

Grip Strength Differences among Individuals Aged 50 Years and Older From 28 European Countries: The SHARE Study

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Abstract Background: During the aging process, grip strength (GS) tends to decrease, which is associated with disability and mortality. The current study investigated the GS differences among older individuals aged 50 years and over from 28 European countries, analyzing data from the Survey on Health, Ageing and Retirement in Europe (SHARE), a cross-national database focused on the older population. Methods: Univariate Analyses of Covariance were conducted separately for men and women who participated in the SHARE study conducted in 2022. A total of 430.720 individuals were examined, including 189.446 (43.98%) men and 241.274 (56.02%) women, with an average age of approximately 67 years ($M = 66.95$, $SD = 9.83$). Principal Findings: An age-dependent decline in GS for both genders and all countries was indicated, observing greater GS reductions with aging in southern countries, compared to North Europe. Women exhibited poorer GS compared to men in all countries. Denmark and Netherlands reported the highest GS, while southern countries like Portugal and Spain revealed the lowest GS ($p < 0.01$), after controlling for age, years of education, citizenship, area of location, number of chronic diseases, body mass index, mobility index and vigorous physical activity. However, the differences in GS were: (a) greater and more pronounced among northern and southern European countries, (b) smaller among northern, western and Baltic countries and (c) less marked among southern and eastern countries. Conclusion: Higher GS was observed in northwest countries, compared to southeast Europe, where lower GS was noted. This emphasizes the need for policies that promote healthy aging and improve access to healthcare services and facilities for older individuals in southeastern European countries.

Keywords: grip strength, old age, Survey on Health, Ageing and Retirement in Europe

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1. Introduction

In recent years, there has been a growing research interest in promoting healthy aging, due to the rapid increase in the global elderly population [1,2]. The World Health Organization defines healthy aging as "the process of developing and maintaining the functional ability that enables well-being in older age" [3,4]. Healthy aging is a multidimensional concept that includes various factors such as health status and muscle strength [4,5,6,7], which is considered as an important indicator of healthy aging [8,9]. During the aging process, there is a decline in musculoskeletal strength, which can predict disability, frailty and mortality [8,9,10].

A commonly used measure of muscle strength is the hand grip strength (GS) test evaluating the maximal grip force produced in a single muscular contraction [9,10,11,12]. In particular, the hand that is a highly used musculoskeletal organ, demands a substantial portion of

the nervous system's capacity despite its size. This supports the crucial role of the hand GS in dealing with the demands of daily activities and life [9,10,11,12]. Further, the GS has been linked to various facets of functional capacity, health and well-being, such as musculoskeletal and mental health, as well as incidence of disability, frailty, risk of hospitalization, cardiovascular death and overall mortality [9,10,11,12].

The health importance of GS has prompted investigations into GS differences among older individuals across various countries and regions [11,12,13]. In particular, a meta-analysis indicated poorer GS in developing countries, such as those in Africa and Asia (excluding Japan), compared to developed countries, such as North America and Europe, pointing out an economically related pattern of GS [12]. Furthermore, a study examining GS differences across 11 European countries revealed an age-dependent decline in GS for both genders, with northern countries exhibiting higher GS, compared to southern ones [13]. However, researchers collected data from 27.456 individuals aged 50

years old and over living in eight northern and three southern European countries included in the Survey on Health, Ageing and Retirement in Europe (SHARE), conducted in 2004 [13]. This raises concerns regarding the representativeness and generalizability of the findings within the European Union (EU). Thus, GS discrepancies among more countries and regions (e.g. western, Baltic and eastern countries) within the EU have not been thoroughly examined over the last decades. The economic trend concerning GS [12,13] emphasizes the importance of GS comparisons across all EU countries. Based on the aforementioned, the investigation of GS variations among older adults across EU member states will provide useful insight into the potential relationships with regional socioeconomic factors and health outcomes. By doing so, the current research will provide a comprehensive understanding of GS disparities within the EU, ultimately informing targeted interventions to promote healthy aging and reduce health inequalities across the European regions.

Therefore, the aim of the current study was to investigate and compare GS among older individuals aged 50 years and over from 28 European countries included in the SHARE conducted in 2022, highlighting gender and age-specific cross-national differences within the EU and controlling for various confounders. Until now, no such research has been carried out.

2. Materials and Methods

2.1. Participants' Selection and Study Design

In the study, data were analyzed from the SHARE, which was conducted in several countries of the EU and Israel [14,15]. The SHARE project is a multidisciplinary and cross-national panel database that focuses on ageing, health, socio-economic status and social and family networks of more than 500,000 non-institutionalized individuals, aged 50 years and older [14,15]. The SHARE was performed through computer-assisted personal interviews over several waves from 2004 to 2024.

The current cross-sectional study analyzed the GS measurements included in the database of 28 European countries, collected during wave 9 between January and October in 2022 [16,17,18]. The countries included in the analysis were the following: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and Switzerland. Due to the limited availability of GS data over time and the lack of several countries' participation in the previous waves (prior to 2022), such as Finland, Croatia, Estonia, Malta etc., those earlier waves were not investigated. Out of the 474,576 individuals who participated in the GP measurements, 43,856 participants were excluded due to missing or invalid GS measurements and outliers. Finally, a total of 430,720 individuals were included in the statistical analyses, comprising of 189,446 (43.98%) men and 241,274 (56.02%) women with an average age of approximately 67 years ($M = 66.95$, $S = 9.83$ years). Table 1 depicts the descriptive statistics of the specific European countries' samples.

Table 1. Descriptive Statistics of the Participants in the Grip Strength Measures

Countries	Samples N	Samples %	Men N	Women N	Age (M, years)	Age (SD, years)
Austria	21.977	5.10	9.146	12.831	67.63	9.91
Belgium	35.974	8.35	16.326	19.648	65.99	10.51
Bulgaria	3.455	0.80	1.411	2.044	67.21	9.93
Croatia	10.538	2.45	4.661	5.877	66.43	9.76
Cyprus	2.276	0.52	959	1.317	70.17	10.27
Czech	28.482	6.61	11.606	16.876	67.65	9.46
Denmark	23.685	5.50	10.913	12.772	66.57	10.30
Estonia	27.317	6.34	10.340	16.977	68.09	10.34
Finland	4.728	1.09	2.197	2.531	68.26	9.61
France	29.134	6.76	12.629	16.505	66.76	10.65
Germany	29.217	6.78	13.792	15.425	66.09	9.71
Greece	20.507	4.76	9.022	11.485	66.30	10.20
Hungary	6.713	1.56	2.874	3.839	66.05	9.31
Ireland	1.603	0.37	716	887	64.94	9.57
Italy	27.410	6.36	12.529	14.881	66.79	9.54
Latvia	4.103	1.00	1.567	2.536	67.20	10.27
Lithuania	4.660	1.08	1.716	2.944	67.68	10.50
Luxembourg	5.461	1.27	2.573	2.888	65.98	9.22
Malta	2.730	0.62	1.214	1.516	68.09	8.76
Netherlands	17.888	4.15	8.184	9.704	66.28	9.76
Poland	18.359	4.26	8.145	10.214	65.96	9.44
Portugal	5.569	1.29	2.436	3.133	66.65	9.42
Romania	4.554	1.06	1.940	2.614	66.33	9.23

Countries	Samples N	Samples %	Men N	Women N	Age (M, years)	Age (SD, years)
Slovakia	3.643	0.85	1.699	1.944	63.04	8.87
Slovenia	18.986	4.41	8.015	10.971	67.35	9.76
Spain	27.770	6.45	12.570	15.200	68.29	10.53
Sweden	25.030	5.81	11.668	13.362	69.19	9.99
Switzerland	18.951	4.40	8.598	10.353	67.49	10.52
Total	430.720	100	189.446	241.274	66.95	9.83

Notes. M = mean; N = number; % = percentage; SD = standard deviation.

2.2. Measures

Country, age, gender, years of education, respondent's citizenship, area of location, number of chronic diseases, body mass index (BMI), mobility index and vigorous physical activity (PA) were recorded using the SHARE-questionnaire, which is translated into the language of each country [14,15,16,17,18]. Each country was assigned a specific code for identification. To record age, gender and citizenship the following questions were used, respectively: "How old are you?", "What is your gender?" and "What is your citizenship?". To assess years of education, participants were asked "How many years have you been in full-time education?". The area of residence was noted based on the building location where the interview took place. Response options included: "a big city", "the suburbs or outskirts of a big city", "a large town", "a small town", "a rural area or village". The number of chronic diseases was based on the question "Has a doctor ever told you that you had any of the diseases on this card?", which has 15 multiple responses. The number of chronic diseases was recorded [14,15,16,17,18]. BMI was based on self-reported values of weight and height and was calculated as: BMI = weight in kilogram (kg) / height in meter² (m²) [14,15,16,17,18]. Mobility index was the sum of four variables: walking 100 meters, walking across a room, climbing several flights of stairs and climbing one flight of stairs. The higher the index, the more difficulties with these activities exist and the lower the mobility [14,15,16,17,18]. It ranged from 0 to 4. Finally, to assess the vigorous PA levels, the question "How often do you engage in vigorous physical activity, such as sports, heavy housework, or a job that involves physical labour?" was used. The response categories of the PA question were "hardly ever or never", "one to three times a month", "once a week" and "more than once a week".

GS was measured using a handheld dynamometer (Smedley, S Dynamometer, TTM, Tokyo, 100 kg), according to the SHARE's methodology [14,15,16,17,18]. Prior to the study, interviewers underwent centrally organized training sessions to ensure a standardized protocol for measuring GS. For each participant, two measurements were recorded per hand, alternating between left and right hand. Valid measurements were defined as those where the two measurements values from each hand differ by less than 20 kg. GS measurements recorded as "0" kg or equal to or greater than "100" kg were excluded, as well as in instances where GS was only measured once for a single hand. The maximum GS value was defined as the highest GS measurement of both hands (2x2) or of one hand (1x2).

2.3. Statistical Analyses

Listwise deletion was applied to address missing values and identify univariate and multivariate outliers [19]. The GS values were transformed with logarithmic functions to solve the problem of non-normal distributions [19]. Means, medians, standard deviations, frequencies, sums and % rates were calculated. To explore the differences in GS between men and women, a preliminary one-way Analysis of Variance (one-way ANOVA) was conducted [19].

To investigate the differences in GS among the countries, two separate Analyses of Covariance (ANCOVA) were conducted for men and women [19], due to the significant differences observed in GS between genders. An initial examination of associations among various demographic variables with GS was performed using the Spearman *r* coefficient. The variables that were significantly related to GS including age, years of education, citizenship, area of location, number of chronic diseases, BMI, mobility index and vigorous PA were subsequently used as covariates in the ANCOVA. In addition, to explore the differences in GS among each 5-year age group across the entire age range in all countries, two separate ANCOVA were performed for men and women, controlling for the aforementioned confounders. For this reason, the age variable was recoded into a different categorical variable including 10 age groups in years: 50–54,99, 55–59,99, 60–64,99, 65–69,99, 70–74,99, 75–79,99, 80–84,99, 85–89,99, 90–94,99 and ≥ 95 . To perform post-hoc comparisons, the Tukey test was applied [19]. A *p* value of < 0.05 was considered statistically significant. The SPSS 25.0 statistical software (SPSS Inc., Chicago, IL, USA) was used in the analyses.

3. Results

3.1. Grip Strength Descriptive Statistics

The overall mean value of GS was $29,21 \pm 15,83$ kg (*M* $\pm$ *SD*). Table 2 and Figure 1 depict the mean values of the GS measurements for each country and gender, separately. Among men, the countries with the highest GS values were Denmark, Netherlands, Finland and Sweden, whereas Portugal, Spain, Bulgaria and Cyprus reported the lowest GS values ($F_{(27,189414)} = 450,749$, $p < 0.01$) (Table 2, Figure 1). Similarly, for women, Denmark, Netherlands, Finland and Switzerland revealed the highest GS values, while Spain, Cyprus, Portugal and Italy showed the lowest GS values ($F_{(27,241242)} = 405,999$, $p < 0.01$) (Table 2, Figure 1).

3.2. Gender and Age-specific Grip Strength Comparisons

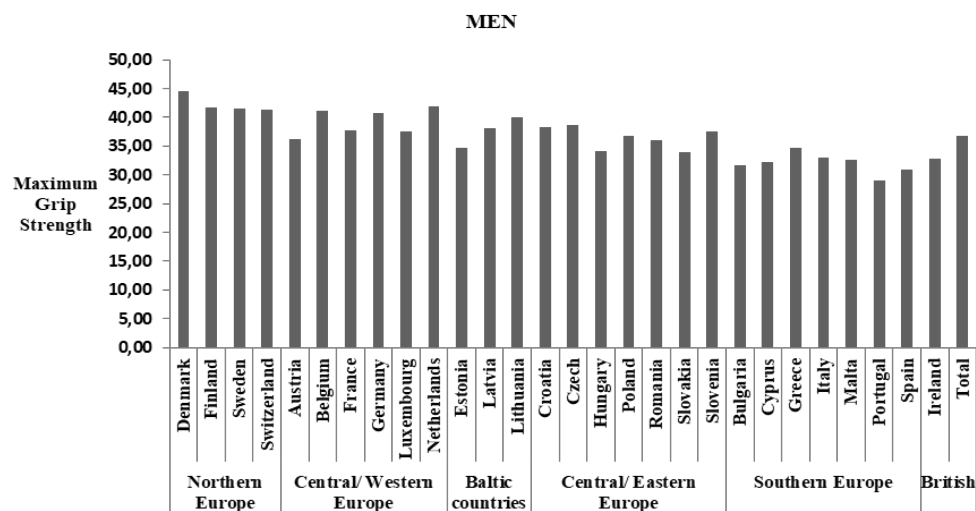
Table 2 and Figure 2 present the *mean* values of the GS measurements for each gender, separately. Significant differences ($F_{(27,430692)} = 443,893$, $p < 0.01$) were found in GS between men $36,75 \pm 17,87$ kg ($M \pm SD$) and women $21,67 \pm 13,80$ kg ($M \pm SD$). Notably, across all countries, women, compared to men, revealed lower GS values (Figure 2). Further, a GS decline was indicated within

each 5-year age group across the entire age range in all countries, both in men ($F_{(9,189414)} = 2323,045$, $p < 0.01$) and in women ($F_{(9, 241242)} = 2250,410$, $p < 0.01$), while controlling for age, years of education, citizenship, area of location, number of chronic diseases, BMI, mobility index and vigorous PA (Figure 3). Supplementary material (Tables S1, S2) depicts decreases in the GS mean values by age group in both genders for all countries, indicating greater reductions in southern Europe, compared to northern countries.

Table 2. Descriptive Statistics of Grip Strength for each Country and Gender Separately

COUNTRY	MEN		WOMEN	
	M (kg)	SD (kg)	M (kg)	SD (kg)
Austria	36,29	21,12	21,80	15,31
Belgium	41,04	15,56	23,46	12,90
Bulgaria	31,67	16,28	20,66	12,71
Croatia	38,34	18,96	22,50	14,35
Cyprus	32,17	15,23	17,08	13,06
Czech	38,64	17,85	23,46	13,64
Denmark	44,62	13,90	25,85	11,15
Estonia	34,74	23,19	22,02	14,80
Finland	41,65	14,28	25,02	10,54
France	37,67	18,13	21,16	13,88
Germany	40,72	16,73	24,31	13,43
Greece	34,68	19,44	19,46	15,78
Hungary	34,07	20,21	19,85	15,43
Ireland	32,71	21,83	19,04	16,15
Italy	33,07	20,27	18,71	16,01
Latvia	38,10	20,08	21,66	15,90
Lithuania	39,96	14,74	24,52	11,69
Luxembourg	37,59	18,87	20,81	15,58
Malta	32,70	15,66	20,29	11,49
Netherlands	41,98	14,87	25,13	12,34
Poland	36,71	18,32	21,77	14,30
Portugal	28,98	20,90	17,25	15,09
Romania	35,99	16,03	22,32	12,76
Slovakia	33,91	20,21	20,18	15,88
Slovenia	37,44	20,44	22,89	14,23
Spain	30,82	18,75	16,89	14,70
Sweden	41,53	14,80	24,09	12,08
Switzerland	41,25	13,58	24,65	11,26
Total	36,75	17,87	21,67	13,80

Notes. Kg = kilogram; M = mean; SD = standard deviation.



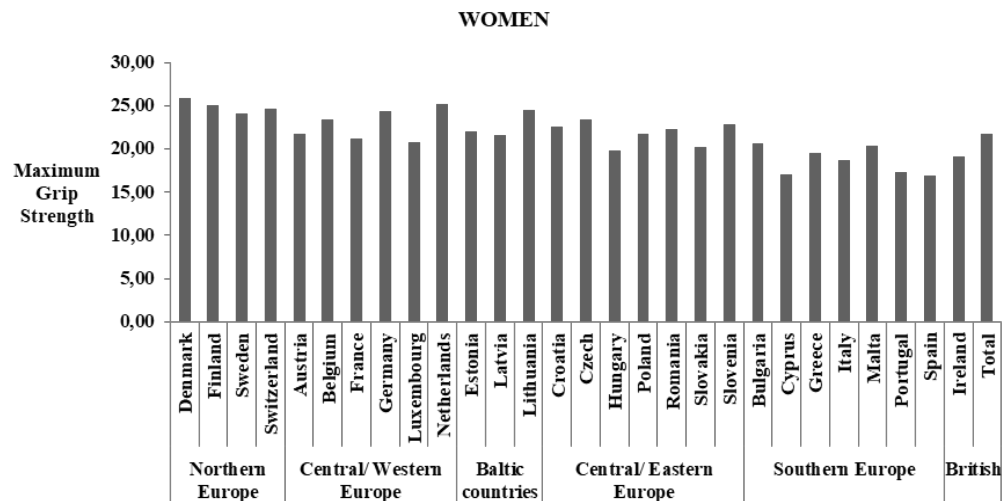


Figure 1. Men's and Women's Maximum Grip Strength Mean Values for each Country

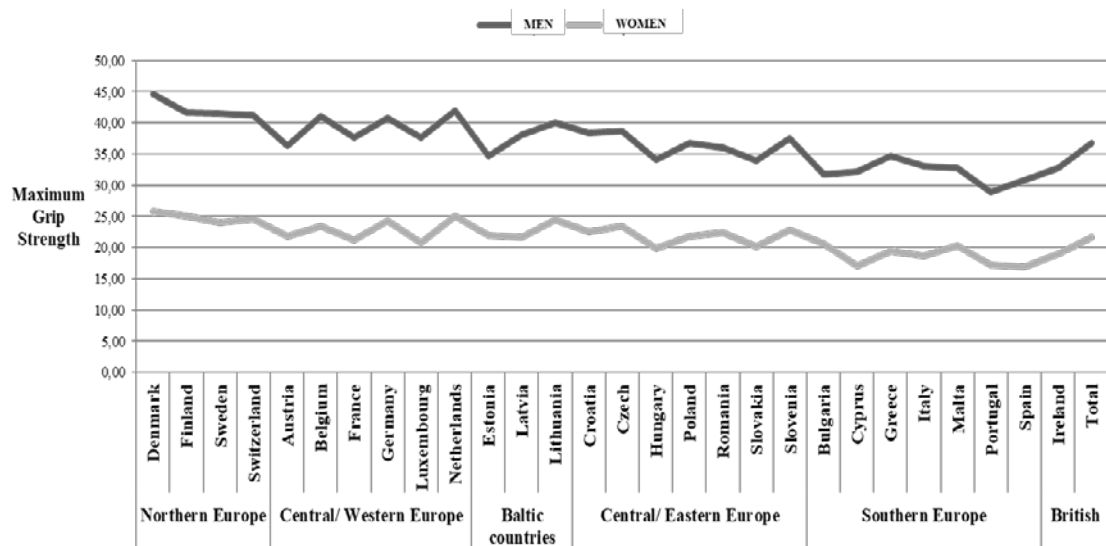
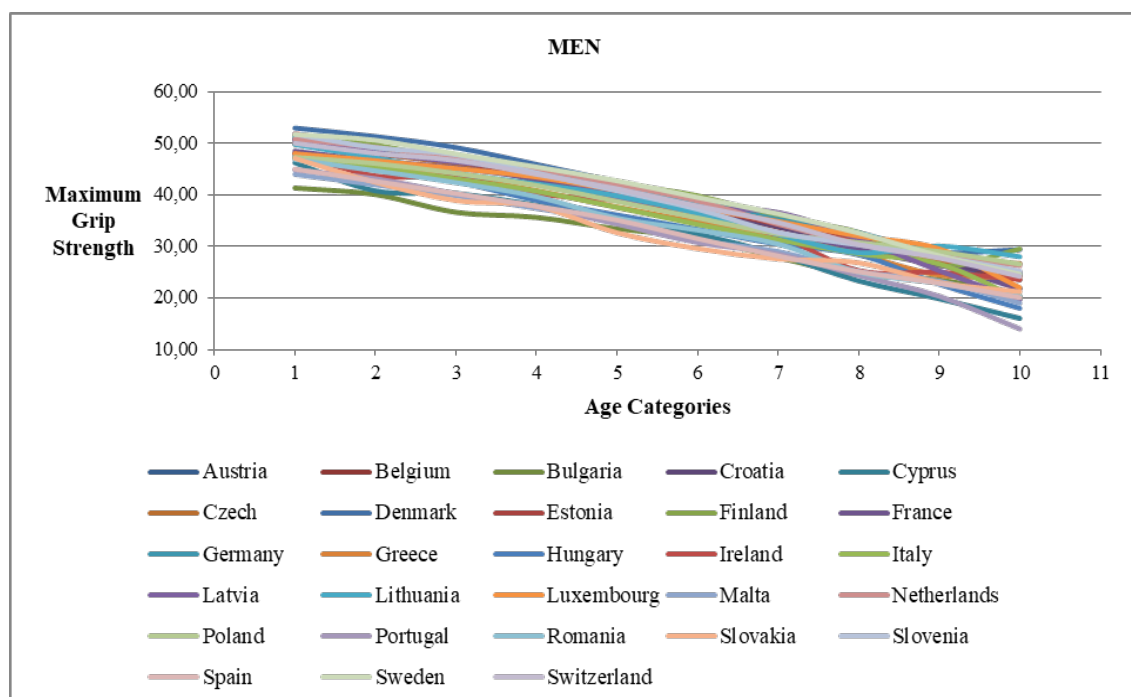


Figure 2. Maximum Grip Strength Mean Values for each Country and Gender



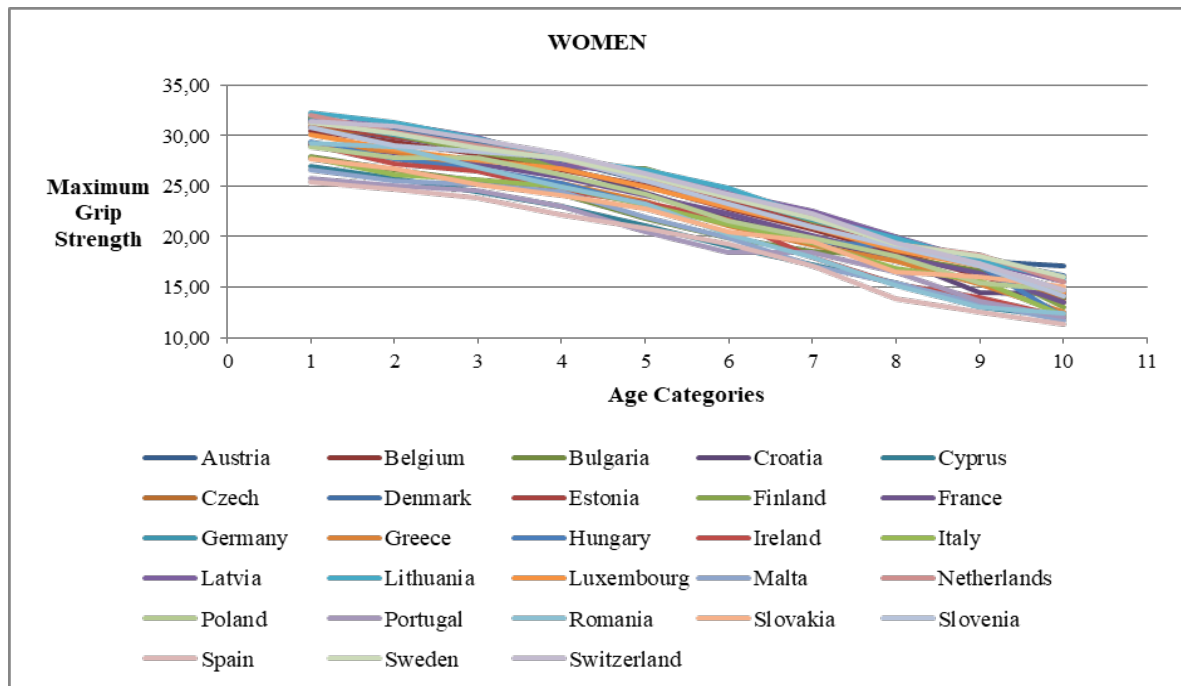


Figure 3. Men's and Women's Maximum Grip Strength Mean Values by 5-year Age Group and Country

3.3. Grip Strength Comparisons among Countries

Significant differences in men's GS were found across countries ($F_{(27,189414)} = 450,749$, $p < 0.01$), while controlling for age, years of education, citizenship, area of location, number of chronic diseases, BMI, mobility index and vigorous PA. Significant effects were indicated for the covariates of age ($F_{(1,189414)} = 66431,24$, $p < 0.01$), years of education ($F_{(1,189414)} = 320,357$, $p < 0.01$), citizenship ($F_{(1,189414)} = 170,959$, $p < 0.01$), area of location ($F_{(1,189414)} = 662,661$, $p < 0.01$), number of chronic diseases ($F_{(1,189414)} = 24,676$, $p < 0.01$), BMI ($F_{(1,189414)} = 3028,870$, $p < 0.01$), mobility index ($F_{(1,189414)} = 1664,237$, $p < 0.01$) and vigorous PA ($F_{(1,189414)} = 106,896$, $p < 0.01$). Together, these variables accounted for 35% of the variance in men's GS. Table 3 depicts the differences in men's GS across the countries analyzed, based on post hoc comparisons. More specifically, Denmark, compared to the other 27 countries, showed the highest men's GS value ($p < 0.05$), whereas Portugal revealed the lowest men's GS value ($p < 0.05$) than the 27 countries (Table 3). As shown in Table 3 and Figure 1, larger differences in men's GS were evident between northern European countries and southern countries, exemplified by the difference between Denmark and Portugal. In contrast, smaller differences in men's GS were found either among northern European countries and western or Baltic countries (such as among Finland, Germany and Lithuania), or among southern and eastern European countries, such as Greece and Poland. In line with this, smaller or insignificant differences in men's GS were observed within each European region, including

comparisons between Sweden and Switzerland or Spain and Malta (Table 3, Figure 1).

Significant differences in women's GS were indicated among countries ($F_{(27,241242)} = 405,999$, $p < 0.01$), after controlling for age, years of education, citizenship, area of location, number of chronic diseases, BMI, mobility index and vigorous PA. Significant effects were indicated for the covariates of age ($F_{(1,241242)} = 68785,081$, $p < 0.01$), years of education ($F_{(1,241242)} = 515,290$, $p < 0.01$), citizenship ($F_{(1,241242)} = 257,086$, $p < 0.01$), area of location ($F_{(1,241242)} = 1071,348$, $p < 0.01$), BMI ($F_{(1,241242)} = 1502,311$, $p < 0.01$) and mobility index ($F_{(1,241242)} = 1513,943$, $p < 0.01$). The variables explained the 29% of the variance in women's GS. Table 4 presents the differences in GS that were indicated among the countries in women, according to the post hoc comparisons. Notably, Denmark demonstrated the highest women's GS value compared to the other countries, ($p < 0.05$), with the exception of an insignificant difference with Finland. Conversely, Spain showed the lowest women's GS value ($p < 0.05$) when compared to other countries, apart from its insignificant differences with Cyprus and Portugal (Table 4). Furthermore, higher differences in women's GS were noted between northern countries with southern countries, particularly between Denmark and Spain. Conversely, lower differences in women's GS were observed either among northern countries in comparison to western and Baltic countries (e.g., Finland, Netherlands and Lithuania), or among southern and eastern countries, such as between Italy and Hungary. Similarly, low to insignificant differences in women's GS were found among countries within each European region, such as between Sweden and Switzerland or Spain and Portugal (Table 4, Figure 1).

Table 3. Men's Differences in Grip Strength among Countries, according to the Post-hoc Comparisons ($p < 0.05$)

	AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	DE	GR	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE	CH
AT	-	-4.75	4.63	-2.05	4.13	-2.34	-8.33	1.55	-5.35	-1.38	-4.42	1.62	2.22	2.71	3.58	-1.81	-3.66	NS	3.59	-5.68	NS	7.31	NS	2.39	-1.15	5.47	-5.23	-4.96
BE	4.75	-	9.37	2.70	8.87	2.40	-3.58	6.30	NS	3.37	NS	6.37	6.97	8.33	7.98	2.94	NS	3.45	8.34	-9.3	4.33	12.1	5.05	7.14	3.60	12.2	NS	NS
BG	-4.63	-9.37	-	-6.68	NS	-6.97	-13.0	-3.07	-9.98	-6.01	-9.05	-3.01	-2.41	NS	NS	-6.43	-8.29	-5.92	NS	-10.3	-5.04	2.68	-4.32	NS	-5.78	NS	-9.86	-9.59
HR	2.05	-2.70	6.68	-	6.18	NS	-6.28	3.60	-3.30	NS	-2.37	3.67	4.27	5.63	5.28	NS	NS	NS	5.64	-3.63	1.64	9.36	2.36	4.44	NS	7.52	-3.18	-2.91
CY	-4.13	-8.87	NS	-6.18	-	-6.47	-12.5	-2.57	-9.48	-5.51	-8.55	-2.51	NS	NS	NS	-5.93	-7.79	-5.42	NS	-9.81	-4.54	3.18	-3.82	NS	-5.27	NS	-9.36	-9.09
CZ	2.34	-2.40	6.97	NS	6.47	-	-5.99	3.90	-3.01	.96	-2.08	3.96	4.56	5.92	5.57	NS	NS	NS	5.94	-3.34	1.93	9.65	2.65	4.73	1.19	7.81	-2.89	-2.62
DK	8.33	3.58	13.0	6.28	12.5	5.99	-	9.88	2.98	6.95	3.01	9.95	10.6	11.9	11.6	6.52	4.67	7.03	11.9	2.65	7.91	15.7	8.64	10.7	7.18	13.8	3.10	3.37
EE	-1.55	-6.30	3.07	-3.60	2.57	-3.90	-9.88	-	-6.91	-2.93	-5.98	NS	NS	NS	NS	1.68	-3.36	-5.22	-2.85	2.04	-7.23	-1.97	5.76	NS	-2.70	3.92	-6.79	-6.51
FI	5.35	NS	9.98	3.30	9.48	3.01	-2.98	6.91	-	3.97	NS	6.97	7.57	8.93	8.58	3.55	NS	4.05	8.94	NS	4.94	12.7	5.66	7.74	4.20	10.8	NS	NS
FR	1.38	-3.37	6.01	NS	5.51	-9.6	-6.95	2.93	-3.97	-	-3.04	3.00	3.60	4.96	4.61	NS	-2.28	NS	4.97	-4.30	.96	8.69	1.69	3.77	NS	6.85	-3.85	-3.58
DE	-4.42	NS	9.05	2.37	8.55	2.08	-3.91	5.98	NS	3.04	-	6.04	6.64	8.00	7.65	2.62	NS	3.13	8.02	-1.26	4.01	11.7	4.73	6.81	3.27	9.89	NS	NS
GR	-1.62	-6.37	3.01	-3.67	2.51	-3.96	-9.95	NS	-6.97	-3.00	-6.04	-	NS	NS	1.61	-3.42	-5.28	-2.92	1.97	-7.30	-2.03	5.69	NS	NS	-2.77	3.85	-6.85	-6.58
HU	-2.22	-6.97	2.41	-4.27	NS	-4.56	-10.6	NS	-7.57	-3.60	-6.64	NS	-	NS	NS	-4.03	-5.88	-3.52	NS	-7.90	-2.64	5.09	-1.91	NS	-3.37	3.25	-7.45	-7.18
IE	-3.58	-8.33	NS	-5.63	NS	-5.92	-11.9	NS	-8.93	-4.96	-8.00	NS	NS	-	NS	-5.39	-7.24	-4.88	NS	9.26	-4.00	3.73	-3.27	NS	-4.73	NS	-8.81	-8.54
IT	-3.23	-7.98	NS	-5.28	NS	-5.57	-11.6	-1.68	-8.58	-4.61	-7.56	-1.61	NS	NS	-	-5.03	-6.89	-4.53	NS	-8.91	-3.64	4.08	-2.92	NS	-4.38	2.24	-8.46	-8.19
LV	1.81	-2.94	6.43	NS	5.93	NS	-6.52	3.36	-3.55	NS	-2.62	3.42	4.03	5.39	5.03	-	NS	NS	5.40	-3.88	NS	9.12	NS	4.19	NS	7.28	-3.43	-3.16
LT	3.66	NS	8.29	NS	7.79	NS	-4.67	5.22	NS	2.28	NS	5.28	5.88	7.24	6.89	NS	-	2.37	7.26	-2.02	3.25	11.0	3.97	6.05	2.51	9.13	NS	NS
LU	NS	-3.45	5.92	NS	5.42	NS	-7.03	2.85	-4.05	NS	-3.13	2.92	3.52	4.88	4.53	NS	-2.37	-	4.89	-4.38	NS	8.61	NS	3.69	NS	6.77	-3.94	-3.66
MT	-3.59	-8.34	NS	-5.64	NS	-5.94	-11.9	-3.04	-8.94	-4.97	-8.02	-1.97	NS	NS	NS	-5.40	-7.26	-4.89	-	-9.27	-4.01	3.72	-3.28	NS	-4.74	NS	-8.82	-8.55
NL	5.68	.93	10.3	3.63	9.81	3.34	-2.65	7.23	NS	4.30	1.26	7.30	7.90	9.26	8.91	3.88	2.02	4.38	9.27	-	5.27	13.0	5.99	8.07	4.53	11.2	NS	NS
PL	NS	-4.33	5.04	-1.64	4.54	-1.93	-7.91	1.97	-4.94	-9.6	-4.01	2.03	2.64	4.00	3.64	NS	-3.25	NS	4.01	-5.27	-	7.73	NS	2.80	NS	5.89	-4.82	-4.55
PT	-7.31	-12.1	-2.68	9.36	-3.18	-9.65	-15.7	-5.76	-12.7	-8.69	-11.7	-5.69	-5.09	-3.73	-3.08	-9.12	-11.0	-8.61	-3.72	-13.0	-7.73	-	-7.00	-4.92	-8.46	-1.84	-12.5	-12.3
RO	NS	-5.05	4.32	-2.36	3.82	-2.65	-8.64	NS	-5.66	-1.69	-4.73	NS	1.91	3.27	2.92	NS	-3.97	NS	3.28	-5.99	NS	7.00	-	NS	NS	5.16	-5.54	-5.27
SK	-2.39	-7.14	NS	-4.44	NS	-4.73	-10.7	NS	-7.74	-3.77	-6.81	NS	NS	NS	NS	-4.19	-6.05	-3.69	NS	-8.07	-2.80	4.92	NS	-	-3.54	3.08	-7.62	-7.35
SI	1.15	-3.60	5.78	NS	5.27	-1.19	-7.18	2.70	-4.20	NS	-3.27	2.77	3.37	4.73	4.38	NS	-2.51	NS	4.74	-4.53	NS	8.46	NS	3.54	-	6.62	-4.08	-3.81
ES	-5.47	-10.2	NS	-7.52	NS	-7.81	-13.8	-3.92	-10.8	-6.85	-9.89	-3.85	-3.25	NS	-2.24	-7.28	-9.13	-6.77	NS	-11.2	-5.89	1.84	-5.16	-3.08	-6.62	-	-10.7	-10.4
SE	5.23	NS	9.86	3.18	9.36	2.89	-3.10	6.79	NS	3.85	NS	6.85	7.45	8.81	8.46	3.43	NS	3.94	8.82	NS	4.82	12.5	5.54	7.62	4.08	10.7	-	NS
CH	4.96	NS	9.59	2.91	9.09	2.62	-3.37	6.51	NS	3.58	NS	6.58	7.18	8.54	8.19	3.16	NS	3.66	8.55	NS	4.55	12.3	5.27	7.35	3.81	10.4	NS	-

Notes. AT = Austria; BE = Belgium; BU = Bulgaria; CH = Switzerland; CY = Cyprus; CZ = Czech; DE = Germany; DK = Denmark; EE = Estonia; ES = Spain; FI = Finland; FR = France; GR = Greece; HR = Croatia; HU = Hungary; IE = Ireland; IT = Italy; LT = Lithuania; LU = Luxembourg; LV = Latvia; MT = Malta; NL = Netherlands; PL = Poland; PT = Portugal; RO = Romania; SE = Sweden; SI = Slovenia; SK = Slovakia; NS = non-significant.

Table 4. Women's Differences in Grip Strength among Countries, according to the Post-hoc Comparisons ($p < 0.05$)

	AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	DE	GR	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE	CH
AT	-	-1.66	1.14	NS	4.73	-1.65	-4.04	NS	-3.21	.65	-2.51	2.35	1.96	2.77	3.09	NS	-2.71	1.00	1.51	-3.33	NS	4.55	NS	1.62	-1.09	4.92	-2.28	-2.85
BE	1.66	-	2.80	.96	6.38	NS	-2.39	1.44	-1.56	2.30	-.85	4.00	3.61	4.42	4.75	1.80	-1.06	2.65	3.17	-1.67	1.69	6.21	1.14	3.28	NS	6.57	-.63	-1.19
BG	-1.14	-2.80	-	-1.83	3.59	NS	-5.18	-1.35	-4.35	NS	-3.65	1.20	NS	NS	1.95	NS	-3.85	NS	NS	-4.47	-1.11	3.41	-1.66	NS	-2.23	3.78	-3.42	-3.99
HR	NS	-.96	1.83	-	5.42	-.96	-3.35	NS	-2.52	1.34	-1.81	3.04	2.65	3.46	3.78	NS	-2.02	1.69	NS	-2.64	NS	5.25	NS	2.31	NS	5.61	-1.59	-2.16
CY	-4.73	-6.38	-3.59	-5.42	-	-6.38	-8.77	-4.94	-7.94	-4.08	-7.23	-2.38	-2.77	NS	-1.64	-4.58	-7.44	-3.73	-3.22	-8.06	-4.70	NS	-5.25	-3.11	-5.82	NS	-7.01	-7.58
CZ	1.65	NS	2.79	.96	6.38	-	-2.39	1.44	-1.56	2.30	-.85	4.00	3.61	4.42	4.74	1.80	-1.06	2.65	3.16	-1.68	1.68	6.21	1.13	3.27	NS	6.57	-.63	-1.20
DK	4.04	2.39	5.18	3.35	8.77	2.39	-	3.83	NS	4.69	1.54	6.39	6.00	6.81	7.14	4.19	1.33	5.04	5.55	.72	4.07	8.60	3.53	5.67	2.96	8.96	1.76	1.19
EE	NS	-1.44	1.35	NS	4.94	-1.44	-3.83	-	-3.00	.86	-2.29	2.56	2.17	2.98	3.30	NS	-2.50	1.21	1.72	-3.12	NS	4.77	NS	1.83	-.88	5.13	-2.07	-2.64
FI	3.21	1.56	4.35	2.52	7.94	1.56	NS	3.00	-	3.86	NS	5.56	5.17	5.98	6.31	3.36	NS	4.21	4.72	NS	3.24	7.77	2.70	4.84	2.13	8.13	NS	NS
FR	-.65	-2.30	NS	-1.34	4.08	-2.30	-4.69	-.86	-3.86	-	-3.15	1.70	1.31	2.12	2.45	NS	-3.36	NS	NS	-3.97	-.62	3.91	-1.16	NS	-1.73	4.27	-2.93	-3.50
DE	2.51	.85	3.65	1.81	7.23	.85	-1.54	2.29	NS	3.15	-	4.85	4.46	5.27	5.60	2.65	NS	3.50	4.02	-.82	2.54	7.06	1.99	4.13	1.42	7.42	NS	NS
GR	-2.35	-4.00	-1.20	-3.04	2.38	-4.00	-6.36	-2.56	-5.56	-1.70	-4.85	-	NS	NS	.75	-2.20	-5.06	-1.35	NS	-5.67	-2.32	2.21	-2.86	NS	-3.43	2.57	-4.63	-5.20
HU	-1.96	-3.61	NS	-2.65	2.77	-3.61	-6.00	-2.17	-5.17	-1.31	-4.46	NS	-	NS	1.14	-1.81	-4.67	NS	NS	-5.28	-1.93	2.60	-2.47	NS	-3.04	2.96	-4.24	-4.81
IE	-2.77	-4.42	NS	-3.46	NS	-4.42	-6.81	-2.98	-5.98	-2.12	-5.27	NS	NS	-	NS	-2.62	-5.48	NS	NS	-6.10	-2.74	NS	-3.29	NS	-3.86	2.15	-5.05	-5.62
IT	-3.09	-4.75	-1.95	-3.78	1.64	-4.74	-7.14	-3.30	-6.31	-2.45	-5.60	-.75	-1.14	NS	-	-2.95	-5.81	-2.10	-1.58	-6.42	-3.06	1.46	-3.61	-1.47	-4.18	1.83	-5.37	-5.94
LV	NS	-1.80	NS	NS	4.58	-1.80	-4.19	NS	-3.36	NS	-2.65	2.20	1.81	2.62	2.95	-	-2.86	NS	NS	-3.47	NS	4.41	NS	1.48	-1.23	4.77	-2.43	-3.00
LT	2.71	1.06	3.85	2.02	7.44	1.06	-1.33	2.50	NS	3.36	NS	5.06	4.67	5.48	5.81	2.86	-	3.71	4.23	NS	2.74	7.27	2.20	4.34	1.63	7.63	NS	NS
LU	-1.00	-2.65	NS	-1.69	3.73	-2.65	-5.04	-1.21	-4.21	NS	-3.50	1.35	NS	NS	2.10	NS	-3.71	-	NS	-4.32	NS	3.56	-1.51	NS	-2.08	3.92	-3.28	-3.85
MT	-1.51	-3.17	NS	-2.20	3.22	-3.16	-5.55	-1.72	-4.72	NS	-4.02	NS	NS	NS	NS	NS	-4.23	NS	-	-4.84	-1.48	3.04	-2.03	NS	-2.60	3.41	-3.79	-4.36
NL	3.33	1.67	4.47	2.64	8.06	1.68	-.72	3.12	NS	3.97	.82	5.67	5.28	6.10	6.42	3.47	NS	4.32	4.84	-	3.36	7.88	2.81	4.95	2.24	8.24	1.05	NS
PL	NS	-1.69	1.11	NS	4.70	-1.68	-4.07	NS	-3.24	.62	-2.54	2.32	1.93	2.74	3.06	NS	-2.74	NS	1.48	-3.36	-	4.52	NS	1.59	-1.12	4.89	-2.31	-2.88
PT	-4.55	-6.21	-3.41	-5.25	NS	-6.21	-8.60	-4.77	-7.77	-3.91	-7.06	-2.21	-2.60	NS	-1.46	4.41	-7.27	-3.56	-3.04	-7.88	-4.52	-	-5.07	-2.93	-5.64	NS	-6.84	-7.74
RO	NS	-1.14	1.66	NS	5.25	-1.13	-3.53	NS	-2.70	1.16	-1.99	2.86	2.47	3.29	3.61	NS	-2.20	1.51	2.03	2.81	NS	5.07	-	2.14	NS	5.44	-1.76	-2.33
SK	-1.62	-3.28	NS	-2.31	3.11	-3.27	-5.67	-1.83	-4.84	NS	-4.13	NS	NS	NS	1.47	-1.48	-4.34	NS	NS	-4.95	-1.59	2.59	2.14	-	-2.71	3.30	-3.90	-4.76
SI	1.09	NS	2.23	NS	5.82	NS	-2.96	.88	-2.13	1.73	-1.42	3.43	3.04	3.86	4.18	1.23	-1.63	2.08	2.60	-2.24	1.12	5.64	NS	2.71	-	6.00	-1.19	1.47
ES	-4.92	-6.57	-3.78	-5.61	NS	-6.57	-8.96	-5.13	-8.13	-4.27	-7.42	-2.57	-2.96	-2.15	-1.83	-4.77	-7.63	-3.92	-3.41	-8.24	-4.89	NS	-5.44	-3.30	-6.00	-	-7.20	-7.77
SE	2.28	.63	3.42	1.59	7.01	.63	-1.76	2.07	NS	2.93	NS	4.63	4.24	5.05	5.37	2.43	NS	3.28	3.79	-1.05	2.31	6.84	1.76	3.90	1.19	7.20	-	NS
CH	2.85	1.19	3.99	2.12	7.58	1.20	-1.19	2.64	NS	3.50	NS	5.20	4.81	5.62	5.94	3.00	NS	3.85	4.36	NS	2.88	7.41	2.33	4.47	1.76	7.77	NS	NS

compared the found discrepancies among them, providing an original and comprehensive understanding of the overall GS disparities within the EU. Notably, the most pronounced differences in GS were indicated among northern and southern countries, such as between Denmark and Cyprus. In contrast, smaller differences were observed among northern, western and Baltic countries, such as between Netherlands and Lithuania. Similarly, there were minimal differences in GS among southern and eastern countries, such as between Italy and Hungary, as well as among countries within each European region. Further, greater reductions in GS with aging were indicated in south Europe, compared to northern countries. These findings could be attributed to genetic, environmental and socio-economic differences among European countries and regions [12,20,21,22,23,24,25,26,27,28,29].

Genetic determinants related to muscle mass and strength have been documented [20,21] and may help to explain part of the GS differences observed among European countries. Studies focusing on different ethnic groups have indicated differences in muscle composition, anatomy and metabolism [22]. Additionally, gender's genetic differences in muscle mass [23] could account for the lower women's GS, compared to men, across the 28 countries. However, existing research on specific gene associated with either muscle mass loss with aging or GS discrepancies among countries remains controversial [23]. While some of the GS variability among older individuals could be attributed to genetic factors, the majority is influenced by environmental and socio-economic factors [24,25,26,27,28,29]. Worth noting that, countries in the southeast Europe tend, on average, to be less economically developed, compared to northern and western regions. This disparity could be linked to lower average incomes and limited access to health care and policies promoting physical activity and healthy lifestyle [24,25,30,31].

According to the Eurobarometer [30], Europeans who perceive their household financial situation as good are predominantly in northern and western countries, such as Netherlands (93%), Denmark and Sweden (89%). This contrasts with southeastern countries such as Bulgaria (43%), Greece (46%) and Hungary (51%) where significantly lower values were reported. This trend was confirmed in the provision of public services assessment [30] or for various factors affecting the health systems' quality, such as medical infrastructure [31]. In line with this, a large percentage of individuals from southern and eastern European countries report facing financial barriers that limit their access to healthcare systems [31]. Many believe that their local authorities do not do enough to promote physical activity among citizens [25]. Furthermore, these regions experience a notable decline in physical activity with aging, which is linked to reductions in strength, musculoskeletal function, GS and overall physical performance [25,26,27,30,31]. This could explain the greater decreases in GS with aging found in southern countries, compared to north Europe. As a consequence, financial difficulties, along with limited access to public health services and policies that encourage active and healthy lifestyle appear to be important determinants of the poorer GS in southeastern Europe. This highlights the urgent need for applying national policies and strategies

that promote physical activity, healthy aging and improved access to health care in these countries and European regions [25,27,31].

In addition, poorer GS was observed in women, compared to men, across all countries, in consistency with previous studies [28,29]. This finding could be attributed to genetic differences in muscle mass related to gender [23] and to various environmental factors [28]. For instance, a study that examined 849 Swedish older individuals over a 22-year period, identified lifestyle-related predictors contributing in women's GS decline with aging, such as smoking and stress. In contrast, the factors affecting men's GS were more physically oriented, including physical activity and chronic disorders [28]. This distinct gender pattern highlights the necessity of separate intervention strategies for men and women aimed at enhancing muscle strength and promoting healthy aging for both genders.

Finally, the current study has several limitations that should be considered. First, due to its cross-sectional nature, the data do not allow for observing longitudinal GS trends or justifying a cause-and-effect relationship. Second, body height and weight were not included as covariates. However, previous research has shown decreases in GS with aging in various European countries when accounting for height and weight [13]. Third, the countries' sample sizes were unequal. Despite the aforementioned limitations, this study has notable advantages worth considering. Key features include the investigation of GS differences across large samples from 28 European countries, separate analyses for men and women, GS examination by 5-year age group and the inclusion of age, years of education, citizenship, area of location, number of chronic diseases, BMI, mobility index and vigorous PA as covariates. Furthermore, the SHARE database provides high quality and representative European data, benefiting from a high degree of standardization in data collection [14,15,16,17,18]. Lastly, the sample size is sufficient to detect small effects and minimize standard error [14,15,16,17,18].

5. Conclusions

The current study revealed an age-dependent decline in GS, as well as differences in its prevalence among the 28 European countries examined. Higher GS was observed in northern and western countries, while lower GS was reported in southeast Europe. Considering the value of GS as an indicator of health status, this emphasizes the need of national policies promoting physical activity, healthy aging and increased access to healthcare for older individuals in southern and eastern countries. Future studies should be carried out to further investigate and explore GS disparities over time among the European countries.

6. Availability of the SHARE Data

This research was conducted by analyzing data from the SHARE's wave 9 [16,17,18]. These data are publicly available in the SHARE website without permission [14,15,16,17,18]. The SHARE has been funded by the European Commission, the German Ministry of Education

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Appendix A

Supplementary Data

Table S1. Men's Grip Strength Mean Values by Age Category and Country

COUNTRY	Grip Strength Mean Values (Kg) by Age Category (years)									
	50-54,99	55-59,99	60-64,99	65-69,99	70-74,99	75-79,99	80-84,99	85-89,99	90-94,99	≥ 95
Austria	50,12	47,82	46,80	44,51	41,42	38,05	33,88	31,07	27,17	22,88
Belgium	50,09	48,42	46,38	43,72	40,69	37,25	33,72	30,69	27,23	23,56
Bulgaria	41,35	40,08	36,63	35,64	33,43	31,64	27,86	24,47	23,57	18,31
Croatia	50,71	49,46	46,34	42,85	39,65	37,08	33,85	29,66	26,40	25,00
Cyprus	45,02	42,64	40,26	37,84	35,12	31,52	28,15	25,08	22,84	19,07
Czech	49,82	48,06	46,07	43,82	41,09	38,04	34,51	30,91	27,25	26,70
Denmark	52,98	51,33	49,19	45,92	42,54	39,12	35,18	31,20	28,81	29,40
Estonia	51,84	49,55	46,59	43,63	41,24	37,81	34,27	31,06	28,21	24,33
Finland	51,55	49,71	46,62	44,56	42,21	39,83	35,63	32,69	26,22	29,50
France	48,50	46,68	45,27	43,10	40,20	36,01	32,45	29,34	26,44	21,73
Germany	51,14	48,89	46,62	44,79	41,82	38,59	35,21	32,67	28,05	24,60
Greece	47,96	45,27	43,56	40,84	37,66	34,71	31,89	28,49	24,44	21,14
Hungary	47,51	45,13	42,60	38,96	36,11	33,34	30,45	28,39	22,69	18,00
Ireland	48,05	43,72	43,47	40,21	38,91	35,82	32,11	25,31	25,00	22,60
Italy	47,16	45,38	43,11	40,74	37,58	34,29	31,32	28,59	26,60	19,80
Latvia	50,80	48,22	46,36	44,51	39,61	37,50	36,57	31,44	25,29	19,64
Lithuania	49,79	47,18	44,22	42,16	39,82	36,42	32,33	28,80	30,06	28,00
Luxembourg	48,02	46,67	45,13	43,46	40,88	37,57	34,85	31,99	29,53	22,00
Malta	46,25	40,80	40,27	38,04	35,58	32,44	28,41	23,32	19,86	16,04
Netherlands	50,86	49,25	47,07	44,98	42,05	38,84	34,34	30,61	28,44	26,27
Poland	47,30	46,11	44,18	41,84	38,74	35,54	32,45	30,75	29,00	26,59
Portugal	40,00	41,95	39,85	37,40	34,78	31,20	28,03	25,14	22,30	13,72
Romania	46,88	44,69	42,40	39,67	35,49	33,18	30,47	25,02	22,86	20,33
Slovakia	47,11	42,45	38,92	37,83	32,66	29,59	27,58	26,83	23,00	21,22
Slovenia	51,77	49,19	47,80	44,25	40,81	37,23	32,72	30,29	28,04	25,25
Spain	44,86	43,16	40,24	37,72	34,35	31,77	29,53	25,34	24,33	18,24
Sweden	51,75	50,62	47,95	45,42	42,73	39,52	36,33	32,61	28,20	24,60
Switzerland	50,03	48,08	46,68	44,00	41,20	37,83	34,66	30,37	27,75	24,18

Note. Kg = kilogram.

Table S2. Women's Grip Strength Mean Values by Age Category and Country

COUNTRY	Grip Strength Mean Values (Kg) by Age Category (years)									
	50-54,99	55-59,99	60-64,99	65-69,99	70-74,99	75-79,99	80-84,99	85-89,99	90-94,99	≥ 95
Austria	31,66	30,30	29,21	27,56	25,50	23,29	20,93	19,15	17,56	17,09
Belgium	30,45	29,33	28,16	26,55	25,09	22,75	20,68	18,44	16,13	13,86
Bulgaria	27,96	26,56	25,47	24,16	21,80	19,89	18,51	18,09	16,60	14,00
Croatia	30,82	29,82	28,65	26,91	24,27	21,79	19,72	17,87	14,47	14,33
Cyprus	26,59	25,53	25,11	24,39	21,92	19,89	17,08	15,45	13,43	10,00
Czech	30,95	30,01	28,85	27,74	25,93	24,05	21,81	19,48	17,86	13,50
Denmark	31,79	30,56	29,08	27,62	26,12	23,63	21,41	19,29	18,66	17,13
Estonia	31,25	29,87	29,07	27,70	25,63	23,67	21,40	19,44	17,11	14,60
Finland	31,81	30,15	28,35	26,98	26,67	24,15	21,59	19,99	17,08	14,00
France	29,16	28,30	27,26	25,84	24,09	22,25	20,07	18,02	16,40	13,50
Germany	31,53	30,12	29,00	27,93	26,02	23,91	21,67	19,48	17,20	14,73
Greece	29,24	28,37	26,61	25,23	23,52	21,08	19,18	17,64	15,27	12,50
Hungary	29,32	27,69	26,71	25,27	23,16	21,38	19,45	19,00	17,13	12,00
Ireland	29,11	27,23	26,51	24,56	23,33	21,69	17,93	15,25	14,00	12,09
Italy	27,00	25,76	24,44	22,96	21,04	19,01	17,28	15,38	12,98	12,03
Latvia	31,38	31,22	29,85	27,12	26,20	24,34	22,51	20,00	17,55	15,57
Lithuania	32,25	31,35	29,71	27,64	26,58	24,81	21,93	19,88	17,57	15,86
Luxembourg	30,11	28,68	27,53	26,67	24,91	22,83	20,99	18,65	17,14	14,50
Malta	27,85	26,12	25,60	24,98	23,08	21,17	19,34	16,88	15,65	12,14
Netherlands	32,03	30,33	29,00	27,70	25,67	23,90	22,20	19,26	18,24	17,56

COUNTRY	Grip Strength Mean Values (Kg) by Age Category (years)									
	50-54,99	55-59,99	60-64,99	65-69,99	70-74,99	75-79,99	80-84,99	85-89,99	90-94,99	≥ 95
Poland	28,92	27,82	27,76	26,08	24,15	21,61	19,86	18,09	15,44	14,73
Portugal	25,72	25,04	24,54	23,00	20,47	18,41	18,38	16,49	13,62	12,00
Romania	29,20	28,88	26,90	24,98	23,19	20,29	17,96	15,15	13,00	12,47
Slovakia	27,65	26,71	25,18	24,02	22,72	20,53	19,46	16,56	14,00	16,00
Slovenia	30,80	29,05	28,39	27,78	25,51	23,22	20,99	18,98	17,08	14,07
Spain	25,36	24,67	23,89	22,13	20,86	19,29	17,10	13,91	12,50	11,33
Sweden	31,32	30,16	28,81	27,63	25,95	23,79	21,78	19,32	18,10	16,00
Switzerland	31,47	30,93	29,67	28,22	26,22	24,19	22,27	19,36	17,32	14,74

Note. Kg = kilogram.