The Gender and Educational Gradient in Fine Motor Skills among Older Adults:

A Fixed Effects Growth Curve Model Approach

Master's Degree Programme in Inequalities, Interventions and New Welfare State
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Abstract

A substantial increase in life expectancy represents a major demographic shift in recent decades, making the quality of life of the growing elderly population an increasingly central topic. In this thesis, I assess the strength of older adults' fine motor skills, which are needed for tasks like dressing, eating, or picking up small objects. Using longitudinal data from the Survey of Health, Ageing and Retirement in Europe (SHARE), this study explores how difficulties in fine motor skills change over time, and whether these patterns vary by sex and education among adults aged 50 and older.

Using fixed-effects growth-curve models, I examine within-individual changes in fine motors over age and assess whether sex and education act as moderators of this relationship. The analyses draw on 145,970 individuals and 378,709 observations from SHARE waves 1–2 and 4–9. Overall, fine motor difficulties increase with age, particularly after age 70. The difference in age-related change by sex is small, with women showing a slightly steeper increase. Education, however, significantly moderates the age trajectories of men and women: individuals with higher levels of education experience a slower rise in fine motor difficulties than those with lower education, with the disparity most apparent at the lower end of the educational spectrum and among women. Additional control variables show that chronic disease is associated with higher difficulty scores, whereas more frequent physical activity is associated with lower difficulty scores.

Keywords: Aging, fine motor skills, older adults, SHARE, fixed effects model, longitudinal analysis.

1. Introduction

One of the major demographic changes of the last decades is the increase in the life expectancy of individuals, resulting in the rising proportion of the elderly population (Nowossadeck et al., 2019). According to projections from the WHO, one in six people worldwide will be aged 60 years or older by 2030. As a result, between 2020 and 2050, the population aged 60 years and older is expected to increase from 1 to 2.1 billion and the one aged 80 years or above is expected to triple, reaching 426 million. (Noto, 2023).

With the vast majority of individuals now reaching old age, it is key to evaluating the quality of the years they are going to spend in it. Physical competencies play a crucial role in human functioning by assisting them in carrying out activities ranging from simple movements to complex tasks. However, as people get older, motor abilities can deteriorate, affecting independence, and well-being. Nonetheless, these changes are different for everyone and are strongly influenced by various factors.

This study will contribute to the literature on health in later life by exploring the decline in fine motor skills over age, focusing on whether this decline differs by sex and education levels. Using longitudinal data from the Survey of Health, Ageing and Retirement in Europe (SHARE), this study examines the age trajectories of men and women's motor skills aged in the population 50 years and older in Europe and whether there are socioeconomic differences in terms of education. The main contribution is that the study provides cross-national evidence on how fine motor skill difficulties change with age, and whether these patterns vary by sex and education across Europe. In addition, by using repeated observations over time and fixed-effects growth-curve models, the analysis focuses on within-person change and reduces bias from unobserved time-invariant differences between individuals.

While many studies have examined motor function and aging, several key limitations remain which this study aims to address. First, much of the existing evidence relies on cross-sectional designs, meaning that observed differences may reflect cohort variation rather than true age-related change within individuals. Second, previous research suggests that fine motor performance and cognitive functioning tend to be related, but studies have often not followed individuals over time to assess how these patterns develop with aging, nor have they consistently tested whether these associations and trajectories differ by sex and educational attainment (Ji et al., 2026; Geroin et al., 2024; Zhang et al., 2024; Blanchet et al., 2024; Kim, 2023; Soyuer et al., 2023).

Third, previous research has paid limited attention to socioeconomic status in the context of fine motor skills and aging, even though education and health are shaped by interconnected processes that are difficult to disentangle from income and broader life-course circumstances (Kondirolli & Sunder, 2022). Building on these gaps, this study examines fine motor skill trajectories as people age and tests whether these trajectories differ by sex and education. It contributes to a better comprehension of inequalities in physical functioning among older populations and helps inform health policy aimed at promoting healthy aging.

2. Literature Review

2.1. How motor skills vary over age

Motor development involves a diverse array of experiences, ranging from an infant's first attempt to hold an object to the precise coordination needed for more complex motor tasks in adulthood. (Payne & Isaacs, 2024). Motor skills are generally categorized into two types: gross motor skills, which involve large muscle groups and include actions such as walking, jumping, or running; and fine motor skills, which depend on the small muscles of the hands, fingers, and forearms to execute detailed movements like writing, typing, or playing an instrument (Zhang et al., 2024).

Fine motor skills are essential for performing everyday tasks that support both independence and overall well-being. Activities such as fastening buttons, cooking, and handwriting all require precise coordination of the hands and fingers (Hadžimehmedović et al., 2023). Fine motor skills tend to develop rapidly during childhood and adolescence, with noticeable improvements in hand coordination and object handling until the ages of 19 and 25 but this performance begins to decline with aging. By the time individuals reach their mid-fifties and older, a more noticeable drop in motor proficiency is often observed—sometimes resembling childhood levels, especially in tasks that demand quick and coordinated movements (Shamsipour Dehkordi et al., 2022).

As ageing progresses, various other factors such as physical, biological, and environmental factors come into play. The "Wear and Tear Theory of Aging" suggests that this decline can be explained by the gradual deterioration of cells and tissues during the aging process, which results from the repeated use and increased stress over time, leading to oxidative stress and other deteriorative processes (Sattaur, 2020). One example of such deterioration regard sarcopenia, or the gradual loss of muscle mass, which reduces hand strength and stamina, making basic tasks harder to perform. Further, slower cognitive processing and neurotransmitter changes contribute to difficulties in fine motor tasks (Zapparoli et al., 2022). Environmental factors, such as physical inactivity and unhealthy diet, also accelerate motor decline (Guo et al., 2023; Hadi Mogavi et al., 2024).

Hypothesis 1: Fine motor difficulties increase with age, and this age-related decline accelerates after age 70.

2.2. Differences in motor skills by sex

Sex contributes to the differences in motor skills performance among older adults. Although women live longer than men, previous studies have shown that women that they are more likely to have reduced motor capabilities later in life than men, due to greater levels of disability and comorbidity. For instance, recent evidence shows that women aged 70–79 experience significantly greater motor impairments than their male counterparts, particularly in global coordination, balance, and body schema— or lower-limb functionality (Carvalho De Abreu et al., 2021; Maria Andreis et al., 2018).

From a biological point of view, women face greater physiological challenges than men. First, scholars observed that women experience greater difficulties in daily activities involving gross mobility, such as climbing stairs, lifting objects, and performing heavy housework (Scheel-Hincke et al., 2020). These deficits are partly linked to women's earlier declines in lower-limb strength, lower endurance, and greater intramuscular fat accumulation. Additionally, women tend to accumulate more peripheral fat, while men generally accumulate fat in the abdominal area (Wang et al., 2024). This variation in fat distribution adds to fine motor skill disparities between men and women. The other significant factor is that, particularly after menopause, there is a loss of muscle mass and density in women, which may contribute to reduce their physical activity and, consequently, hasten the loss of fine motor skills (Gould et al., 2022). Conversely, men's long exposure to testosterone maintains higher muscle mass and strength, which enables them to be more physically active and slows down the loss of fine motor skills (Carvalho de Abreu et al., 2021). In addition, there are some age-related motor skills that demonstrate sex differences; for example, men are more likely to be afflicted with tremor disorders, while women are more likely to be afflicted with restless legs syndrome, both of which can significantly affect fine motor control and overall quality of life (Jiang et al., 2024; Schrag et al., 2023).

Besides biological factors, gender differences can also reflect life-course mechanisms, which accumulate over time. The Gender Schema theory helps explain how gendered pathways throughout the life course lead to distinct cumulative advantages and disadvantages, resulting in unequal functional outcomes later in life (Bem, 1981). Throughout adulthood, both sexes encounter a variety of work and family roles. These life experiences draw on different social expectations, labour market demands, as well as everyday life activities. Women's greater involvement in care and unpaid domestic work may increase their long-term exposure to repetitive hand-intensive tasks and strain. Such tasks, which include caregiving, may condition motor functioning further into later life.

Hypothesis 2: Fine motor skills decline with age differently for men and women, with women experiencing a steeper decline compared to men.

2.3. How men's and women's motor skills change by education

Along with sex-related factors, education is an important determinant in overall health and the retention of motor skills. The Cognitive Reserve Theory states that lifelong intellectual engagement, especially formal education, builds a 'reserve' which allows for functioning despite neural changes associated with age (Stern 2002). As such, greater educational attainment is associated with more efficient or flexible brain networks that help to compensate for a decline in fine motor skills. As a result, those with a higher educational level may experience a slower decline in fine motor skills as compared to those with a lower educational level.

The literature suggests that educational attainment is associated with better health in adulthood, which may impact one's fine motor skill decline over age. Pursuing higher education results in a lower mortality risk and greater life expectancy. Thus, university education gives learners the resources and working-life conditions conducive to healthier ageing (Howe et al., 2023). Consequently, highly educated people may see a slow rise in fine motor difficulties over time, whereas less educated people suffer a steep dive in fine motor skills in later life. Reflecting this, individuals with secondary and tertiary education report better self-perceived health than their less educated counterparts (Fletcher et al., 2021). Moreover, these authors suggest that education is an intermediary that gives individuals the knowledge and resources to manage their health effectively and thereby reduce their risk of suffering functional difficulties (Magnani et al., 2024; Shah et al., 2023).

One possible explanation for the impact of education on rate of functional decline is that those with more educational attainment engage in more health-promoting behaviors and/or have greater access to support. Higher education levels correlate with a more physically active lifestyle, an important element which has the potential to improve health as well as reduce risk of chronic disease (Kari et al., 2020). Moreover, access to healthcare, social support networks, and economic opportunities is often facilitated by education, which may promote preventive care and adherence to health guidelines. These advantages may support healthier ageing and, in turn, contribute to lower morbidity, disability, and a slower increase in functional difficulties over time (Raghupathi & Raghupathi, 2020).

Hypothesis 3: Low-educated individuals experience a significantly steeper age-related decline in fine motor skills than with higher education levels.

3. Data and Methods

3.1. Description of Sample

My analysis is based on the Survey of Health, Ageing and Retirement in Europe (SHARE), a multidisciplinary longitudinal survey, representative of the noninstitutionalized population age 50 and over (Borsch-Supan et al., 2005, 2008). The structure of the data is a panel that carries nine waves. The data set contains approximately 160,000 individuals aged 50 or older, with over 616,000 interviews. It covers 28 European countries and Israel. The unit of observation is the individual respondent. Time is presented by the different waves of data collection, each wave depicting a specific time point (SHARE-ERIC, 2016). Observations with missing values were listwise deleted.

There are (N = 378,709) observations from (n = 145,970) individuals, with an average of 2.59 waves per person that shows the data is unbalanced. I excluded those observations aged below 50. Although SHARE data surveys people in their 50s and older spouses of the target persons may also be interviewed and may therefore be below this threshold. We also omitted individuals having missing values on the variable used for the analysis.

3.2. Measures

Fine motor skill is the dependent variable in the analysis. It is a time-varying variable, meaning it changes over time. These variable measures the difficulty an individual experiences in performing tasks that require fine motor skills, such as picking up a coin, eating or cutting food, and dressing. The variable is coded as follows: 0 for no difficulty, 1 for mild difficulty, 2 for moderate difficulty, and 3 for extreme difficulty. In the analysis, it is treated as a continuous variable, with higher values representing greater difficulty in performing these tasks.

The main independent variable is the age of the individual at the end of the year, which is obtained by subtracting the birth year from the year of the interview. Age is operationalized in different ways, with some studies modeling age continuously in years (Skrzek et al., 2015; Carvalho de Abreu et al., 2021; Clouston et al., 2020), while others use age cohorts or age bands to compare life stages (Mogavi et al., 2024; Scheel-Hincke et al., 2020; Marešová et al., 2023; Ahrenfeldt et al., 2019; Caselli et al., 2022). In this study, age is operationalized as a five-category variable constructed from respondents' age in years: 50–59 years, 60–69, 70–79 80–89, 90 years and above.

Other independent variables are sex and education. Sex is an indicator coded into two categories: 0 for male and 1 for female and is a time constant. We considered education of the individual in the first time of their appearance in the panel (since education had low variation over time among older adults). Education level is a categorical covariate. It is a time-constant variable, meaning it remains fixed over time. This variable indicates the highest level of education attained by individuals in the sample. The categories range from 1 to 5, with higher numbers representing higher levels of education. The categories are as follows: "No education," "Primary education," "Secondary and post-secondary (non-tertiary)," "Tertiary education and above (including still in school)," and "Other," which includes any educational levels not captured by the previous categories.

Relationship status, chronic disease and physical activity are the control variables. Chronic disease is a time-varying variable. Initially, the variable ranges from 1 to 10, with 0 indicating no chronic disease and 10 indicating the highest number of chronic diseases. It is treated as a continuous variable in the analysis. Relationship status is a categorical covariate. It is a time-varying variable, meaning it varies between the waves Initially, this variable had six categories, but it was recoded into three categories for analysis: "Married/living with a partner," "Never married," and "Divorced/Widowed.”.

Physical activity is a categorical covariate representing a protective factor in the analysis. It is a time-varying variable, meaning it changes over time. The variable indicates the frequency of vigorous sports or activities performed by individuals, with four categories: 1 for "Hardly ever, or never", 2 for "One to three times a month," 3 for "Once a week," and 4 for "More than once a week." This variable is treated as a categorical variable in the analysis, where higher values indicate more frequent participation in vigorous physical activity.

3.3. Analytical Methods

To address the research questions on how fine motor skills change with age and whether age trajectories differ by education and sex, growth-curve models were estimated. The term “growth curve” refers to how an outcome changes over time (or age) in panel data. In this study, it describes how fine motor skill difficulties change with age. I estimate this age-related trajectory using a fixed-effects linear regression model, which controls unobserved heterogeneity. Growth curves are typically estimated using random-effects or latent growth-curve models. Nevertheless, such estimates can be biased if there is self-selection across age groups – for instance, because of different mortality or panel attrition. In contrast, the fixed-effects method estimates the within-individual age effect, meaning how fine motor skill difficulties evolve as the same person gets older. This method reduces the bias from unobserved heterogeneity and self-selection (Brüderl and Ludwig., 2013). The Hausman test confirmed that the fixed effects model was preferred over the random effects model, indicating that the random effects model assumption of no correlation between unobserved heterogeneity and the covariates does not hold.

I first used Pooled Ordinary Least Squares (POLS) regression model for my analysis, which served as a baseline model to estimate the relationship between independent and continuous dependent variables. As POLS does not decompose the error into an individual-specific (time-invariant) component and a time-varying component, POLS neglects the panel structure when estimating the relationship between age and fine motor skill difficulties, treating the data as independent.

Since pooled OLS treats datasets as repeated cross-sectional observations collected from different individuals at various time points, it fails to account for the fact that multiple observations from the same individual over time are serially correlated, meaning that the error terms (or residuals) for the same person tend to be correlated across waves because repeated measures from the same individual are not independent (Bashir et al., 2023). A key consequence is that pooled OLS can underestimate standard errors and overstate statistical significance, which can lead to misleading inference about the relationship between age and fine motor skill difficulties (Bashir et al., 2023). Another major drawback of using pooled OLS on panel datasets is that it does not control for unobserved heterogeneity. Unobserved heterogeneity concerns time-invariant individual-specific characteristics that may be related to both age and fine motor difficulties, such as cohort (year of birth), baseline health, socioeconomic background, or other fixed traits that may also affect survival probability. This omission can lead to biased and inconsistent estimates (Alemu et al., 2024).

To address these limitations, I used a Fixed effects model (FE). Unlike pooled OLS, FE assumes that unobserved heterogeneity is a fixed effect and accounts for it by comparing everyone to themselves across waves (i.e., removing their time-invariant baseline differences). As FE only focuses only on within-unit variation, e.g., how fine motor skill difficulties change with age within the same person, the effects of time-invariant variables such as sex and education cannot be directly estimated. However, I examine whether sex or education moderate the within-person trajectories of motor skills decline. By doing so, the fixed effects model provides less biased estimation, ensuring that the association of independent variables is accurately measured (Bashir et al., 2023). The estimation of fixed effects is obtained by time-demeaning the observations to remove time invariant characteristics/between unit variation and keeps only within unit variation. This process effectively removes the influence of factors that do not change over time, focusing solely on within individual variations. Our model can be written as follows:

$$\boldsymbol{\ddot{Finemotorskills}_{it} = b_1 \ddot{Age}_{it} + \ddot{u}_{it}}$$

The symbol ¨ represents that the term has been time demeaned. u_{it} is the random error, capturing time-varying influences on fine motor difficulties that are not observed in the data such as temporary health shocks and measurement error.

Even though the FE model is estimated to use a within-person (demeaned) transformation, when producing the predicted lines, Stata adds back the mean level of motor skills for the age groups, so the figure can also be interpreted in terms of predicted levels by age (Cameron & Trivedi, 2005).

Building on the fixed effect model just described, I also include interaction terms to test H2 and explore how the effect of age on fine motor skills changes by individual's sex. I further extended the analysis to test H3 and included a three-way interaction between age, sex and education to see whether the relationship between independent and dependent variable differs by men’s and women’s education. This part of the analysis explores how education influences people's health trajectories by sex, comparing individuals with lower education to those with higher education.

4. Results

4.1. Descriptive Results.

Table 1 (a): Summary statistics of the variables introduced in the analytical model

Source: SHARE (Wave 1-2, 4-9)

Variable		Mean	Std. Dev
Fine Motor Skills	**Overall**	.15	0.47
	Between		0.43
	Within		0.29
Age	**Overall**	2.37	1.03
	Between		1.01
	Within		.43
Gender	**Overall**	1.55	0.49
	Between		0.49
	Within		0
Education Level	**Overall**	2.96	0.75
	Between		0.75
	Within		0
Chronic Disease	**Overall**	1.82	1.60
	Between		1.46
	Within		0.83
Marital Status	**Overall**	1.53	0.85
	Between		0.82
	Within		0.25
Physical Activity	**Overall**	2.35	1.32
	Between		1.14
	Within		0.81

Table 1 (b): Summary statistics of the catagoriacal variables introduced in the analytical model

Source: SHARE (Wave 1-2, 4-9

Categories	Percentage
Age	
50-59	22.58%
60-69	34.58%
70-79	27.71%
80-89	13.16%
90+	1.97%
Sex	
Male	44.33%
Female	55.67%
Education Level	
No education	3.93%
Primary Education	18.36%
Secondary and Post Secondary	55.52%
Tertiary	21.78%
Others	0.41%
Marital Status	
Married/with a partner	70.58%
Never Married	5.50%
Divorced or Widowed	23.92%
Physical Activity	
Hardly ever or never	43.98%
One to three times a month	9.64%
Once a week	13.77%
More than once a week	32.66%

Table 1 (a) summarizes the descriptive statistics of the study sample, showing the between and within variation (reported as standard deviations and percentages of catagorical variables. The average level of fine motor difficulty is 0.15, indicating that on a 0–3 scale most observations lie very close to "No difficulty." The overall standard deviation (SD) shows the dispersion of all observations around the grand mean (around 0.48 points). The between SD captures how much people, on average, differ from one another (0.43), whereas the within SD (0.29) reflects the average change within the same individual. Because within variation is smaller than between, there are typically more differences across individuals than within themselves

Age was modelled using a categorical and is therefore summarized here as a five-level age measure (range 1–5): 50–59, 60–69, 70–79, 80–89, 90 and above. The mean age category is 2.37, meaning individuals lie, on average, in the category 60−69. The between SD (1.01) indicates sizeable differences across individuals in their average age category, while the within SD (0.43) shows comparatively limited within-person change across waves—consistent with short panel windows relative to the life course. The mean value for sex is 1.56, which indicates that, on average, the sample is skewed towards females, as this variable is coded as 1 for males and 2 for females. The within variation is 0, implying that sex does not change for individuals over time within the panel, which is expected since sex is a time-invariant characteristic. The mean education level is 2.97, indicating that, on average, individuals in the sample have an education level between secondary/post-secondary non-tertiary and tertiary education. Also in this case, the within variation is 0, indicating that individuals do not experience changes in their education levels over time.

Regarding controls, chronic disease shows substantial variability across individuals, with the mean number of chronic diseases being around 1.82, indicating that, on average, individuals report slightly more than 1 chronic disease. The mean value for marital status is 1.53, indicating that, on average, individuals in the sample are married/partnered. Marital status shows stability over time for most individuals, but there is variability across individuals. Physical activity shows notable variability across individuals. The mean level of physical activity is 2.35, indicating that, on average, individuals report moderate levels of physical activity. However, there is considerable fluctuation among individuals over time, with some showing substantial increases or decreases in activity levels, while others maintain a relatively stable activity level over the observed periods.

Table 1 (b) shows the percentages of categorical variables in the analysis. According to the tabe, the sample is concentrated in younger old age group, especially 60-69 year age group

(34.58%) and 70-79 years (27.71%) with a very small share aged 90 and above (1.97%). It is also slightly skewed towards females, with women accounted for 55.67% of the sample. The sample largely consists of respondents with at least secondary education (55.52% secondary/post-secondary and 21.78% tertiary), and most respondents were married or living with a partner (70.58%).

Table 2. Distribution of Fine Motor Skills

Source: Share Data (Wave 1-2, 4-9

Fine moto skills	Overall		Between		Within
	Frequency	Percent	Frequency	Percent	Percent
No difficulty	336,788	88.93	136,846	93.75	94.43
Mild difficulty	30,651	8.09	22,684	15.54	52.71
Moderate difficulty	7,430	1.96	6,258	4.29	50.05
Extreme difficulty	3,840	1.01	3,222	2.21	51.83
Total	378,709	100.00	169,010	115.78	86.37
		n = 145,970			

Table 2 shows the distribution of the dependent variable of the analytical model, i.e., fine motor skills, decomposing it into overall, between and within percentages, providing additional details on overall, within and between variations of fine motor skills. The overall distribution shows that most observations in the sample report no difficulty with fine motor skills (88.93%). Reports of mild difficulty account for around 8 %, while moderate and extreme difficulties are comparatively rare, around 1–2%. This indicates that fine motor problems are uncommon in the sample.

The between columns in Table 2 summarize how many distinct individuals out of the total ever appear in each category across waves. Here, 93.75% of individuals have at least one wave with no difficulty. Still, a non-trivial minority ever experience problems: 15.54% ever report mild difficulty, 4.29% ever report moderate difficulty, and 2.21% ever report extreme difficulty (e.g., moving between no/mild/moderate). Thus, the sum of the percentages from each category exceeds 100% because many respondents transition across categories over time.

The within column reflects persistence—the average share of an individual's observed waves spent in that category among those who ever enter it. Individuals who ever report no difficulty spend, on average, 94.42% of their observed time in that state, indicating high stability. By contrast, among those who ever experience difficulties, the average time spent in that state is roughly half of their observation window: 52.75% for mild, 49.96% for moderate, and 51.77% for extreme. Overall, most individuals remain in no difficulty for nearly all observed waves. However, once difficulties appear, they tend to persist for about half of the observed period on average, suggesting meaningful chronicity rather than purely transient episodes for those affected.

Table 3. Transition Matrix for Fine Motor Skills

Source: Share Data (Wave 1-2, 4-9

Fine motor skills index	**Fine motor skills index** **0. No Difficulties**	**1. Mild difficulties**	**2. Moderate difficulties**	**3. Extreme difficulties**
0. No Difficulties	92.25	6.16	1.09	0.50
1. Mild difficulties	53.99	34.73	8.850	3.44
2. Moderate difficulties	28.63	30.81	25.12	15.45
3. Extreme difficulties	21.76	16.84	21.84	39.56

Table 3 presents the transition matrix for the fine motor skills index across SHARE waves. No difficulty is by far the most stable state; once people have no difficulty, they typically remain difficulty-free. Those in no difficulty in a given wave had 92% probability of remaining in the same category the following year, whereas the remaining 8% moved to other categories. Extreme difficulties category is less stable: those in extreme difficulties in a given wave have 40% probability of remaining in that category, while 60% move to lower-difficulty categories the following year.

4.1. Analytical Results

Now, we turn to Table 4, which shows the baseline results from the pooled OLS and fixed effects (FE) models. Overall, the results suggest that fine motor skill difficulties increase with age, but the pattern is different by age groups. Compared with the reference group aged 50–59, the pooled OLS results show small differences for those aged 60–69 ($\beta = -0.015$) and 70–79 ($\beta = 0.001$), but the coefficients become much larger in older age groups. In particular, being aged 80–89 is linked to a 0.123 ($p < 0.001$) unit higher fine motor difficulty score and being 90+ is linked to a 0.484 ($p < 0.001$) unit higher score.

In the FE model, the age gradient is even steeper, indicating that within-person ageing over time is associated with rising fine motor difficulties. Relative to ages 50–59, moving into the 70–79 category is associated with a 0.037 increase, rising to 0.178 for 80–89, and 0.563 for 90+ (all coefficients are significant at conventional levels). This stronger pattern in the FE estimates suggests that controlling for time-invariant individual characteristics matters, and that the deterioration in fine motor skills becomes more pronounced at the oldest ages.

Table 4. Determinants of Fine Motor Skills: Pooled OLS and Fixed-Effects Regression

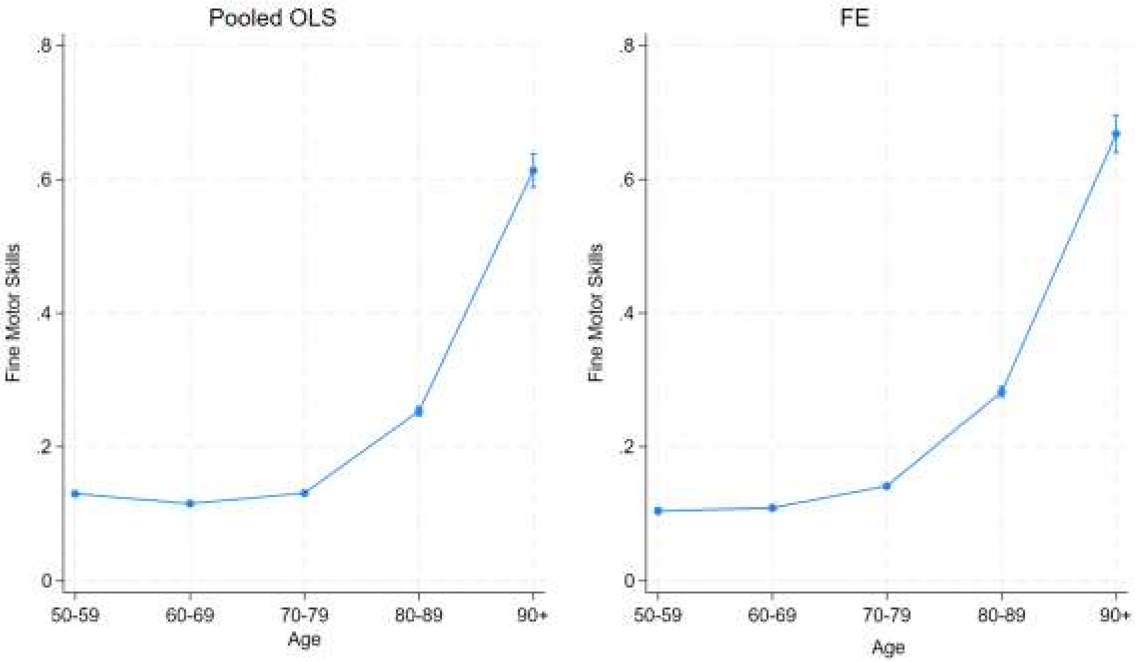
*Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Variable	**Model 1 (POLS)**	**Model 2 (FE)**
Age (ref. 50-59)		
60–69	-0.015***	0.004**
70–79	0.001	0.037***
80–89	0.123***	0.178***
90+	0.484***	0.563***
Sex (ref. male)		
Female	-0.013***	(omitted)
Education Level (ref. No Education)		
Primary Education	-0.070***	(omitted)
Secondary Education	-0.092***	(omitted)
Tertiary Education	-0.111***	(omitted)
Other	-0.035	(omitted)
Chronic Disease/s	0.062***	0.038***
Marital Status (ref. Married/have a partner)		

Never Married	0.029***	-0.005
Divorced/Widowed	0.028***	0.056***
Physical Activity Index (Ref. Hardly ever or never)		
One to three times a week	-0.143***	-0.061***
Once a week	-0.131***	-0.053***
More than once a week	-0.120***	-0.048***
Constant	-0.163***	-0.493***

The comparison between POLS and FE are also shown graphically in Figure 1, which depicts the predicted motor skills over age categories. In both models, age has a negative association with fine motor skills. As an individual gets older, their fine motor skills start deteriorating, and the effect remains statistically significant in each specification. In pooled OLS, the age pattern is upward overall, but it is flatter at younger older-age bands and only rises sharply at later ages. The slopes differ because pooled OLS does not account for unobserved heterogeneity, whereas FE focuses on within-individual variation and removes time-invariant factors. Therefore, it provides a more accurate estimate of how ageing is linked to fine motor difficulties.

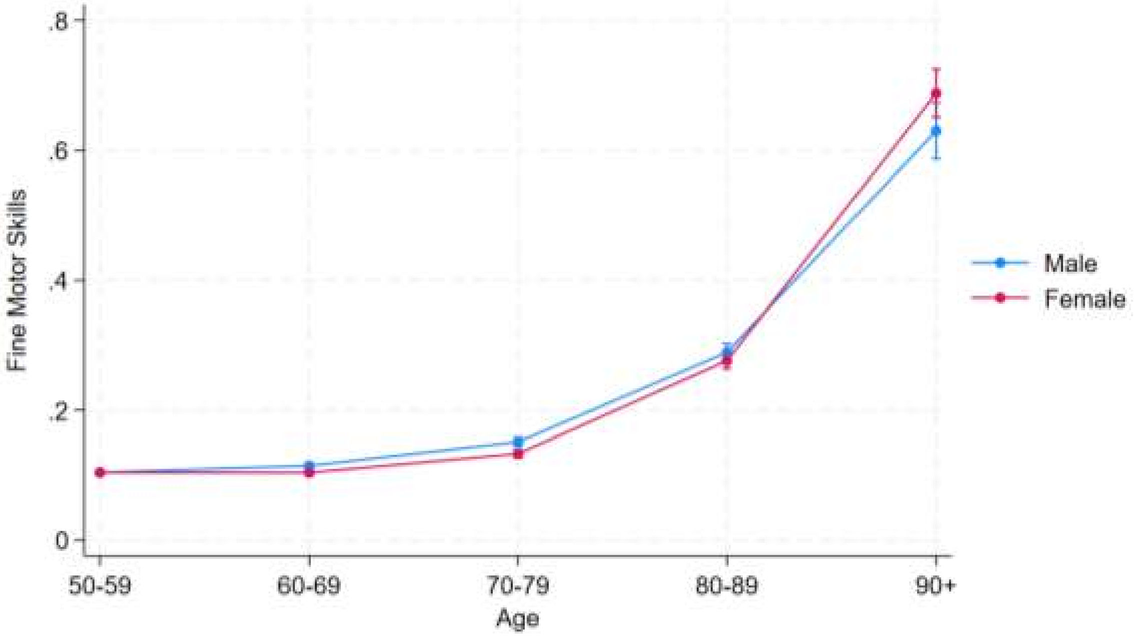
Figure 1: Fine Motor Skills over age



Source: Share Data (Wave 1-2, 4-9)

Note: 1) The scale for fine motor skills ranges from 0 to 3, where higher values indicate greater motor skill difficulties 2) Confidence intervals graphed at the 95% level. Predictions are derived from a Fixed Effects model, where the dependent variable is fine motor skills and the independent variables are age and other covariates are sex and education, marital status, chronic diseases, physical activity

Figure 2: Change in Predicted Motor Difficulties over Age, by sex



Source: Share Data (Wave 1-2, 4-9)

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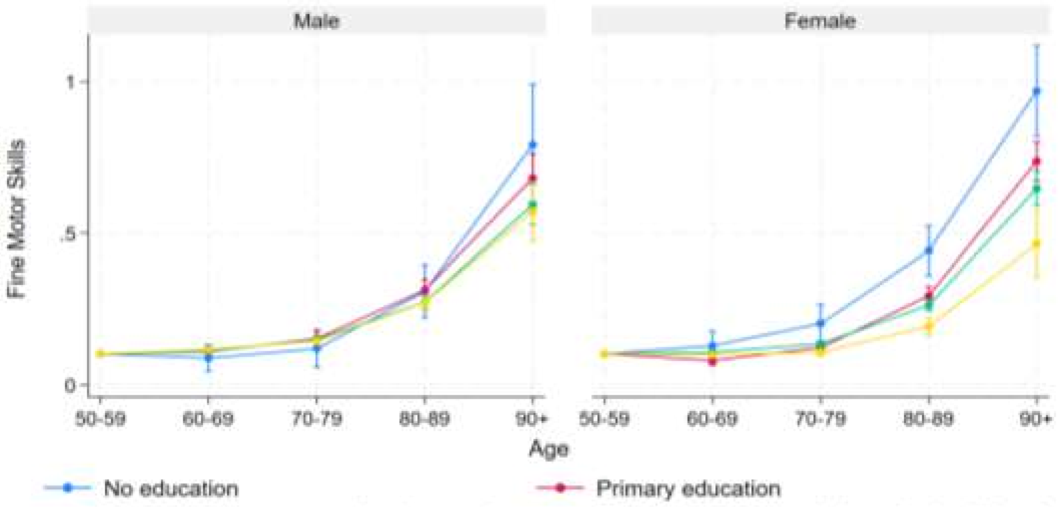
4.2. Does the decline in motor skills over age differ by sex?

Now, the focus is on how the interaction with age and sex affects fine motor skills. The results are displayed in figure 2. Both sexs experience an increase in fine motor difficulties with age, but the effect is slightly stronger for women. Women show steeper slopes in comparison to men. However, the difference is small and not statistically significant (as confidence intervals overlap almost entirely). (POLS results are in the Appendix)

Figure 3: Interaction between Age, Sex, and Education Level in Fine Motor Skills –



Source: Share Data (Wave 1-2, 4-9)

Note: 1) The scale for fine motor skills ranges from 0 to 3, where higher values indicate greater motor skill difficulties 2) Confidence intervals graphed at the 95% level. Predictions are derived from a Fixed Effects model, where the dependent variable is fine motor skills and the independent variables are age and other covariates are sex and education, marital status, chronic diseases, physical activity

4.3. Does education moderate the decrease in motor skills over time?

Figure 3 shows the interaction between the covariates age, sex and education from the FE model. Educational level moderates the age-related change in fine motor difficulties, with highly educated individuals showing a slower increase in motor difficulties as they age compared to their less educated counterparts. The sex gap in motor difficulties across all four educational stages is consistent with women showing a steeper increase in difficulties over time than men. The gap is more pronounced for the no education and primary education category, with women showing the sharpest rise in difficulties as age increases.

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4.4. Control Variables

In Model 2 in Table 4 (Fixed Effects), the estimates focus on within-person change over time, meaning the model controls for all time-invariant characteristics of an individual. This is why sex and education are omitted from the FE model. For the time-varying controls, the coefficient for chronic disease remains positive, showing that when an individual develops more chronic conditions over time, their fine motor difficulty score increases. Marital status also matters in FE. The results show that transitioning into divorced or widowed is linked with higher fine motor difficulties. Finally, physical activity remains protective in the FE model. Individuals who are physically active report lower fine motor difficulty scores compared to periods when they are hardly ever active.

5. Discussion

This study examines how fine motor skill difficulties change with age, and whether these age trajectories differ by sex and education among adults aged 50+ in Europe, using longitudinal data from SHARE. I use fixed effects linear regression to focus on the individual change in motor skills over age, while controlling unobserved heterogeneity. I also explore a two-way interaction between age and sex, as well as a three-way interaction between age, sex, and education to examine whether education moderates these trajectories differently for men and women

My results show that age is positively related to the elderly people's difficulty in mobility index, meaning that the more people age, the greater the difficulties they face. Importantly, we also find a steeper increase in difficulties at ages 80 and above, which suggests that the decline in fine motor skills becomes sharpest as individuals enter the oldest ages. This age-related deterioration is consistent with the "wear and tear theory", which poses that this is in line with my expectations that the repeated use and accumulated stress over time can gradually weaken the body and make functional difficulties more likely in later life in elderly people (Sattaur, 2020).

I also find that the decline in fine motor skills is similar for men and women. This result is quite contrary to my expectations of elderly women having more fine motor difficulties as they age. The sex differences are not very large, and, in some age ranges, the coefficients and confidence intervals completely overlap, suggesting that the sex gap is limited once we account for within-person change. The only exception is the shift from the age group 80–89 to 90+, which is slightly steeper for women than men. So, the sex gap would become slightly more visible as age increases. These results may suggest that some of the expected sex differences in fine motor skills reflect earlier life circumstances or other time-invariant factors, rather than clear differences in within-person change over time.

This explanation aligns well with Gender Schema theory, according to which sex roles and social expectations shape what men and women are more likely to do across their lives and that these exposures can cumulate into later functional disadvantages (Bem, 1981). Men may have long histories in physically demanding work that can wear out joints and muscle strength. Women, meanwhile, accumulate repetitive domestic and caring demands that draw on their resources and time for leisure-time physical activity and contribute to a gradual decline in fine motor function. At the same time, biological pathways can also matter; for instance, men are usually stronger and more active than women. Furthermore, women deal with the worse mobility-related physiological complications due to menopause- and hormone-related changes (Abreu et al., 2021).

For hypothesis three, the results are broadly in line with expectations, as lower educated individuals experience a steeper age-related deterioration in fine motor skills than those with higher education, with the clearest disadvantage concentrated among low-educated women. My results show that education moderates fine motor skills ageing trajectories of men and women. Highly educated men and women have lower difficulties and a slower deterioration, but the clearest difference is concentrated among low-educated women, especially those in the no education and primary education groups, where the increase is steepest. In contrast, tertiary educated men and women show the lowest difficulties and the slowest decline, and while men show no clear difference between secondary and tertiary education based on the confidence intervals, women show clearer differences between these educational groups. Similarly, evidence shows that people with lower education face earlier motor decline (Zhang et al., 2024). Thus, the strongest vulnerability (meaning the steepest decline in motor skills) would be the cumulative disadvantage of being both low educated and female, which is consistent with Sex Schema theory, according to which sexed roles and unequal opportunities across the life course can translate into steeper functional decline over time (Bem, 1981).

Education looks protective, because the advantage of education seems to show up not only in lower levels of difficulty but also in a slower ageing-related worsening, especially among women. One possible explanation is that, in line with Sex Schema theory, the life-course differences between low- and highly educated women may be more pronounced than those between low- and highly educated men (Bem, 1981). Lower-educated women may experience a greater accumulation of disadvantage through more constrained work opportunities, heavier caregiving and domestic responsibilities, and fewer health-promoting resources across the life course, which could accelerate functional decline over time. At the same time, higher education may provide women with greater cognitive, social, and material resources, making the educational gradient more visible among women. This interpretation also fits earlier evidence showing that higher education is associated with better cognitive performance, while the disadvantage of having no education appears more pronounced among women (Ahrenfeldt et al., 2019).

My results on control variables suggest that chronic disease burden is linked with worsening fine motor functioning, as people with chronic conditions show a steeper increase in fine motor difficulties. This matches evidence that multimorbidity is associated with weaker grip strength, and that stronger grip strength tends to coincide with less multimorbidity (Blanchet et al., 2024). Similar evidence links having two or more chronic diseases with weaker grip strength (Lin et al., 2021).

Relationship status is also linked with motor difficulties. Divorced and widowed people face more difficulties than those married/partnered, though selection may play a role, as healthier people remain partnered and health shocks can precede divorce or widowhood. This aligns with evidence that successful ageing groups are less likely to be without a spouse and show lower prevalence of handgrip weakness and asymmetry (Ji et al., 2026). In our study, those who never marry report fewer difficulties than the married, so these differences are not uniform and should be interpreted cautiously.

Physical activity is negatively associated with fine motor difficulties. Activity may help through reduced inflammation and adaptations linked with neuroplasticity (Kim, 2023; Soyuer et al., 2023). But the direction can also run the other way, since limitations can reduce activity; reduced mobility can lower activity and muscle strength, which can then worsen function further (Soyuer et al., 2023). Overall, the findings support promoting physical activity and muscular fitness to reduce functional burden in multimorbidity, while recognizing limits from reverse causality and self-reported measures (Blanchet et al., 2024).

A major strength of this work is that it fills a gap in the existing literature by using SHARE data across several European countries. Unlike many cross-sectional studies, our longitudinal fixed effects approach focuses on within-person change over time, although it does not establish causality. Since SHARE covers multiple European countries, the findings are likely to be representative of older population in Europe rather than reflecting one local context.

Another strength is that this study focuses on fine motor functioning in later life and links key social factors, especially education (as a proxy for socioeconomic status), to fine motor difficulties. Socioeconomic status is often not explored enough in relation to mobility and age-related decline, and by adding educational groups to fine motor difficulties our study helps fill this gap. In other words, while many studies examine education and overall health outcomes, evidence specifically on fine motor skill difficulties remains scarce.

There are also a few limitations of my study, although the fixed effects model strengthens the analysis by focusing on within-person change, it can only use individuals who show variation over time and it does not fully remove time-varying confounding, so the within-person estimates should be interpreted cautiously we do not observe a clear sex effect on fine motor skills in the fixed effects results, which may partly reflect that controlling for unobserved time-invariant heterogeneity attenuates between-person sex differences

Since SHARE covers multiple countries, it may potentially yield evidence of country-group analysis. For instance, if one considers Central and Eastern European countries separately, they can learn the impact of the differences in the culture, economy, and health-care system on the rate of decline in motor skills. Future researchers can include job status and area of residence (urban-rural) since different kinds of job types and areas of residence may involve varying physical demands and issues of activities. Future research could further investigate physical activity as a protective factor and address these limitations with stronger measures and designsIt would also be interesting to test whether grip strength moderates the link between chronic disease burden and fine motor difficulties, and whether those people who have stronger fine motor muscles are the ones who remain more physically active. From a public health perspective, these findings emphasise promoting physical activity and improving muscular fitness to counteract the harmful association between multimorbidity and fine motor skill difficulties, especially given age-related declines in muscle mass and strength (Blanchet et al., 2024).

Looking forward, future research can further unpack the behavioural pathways behind these associations. In particular, it would be useful to test all four health-related behaviours (physical activity, smoking, alcohol drinking, and healthy eating/fruit–vegetable intake) as pathways linking age to fine motor skills in both men and women, since earlier evidence shows physical activity was the main mediator in both sexes (Pothisiri et al., 2021). Overall, the findings are expected to guide policymakers in designing public health interventions that promote healthy ageing and improve quality of life for older adults throughout Europe. In line with our results, these findings also support guidance suggesting that older adults should do muscle-strengthening activities for major muscle groups at least twice per week, and public health strategies could consider resistance training to improve muscular fitness and reduce functional burden linked with ageing and chronic disease.

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Appendix

AI Declaration: I used ChatGPT to proofread some parts of the thesis for grammar and spelling.

Figure A1: Interaction between Age and Sex in Motor Difficulties – Pooled OLS