Differences in Physical Health across Populations and their Implications for the Old-Age Dependency Ratios in High, Middle and Low Income Countries

Kämpfen Fabrice[a,*] Kohler Iliana V.[b] and Maurer Jürgen[a,c,d,e]

[a]Department of Economics, HEC, University of Lausanne, Switzerland
[b]Population Studies Center and Department of Sociology, University of Pennsylvania, PA
[c]RAND Corporation, Arlington, VA, USA
[d]CESR, USC, Los Angeles, CA, USA
[e]MEA, Munich, Germany

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Abstract

The standard approach to compare the burden of population aging across countries –the old age dependency ratio (OADR)– does not account for important differences across populations such as differences in physical health, disability and functional capacity, which are factors for dependency and labor force participation. We investigate how OADRs observed across high, middle and low countries change if differences in physical health and functional limitations are accounted for. We propose an adjusted measure of the OADR based on an objective and comparable indicator of physical health and functioning –grip strength (GS)–. GS is predictive for future mobility decline, disability and mortality. We show that this adjustment is particularly important and results in different patterns compared to the ones based on a standard definition of OADR: accounting for differences in physical health and functioning, the OADRs for low and middle income countries increase while they greatly decline for high income countries.

Keywords: Old age depedency ratio (OADR), grip strength, physical health, country comparisons

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*Corresponding author. E-mail address: fabrice.kaempfen@unil.ch, Tel.: +41 21 692 33 20. Do not quote or circulate without permission of the authors.

1 Introduction

Populations across the world are aging and although there are substantial differences in its pace and extent, population aging is an universal phenomenon that occurs across developed and developing countries/regions (Gavrilov and Heuveline, 2003; World Health Organization, 2015). This shift in the demographic landscapes brings along a wide variety of consequences for the sustainability of the health care sectors (Barer *et al.*, 1987), pension systems (Bongaarts, 2004) and labor markets (Börsch-Supan, 2003). To evaluate the burden of population aging and the associated challenges, policy makers usually rely on demographic indicators such as the "old-age dependency ratio (OADR)", a concept and measure that is widely used to rank countries/regions by the dependency burden on the working population (normally defined as those age 15-64 years) as it is normally assumed that the economically active population will provide for the health, pension, social security and other needs of the non-working population (65+ years old). A high OADR suggests high dependency burden on the population 15-64 years old and it is a measure that reflects the pressure on the economically active population due to aging.

Comparing the burden of aging across countries/regions based on the OADR is problematic since this is an indicator that is entirely based on chronological age and reflects differences in age structures across populations, and as a result provides only very limited assessment of the wide-range of challenges associated with population aging. Moreover, the standard definition of OADR does not reflect differences across populations by other important indicators such as diverse experience among older populations in physical health, experienced disability levels and functional capacity, which are important factors for dependency, or differences in active labor force participation and economic activity (United Nations, 2017). The limitations of the OADR measure are well known and several alternative measures have been proposed such as the "prospective old-age dependency ratio (POADR)" that is consistent with the idea that the onset of dependency may be delayed as life expectancy increases (Sanderson and Scherbov, 2005, 2010, 2015), or the "cognition-adjusted dependency ratio" that takes into account differences in the age profile of cognitive functioning (Skirbekk *et al.*, 2012). To our best knowledge, no attempts have been made to adjust the OADR for differences in physical functioning observed across populations. The latter are of particular importance to be considered since large body of evidence has shown that populations in high, middle and low income countries differ substantially in terms of physical health and associated limitations and disabilities. Specifically, the burden of diseases and resulting physical disabilities in low and middle income countries is higher compared to developed economies, resulting in lower economic productivity and higher dependence on social and familial transfers (Kohler *et al.*, 2012; Payne *et al.*, 2018; World Health Organization, 2015).

In the present analysis, we investigate how the patterns of OADR observed across different high, middle and low countries/regions change if differences in physical health and functional limitations are accounted for. We use an adjusted measure of the OADR based on an objective and comparable indicator of physical health –grip strength–. Grip strength is an objective and accurate measure of physical performance and health that has been shown to be predictive for future mobility decline, disability and mortality (Cooper *et al.*, 2010; Giampaoli *et al.*, 1999; Hicks *et al.*, 2011; Rantanen *et al.*, 1999, 2000; Sallinen *et al.*, 2010; Sasaki *et al.*, 2007; Syddall *et al.*, 2003; Taekema *et al.*, 2010). As a reliable and objective health indicator, it has been collected following comparable/identical study protocols in many population-based surveys around the world, including developing countries for which the availability of physical health-related data on older individuals is still limited.

Our adjustment of the OADRs follows the approach developed by Skirbekk *et al.* (2012), whose measure of OADR adjusts for differences in cognitive abilities across populations. While undeniably important, this adjustment is less appropriate especially in the context of lower income countries, where manual labor is widely prominent and participation in the labor force depends to a large extent on the ability to perform high intensity labor tasks that are strongly associated and depend on physical health and functioning.

By considering grip strength as an objective indicator of physical health and functioning, we investigate the variation in the levels and the rate of decline by age in grip strength observed across populations. Our results show that this adjustment is of particular importance and results in different patterns compared to the ones based on a standard definition of OADR: specifically, our approach shows that, once we account for differences in physical health and functioning, the old age dependency ratios for low and middle income countries increase while they greatly decline for high income countries.

2 Methodology

2.1 Data and Measurements

Our analysis includes a diverse set of countries along the social, economic and human development spectrum. We use data from well-established aging studies that have collected measurements of grip strength following comparable, and in most cases identical study protocols using the procedures to obtain grip strength developed by the "Health and Retirement Study (HRS)" in the U.S. as the standard for these studies. The following data sources have been used for this analysis: HRS for the United States, the "Mature Adults Cohort of the Malawi Longitudinal Study of Families and Health (MLSFH-MAC)" for Malawi, the "Survey of Health, Aging and Retirement in Europe (SHARE)" for continental, southern and eastern European countries, and the "China Health and Retirement Study (CHARLS)". For South Africa we use data from two data sources: HAALSI (Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community in South Africa (HAALSI)) and SAGE (WHO Study on Global Aging and Adult Health (SAGE)). SAGE data are also used to estimate the patterns of grip strength for Ghana, India and Russia. Table 1 summarizes the main characteristics of the data used in this study. To account for notable demographic, social and economic differences between countries, we define 3 European regions and we group the data for several countries: Continental Europe, Southern Europe and Eastern Europe. The grouping of the countries does not have implications for our analysis since all data on grip strength have been collected as part of the country-specific implementation of SHARE and all SHARE countries follow identical protocols for their data collections (Börsch-Supan and Jürges, 2005).

2.2 Comparison of grip strength between countries/regions

We define our measure of grip strength as being the maximum score obtained by the respondents using their dominant hand, assuming that at least two measurements were recorded for the dominant hand and assuming that the difference between these two measurements was no larger than 20kg. For those who were ambidextrous[1], we take the max of the 4 measurements assuming that 4 measurements were recorded for these individuals and we excluded those for which the difference was greater than 20kg in the two measurements of the hand for which the highest score was recorded. We removed observations corresponding to the top and bottom 1% of our measure of grip strength in each country/region to get rid of outliers. Weights were used when available.

Cross-country comparison in our measure of grip strength is conducted by calculating age- and sex-specific weighted means by country/region. We then perform country/region- and sex-specific locally weighted regressions of these means on age and plot the resulting coefficients by age and sex.

[1] Our study sample consist of 98,004 observations across all countries considered in this analysis. 90.45% of them are right handed, 6.19% are left handed and 3.37% are ambidextrous. Once weighted, our study sample represent a total population of about 737.3 million individuals (note that weights are not available for the MLSFH and HAALSI data).

Table 1: Descriptive statistics of our study samples

Region/Country	Dataset	Years	Number of obs.	Female (%)	weights available
United States of America	HRS	2010	7,872	56.6	yes
Continental Europe	SHARE	2015	26,142	54.5	yes
Southern Europe	SHARE	2015	15,655	53.8	yes
Eastern Europe	SHARE	2015	16,124	58.8	yes
Russia	SAGE	2007-2010	2,917	62.2	yes
China	CHARLS	2015	12,117	51.0	yes
India	SAGE	2007	5,775	47.2	yes
Ghana	SAGE	2007-2008	3,568	44.1	yes
Malawi	MLSFH	2017	1,105	58.5	no
South Africa	SAGE	2007-2008	3,076	57.0	yes
South Africa	HAALSI	2014-2015	3,653	53.1	no

Note: Continental Europe comprises Austria, Belgium, Switzerland, Germany, Denmark, France, Luxembourg, the Netherlands and Sweden. Southern Europe comprises Spain, Italy, Israel, Greece and Portugal. Eastern Europe comprises Croatia, Poland, Czech Republic, Slovenia and Estonia. Our sample is restricted to individuals with valid measures of grip strength as explained in the text and to those who are 50 and above. Once weighted, our study sample represent a total population of about 737.3 million individuals (note that weights are not available for the MLSFH and HAALSI data).

2.3 Old Age Dependency Ratio Adjusted for Physical Performance (Grip Strength)

Because of the important variations across regions/countries in the shares of populations that have poor physical functioning, and are thus unable to work, the standard measurement of the old-age dependency ratio can be particularly misleading if differences in physical health and mobility limitations across populations are not accounted for. Specifically, the old age-dependency ratio measures the number of elderly people (i.e., those age 65+ years old) as a share of those of working age (usually defined as those age 15 to 64 years old) and reflects how many retired people a labor force participant/worker has to sustain, but it does not adjust for any other important differences between countries/regions.

In the same spirit as in Skirbekk *et al.* (2012), we therefore propose to adjust the measurement of the old age-dependence ratio by considering the region/country- and sex-specific rates of individuals who are limited in their physical health (i.e., mobility) as indicated by their grip strength level. More specifically, one version of the crude measure of age-dependency ratio is usually computed as follows:

$$OADR_i = \frac{|male_{65+,i}| + |female_{65+,i}|}{|male_{15-64,i}| + |female_{15-64,i}|} \tag{1}$$

where $OADR$ stands for original age-dependency ratio, i the name of the region/country under consideration, and $|A|$ represents the cardinality of the set A.

Our proposed adjusted old age-dependency ratio takes into account the sex- and region/country-specific rates of individuals above 50 years old who have their grip strength level above a certain threshold. Mathematically, our proposed ratio takes the following form:

$$AADR_i = \frac{|male_{50+,i}| * r_{m,i} + |female_{50+,i}| * r_{f,i}}{|male_{15-49,i}| + |male_{50+,i}| * (1 - r_{m,i}) + |female_{15-49,i}| + |female_{50+,i}| * (1 - r_{f,i})} \tag{2}$$

where $AADR$ stands for adjusted age-dependency ratio, i the name of the region/country under consideration, $|A|$ represents the cardinality of the set A and $r_{s,i}$ the sex-specific rate of individuals aged 50+ who have grip strength level lower than a specific threshold (as explained below), in region i with $s = \{m, f\}$ for males and females, respectively.

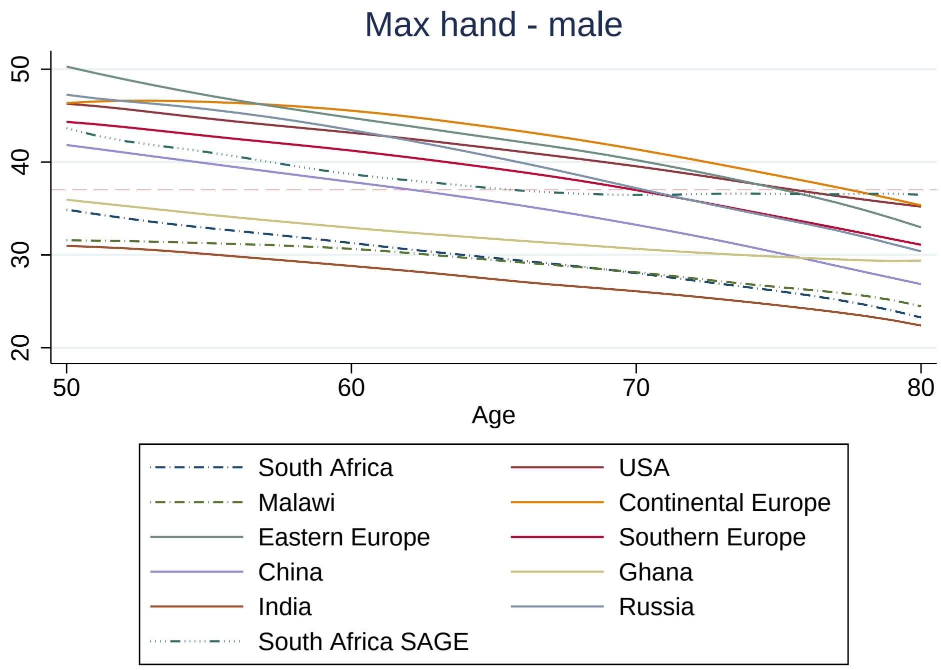
More specifically, we compute the percentages of individuals aged 50 and above in a given country/region who have their measured grip strength below the grip strength threshold derived in Sallinen *et al.* (2010). Indeed, using Receiver Operating Characteristics (ROC) analysis and data from Finland, Sallinen *et al.* (2010) show that a grip strength value below 37 for males and 21 for females were indicator of mobility limitations among older adults, with mobility limitations being defined in their study as having difficulties in walking 500 meters or climbing one flight of stairs. We therefore use these thresholds to compute country/region- and sex-specific rates $r_{s,i}$ using the datasets detailed in Table 1. Furthermore, we use data from the World Population Prospects (2017 Revision) to obtain the age category-specific numbers of males and females who are living in region/country i to compute our two measures of the old age-dependency ratio.

3 Results

Figures 1 and 2 show our grip strength measures by region/country and age for males and females, respectively. For all the regions and countries considered in our analysis, grip strength is declining with age with a rate of decline that is rather similar across countries. What is perhaps more surprising is the variation in level of grip strength across regions/countries in these two figures. For instance, at age 50, a man from Eastern Europe has on average a grip strength that is about 20kg higher than a male of the same age in Malawi or India. The gap remains important as men and women age, although the difference is less pronounced at older ages, especially for females for which we can observe a convergence in grip strength as females get older.

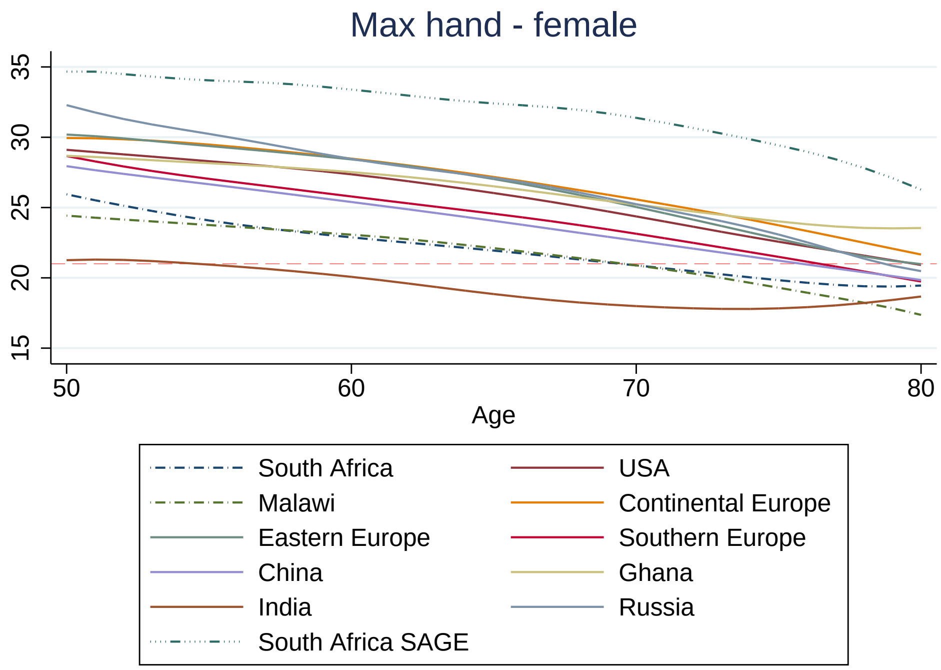
The red horizontal dashed lines in these two plots represent the grip strength level that predicts mobility limitations as in Sallinen *et al.* (2010), that is a value of grip strength of 37 for males and 21 for females. As one can see in Figure 1, males from high income regions/countries have average

Figure 1: Maximum grip strength measurements for males across regions/countries by age



Note: Continental Europe comprises Austria, Belgium, Switzerland, Germany, Denmark, France, Luxembourg, the Netherlands and Sweden. Southern Europe comprises Spain, Italy, Israel, Greece and Portugal. Eastern Europe comprises Croatia, Poland, Czech Republic, Slovenia and Estonia. Table 1 describes in details about the dataset we use in our analysis. The horizontal red dashed line represents the grip strength level that predicts mobility limitations as in (Sallinen *et al.*, 2010), which is equal to 37 for males.

Figure 2: Maximum grip strength measurements for females across regions/countries by age



Note: Continental Europe comprises Austria, Belgium, Switzerland, Germany, Denmark, France, Luxembourg, the Netherlands and Sweden. Southern Europe comprises Spain, Italy, Israel, Greece and Portugal. Eastern Europe comprises Croatia, Poland, Czech Republic, Slovenia and Estonia. Table 1 describes in details about the dataset we use in our analysis. The horizontal red dashed line represents the grip strength level that predicts mobility limitations as in (Sallinen *et al.*, 2010), which is equal to 21 for females.

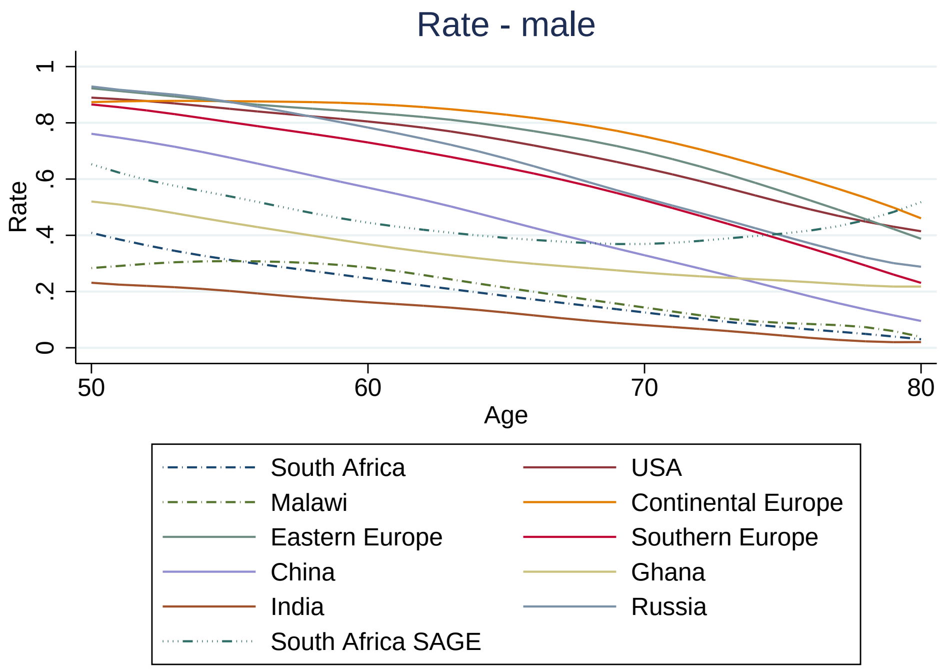
grip strength levels that are well above the 37 cutoff and their curves cross the red dashed line only later in life at around 70+. Males from African countries and India however appear to have an average grip strength level that is below 37 even at 50 years old.

For females (Figure 2), the picture is a bit different as females from all the regions/countries we consider have an average grip strength level that is above 21 at 50 years old. The grip strength level in High and Middle Income regions/countries on average cross the horizontal red line in their late 70s whereas females from Malawi and South Africa (HAALSI) on average cross that threshold at 70 and even earlier in India.

Figures 1 and 2 potentially hide a lot of heterogeneity within the same region/country and age category because they represent averages. In Figures 3 and 4, we therefore plotted the share of individuals in our study samples who have grip strength level that is above the sex-specific thresholds derived by Sallinen *et al.* (2010) by region/country and age. Again, variations in these rates across regions/countries are quite remarkable, especially for males, where more than 90% of the males from Europe and the USA have grip strength level that is above the threshold whereas that is the case for less than half of them in Ghana, Malawi, South Africa (HAALSI) and India at the age of 50. These rates decline over time for both females and males, although the declines appear to be less pronounced for females and remain quite high (about 60%) for females in most of the regions/countries we consider in our analysis.

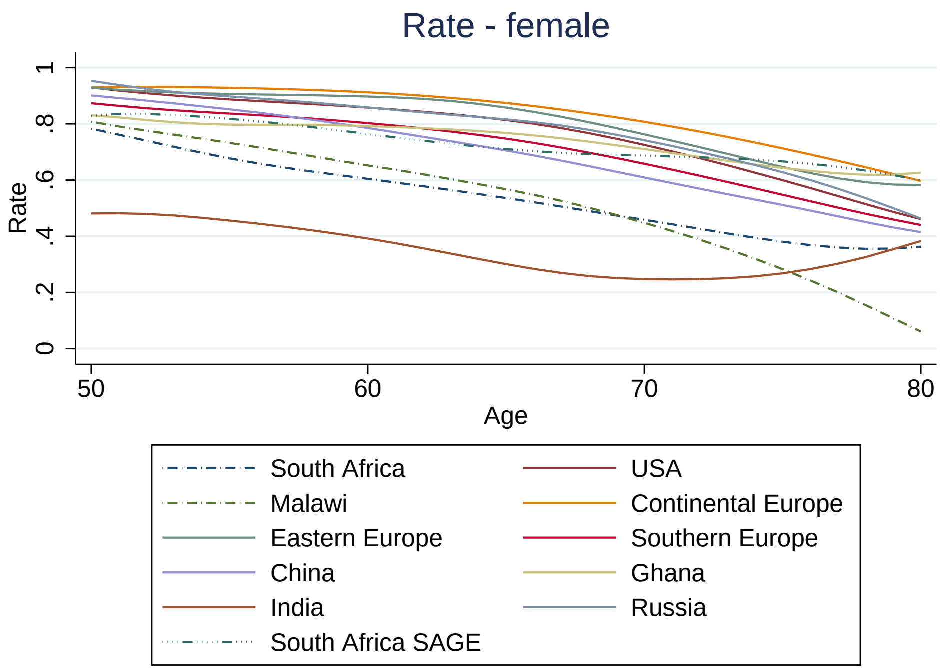
Table 2 reports the values of the original age-dependency ratio (computed using equation 1) and the one adjusting for mobility limitations (computed using equation 2). We also report the corresponding ranks in these ratios of the regions/countries we consider in our analysis. When looking at the original age-dependency ratio, we can see that the ranking in that ratio corresponds very well to the income level in a particular region/country. Low-Income countries have low dependency ratios and high income countries have high dependency ratios. Middle Income countries like India, China and Russia stand in the middle. Our results when looking at our adjusted age-dependency ratio show a somewhat different picture. Even though low income countries still have the lowest dependency ratio, one can see that the ranking between middle and high income countries change quite substantially. More specifically, the European regions and the USA appear to have significantly lower age-dependency ratios when adjusting for mobility limitations. On the other hand, India and China both have their dependency rations increased, which is also reflected in their jump in the ranking. The USA and Southern Europe have the same ranking as in the original age-dependency ratio even though their ratios have substantially decreased.

Figure 3: Rate of males who have grip strength level higher than the threshold by region/country and age category



Note: Continental Europe comprises Austria, Belgium, Switzerland, Germany, Denmark, France, Luxembourg, the Netherlands and Sweden. Southern Europe comprises Spain, Italy, Israel, Greece and Portugal. Eastern Europe comprises Croatia, Poland, Czech Republic, Slovenia and Estonia. Table 1 describes in details about the dataset we use in our analysis. The rates correspond to the share of males who have a grip strength level higher than 37.

Figure 4: Rate of females who have grip strength level higher than the threshold by region/country and age category



Note: Continental Europe comprises Austria, Belgium, Switzerland, Germany, Denmark, France, Luxembourg, the Netherlands and Sweden. Southern Europe comprises Spain, Italy, Israel, Greece and Portugal. Eastern Europe comprises Croatia, Poland, Czech Republic, Slovenia and Estonia. Table 1 describes in details about the dataset we use in our analysis. The rates correspond to the share of females who have a grip strength level higher than 21.

Table 2: Adjusted and unadjusted age-dependency ratios

Region	OADR	rank	AADR	rank
Malawi[a]	.057	1	.087	2
Ghana	.059	2	.086	1
South Africa SAGE	.077	3	.092	3
South Africa HAALSI[a]	.077	3	.161	9
India	.086	4	.226	11
China	.133	5	.154	8
Russia	.194	6	.108	5
USA	.221	7	.126	7
Eastern Europe	.240	8	.101	4
Continental Europe	.304	9	.115	6
Southern Europe	.312	10	.198	10

Note: Data from the World Population Prospects: The 2017 Revision. OADR stands for original age-dependency ratio and AADR stands for adjusted age-dependency ratio. [a]: no weight available and hence the rates $r_{s,i}$ computed for these two countries are not based on nationally representative data.

4 Discussion and Conclusion

Cross-country analysis in health and functioning disability requires objective measures that are comparable across countries and studies (Kämpfen *et al.*, 2018). To assess differences in physical function impairment across countries, we use grip strength, which is a well-known predictor of disability in older people (Giampaoli *et al.*, 1999; Sallinen *et al.*, 2010).

While the rates of decline in grip strength over age are relatively similar across countries, we show that there are large variations in the level of grip strength across countries. These differences in grip strength could indicate that average disability rates of the older population could substantially vary across countries as well.

The old age dependency ratio, which is usually used as an indicator of the potential pressure an economy may face in labor market and pension system in supporting dependent individuals, only takes into account the age structure of populations and not their average health characteristics and potential disabilities. We therefore propose a refined version of the age-dependency ratio which adjusts for the average disability rate of the population using grip strength.

We show that these adjustments increase the age dependency ratio for Low and Middle Income Countries while they greatly reduces the ones of High Income Countries.

4.1 Next steps

The results from our analysis pertain to a specific set of countries and the next step of our analysis is to include additional countries where population-level data on grip strength are available. Specifically, we plan to add Burkina Faso, another low-income sub-Saharan African (SSA) country in order to obtain a better understanding of the grip strength characteristics and consequences on old age dependency ratio in Low Income countries. Expanding the data on SSA will help to cast more light on aging trends and patterns in this region.

In addition, we will use data from the Longitudinal Aging Study in India (LASI) to determine to what extent the results we derive using the India SAGE data hold. Assuming both datasets (India SAGE and LASI) are representative of India and contain a large number of observations, results using these two different samples should in theory be in the same ballpark. Large differences would raise concerns about the quality of the data collected in one (or both) of these studies and the meaning and interpretation of cross-country analysis in general, which is a point raised by Kämpfen *et al.* (2018).

An additional step in our analysis is to derive a better understanding of how the calculated grip strength threshold may impact our results and to do so we will perform sensitivity analysis based on different grip strength thresholds. Last, we plan to expand the discussion of what are the implications of this new approach to calculated an old age dependency ratio adjusted for physical health for policy makers.

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