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Associations of Physical Activity, Mobility, and Obesity in Older Europeans. A Replication Study using the Survey of Health, Ageing and Retirement in Europe (SHARE)

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Associations of Physical Activity, Mobility, and Obesity in Older Europeans.

A Replication Study using the Survey of Health, Ageing and Retirement in Europe (SHARE)

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Abstract

Background: Obesity is a risk factor for numerous diseases. Being physically inactive and having impaired mobility might be both, risk factors and consequences of high body weight. Activity and mobility might interact in their influence on body weight.

Objective: This study aimed to replicate the findings of a previous study by Asp et al. (2017) on the association between self-reported physical activity, mobility, and obesity based on data from Sweden. Additionally, the same associations were explored in a larger, cross-national sample as well as a smaller subsample using device-measured activity instead of self-reported physical activity.

Data & Methods: Analysis were conducted using data from the eighth wave of the Survey of Health, Ageing and Retirement in Europe (SHARE). Three samples were generated: 1) Only Swedish data to replicate the original study. 2) Data from all 27 SHARE countries. 3) A subsample of respondents participating in the accelerometer study from 10 countries. Comparable to the original study, odds ratios for risk of obesity were reported based on logit regressions.

Results: The replication with Swedish data confirmed the correlation between mobility and obesity. Identical to the original study, the correlation between physical activity and obesity was confirmed only in individuals without mobility impairment. When expanding the sample to include individuals 50 years and older from 27 countries and including additional variables such as smoking behaviour, diseases, and partnership status, the results remained consistent. In addition, it was found that inactivity is associated with increased odds of obesity. Furthermore, a subsample analysis using device-measured physical activity showed no correlation between average acceleration (ENMO) and obesity. However, a linear model suggested a correlation between device-measured activity (ENMO) and body mass index. When examining this correlation separately for mobile and non-mobile individuals, it was significant only for mobile individuals.

Conclusion: These findings support the original study's results and indicate that limitations in mobility play a crucial role in the relationship between physical activity and obesity. The study highlights the importance of considering both self-reported and device-measured physical activity and provides further insights into the associations between physical activity, mobility, and obesity in a diverse, cross-national sample.

Keywords: overweight, body weight, inactivity, limitations in walking, accelerometer

1. Introduction

Obesity is a risk factor for cardiovascular diseases and diabetes (X. Liu et al. 2017; Gill and Cooper 2008; Sattelmair et al. 2011). With 13 % of the worldwide population aged 18 years and older being obese (WHO 2021), it "has now reached epidemic proportions" (WHO 2023, 2). Physical activity is an important prevention strategy for various diseases (WHO 2020) and it is also linked to reducing obesity. The proportion of the global adult population with insufficient physical activity is estimated at 25% (Guthold et al. 2018). Concordant results from cross-sectional and longitudinal analyses, as well as intervention studies document the inverse relationship of physical activity and bodyweight (e.g., Zhu et al. 2020; Cárdenas Fuentes et al. 2018; Jakicic et al. 2014).

Regular physical activity comes with many advantages that may be even more important in old age. High (health-related) quality of life (Marquez et al. 2020) and maintaining cognitive functions (Zhu et al. 2017; Umegaki et al. 2018) have been identified as correlates of physical activity and exercise in old age. However, with ageing, muscle mass is declining (Janssen and Ross 2005) which might make physical activity more challenging or lower the level of achievable physical activity. Another factor that is prejudicial to high physical activity in old age is increasing morbidity, especially impairment in physical functioning (Keats et al. 2017). Older people are more likely to have limitations in mobility (Leopold and Engelhardt 2013) and therefore struggle more to preserve physical activity. Conversely, physical activity can help to maintain mobility (Glass et al. 2021; Koster et al. 2008). Therefore, not only physical activity, also the ability to be physically active are of importance when analysing health (behaviour) in old age.

Studies using different metrics of physical activity – self-reported as well as device-measured – showed a correlation of physical activity and obesity (Cleven et al. 2020; Suorsa et al. 2023). Only some studies considered the role of limitations in mobility in this relationship. Asp et al. (2017) investigated the association of self-reported physical activity, mobility, and obesity in a cross-sectional sample of Swedish men and women 65 years and older ("Health on equal terms" survey conducted in 2012; N=2,558). Results showed higher prevalence of obesity for people with impaired physical mobility. Physical activity was only correlated to obesity in people without mobility impairment.

The aim of this study was to replicate the study by Asp et al. (2017) with another dataset, namely the Survey of Health, Ageing and Retirement in Europe (SHARE). Sample, variables, and analyses were as close as possible to the original study. Further analyses investigated the associations of physical activity, physical mobility, and obesity in a cross-sectional, multi-national sample including additional control variables. Additionally, this study explored the possibility to conduct the same analyses in a smaller subsample using device measured activity instead of self-reported physical activity.

2. Data and methods

The analysis of associations between physical activity, mobility, and obesity used data from wave 8 release 8.0.0 of the Survey of Health, Ageing and Retirement in Europe (SHARE) (Börsch-Supan 2022). SHARE is an interdisciplinary panel survey of people 50 years and older in various European countries (Börsch-Supan et al. 2013). SHARE questionnaires were harmonised ex-ante, and data was collected via face-to-face interviews conducted by trained interviewers. Data collection of the eighth wave of SHARE started in October 2019 in 27 countries and was suspended in March 2020 due to the outbreak of the COVID-19 pandemic (Scherpenzeel et al. 2020). SHARE wave 8 included an additional device-based measurement of physical activity in a subsample in ten countries (Scherpenzeel et al. 2021).

Section 2.1 describes which information on mobility, physical activity, obesity, and several control variables, were provided in SHARE wave 8 and how this was used in the analyses. In this paper, different samples based on the SHARE wave 8 data were used, described in detail in section 2.2. Section 2.3 informs about the statistical methods applied in this study.

2.1 Measures

Obesity

Self-reported weight and height were used to calculate individual body mass index (BMI) according to the standard formula (body weight in kilograms divided by the square of height in meters). Obesity was defined as BMI equal or greater than 30 kg/m^2. This is a commonly used threshold that was also applied in the Asp et al. study.

Mobility

In the original study, mobility was defined by the ability to "walk up stairs without difficulty (for example getting on a bus or a train)" and "take a short walk (about five min) at a reasonably fast pace" (Asp et al. 2017, 86). Similarly, mobility for SHARE respondents was defined by having neither difficulties in walking 100 metres, nor climbing one flight of stairs without resting.

Physical activity

The indicator for physical activity used by Asp et al. was generated by means of two questions. Respondents were considered as active if they reported either leisure time movement (during which they break a sweat) of at least 30 minutes at least once per week; or more than 3 hours per week of "moderately strenuous activities" that warms up their body (Asp et al. 2017, 86).

The measures of physical activity in SHARE deviated due to the different questions available in the questionnaire. SHARE collected information about self-reported physical activity by means of two questions. The first one recorded how often respondents do sports or activities that are *vigorous*, the second one recorded the frequency of activities requiring a *moderate* level of energy. The response options were "more than once a week", "once a week", "one to three times a month" and "hardly ever/never".

The answers to both questions were combined into a new indicator which rescales self-reported physical activity onto a three-level scale. Respondents were considered as inactive if they report to hardly ever or never do activities requiring a moderate level of energy. Respondents who report doing sports or activities that are vigorous more than once a week were classified as active.[1] All other individuals were classified in the "medium activity" group.

Controls

A range of controls was included for the purpose of this analysis, comparable to the four covariates used in Asp et al. (2017): gender, age, socio-economic status, and fruit and vegetable intake. Gender was a dichotomous categorical variable. Age was grouped in ten-year intervals and an open-ended interval: 50-59, 60-69, 70-79, 80+ years.[2] Education was coded in SHARE according to the 1997's International Standard Classification of Education (ISCED), which allows for the standardised reporting of education statistics at international level (UNESCO 2012). The seven original ISCED-levels were grouped in a three-level categorical variable that takes the level low (no or primary education, ISCED levels 0 and 1), medium (secondary education, ISCED levels 2, 3 and 4), and high (tertiary education, ISCED levels 5 and 6). Diet quality was approximated using a dummy variable, which constituted a different approach from the continuous approach of Asp et al. (2017). Respondents in SHARE were

[1] A few respondents reported to be hardly ever moderately active and vigorously active more than once per week. Those were considered as active.

[2] The age categories in the original study deviate as they were specified in five-years intervals: 65-69, 70-74, 75-79, 80-84, 85+. Category 50-59 is only applicable in the additional analyses using the larger SHARE sample and the age threshold of 50.

asked to answer the question “how often do you eat servings of fruits or vegetables?” with response options “every day”, “3-6 times a week”, “twice a week”, “once a week”, and “less than once a week”. The responses were thus recoded into a dummy variable indicating a daily intake of fruit or vegetables.

For further analyses complementing the replication study, additional controls available in SHARE were used. The rich number of covariates available in SHARE allowed to include a wide range of individual level controls to the analysis, such as respondent’s current and previous smoking behaviours. The generated categorical variable records if respondents never smoked, smoked in the past but quit, or were smoking at the time of the interview. Respondents were also asked whether they had been diagnosed or told by a doctor to have specific health conditions, such as: a heart attack including myocardial infarction or coronary thrombosis or any other heart problem including congestive heart failure, high blood pressure or hypertension, a stroke or cerebral vascular disease, and diabetes or high blood sugar. Finally, a dummy variable recorded the presence of a partner in the household. A country variable was used to control for factors varying at country level.

Device measured physical activity

Additional to the self-reported physical activity, in SHARE wave 8 device-based measurement of activity is available for a subsample of respondents (Scherpenzeel et al. 2021). A subsample of SHARE panel respondents were asked to wear an Axivity AX3 (Axivity, Newcastle upon Tyne, UK) tri-axial accelerometer on the thigh for eight consecutive days in everyday life. Devices were set to a sampling frequency of 50 Hz (range +-8*g*). SHARE provides aggregates measures of accelerometer data, generated with GGIR version 2.4-0 (Migueles et al. 2019). Data processing in GGIR comprised auto-calibration, non-wear detection and imputation of non-wear time (van Hees et al. 2014; Sabia et al. 2014). More details on the processing of accelerometer data in SHARE is available elsewhere (SHARE 2022, 67–71).

One of the metrics provided in the SHARE dataset is Euclidean norm minus one with negative vales set to zero (ENMO) which describes the average volume of activity in a time interval. The Euclidean norm is the vector magnitude, combining the acceleration of the three axes to one vector:

$$\sqrt{x^2 + y^2 + z^2}$$

As accelerometers also record gravity, 1 gravity unit ($1g = 9.81\frac{m}{s^2}$) is subtracted from the Euclidean norm. ENMO is calculated with the formula $\sqrt{x^2 + y^2 + z^2} - 1$ (negative values set to zero) and denoted in milligravity units ($1\ \text{m}g = 9.81\frac{\text{m}}{\text{s}^2}/1000$) (van Hees et al. 2013). The average Euclidean norm minus one with negative vales set to zero (ENMO) over the whole observation period was used as measure for volume of physical activity (Migueles et al. 2021).

Further controls were included to extend the analysis and ensure result comparability beyond the extraordinary situation in which the data was collected: Some of the measurements were conducted in the onset of the COVID-19 pandemic therefore individuals’ ability to be physically active might have been influenced by governments’ control measures. In fact, the different protective and self-isolation policies which have been adopted and modified over time by national governments might have affected respondents’ movement habits and patterns. To account for this situation, the stringency index at time of measurement based on the Oxford Coronavirus Government Response Tracker (OxCGRT) (Hale et al. 2021) was added as a covariate. The OxCGRT is a database that allows to compare government policies to contain the spread of COVID-19 virus. The stringency index is using a scale from 0 to 100 with higher values indicating stricter regulations. Finally, the month in which the accelerometer has been worn and number of valid measurement days were included.

2.2 Sample

To replicate the analysis by Asp et al., a sample of all respondents from Sweden age 65 years and older was used. A multi-national sample of all available respondents 50 years and older from all SHARE countries served as comparison. Additional analyses were based on the smaller sample of participants of the accelerometer study which was conducted as sub-study in 10 countries. Cases with missing information in one or more variables used in the respective analysis were excluded.

The Swedish 65+ sample consisted of 1,946 cases. The whole SHARE sample included 44,565 cases from 27 countries. In the sample of accelerometer participants, only those with at least four days, each with at least 16 hours of valid wear time, were considered for analysis. The accelerometer sample consisted of 801 cases. Table 1 depicts the composition of the three different samples. A more detailed overview including all covariates is available in Appendix 1.

2.3 Statistical methods

The statistical methods applied include chi square tests to assess the bivariate associations of physical activity and obesity as well as logit regression to perform multivariate analyses. Analysis of the metric

Table 1: Sample description

		Sweden 65+ N=1,946	SHARE 50+ N=44,565	Accelerometer N=801
Gender				
Female	%	47.4	43.1	41.3
Male	%	52.6	56.9	58.7
Age				
50-59	%	-	13.1	19.6
60-69	%	22.6	36.7	35.8
70-79	%	50.3	32.8	31.6
80+	%	27.1	17.5	13.0
Obesity				
Obese	%	16.2	23.7	25.5
Not obese	%	83.8	76.3	74.5
Self-reported activity				
Inactive	%	6.4	13.4	9.2
Medium active	%	56.5	55.6	60.3
Very active	%	37.2	31	30.5
Mobility				
Limitations	%	7.6	11.8	9.4
No limitations	%	92.4	88.2	90.6
Countries		Sweden	Sweden, Germany, Spain, Italy, France, Denmark, Belgium, Czech Republic, Poland, Slovenia, Austria, Netherlands, Greece, Switzerland, Israel, Luxembourg, Hungary, Estonia, Croatia, Lithuania, Bulgaria, Cyprus, Finland, Latvia, Malta, Romania, Slovakia	Sweden, Germany, Spain, Italy, France, Denmark, Belgium, Czech Republic, Poland, Slovenia

Data: SHARE Wave 8 Release 8.0.0. (unweighted).

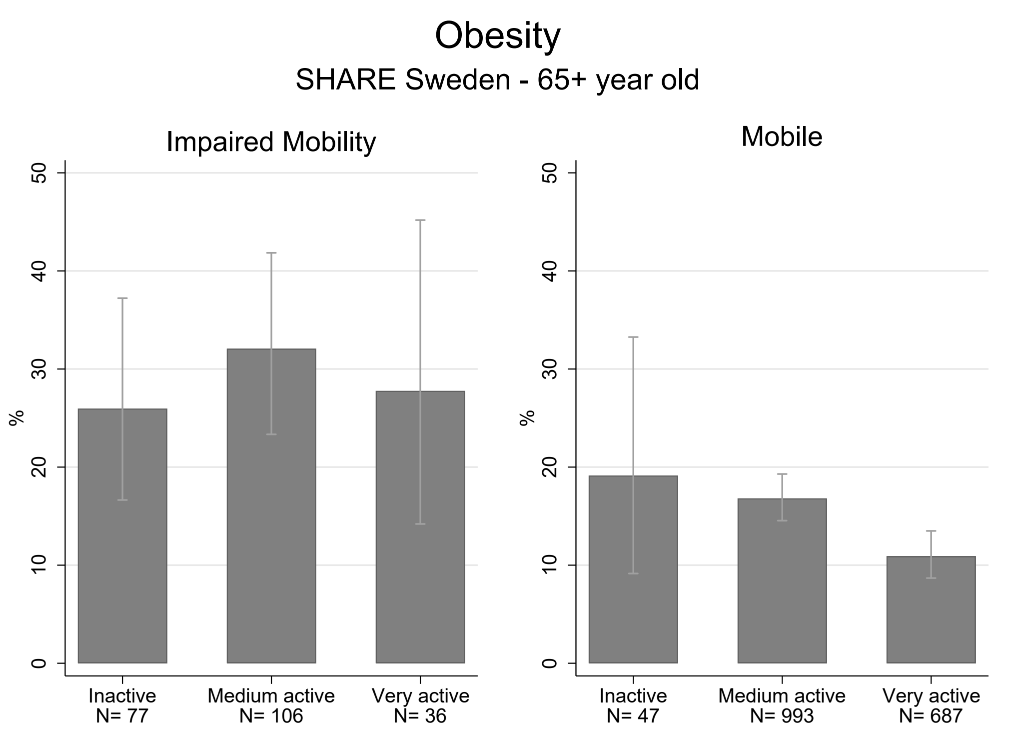
measure of body mass index also used linear OLS regression. The analyses were carried out using Stata 17 (StataCorp 2021).

3. Results

Figure 1 illustrates the prevalence of obesity in people with and without impaired physical mobility by self-reported physical activity in the Swedish sample of 65+ years old. The overall prevalence of obesity was 16.2%[3], with considerably lower prevalence in people without impaired mobility compared to those with impairment in mobility, 14.5% and 29.2%, respectively. In mobile individuals, higher self-reported physical activity was associated to lower prevalence of obesity, indicated by a chi-square test (X^2 (2, N = 1,727) = 12.211, p = .002). Self-reported activity levels and obesity were not significantly correlated in impaired individuals (X^2 (2, N = 219) = .846, p = .655).

To replicate the analyses of Asp et al., multivariate logit regressions were performed with the Swedish 65+ sample with the same set of control variables. Results reported in Table 2 were identical to the Asp et al. analyses: Impairment in mobility was correlated to higher, being (very) active to lower odds of obesity (model 1). In the following models, the sample was split into mobile (model 2) and mobility impaired (model 3) individuals. In line with the results from Asp et al. the coefficient of the activity variable was only significant in the mobile subsample. Adding more controls (partner in household, smoking, medical conditions) to models 1-3 did not change these results (not shown).

Figure 1: Obesity by mobility and self-reported physical activity obesity – Sample (Sweden, 65+) and control variables comparable to Asp et al (2017)



Data: SHARE Wave 8 Release 8.0.0 (unweighted) with 95% confidence intervals.

[3] All reported prevalence of obesity in this study refer to unweighted samples.

Table 2: Logit regression: Odds rations for obesity – Sample (Sweden, 65+) and control variables comparable to Asp et al (2017)

	(1) All	(2) Mobile	(3) Impaired Mobility
Mobility	0.38 ***		
	(0.07)		
Active			
Inactive	0.87	1.33	0.77
	(0.23)	(0.52)	(0.27)
Very active	0.59 ***	0.59 ***	0.74
	(0.09)	(0.09)	(0.33)
Gender			
Female	1.00	1.05	0.79
	(0.13)	(0.15)	(0.25)
Age			
70-79	0.56 ***	0.53 ***	0.92
	(0.09)	(0.08)	(0.50)
80+	0.39 ***	0.35 ***	0.67
	(0.08)	(0.08)	(0.36)
Respondent education level			
medium	0.80	0.74	0.94
	(0.13)	(0.14)	(0.35)
high	0.46 ***	0.39 ***	0.82
	(0.09)	(0.08)	(0.34)
Fruit or vegetables intake			
high	0.83	0.76 +	1.12
	(0.12)	(0.12)	(0.41)
Intercept	1.44	0.65 +	0.69
	(0.41)	(0.16)	(0.43)
Pseudo R-squared	0.05	0.04	0.01
Number of observations	1,946	1727	219

*** p<.001, ** p<.01, * p<.05, + p<.1

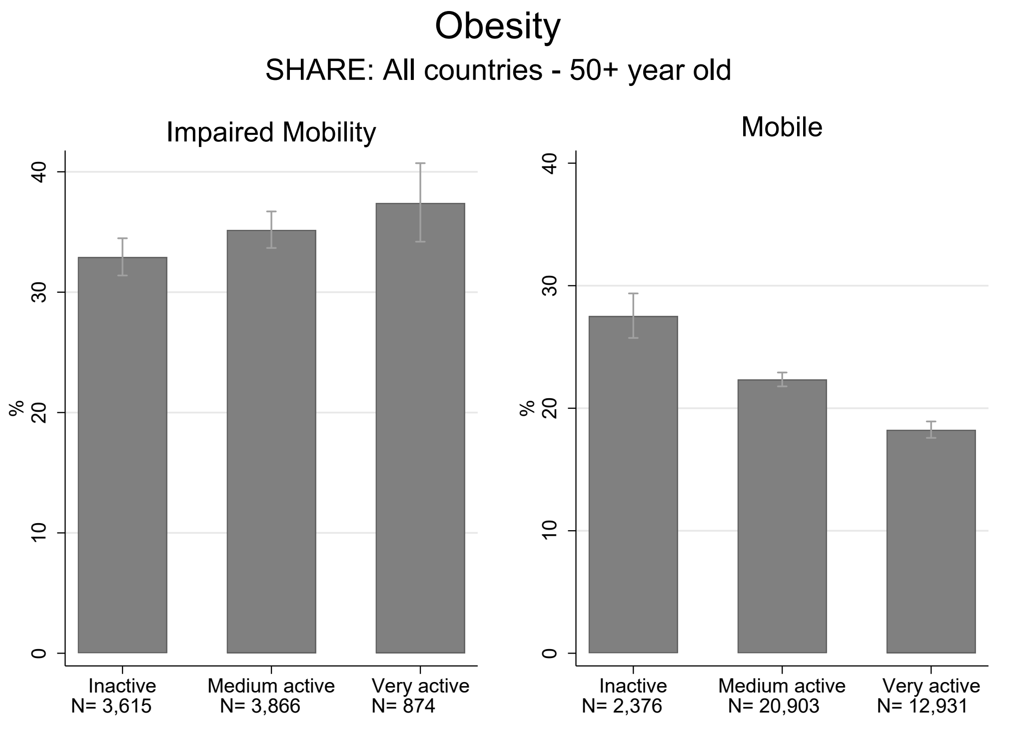
Note: Standard Error in parentheses.

Data: SHARE Wave 8 Release 8.0.0. (unweighted).

In a next step, the sample and regression models were modified to check if the results hold in a larger sample with additional control variables. The sample of all SHARE respondents from Wave 8 was used instead of the Swedish sample and the lower age threshold was set to 50 years (compared to 65).

The prevalence of obesity in the full SHARE 50+ sample was 23.7%, thus higher compared to the Swedish sample 65+. Again, people without impairment in mobility were less likely to be obese compared to those with limitations, 21.2% and 34.4%, respectively. In concordance with the smaller Swedish sample, the chi-square tests indicated a correlation of higher self-reported physical activity with lower prevalence of obesity for mobile individuals (X^2 (2, N = 36,210) = 140.91, p = .000). However, the association was reversed for mobility impaired individuals: More active individuals had a higher prevalence for obesity (X^2 (2, N = 8,355) = 8.065 p = .018), see Figure 2.

Figure 2: Obesity by mobility and self-reported physical activity obesity



Data: SHARE Wave 8 Release 8.0.0 (unweighted) with 95% confidence intervals.

In the logit regression exploiting the multi-national sample, additional controls were country, whether a partner was living in the same household, and various medical conditions (heart attack, high blood pressure or hypertension, stroke, diabetes, or high blood sugar). Results presented in Table 3 confirmed the associations of obesity to both, mobility, and high activity. Again, mobility was associated with lower odds of obesity (Table 3, model 1). In the large sample with additional controls,

Table 3: Logit regression: Odds rations for obesity – SHARE: All countries 50+

	(1) All	(2) Mobile	(3) Impaired Mobility
Mobility	0.54 ***		
	(0.02)		
Active			
Inactive	1.14 ***	1.31 ***	1.08
	(0.04)	(0.07)	(0.06)
Very active	0.80 ***	0.79 ***	1.02
	(0.02)	(0.02)	(0.08)
Intercept	0.56 ***	0.33 ***	0.49 ***
	(0.05)	(0.03)	(0.10)
Number of observations	44,565	36,210	8,355
Pseudo R-squared	0.09	0.08	0.08

*** p<.001, ** p<.01, * p<.05, + p<.1

Notes: Full table in Appendix 2. Standard Error in parentheses. Controls: gender, age, education, Fruit or vegetables intake, Smoking habit, Partner in household, Heart attack, High blood pressure or hypertension, Stroke, Diabetes, or high blood sugar

Data: SHARE Wave 8 Release 8.0.0 (unweighted).

Table 4: Logit regression: Odds rations for obesity – SHARE: Accelerometry 50+

	(1) All	(2) Mobile	(3) Impaired Mobility
Mobility	0.50 **		
	(0.12)		
ENMO	0.99	0.99 +	1.02
	(0.00)	(0.01)	(0.02)
Intercept	3.34	4.19	0.32
	(2.96)	(4.20)	(0.89)
Pseudo R-squared	0.14	0.14	0.33
Number of observations	801	675	126

*** p<.001, ** p<.01, * p<.05, + p<.1

Notes: Full table in Appendix 3. Standard Error in parentheses. Controls: Gender, age, education, fruit/vegetable intake, smoking, partner in household, heart attack, high blood pressure or hypertension, stroke, diabetes, or high blood sugar, country, OxCGRT stringency index, month of accelerometry measurement, number of days accelerometry measured

Data: SHARE Wave 8 Release 8.0.0 (unweighted).

activity was correlated to lower odds of obesity, too. However, compared to the previous models, the coefficient for being inactive was significant as well: inactivity was correlated to higher odds of obesity. Again, the correlation between activity and obesity was present only in mobile (model 2), but not in mobility impaired individuals (model 3). The bivariate correlation of self-reported physical activity and obesity in mobility impaired individual shown in Figure 2 was therefore not confirmed.

In the last step, the same models were tested with a device-based measure of physical activity instead of self-reported activity. As the accelerometer study was a sub-study of SHARE Wave 8, the sample is considerably smaller (N=801) with observations from ten different countries (see section 2.2). Average acceleration (ENMO) was used as a metric covering the total volume of activity. Additional controls, specific to the accelerometer measurements, were included (see section 2.1). Consistent with the previous results, being mobile was significantly correlated with lower odds of being obese (Table 4, model 1). However, ENMO was not correlated to obesity in the full sample. When looking at subsamples divided by mobility impairment, there was no significant correlation either. Only the coefficient of ENMO (OR = 0.99, p = 0.068) trended towards the previous finding of higher activity associated to lower odds of obesity in the sample of mobile individuals.

Table 5: Linear OLS Regression: Coefficients for body mass index (BMI) – SHARE: Accelerometry 50+

	(1) All	(2) Mobile	(3) Impaired Mobility
Mobility	-1.95 ***		
	(0.47)		
ENMO	-0.02 +	-0.02 *	0.01
	(0.01)	(0.01)	(0.04)
Intercept	32.74 ***	32.35 ***	30.12 ***
	(1.58)	(1.58)	(5.99)
R-squared	0.21	0.19	0.38
Number of observations	801	675	126

*** p<.001, ** p<.01, * p<.05, + p<.1

Notes: Full table in Appendix 4. Standard Error in parentheses. Controls: Gender, age, education, fruit/vegetable intake, smoking, partner in household, heart attack, high blood pressure or hypertension, stroke, diabetes, or high blood sugar, country, OxCGRT stringency index, month of accelerometry measurement, number of days accelerometry measured

Data: SHARE Wave 8 Release 8.0.0 (unweighted).

When using BMI as a metric measure of body weight – instead of the binary obesity indicator – in a linear OLS regression, the pattern of the previously shown results on self-reported activity were confirmed (Table 5): More activity was associated with lower BMI, but only in mobile individuals.

4. Discussion

In this study, the analyses by Asp et al. (2017) were replicated with another data source and additional analyses to check the robustness of the original study's findings. Asp et al. (2017) looked at the relationship of limitations in mobility, physical activity, and overweight in a sample of the Swedish population of age 65 and older. The replication used the Swedish sample of the eighth wave of the Survey of Health, Ageing and Retirement in Europe (SHARE), restricted to 65+ years old respondents. Variables were constructed as similar as possible to the original study. The analysis with SHARE data confirmed the results of the original study, i.e., mobility was correlated to obesity and activity was correlated to obesity only in mobile individuals.

When extending the sample to the complete SHARE wave 8 sample, including individuals 50 years and older in 27 countries, and adding information on smoking behaviour, various diseases, and partnership, the same result was observed as well. However, not only the coefficient of activity showed significant correlations with less risk of obesity, it is also indicated that inactivity (an indicator that was not part of the original study by Asp et al.) was associated with increased odds for obesity.

The mentioned results, including the original study by Asp et al., were based solely on self-reported physical activity. With a subsample of SHARE wave 8 it is possible to check if these associations also hold for device-measured activity. No correlation of average acceleration (ENMO) and the binary obesity measure was observed, but the linear model suggested that device-measured activity (ENMO) and BMI were correlated. When looking at this correlation separately for mobile and non-mobile individuals, it was again only significant for mobile individuals.

Besides the original study, concordant results of independent associations of mobility, physical activity, and obesity were already presented by Kaplan et al. (2003) and several studies showed that both, physical activity and obesity, was associated with impaired physical mobility (e.g., Glass et al. 2021; Koster et al. 2008).

When looking at obesity, the results in this study were not consistent for the measures of self-reported versus device-based physical activity. This might be due to the smaller sample size in the device-based analysis. Another source for inconsistence might be the nature of the measures. While the self-report asked for the frequency of moderate and vigorous activities, the ENMO was considered as a measure for total volume of activity; The correlation of these two measures is moderate (Franzese et al. 2023).

The finding of a stronger correlation of self-reported physical activity to obesity than for ENMO, counters the results by Guo, Key, and Reeves (2019). Their cross-sectional analysis of the UK Biobank data using wrist worn accelerometers found "an approximately twofold larger inverse association between waist circumference and physical activity when measured by accelerometer rather than questionnaire" (Guo, Key, and Reeves 2019, 3).

It is important to note that physical inactivity is only one of the risk factors for obesity. Other risk factors include diet, energy metabolism, hormones, and genetics (Ghosh and Bouchard 2017). The direction of causality in the relationship between physical activity, mobility, and body weight is a crucial issue that could not be addressed properly in the analyses due to the cross-sectional nature of the data. The causal relationship of physical activity and body weight might run in both directions (Carrasquilla et al. 2022; Suorsa et al. 2023). Some studies indicated that the causal direction run rather from obesity to future activity and sedentary behaviour than the other way round (Ekelund et al. 2008; Skrede et al. 2021; Pelclová et al. 2021).

Overall, these results contribute to our understanding of the associations between mobility, physical activity, and obesity in older adults, emphasizing the importance of promoting physical activity and addressing mobility limitations to prevent obesity and its associated health risks. Further research with longitudinal data is needed to explore the underlying mechanisms and potential interventions that can improve physical activity levels and mobility in older populations.

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Appendix

Appendix 1: Description of Samples

		Sweden 65+ N=1,946	SHARE 50+ N=44,565	Accelerometry N=801
Gender				
Female	%	47.4	43.1	41.3
Male	%	52.6	56.9	58.7
Age				
50-59	%	-	13.1	19.6
60-69	%	22.6	36.7	35.8
70-79	%	50.3	32.8	31.6
80+	%	27.1	17.5	13.0
Obesity				
Obese	%	16.2	23.7	25.5
Not obese	%	83.8	76.3	74.5
Self-reported activity				
Inactive	%	6.4	13.4	9.2
Medium active	%	56.5	55.6	60.3
Very active	%	37.2	31	30.5
Mobility				
Limitations	%	7.6	11.8	9.4
No limitations	%	92.4	88.2	90.6
Education				
low	%	19.6	16.9	14.9
medium	%	46.7	59.3	60.8
high	%	33.8	23.8	24.3
Fruit or vegetables intake				
low	%	22.7	26.4	21.6
high	%	77.3	73.6	78.4
Partner in household				
Yes	%	67.0	69.3	72.8
No	%	33.0	30.7	27.2
Heart attack				
No	%	86.9	87.0	88.4
Yes	%	13.1	13.0	11.6
High blood pressure or hypertension				
Yes	%	44.9	45.9	43.8
No	%	55.1	54.1	56.2
Stroke				
Yes	%	4.5	4.3	4.0
No	%	95.5	95.7	96.0
Diabetes or high blood sugar				
Yes	%	13.1	14.8	15.9
No	%	86.9	85.2	84.1
Smoking habit				
Never smoked	%	47.5	58.5	52.8
Smoked in the past	%	46.1	27.3	31.7
Currently smoking	%	6.3	14.1	15.5

Appendix 1 continued

		Sweden 65+ N=1,946	SHARE 50+ N=44,565	Accelerometry N=801
Country				
Sweden	%	100	5.1	7.7
Germany	%		6.4	13.6
Spain	%		4.2	7.6
Italy	%		4.7	8.4
France	%		5.4	8.9
Denmark	%		4.7	4.1
Belgium	%		4.3	9.4
Czech Republic	%		5.9	12.5
Poland	%		4.5	15.5
Slovenia	%		5.4	12.4
Austria	%		3.4	
Netherlands	%		4.1	
Greece	%		6.5	
Switzerland	%		4.1	
Israel	%		1.8	
Luxembourg	%		2.0	
Hungary	%		1.7	
Estonia	%		6.6	
Croatia	%		2.6	
Lithuania	%		3.1	
Bulgaria	%		1.8	
Cyprus	%		1.0	
Finland	%		2.5	
Latvia	%		1.7	
Malta	%		1.5	
Romania	%		2.7	
Slovakia	%		2.1	

Data: SHARE Wave 8 Release 8.0.0 (unweighted).

Appendix 2: Logit regression on obesity – SHARE Wave 8 sample

	(1) All			(2) Mobile			(3) Impaired Mobility		
Mobility	0.54	***	(0.02)						
Active									
Inactive	1.14	***	(0.04)	1.31	***	(0.07)	1.08		(0.06)
Very active	0.80	***	(0.02)	0.79	***	(0.02)	1.02		(0.08)
Gender									
Female	1.06	*	(0.03)	0.98		(0.03)	1.47	***	(0.08)
Age									
60-69	0.79	***	(0.03)	0.79	***	(0.03)	0.73	**	(0.08)
70-79	0.55	***	(0.02)	0.53	***	(0.02)	0.57	***	(0.06)
80+	0.26	***	(0.01)	0.26	***	(0.02)	0.25	***	(0.03)
Respondent education level									
medium	0.83	***	(0.03)	0.78	***	(0.03)	0.93		(0.06)
high	0.59	***	(0.03)	0.53	***	(0.03)	0.85	+	(0.08)
Fruit or vegetables intake									
high	0.97		(0.03)	0.95		(0.03)	1.08		(0.06)
Smoking habit									
Smoked in the past	1.14	***	(0.03)	1.14	***	(0.04)	1.17	*	(0.07)
Currently smoking	0.69	***	(0.03)	0.70	***	(0.03)	0.63	***	(0.05)
Partner in household	1.02		(0.01)	1.04	**	(0.02)	0.94	*	(0.03)
Heart attack	1.11	**	(0.04)	1.11	*	(0.05)	1.12	*	(0.06)
High blood pressure or hypertension	2.09	***	(0.05)	2.21	***	(0.06)	1.66	***	(0.09)
Stroke	0.81	***	(0.05)	0.90		(0.07)	0.79	**	(0.06)
Diabetes or high blood sugar	2.02	***	(0.06)	2.08	***	(0.08)	1.88	***	(0.11)
Country identifier									
Germany	1.13		(0.09)	1.08		(0.10)	1.40	+	(0.24)
Sweden	0.90		(0.08)	0.84	+	(0.08)	1.29		(0.26)
Netherlands	0.90		(0.08)	0.84		(0.09)	1.16		(0.23)
Spain	0.98		(0.09)	0.86		(0.09)	1.28		(0.22)
Italy	0.58	***	(0.05)	0.51	***	(0.06)	0.76		(0.13)
France	1.00		(0.09)	0.92		(0.09)	1.27		(0.23)
Denmark	1.00		(0.09)	0.99		(0.10)	1.08		(0.22)
Greece	0.80	**	(0.07)	0.79	*	(0.08)	0.85		(0.14)
Switzerland	0.78	**	(0.07)	0.73	**	(0.08)	1.19		(0.27)
Belgium	1.05		(0.09)	0.99		(0.10)	1.22		(0.23)
Israel	0.84		(0.10)	0.84		(0.12)	0.86		(0.19)
Czech Republic	1.58	***	(0.13)	1.61	***	(0.15)	1.46	*	(0.26)
Poland	1.28	**	(0.11)	1.32	**	(0.13)	1.20		(0.21)
Luxembourg	1.12		(0.12)	1.04		(0.12)	1.58	+	(0.37)
Hungary	1.26	*	(0.14)	1.41	**	(0.17)	0.92		(0.20)
Slovenia	1.23	*	(0.10)	1.20	+	(0.11)	1.40	*	(0.24)
Estonia	1.77	***	(0.14)	1.83	***	(0.17)	1.67	**	(0.27)
Croatia	1.19	+	(0.11)	1.27	*	(0.14)	1.04		(0.20)
Lithuania	1.72	***	(0.16)	1.67	***	(0.17)	1.91	**	(0.38)
Bulgaria	0.92		(0.10)	0.92		(0.12)	0.99		(0.20)

Cyprus	0.86		(0.12)	0.78		(0.14)	1.04		(0.24)
Finland	1.20	+	(0.12)	1.15		(0.13)	1.53	+	(0.38)
Latvia	2.26	***	(0.24)	2.26	***	(0.26)	2.05	**	(0.53)
Malta	2.74	***	(0.29)	2.63	***	(0.31)	2.67	***	(0.69)
Romania	1.49	***	(0.14)	1.48	***	(0.16)	1.53	*	(0.27)
Slovakia	1.07		(0.11)	1.07		(0.13)	1.04		(0.24)
Intercept	0.56	***	(0.05)	0.33	***	(0.03)	0.49	***	(0.10)
Pseudo R-squared	0.09			0.08			0.08		
Number of observations	44,565			36,210			8,355		

*** p<.001, ** p<.01, * p<.05, + p<.1

Data: SHARE Wave 8 Release 8.0.0 (unweighted).

Appendix 3: Table 4 including all covariates: Logit regression: Odds rations for obesity – SHARE: Accelerometry 50+

	(1) All			(2) Mobile			(3) Impaired Mobility		
Mobility	0.50	**	(0.12)						
ENMO	0.99		(0.00)	0.99	+	(0.01)	1.02		(0.02)
Gender									
Female	1.16		(0.23)	1.13		(0.25)	1.57		(0.95)
Age									
60-69	0.55	*	(0.13)	0.54	*	(0.14)	0.45		(0.43)
70-79	0.32	***	(0.09)	0.25	***	(0.08)	0.45		(0.42)
80+	0.08	***	(0.03)	0.06	***	(0.04)	0.07	**	(0.07)
Respondent education level									
medium	0.78		(0.22)	0.66		(0.23)	0.30		(0.24)
high	0.61		(0.20)	0.49	+	(0.19)	0.86		(0.88)
Fruit or vegetables intake									
high	1.02		(0.23)	0.87		(0.21)	1.36		(0.99)
Smoking habit									
Smoked in the past	0.82		(0.18)	0.75		(0.18)	2.10		(1.40)
Currently smoking	0.53	*	(0.15)	0.67		(0.20)	0.11	**	(0.09)
Partner in household	0.98		(0.11)	1.01		(0.13)	0.72		(0.25)
Heart attack	1.20		(0.35)	1.55		(0.54)	0.60		(0.38)
High blood pressure or hypertension	2.61	***	(0.50)	2.79	***	(0.59)	3.37	+	(2.20)
Stroke	1.16		(0.52)	0.89		(0.52)	2.39		(2.22)
Diabetes or high blood sugar	2.00	**	(0.48)	2.11	**	(0.58)	2.00		(1.28)
Country identifier									
Sweden	0.68		(0.34)	0.81		(0.43)	0.04	+	(0.07)
Spain	1.89		(0.81)	1.61		(0.79)	3.54		(4.70)
Italy	0.70		(0.31)	0.62		(0.32)	0.36		(0.45)
France	1.43		(0.56)	1.42		(0.62)	2.04		(2.86)
Denmark	0.69		(0.47)	0.78		(0.55)			0
Belgium	1.16		(0.47)	1.46		(0.65)	0.10	+	(0.13)
Czech Republic	1.13		(0.41)	1.18		(0.48)	0.41		(0.49)
Poland	1.69		(0.59)	2.17	+	(0.86)	0.34		(0.34)
Slovenia	2.16	*	(0.79)	2.34	*	(0.99)	0.78		(0.82)
OxCGRT stringency index	1.01		(0.01)	1.00		(0.01)	0.99		(0.02)
Month of measurement									
February	1.07		(0.29)	0.95		(0.30)	8.77	**	(7.37)
March	1.09		(0.46)	1.33		(0.63)	1.83		(2.20)
November	1.83		(0.73)	2.79	*	(1.30)	0.99		(0.94)
December	1.59		(0.48)	1.56		(0.54)	4.35	+	(3.60)
N AX days	0.83	*	(0.07)	0.76	**	(0.08)	1.18		(0.30)
Intercept	3.34		(2.96)	4.19		(4.20)	0.32		(0.89)
Pseudo R-squared	0.14			0.14			0.33		
Number of observations	801			675			126		

*** p<.001, ** p<.01, * p<.05, + p<.1

Data: SHARE Wave 8 Release 8.0.0 (unweighted).

Appendix 4: Table 5 including all covariates: Linear OLS Regression: Coefficients for body mass index (BMI) – SHARE: Accelerometry 50+

	(1) All			(2) Mobile			(3) Impaired Mobility		
Mobility	-1.95	***	(0.47)						
ENMO	-0.02	+	(0.01)	-0.02	*	(0.01)	0.01		(0.04)
Gender									
Female	-0.40		(0.35)	-0.65	+	(0.35)	0.80		(1.32)
Age									
60-69	-1.77	***	(0.46)	-1.50	***	(0.44)	-4.08	+	(2.11)
70-79	-2.76	***	(0.50)	-2.87	***	(0.50)	-3.88	+	(2.07)
80+	-4.89	***	(0.63)	-4.46	***	(0.65)	-6.70	**	(2.22)
Respondent education level									
medium	-0.05		(0.51)	-0.83		(0.55)	0.68		(1.56)
high	-0.76		(0.59)	-1.35	*	(0.60)	0.16		(2.39)
Fruit or vegetables intake									
high	-0.01		(0.40)	-0.34		(0.40)	0.91		(1.57)
Smoking habit									
Smoked in the past	-0.07		(0.37)	-0.03		(0.37)	0.43		(1.45)
Currently smoking	-1.52	**	(0.48)	-1.11	*	(0.49)	-3.51	*	(1.61)
Partner in household	0.06		(0.19)	0.20		(0.19)	-0.52		(0.73)
Heart attack	0.20		(0.53)	0.69		(0.58)	-1.46		(1.38)
High blood pressure or hypertension	2.47	***	(0.34)	2.41	***	(0.34)	2.18		(1.39)
Stroke	-0.90		(0.84)	-0.96		(0.92)	-0.84		(2.13)
Diabetes or high blood sugar	1.61	***	(0.46)	1.33	**	(0.48)	1.96		(1.50)
Country identifier									
Sweden	-1.10		(0.77)	-0.76		(0.75)	-4.87		(3.14)
Spain	1.59	*	(0.78)	1.29	+	(0.77)	3.03		(2.93)
Italy	-1.71	*	(0.77)	-1.28		(0.78)	-4.70	+	(2.56)
France	-0.03		(0.72)	0.08		(0.69)	0.98		(3.36)
Denmark	-0.91		(0.93)	-0.71		(0.87)			0
Belgium	-0.36		(0.70)	0.09		(0.70)	-4.16		(2.75)
Czech Republic	0.47		(0.64)	0.95		(0.64)	-1.91		(2.58)
Poland	0.71		(0.64)	1.05		(0.64)	-1.09		(2.17)
Slovenia	0.64		(0.67)	0.92		(0.67)	-1.43		(2.30)
OxCGRT stringency index	0.02		(0.01)	0.01		(0.01)	0.02		(0.05)
Month of measurement									
February	-0.45		(0.48)	-0.57		(0.48)	2.32		(1.76)
March	-0.46		(0.73)	0.24		(0.74)	-1.50		(2.54)
November	-0.06		(0.75)	0.92		(0.80)	-2.08		(2.13)
December	0.42		(0.53)	0.43		(0.54)	0.93		(1.81)
N AX days	-0.24		(0.15)	-0.38	*	(0.16)	0.39		(0.54)
Intercept	32.74	***	(1.58)	32.35	***	(1.58)	30.12	***	(5.99)
R-squared	0.21			0.19			0.38		
Number of observations	801			675			126		

*** p<.001, ** p<.01, * p<.05, + p<.1

Data: SHARE Wave 8 Release 8.0.0 (unweighted).