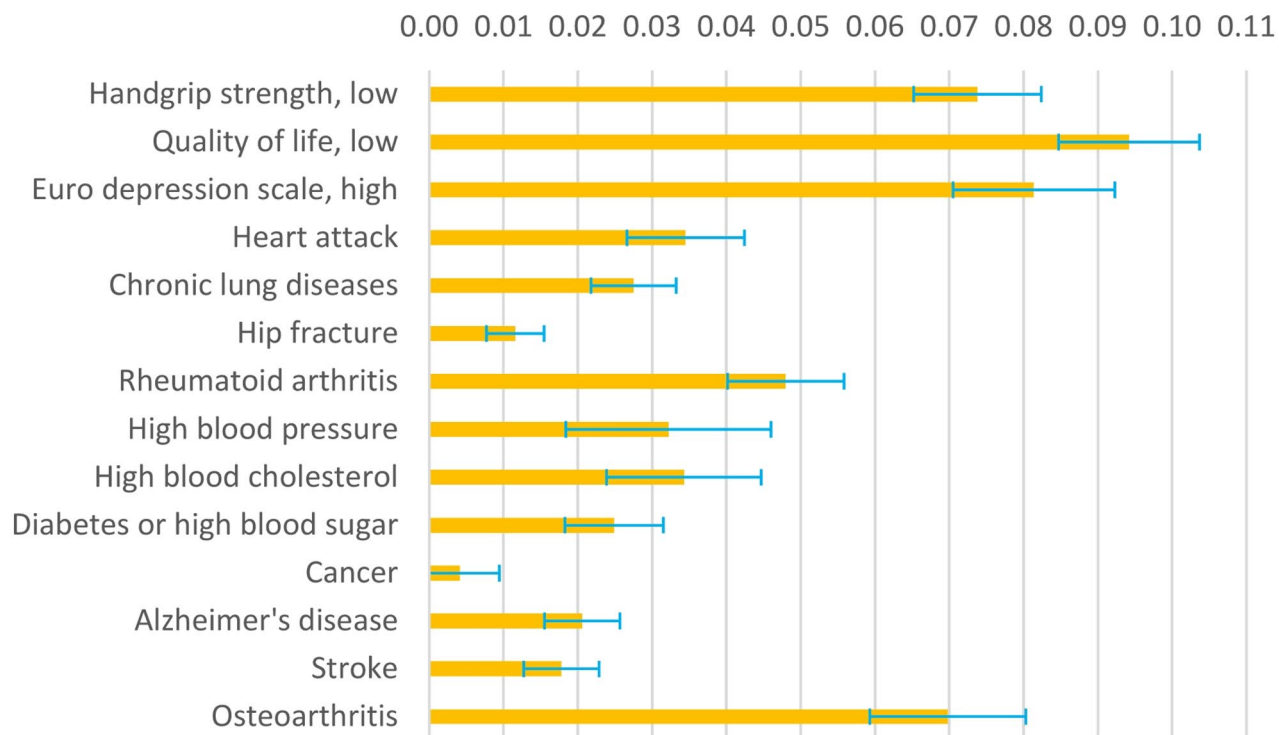

Fig. 1. Regression coefficients and 95% confidence intervals from all respondents with difficulty lifting 5-kg on the incidence of various musculoskeletal, metabolic, cardiovascular, and neurological diseases. The CI for cancer has been truncated from a slightly negative value to 0.

	Effect of difficulty lifting 5 kg					Relative	Sample
	Estimate	95% confidence interval		R-square	Average	Risk Ratio	size
	β	Lower	Upper	R²	Risk	RRR	n
Handgrip strength, low	0.0321 ***	0.0147	0.0495	0.010	0.0190	2.69	10,390
Quality of life, low	0.0998 ***	0.0704	0.1292	0.032	0.0462	3.16	10,062
Euro depression scale, high	0.0917 ***	0.0596	0.1238	0.020	0.0378	3.42	7530
Heart attack	0.0642 ***	0.0362	0.0922	0.007	0.0633	2.01	10,001
Chronic lung diseases	0.0351 ***	0.0158	0.0544	0.005	0.0360	1.97	10,715
Hip fracture	0.0111 *	0.0009	0.0213	0.003	0.0096	2.16	11,083
Rheumatoid arthritis	0.0488 ***	0.0274	0.0702	0.024	0.0409	2.19	10,769
High blood pressure	0.0537 *	0.0121	0.0953	0.021	0.1976	1.27	7561
High blood cholesterol	0.0499 **	0.0164	0.0834	0.014	0.1359	1.37	8875
Diabetes or high blood sugar	0.0383 **	0.0142	0.0624	0.008	0.0609	1.63	10,018
Cancer	0.0140	-0.0031	0.0311	0.006	0.0433	1.32	10,731
Alzheimer's disease	0.0120 *	0.0022	0.0218	0.004	0.0076	2.59	11,237
Stroke	0.0259 **	0.0090	0.0428	0.008	0.0252	2.03	10,826
Osteoarthritis	0.0422 **	0.0157	0.0687	0.041	0.0954	1.44	10,031
Average, simple	0.0442	0.0208	0.0676	0.015	0.0585	2.09	9988

Table 2. The incidence regressions of 14 diseases among men aged 50–65 during 2014–2020, based on the difficulty lifting 5 kg in 2013. A linear probability regression model with robust standard errors was estimated for each of the 14 diseases. Incidence implies that the respondent did not have the disease in the baseline year (2013). P-values: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Effect of difficulty lifting 5 kg					Relative	Sample
	Estimate	95% confidence interval		R-square	Average	Risk Ratio	size
	β	Lower	Upper	R²	Risk	RRR	n
Handgrip strength, low	0.0375 ***	0.0275	0.0475	0.018	0.0207	2.81	13,417
Quality of life, low	0.0663 ***	0.0519	0.0807	0.029	0.0517	2.28	13,139
Euro depression scale, high	0.0696 ***	0.0513	0.0879	0.021	0.0674	2.03	9676
Heart attack	0.0224 ***	0.0124	0.0324	0.008	0.0345	1.65	13,824
Chronic lung diseases	0.0290 ***	0.0191	0.0389	0.008	0.0316	1.92	14,112
Hip fracture	0.0045	-0.0001	0.0091	0.002	0.0084	1.53	14,601
Rheumatoid arthritis	0.0554 ***	0.0413	0.0695	0.036	0.0617	1.90	13,557
High blood pressure	0.0381 ***	0.0165	0.0597	0.022	0.1630	1.23	10,355
High blood cholesterol	0.0440 ***	0.0255	0.0625	0.018	0.1311	1.34	11,911
Diabetes or high blood sugar	0.0250 ***	0.0140	0.0360	0.010	0.0416	1.60	13,639
Cancer	0.0059	– 0.0029	0.0146	0.003	0.0343	1.17	13,724
Alzheimer's disease	0.0067 **	0.0022	0.0111	0.003	0.0063	2.06	14,763
Stroke	0.0136 ***	0.0071	0.0201	0.004	0.0130	2.05	14,402
Osteoarthritis	0.0854 ***	0.0652	0.1056	0.056	0.1453	1.59	12,150
Average, simple	0.0360	0.0236	0.0483	0.017	0.0579	1.80	13,091

Table 3. The incidence regressions of 14 diseases among women aged 50–65 during 2014–2020, based on the difficulty lifting 5 kg in 2013. P-values: ** $p < 0.01$, *** $p < 0.001$.

diseases except cancer and heart attack. The highest RRR was observed for developing a poor QoL (RRR = 2.49), followed by high depression (RRR = 2.25) and low HGS (RRR = 2.18) (Table 4). Next, among women aged 66 or above, difficulty lifting 5 kg increased the risk of all diseases except cancer and high blood pressure. The highest RRR was observed for poor QoL (RRR = 1.81), followed by low HGS (RRR = 1.76) and high depression (RRR = 1.65) (Table 5).

Lastly, we presented an average disease effect based on all the diseases investigated in this study. We found that the risk of developing diseases was higher in men than women for a given age group. For example, among the respondents aged 50–65, RRR for the average disease effect was 2.09 in men (Table 2) and 1.8 in women (Table 3). Similarly, for the respondents aged 66 or above, the RRR for the average disease effect was 1.57 for men (Table 4) and 1.41 for women (Table 5).

	Effect of difficulty lifting 5 kg					Relative	Sample
	Estimate	95% confidence interval		R-square	Average	Risk Ratio	size
	β	Lower	Upper	R²	Risk	RRR	n
Handgrip strength, low	0.1420 ***	0.1138	0.1702	0.116	0.1204	2.18	9158
Quality of life, low	0.1340 ***	0.1073	0.1607	0.073	0.0902	2.49	9229
Euro depression scale, high	0.0859 ***	0.0596	0.1122	0.035	0.0690	2.25	7496
Heart attack	0.0187	-0.0050	0.0424	0.008	0.1145	1.16	8329
Chronic lung diseases	0.0322 ***	0.0167	0.0477	0.006	0.0569	1.57	10,513
Hip fracture	0.0097 *	0.0009	0.0186	0.005	0.0198	1.49	10,901
Rheumatoid arthritis	0.0263 **	0.0099	0.0427	0.035	0.0622	1.42	10,501
High blood pressure	0.0624 ***	0.0267	0.0981	0.026	0.2667	1.23	6160
High blood cholesterol	0.0314 *	0.0067	0.0561	0.010	0.1569	1.20	8451
Diabetes or high blood sugar	0.0245 **	0.0068	0.0422	0.014	0.0749	1.33	9415
Cancer	0.0065	-0.0082	0.0212	0.004	0.0684	1.10	10,080
Alzheimer's disease	0.0417 ***	0.0259	0.0575	0.035	0.0521	1.80	11,118
Stroke	0.0225 **	0.0073	0.0377	0.005	0.0548	1.41	10,353
Osteoarthritis	0.0420 ***	0.0216	0.0624	0.041	0.1255	1.33	9663
Average, simple	0.0486	0.0279	0.0693	0.030	0.0952	1.57	9383

Table 4. The incidence regressions of 14 diseases among men aged 66 or above during 2014–2020, based on the difficulty lifting 5 kg in 2013. P-values: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Effect of difficulty lifting 5 kg					Relative	Sample
	Estimate	95% confidence interval		R-square	Average	Risk Ratio	size
	β	Lower	Upper	R²	Risk	RRR	n
Handgrip strength, low	0.0873 ***	0.0717	0.1029	0.110	0.1148	1.76	10,516
Quality of life, low	0.0941 ***	0.0786	0.1096	0.071	0.1157	1.81	10,804
Euro depression scale, high	0.0793 ***	0.0613	0.0973	0.044	0.1215	1.65	8624
Heart attack	0.0419 ***	0.0285	0.0553	0.016	0.0951	1.44	11,007
Chronic lung diseases	0.0245 ***	0.0159	0.0331	0.005	0.0434	1.56	13,179
Hip fracture	0.0154 ***	0.0080	0.0228	0.011	0.0354	1.44	13,279
Rheumatoid arthritis	0.0478 ***	0.0344	0.0612	0.053	0.1056	1.45	11,946
High blood pressure	− 0.0069	− 0.0308	0.0171	0.024	0.2660	0.97	6903
High blood cholesterol	0.0210 *	0.0044	0.0376	0.012	0.1645	1.13	10,051
Diabetes or high blood sugar	0.0188 ***	0.0087	0.0289	0.014	0.0604	1.31	11,935
Cancer	0.0020	− 0.0060	0.0101	0.002	0.0441	1.05	12,594
Alzheimer's disease	0.0207 ***	0.0116	0.0298	0.040	0.0583	1.36	13,731
Stroke	0.0171 ***	0.0088	0.0254	0.006	0.0446	1.38	12,973
Osteoarthritis	0.0797 ***	0.0613	0.0981	0.051	0.2073	1.38	10,326
Average, simple	0.0388	0.0255	0.0521	0.033	0.1055	1.41	11,276

Table 5. The incidence regressions of 14 diseases among women aged 66 or above during 2014–2020, based on the difficulty lifting 5 kg in 2013. P-values: * $p < 0.05$, *** $p < 0.001$.

Discussion

In this large-scale study of 51,536 geriatric adults from 14 European countries and Israel, we report significant associations of a self-reported difficulty to lift 5 kg of weight with several chronic diseases and reduced QoL. Specifically, difficulty in lifting 5 kg of weight was associated with increased risks of a deficient QoL, higher scores on the Euro depression scale, chronic lung diseases, hip fracture, rheumatoid arthritis, high blood cholesterol, Alzheimer's disease, stroke, and osteoarthritis irrespective of age and gender. Conversely, similar associations were not found between difficulty lifting 5 kg of weight and the risk of diabetes mellitus or cancer.

We observed an elevated risk of developing low HGS among participants with difficulty lifting 5 kg in both age groups and genders. This observation is consistent with the fact that lifting 5 kg of weight primarily requires the contraction of handgrip muscles. We used the cut-off values of 27 kg for men and 16 kg for women as defined by the EWGSOP2[7]. Conversely, the weight of 5 kg was used for both genders. Despite this discrepancy, the risk of developing low HGS was similar between genders aged 50–65. On the other hand, men aged 66 or above exhibited a higher risk of developing low HGS than women of the same age with difficulty lifting 5 kg of weight.

Men have stronger muscles than women due to anabolic hormones. Thus, difficulty in lifting a similar weight indicates significantly more muscle weakness in men than in women, which is consistent with our observation among participants aged 66 or above. Interestingly, we also observed that the coupling between the difficulty in lifting 5 kg of weight and the risk of developing low HGS was stronger after 65 years of age. This finding is consistent with age-related muscle degeneration, which reflects the loss of muscle mass and strength.

Several mechanisms explain the association between difficulty lifting 5 kg of weight and the diseases investigated in this study. First, muscle weakness in these participants suggests a sedentary lifestyle and low physical activity[18], which are risk factors for several diseases reported here[19]. For example, a sedentary lifestyle is associated with higher risks of depression, cardiovascular diseases, metabolic disorders, and neurological deficits. It is also known that muscle weakness and low levels of physical fitness track in childhood and/or adolescence into advanced age[20]. Second, a significant coupling exists between muscle strength and mass. Thus, participants with difficulty lifting 5 kg will likely exhibit muscle wasting. Muscle mass is a significant protein reserve that protects against organ degeneration due to trauma, diseases, and/or aging[21]. Thus, a low muscle mass in the participants with difficulty lifting 5 kg of weight can predispose them to develop chronic diseases. Third, significant associations of muscle weakness are reported with systemic inflammation. It is also established that chronic low-grade inflammation can cause and/or exacerbate various cardiovascular, neurological, and metabolic disorders reported in this study. Fourth, a causal interface is described between muscle weakness and oxidative stress[22]. Thus, individuals with muscle weakness may have elevated oxidative stress and vice versa. It is generally recognized that oxidative stress contributes to several systemic diseases[23]. Thus, difficulty lifting 5 kg of weight may increase the risk of developing chronic diseases.

Among various conditions, a low QoL and higher scores on the Euro depression scale exhibited the most robust associations with difficulty in lifting 5 kg of weight. The association between muscle weakness and poor QoL is well-recognized[24]. We have also previously reported reduced QoL in older adults with reduced HGS[25]. We used the CASP-12 survey here, an internationally standardized tool to measure QoL. A positive association between HGS and CASP-12 has been reported in both genders[26], which is consistent with our observation of poor QoL in patients with difficulty lifting 5 kg of weight. The association between poor QoL and muscle weakness is probably attributed to a dependence on the activities of daily living in these patients due to muscle weakness. CASP-12 investigates autonomy, control, pleasure, and self-realization, which are partly dependent on functional and healthy muscles.

A negative correlation between HGS and depression is well established[27]. Thus, the patients with reduced HGS exhibit a higher prevalence of depression and vice versa[27]. Consistent with these findings, we observed a higher risk of depression in participants with difficulty lifting 5 kg of weight. These participants also exhibited cognitive impairment, as evidenced by a higher risk of developing Alzheimer's disease (AD). This observation agrees with our previous reports of associations between low HGS and AD in older adults[28]. The potential mechanisms associating difficulty in lifting 5 kg of weight with depression and AD may involve altered body biochemistry and lifestyle changes[27]. Muscle strength is negatively influenced by hormonal imbalance, systemic inflammation, and oxidative stress. These factors are also attributed to a higher risk of developing depression and AD[27]. In addition, the sedentary lifestyle in patients with muscle weakness can also increase the risks of acquiring depression and AD[27].

The difficulty of lifting 5 kg of weight also emerged as a risk factor for rheumatoid arthritis (RA) and osteoarthritis. Both diseases share inflammation as a common pathophysiology with muscle weakness[29]. These participants had established muscle weakness before they developed joint diseases. Thus, muscle weakness and the difficulty in lifting 5 kg weight appear to precede RA and osteoarthritis and exhibit prognostic potential for these diseases. In addition, the association of the difficulty of lifting 5 kg with hip fracture supports the established coupling between muscle and bone health. However, it must be noted that RA, which primarily affects the small joints of the hands, may remain subclinical for a considerable time before an established clinical diagnosis is made. Thus, we cannot rule out that a subclinical RA may have contributed to the difficulty of lifting 5 kg of weight at baseline in the study participants.

Participants with difficulty lifting 5 kg weight also exhibited higher risks for developing several cardiovascular diseases, including high blood pressure, heart attack, high blood cholesterol, and stroke. This observation is supported by previous reports that associate low HGS with an elevated risk of morbidity and mortality due to cardiovascular diseases[30].

Previous observations based on large population-based studies suggest inconsistent associations of HGS with cancer and cancer mortality[3,31]. Several factors may explain the disjunction between muscle weakness and cancer. We considered all types of cancers without consideration for individual cancer types. Previous studies suggest an association of muscle weakness with cancer in a cancer-specific manner. For example, a low HGS was associated with breast cancer in women and colorectal cancer in men[31]. However, the association between muscle weakness and cancer may be neutralized when all cancer types are pooled together. In addition, nutritional status and the use of specific gender-specific cut-offs for low HGS also affect the associations between muscle weakness and cancer risk[31]. We did not investigate the nutritional status of participants and considered a similar weight of 5 kg to evaluate muscle weakness in both genders, which may have influenced our observation. However, the HGS cut-off values for muscle weakness differ between men and women[7]. Thus, using different weights for men and women in this study may have been pertinent. Lastly, age-related muscle weakness may conceal cancer-related muscle weakness in advanced age[31].

The major strength of this study is that it has a large representative sample from 14 European countries and Israel. The longitudinal design of the study enhances our confidence in the associations of muscle weakness with various diseases. All data was collected in a harmonized way across multiple European settings using the standardized SHARE questionnaire. However, this study has some limitations. The difficulty of lifting 5 kg of weight was self-reported. The normal HGS is lower in women than men[7]. However, we used 5 kg of weight as a

tool to evaluate muscle weakness without discrimination for gender. We did not consider BMI and muscle mass while considering muscle weakness. Some participants may have subclinical illnesses during the assessment, which were overlooked in this study. A mild to moderate heterogeneity across various European countries may have partly affected our observations. Several participants had multiple comorbidities, which may affect our observations more than individual comorbidities' cumulative effects. Lastly, the selective survival of the study participants may have influenced our data.

In conclusion, we report that a simple dysfunction, such as difficulty lifting 5 kg of weight, can herald the onset of several cardiovascular, neurological, and musculoskeletal disorders along with reduced QoL or mental health. We suggest that difficulty lifting a 5-kg weight may be used as an easy initial preliminary quick and transparent marker of muscle weakness before more sophisticated tools, such as an HGS dynamometer, are employed to assess muscle weakness. Our findings provide an effective, simple, inexpensive, and user-friendly assessment tool for muscle weakness in high-risk individuals in domestic and clinical settings.

Data availability

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Author contributions

Conceptualization; R.Q, M.H, A.K, F.A, F.F, A.A, M.A. & S.A. Data curation; M.H & F.F. Formal analysis; M.H & F.F, Funding acquisition; M.A. & S.A. Investigation; R.Q, M.H, A.K, F.A, F.F, A.A, & S.A. Methodology; M.H & F.F. Project administration; R.Q, M.H, A.K, F.A, F.F, A.A, M.A & S.A. Resources; R.Q, M.H, A.K, F.A, F.F, A.A, M.A & S.A. Supervision; R.Q, M.H, A.K, F.A, F.F, A.A, & S.A. Validation; M.H, & F.F, Writing—original draft; R.Q, M.H, A.K, F.A, F.F, A.A, M.A & S.A. Writing—review & editing; R.Q, M.H, A.K, F.A, F.F, A.A, M.A & S.A.

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Declarations

Competing interests

The authors declare no competing interests.

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