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ORIGINAL RESEARCH

Associations Between Physical Function and Subjective Well-Being in Older Adults From Low- and Middle-Income Countries: Results From the Study on Global AGEing and Adult Health (SAGE)

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Background: Physical function is positively associated with subjective well-being in older adults from high-income nations. This study tests whether this association is evident in low- and middle-income countries. ***Methods:*** Data were drawn from the study on global AGEing and adult health, using nationally representative samples of individuals over 50 years old from China, Ghana, India, Mexico, Russia, and South Africa. Participant interviews measured well-being (quality of life, mood, and happiness) and physical function (grip strength, usual and rapid gait speed). Logistic regressions tested relations between physical function and well-being variables within each country. ***Results:*** Higher physical function measures exhibited moderate, yet significant, associations with increased odds of highly rated well-being ($p < .05$). However, higher gait speeds were unexpectedly associated with decreased odds of highly rated well-being ($p < .05$) in South Africa and Russia. ***Conclusion:*** These results suggest that physical function is generally positively associated with perceived well-being in older individuals from lower income nations.

Keywords: gait speed, global aging, grip strength, happiness, mood, quality of life

Societies worldwide are currently experiencing demographic transition characterized by an increased population of older adults; this trend is apparent across diverse populations, at all levels of economic development (He, Goodkind, & Kowal, 2015). Consistent with this, the world's population is projected to undergo continuous aging this century; consequently, the number of individuals aged 60 years or older is expected to more than double by the year 2050 and more than triple by 2100 (United Nations, 2017). In other words, the global population aged 60 or older is growing faster than all younger age groups (United Nations, 2017). This global increase in older individuals has major social, economic, and health implications. For example, it has become apparent that government delays in adjusting systems to respond to aging raise concerns about how to pay for social and healthcare demands (Berkman et al., 2015).

In response to the growing number of older adults globally, several studies on global aging have sought to identify factors promoting health at increasingly advanced ages. For example, maintaining a high level of physical function has been linked with improved well-being at older ages and delays in the aging process (den Ouden, Schuurmans, Arts, & van der Schouw, 2011; Fox, Stathi, McKenna, & Davis, 2007). Habitual physical activity exerts a powerful influence on both somatic decline and mental health (Fox et al., 2007; Hunter, McCarthy, & Bamman, 2004). It has been well documented that engaging in regular physical activity is protective against several health conditions, including coronary heart disease, Type II diabetes, cancer, and hypertension (Taylor et al., 2004; WHO, 2010). Moreover, consistent exercise may help older adults remain independent for an extended period (den Ouden et al., 2011). Physical activity that improves muscular strength, endurance, and flexibility may act to improve physical function and individual ability to perform daily tasks; ultimately decreasing the risk of falls and improving health outcomes (WHO, 2010).

Physical function has also been associated with future mortality and morbidity risk among older adults. Two common direct measures of physical function in study settings are grip strength (a good proxy of overall muscle condition and strength, measured using a dynamometer) and gait speed (timed walking speed over a set distance, a measure strongly correlated with general physical function; Cooper, Strand, Hardy, Patel, & Kuh, 2014; Cruz-Jentoft et al., 2010). Specifically, stronger grip strength and faster gait speeds have been linked with lower rates of all-cause mortality and morbidity in older populations, an association thought to reflect lifetime exposure to risk factors and peak physical capabilities attained during growth and development (Cooper et al., 2014; Cruz-Jentoft et al., 2010; Van Kan et al., 2009).

Recent research also suggests that engaging in regular physical activity promoting physical function improves not only long-term somatic health in adulthood, but also psychological health (Fritz & Lusardi, 2009; McAuley, Elavsky, Jerome, Konopack, & Marquez, 2005). For example, research in Western countries has documented a significant association between declines in physical function and risk of unhappiness (Blazer, 2003), a relation only partially accounted for by differences in socioeconomic status, medical conditions, and cognitive function (Lenze et al., 2001). Physical decline often impairs individual ability to effectively complete daily tasks and may also prevent participation in social or leisure activities, resulting in feelings of isolation (Blazer, 2003).

Although the mental health benefits of high physical function are relatively well studied in high-income countries, it is unclear whether specific functional measures are similarly linked with subjective well-being in low- and middle-income countries (LMICs). Therefore, it is

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uncertain whether interventions designed to improve physical function (based on studies from high-income nations) would have the hypothesized benefits in LMICs. It is instead possible that the relation between physical function and subjective well-being may not be observed in LMICs. Evidence suggests that up to 62% of variance in perceived quality of life (QOL) can be accounted for by income (per capita gross domestic product; Diener & Diener, 1995); thus, variation in national economic development level may decrease perceptions of general well-being in LMICs.

Cultural factors may also influence subjective well-being. Attitudes concerning aging and social stereotypes about older adults have been shown to detrimentally impact self-rated well-being and health at older ages (Levy, 2003; Mock & Eibach, 2011), and the process of national economic development appears to diminish the value attributed to aging and increase negative perceptions (Bengtson, Dowd, Smith, & Inkeles, 1975). Therefore, it is possible that more positive cultural attitudes toward aging in LMICs may be protective and enhance perceptions of well-being during senescence, even with the declines in physical function that typically occur over time. Finally, previous work indicates that variation in economic development, in conjunction with cultural differences, impacts several factors known to influence physical function and well-being among older adults from LMICs, including accessibility of healthcare, the extent of government support programs for aging populations, level of filial piety, and national disease and migration patterns (Aboderin, 2004; Chen & Silverstein, 2000; Gavrilova & Gavrilov, 2009; Vera-Sanso, 2005). It is consequently possible that the positive correlation between physical function and well-being observed in high-income nations will not be apparent in LMICs due to economic and cultural differences.

On the other hand, physical function appears to play a key role in shaping general perceptions of health, and, thus, subjective well-being ratings (Wilson & Cleary, 1995). In addition, regardless of nationality, the maintenance of physical function is required to retain the ability to live independently and sustain support networks through participation in social activities (Blazer, 2003). Therefore, it is expected that the positive correlation between physical function and perceived well-being documented in high-income populations will also be observed in LMICs, despite any economic and cultural differences. However, this has yet to be directly tested in LMICs and limited datasets are available to test this relation in these settings (Diener, Oishi, & Lucas, 2003).

Studies verifying that the hypothesized positive association between physical function and subjective well-being is apparent in LMICs are critically needed. This information will not only further our understanding of the relation between physical function and subjective well-being, but these data are crucial in the design of more effective healthy aging programs. The promotion of successful aging is particularly important in LMICs, which are expected to support 80% of adults aged 60+ worldwide by the year 2050 (Chatterji et al., 2015). Therefore, the primary object of this study is to determine whether the same significantly positive relation between physical function and well-being documented in high-income nations is also apparent in LMICs.

This study tests the hypothesized links between physical function and subjective well-being using data from the World Health Organization (WHO) study on global AGEing and adult health (SAGE) Wave 1 (Kowal et al., 2012). Nationally representative data were drawn from six LMICs (China, Ghana, India, Mexico, the Russian Federation, and South Africa) to examine these relations in several distinct populations, a unique study design made possible by the unparalleled and large SAGE dataset. Therefore, this study clarifies how specific measures of physical function are associated with various measures of subjective well-being among older adults within each SAGE country. The results produced by this approach will help clarify whether physical function is reliably associated with well-being in different settings, as has been suggested by findings in high-income nations.

Given that previous research indicates that enhanced physical function is linked with the maintenance of muscle strength and the ability to independently complete daily tasks (thus improving perceptions of overall well-being), the following hypothesis is tested: measures of physical function (grip strength, usual and rapid gait speed) will exhibit a positive relation with subjective well-being measures in older adults from each of the LMICs studied.

Methods

Ethical Approval

Study on global AGEing and adult health was approved by the WHO's ethical review committee. In addition, each partner organization implementing SAGE obtained ethical clearance through their respective institutional review bodies. Written informed consent was obtained from all study participants.

Study Design and Participants

Nationally representative samples of adults >50 years old were collected in each participating SAGE country (Kowal et al., 2012) using stratified multistage cluster sampling (Naidoo, 2012). Face-to-face interviews were used to collect household and individual level data between 2007 and 2010. At the time of data collection for SAGE Wave 1, one country was classified as low income (Ghana), two as lower middle income (China and India), and three as upper middle income countries (Mexico, Russia, and South Africa; World Bank, 2007).

Measures of Physical Function

To determine whether levels of physical function influenced participant mental well-being, three measures of participant physical function were included in the analyses. Individual grip strength has been shown to be a reasonable proxy measure for physical strength, while usual and rapid gait speed measures appear to correlate well with overall mobility (Cooper et al., 2014; Cruz-Jentoft et al., 2010). Grip strength was collected using a Jamar hydraulic hand dynamometer (Warrenville, IL). Specifically, participants held their forearm at a right angle to their upper arm and close to their body and then squeezed the device as hard as possible. The highest compression strength was recorded to the nearest kilogram, and this process was repeated for the opposite hand; two measurements were taken for each hand. To control for the effects of body size on the maximum grip strength measurement achieved (highest single compression obtained from all measures collected on both hands), weight-standardized z scores for grip strength were calculated (separately by sex), and these values were subsequently included in the analyses. Gait speed was assessed through timed walks over a 4-m flat area and the participants were instructed to walk at their "normal pace" and "as fast as they could." The lengths of time required to travel this distance at both the participant's usual and rapid walking speed were recorded and calculated in meters per second. Height-standardized z scores for usual and rapid gait speed were calculated, and these values were used during analysis.

Measures of Subjective Well-Being

Previous research suggests that measures of well-being may not be interpreted in an equivalent manner by participants across countries (Diener et al., 2003). Cultural factors also consider for differences in reported well-being, perhaps attributable to different norms dictating appropriate feelings and the importance of mental health (Diener et al., 2003). For example, cultural perceptions and stigmas of depressive symptoms may preclude depression diagnosis in some cultures (Wu et al., 2013), yet other well-being measures may capture poor mental health in circumstances using more socially accepted language. Thus, it has been suggested that several variables be included in well-being studies to better capture the full range of mental health perceptions (Diener, 2000).

Therefore, this study included three commonly used measures of subjective well-being: (a) subjective QOL, (b) self-rated happiness, and (c) reported mood (Diener et al., 2003). These generally relate to two important aspects of psychological well-being: evaluative well-being (or life satisfaction) and hedonic well-being (feelings of happiness or sadness; Steptoe, Deaton, & Stone, 2015). Following a standard approach to distinguish between participants with the highest levels of well-being and those reporting lower levels of well-being (Enkvist, Ekström, & Elmståhl, 2012; Stone, Schwartz, Broderick, & Deaton, 2010), responses to the three well-being questionnaire items were recoded to create dichotomous variables; thereby increasing comparability with other studies. Furthermore, preliminary analyses using multinomial regression models to examine associations between physical function and well-being variables categorized in three groups (i.e., very poor/poor, moderate, and good/very good) indicated that the findings were consistent with a binary model. In other words, individuals categorized in the "moderate" and "very poor/poor" groups exhibited the same relations when compared with individuals classified as "good/very good." Therefore, the results of the dichotomous models are presented to increase interpretability.

During the face-to-face interview, participants were asked: "How would you rate your overall QOL?" using a scale of 1 (*very good*) to 5 (*very poor*). These responses were recoded to create a dichotomous QOL variable (1 = *good*, 0 = *poor*; rating of very poor, poor, or moderate classified as poor QOL, whereas a rating of good or very good was classified as good QOL). In addition, participants were asked: "Taking all things together, how would you say you are these days?" using a similar 5-point scale (1 = *very happy* to 5 = *very unhappy*) to measure general levels of happiness at this moment in life. These responses were reclassified to create a dichotomous happiness variable (1 = *happy*, 0 = *unhappy*; rating of very unhappy, unhappy, or moderate classified as unhappy, whereas a rating of happy or very happy was classified as happy). Finally, participants reported whether they thought their mood was generally worse, the same, or better compared with others. Then, this variable was dichotomously recoded (1 = *good*, 0 = *poor*; rating of "worse" or "the same" as poor mood and rating of "better" as good mood).

Participant Characteristics

Individual characteristics demonstrated in past studies to influence the physical function and perceptions of well-being were included as confounders in all statistical analyses. Past research in high-income nations indicated that participant age and sex influence physical function and risk of reporting poor well-being (Blazer, 2003; Cruz-Jentoft et al., 2010). Therefore, participant sex and age were included in all analyses. Previous work in the United States suggests that differences in physical function and subjective well-being exist between older adults living in urban and rural settings (Amato & Zuo, 1992; King, Rejeski, & Buchner, 1998). Thus, participant setting was classified as urban or rural, based on definitions used by national statistical agencies in each country. To account for various factors associated with household socioeconomic status thought to influence physical function and life satisfaction ratings (King et al., 1998; Pinquart & Sorensen, 2000), reported annual household income was combined with an index of durable goods ownership, dwelling characteristics, and access to services; this wealth variable was then classified into quintiles.

Education level, which has been shown to influence overall health and reported feelings of happiness in high-income countries (Molarius et al., 2007), was standardized across countries using the International Standard Classification of Education (UNESCO, 1997). Education level was included in all analyses to control for the contribution of education level on variation in subjective well-being. In addition, having a spouse has been shown to improve healthy behaviors and subjective well-being (especially in men; Enkvist et al., 2012); therefore, current marital status was included in the analyses categorized as (a) never married/divorced/separated/widowed or (b) currently married/cohabitating.

To control for potential confounding lifestyle factors, a variety of lifestyle measures were also included in the analyses (Strawbridge, Deleger, Roberts, & Kaplan, 2002). Smoking and drinking frequencies were reported during the face-to-face interview and individuals were sorted into categories based on these responses. Smoking categories were defined as "never," "former," "occasionally," and "daily," whereas drinking categories included "never," "former," "occasionally" (<3 days per month), and "moderate/heavy drinker" (>1 days per week). Participant height and weight were measured during the interview and used to calculate body mass index (in kilograms per meter square), this variable was then included to account for the effect of body composition on mental well-being. Several diagnosed health conditions (angina, stroke, chronic lung disease, arthritis, and diabetes) were also included in the models to control for the influence of preexisting conditions on subjective well-being.

In addition, increased physical activity levels (PALs) have been shown to improve both mood and physical functions (Fox et al., 2007; Penninx et al., 2002; Strawbridge et al., 2002). Therefore, self-reported PAL was included in the model to control for this confounder. Total PAL was calculated from interview data. Questions from the Global Physical Activity Questionnaire were utilized to determine self-report physical activity patterns. This questionnaire is designed to collect information about physical activity patterns during various daily activities across different economic settings (Bull, Maslin, & Armstrong, 2009). Participants were asked to report the number of hours during a typical day they spent in vigorous-intensity activities as part of their work, in moderate-intensity activities as part of their work, in vigorous-intensity activities during leisure time, and in moderate-intensity activities during leisure time. Self-reported time spent in vigorous or moderate exercise for both work and leisure were averaged together to create a composite PAL measure (in hours per day).

Cognitive decline has been shown to both compromise physical function (Verghese, Wang, Lipton, Holtzer, & Xue, 2007) and influence subjective well-being ratings (Zank & Leipold, 2001), and was, therefore, controlled for during all analyses. As has been described elsewhere (Gildner, Liebert, Kowal, Chatterji, & Snodgrass, 2014), five cognitive function tests (immediate and delayed verbal recall, forward and backward digit span, and verbal fluency) were used to create a summary variable of cognitive performance for each participant. In addition, proper nutrition has an important effect on both physical function and subjective well-being (Lee & Frongillo, 2001; Norman, Stobäus, Gonzalez, Schulzke, & Pirlich, 2011); thus, self-reported daily amount of produce typically consumed and reported food security were included during analysis. Food security was measured by asking how often in the past year respondents ate less than desired because there was not enough food; the five possible responses were "every month," "almost every month," "some months, but not all," "only 1 or 2 months," and "never."

Finally, depression has been shown to impact well-being as well as physical function. Specifically, depression has been shown to negatively influence both gait speed (Demakakos et al., 2013) and grip strength (Fukumori et al., 2015). Therefore, a diagnosis of depression was included in all models as a dichotomous variable (positive or negative indication of depression) using symptom-based reporting and an algorithm to assign diagnosis based on the World Mental Health Composite International Diagnostic Interview (Kessler et al., 2010). It is important to note that the relation between depression and physical function is complex (e.g., it is unclear whether depression leads to reductions in exercise and physical function, or whether poor physical functionality leads to depression). Further, depression diagnosis is closely related to other well-being measures (e.g., happiness). All models were run twice, once including depression as a covariate and once excluding it. The overall findings did not change with the inclusion of depression; therefore, this full model is presented here.

Statistical Analyses

Using SPSS version 20 (SPSS Inc, Chicago, IL), analyses were conducted separately for each country and results were regarded as significant at $p < .05$. Descriptive statistics are presented for the physical function and well-being variables by country. Individuals missing one or more of the variables of interest were excluded from regression analysis ($n = 4{,}931$), resulting in a final sample size of 30,403 participants. Logistic regressions indicated that participants who were missing normal or rapid gait speed were significantly more likely to rate their well-being as poor compared with participants who completed the gait speed measures ($p < .05$). However, it appears these individuals were unable to complete the walking task to measure gait speed due to physical discomfort, suggestive of more pronounced health problems. Therefore, it is unsurprising that these participants also rated their well-being as low compared with their healthier peers. Given that this study is primarily interested in how slight differences in physical function between relatively healthy people (those who are healthy enough to complete the physical tasks) are linked with subjective well-being, the exclusion of participants who are physically unable to complete the gait speed measures is not expected to alter the results of the analyses.

Examination of association between physical function measures and subjective well-being by country. Three logistic regressions were conducted to assess the relative contribution of three common measures of physical function (grip strength, usual and rapid gait speed) to variation in the same measures of subjective well-being (QOL, happiness, and mood) by country, while controlling for various confounders known to affect physical function and well-being ratings. In each of the three regressions, participant sex, age, and marital status were entered in the first step. Socioeconomic status factors (urban vs. rural setting, income quintile dummy codes, and education level dummy codes) were entered in the second step. Health risk factors (body mass index, PAL, and the smoking and drinking level dummy codes) were then entered in the third step, while the composite cognitive function z score and dietary variables were entered in the fourth step. Preexisting chronic conditions (angina, stroke, chronic lung disease, arthritis, diabetes, and depression) were entered in the fifth step. Finally, the three measures of physical function were entered together in the sixth step.

Results

Descriptive Statistics

Average unstandardized physical function measures were calculated by sex within each country (Table 1). Unsurprisingly, men exhibited higher mean values than women for each variable in all countries. In addition, frequencies of respondents at each level for the dichotomous subjective well-being variables were calculated by country (Table 2).

Physical Function Measures and Subjective Well-Being

Results from the final models controlling for all factors are presented in Table 3. Including the physical function variables significantly improved the model predicting high QOL in China, Ghana, and South Africa ($p < .001$). Grip strength was a significant predictor in China and Ghana ($p < .01$); higher grip strength increased the odds of high QOL ratings in each case (odds ratio [OR] = 1.10 and 1.15, respectively). Higher normal gait speed resulted in increased odds of high QOL ratings in China ($OR = 1.31$, $p = .006$) and Ghana ($OR = 1.47$, $p < .001$), but lower odds in South Africa ($OR = 0.79$, $p = .009$). Likewise, although the addition of these measures did not significantly add to the model, higher normal gait speed resulted in higher likelihood of poor QOL in Russia ($OR = 0.61$, $p = .044$). Finally, higher rapid gait speed resulted in elevated odds of high QOL ratings in South Africa ($OR = 1.47$, $p < .001$).

The addition of the physical function measures significantly improved the model predicting self-reported happiness in China, Ghana, India, and South Africa ($p < .001$). Each unit increase in grip strength saw higher odds of happiness in China ($OR = 1.06$, $p = .039$) and South Africa ($OR = 1.21$, $p < .001$). Each unit increase in normal gait speed resulted in higher odds of happiness in China ($OR = 1.39$, $p < .001$), Ghana ($OR = 1.56$, $p < .001$), India ($OR = 1.42$, $p = .007$), and South Africa ($OR = 1.24$, $p = .024$). Increased rapid gait speed was associated with increased odds of happiness in Ghana ($OR = 1.87$, $p < .001$).

Finally, adding the physical function variables significantly improved the model predicting poor self-rated mood in all countries except Mexico ($p < .05$). Higher grip strength saw a higher likelihood of good mood in China ($OR = 1.08$, $p = .019$), Ghana ($OR = 1.14$, $p = .004$), and Russia ($OR = 1.18$, $p = .017$). Although the addition of the physical function measures did not significantly improve the model for Mexico, higher grip strength was significantly related to reported good mood in this country ($OR = 1.29$, $p = .017$). Each unit increase in normal gait speed resulted in a high likelihood of good mood in Ghana ($OR = 1.27$, $p = .013$), India ($OR = 1.39$, $p = .008$), and South Africa ($OR = 1.35$, $p < .001$). Higher rapid gait speed was linked with a lower likelihood of good mood in South Africa ($OR = 0.76$, $p < .001$).

Table 1 Mean Physical Activity Level, Grip Strength, and Usual and Rapid Gait Speed Over 4 m for Men, Women, and Sexes Combined in Each Country With *SE*, Study on Global AGEing and Adult Health (SAGE) Wave 1 (2007/10)

	Grip strength (kg; *n* = 31,989)	Usual gait speed (m/s; *n* = 31,022)	Rapid gait speed (m/s; *n* = 30,598)
	Mean (*SE*)	Mean (*SE*)	Mean (*SE*)
China total	28.63 (0.11); *n* = 12,340	1.00 (0.002); *n* = 12,240	1.33 (0.003); *n* = 12,176
men	35.09 (0.15); *n* = 5,717	1.00 (0.003); *n* = 5,666	1.40 (0.01); *n* = 5,642
women	23.01 (0.12); *n* = 6,571	0.94 (0.002); *n* = 6,523	1.27 (0.004); *n* = 6,483
Ghana total	28.66 (0.20); *n* = 4,192	0.75 (0.01); *n* = 4,106	1.12 (0.01); *n* = 4,078
men	32.54 (0.27); *n* = 2,201	0.80 (0.01); *n* = 2,142	1.23 (0.01); *n* = 2,129
women	24.30 (0.27); *n* = 1,972	0.70 (0.01); *n* = 1,946	1.00 (0.01); *n* = 1,931
India total	24.16 (0.14); *n* = 6,418	0.82 (0.003); *n* = 6,315	1.20 (0.005); *n* = 6,302
men	28.61 (0.19); *n* = 3,230	0.87 (0.004); *n* = 3,168	1.31 (0.01); *n* = 3,163
women	19.59 (0.19); *n* = 3,167	0.78 (0.004); *n* = 3,126	1.09 (0.01); *n* = 3,118
Mexico total	22.42 (0.22); *n* = 1,998	1.24 (0.05); *n* = 1,973	1.88 (0.08); *n* = 1,925
men	28.72 (0.34); *n* = 774	1.42 (0.08); *n* = 744	2.26 (0.16); *n* = 729
women	18.65 (0.22); *n* = 1,157	1.13 (0.06); *n* = 1,175	1.66 (0.08); *n* = 1,147
Russia total	25.89 (0.31); *n* = 3,653	0.71 (0.01); *n* = 2,870	1.08 (0.01); *n* = 2,638
men	35.29 (0.56); *n* = 1,305	0.75 (0.01); *n* = 1,006	1.18 (0.02); *n* = 936
women	20.73 (0.32); *n* = 2,317	0.68 (0.01);*n* = 1,843	1.02 (0.01); *n* = 1,681
South Africa total	40.15 (0.36); *n* = 3,388	0.79 (0.01); *n* = 3,518	1.17 (0.01); *n* = 3,479
men	44.44 (0.56); *n* = 1,456	0.80 (0.01); *n* = 1,465	1.25 (0.02); *n* = 1,457
women	36.78 (0.45); *n* = 1,902	0.72 (0.01); *n* = 1,986	1.11 (0.02); *n* = 1,970

Table 2 Frequency of QOL, Happiness, and Mood Ratings by Dichotomous Category in Each Country, SAGE Wave 1 (2007/10)

	Frequency of people reporting good vs. poor QOL (*n* = 33,214)	Frequency of people reporting happiness vs. unhappiness (*n* = 32,822)	Frequency of people reporting good vs. poor mood (*n* = 33,309)
China, total *n*	12,754	12,716	12,881
good rating	4,323 (33.9%)	7,434 (58.5%)	2,156 (16.7%)
poor rating	8,431 (66.1%)	5,282 (41.5%)	10,725 (83.3%)
Ghana, total *n*	4,269	4,129	4,268
good rating	1,269 (26.7%)	2,564 (62.1%)	1,764 (41.3%)
poor rating	3,000 (70.3%)	1,565 (37.9%)	2,504 (58.7%)
India, total *n*	6,547	6,543	6,550
good rating	2,180 (33.3%)	3,439 (52.6%)	2,548 (38.9%)
poor rating	4,367 (66.7%)	3,104 (47.4%)	4,002 (61.1%)
Mexico, total *n*	2,203	2,203	2,204
good rating	1,129 (51.2%)	1,128 (51.2%)	590 (26.8%)
poor rating	1,074 (48.8%)	1,075 (48.8%)	1,614 (73.2%)
Russia, total *n*	3,817	3,771	3,786
good rating	828 (21.7%)	1,747 (46.3%)	605 (16.0%)
poor rating	2,989 (78.3%)	2,024 (53.7%)	3,181 (84.0%)
South Africa, total *n*	3,624	3,460	3,620
good rating	1,216 (33.6%)	2,235 (64.6%)	1,271 (35.1%)
poor rating	2,408 (66.4%)	1,225 (35.4%)	2,349 (64.9%)

Note. SAGE, Study on Global AGEing and Adult Health; QOL = quality of life.

Discussion

This study provides a novel test of the associations between physical function and subjective well-being in older adults through comparing data collected using a standard protocol across a diverse set of LMICs, thus clarifying whether the positive association between these variables observed in high-income nations is also present in LMICs. Few studies have tested these relations in LMICs and previous work has typically been reliant upon data collected from small and nonrepresentative population samples. The SAGE sample is unique in that it is very large, drawn from several diverse nations, and representative of the range of living conditions in each country (Kowal et al., 2012). The results of this study generally supported the hypothesis that physical function measures (grip strength, usual and rapid gait speed) are positively associated with measures of subjective well-being in older adults from each SAGE country.

Physical Function and Subjective Well-Being, by Country

Although these measures were not directly compared between the six countries, the regression coefficients and level of significance indirectly suggest that the association strength between physical function and well-being may vary by country (Table 3). For example, these relations exhibit the largest coefficients and the highest levels of significance in the African countries (Ghana and South Africa). Future work is needed to directly test whether the physical function is more strongly related to perceived well-being in these nations.

Although most significant associations between gait speed (both normal and rapid) and subjective well-being were in the hypothesized direction, a couple significant findings were in the opposite direction in South Africa and one in Russia. Specifically,

Table 3 Logistic Regression for Prediction of Subjective Well-Being From Measures of Physical Function, by Country; *OR* (95% CIs)

Variable	China	Ghana	India	Mexico	Russia	South Africa
QOL						
grip strength	1.10 (1.04–1.16)**	1.15 (1.04–1.26)**	1.04 (0.95–1.14)	1.19 (0.99–1.44)	0.99 (0.88–1.11)	1.01 (0.95–1.07)
normal gait speed	1.31 (1.08–1.58)**	1.47 (1.21–1.78)***	0.99 (0.77–1.28)	1.01 (0.95–1.06)	0.61 (0.38–0.99)*	0.79 (0.66–0.94)**
rapid gait speed	0.94 (0.78–1.13)	0.94 (0.72–1.22)	1.04 (0.82–1.33)	1.00 (0.95–1.06)	1.23 (0.82–1.85)	1.47 (1.25–1.72)***
Happiness						
grip strength	1.06 (1.00–1.12)*	0.94 (0.86–1.02)	0.96 (0.87–1.05)	1.13 (0.93–1.36)	1.03 (0.93–1.14)	1.21 (1.13–1.29)***
normal gait speed	1.39 (1.16–1.67)***	1.56 (1.22–2.00)***	1.42 (1.10–1.84)**	1.08 (0.99–1.17)	0.97 (0.63–1.49)	1.24 (1.03–1.49)*
rapid gait speed	1.02 (0.85–1.23)	1.87 (1.39–2.52)***	1.07 (0.84–1.36)	0.94 (0.87–1.02)	0.99 (0.67–1.45)	1.18 (0.99–1.40)
Mood						
grip strength	1.08 (1.01–1.15)*	1.14 (1.04–1.24)**	1.04 (0.95–1.14)	1.29 (1.05–1.59)*	1.18 (1.03–1.34)*	1.02 (0.97–1.08)
normal gait speed	0.93 (0.74–1.17)	1.27 (1.05–1.54)*	1.39 (1.09–1.77)**	1.01 (0.95–1.07)	0.83 (0.50–1.40)	1.35 (1.15–1.58)***
rapid gait speed	1.21 (0.98–1.51)	0.84 (0.65–1.09)	0.92 (0.73–1.15)	1.01 (0.95–1.07)	1.34 (0.86–2.07)	0.76 (0.66–0.89)***

Note. CIs = confidence intervals; QOL = quality of life. Comparisons are statistically significant at: $^*p < .05$, $^{**}p < .01$, and $^{***}p < .001$. All well-being variables are coded so that 1 = good and 0 = poor. All analyses controlled for participant sex, age, marital status, house location, highest education level, household income quintile, body mass index, physical activity level, smoking and drinking frequencies, composite cognitive function score, diet (produce consumption and food security), chronic health conditions (angina, stroke, chronic lung disease, arthritis, and diabetes), and depression diagnosis.

in South Africa an increased normal gait speed was associated with lower odds of reporting high QOL and higher rapid gait speed was related with a decreased likelihood of reporting good mood. Similarly, elevated normal gait speed was associated with reduced odds of reporting high QOL in Russia. It is possible that, although gait speed represents a useful predictor of future disability and mortality (Van Kan et al., 2009), this measure may not be as closely related to current physical function. Therefore, gait speed may not be reliably associated with subjective well-being as expected in all study populations.

These findings in the opposite direction than expected may be the result of older adults in these populations engaging in higher levels of physical activity than desired. It is possible that these adults engage in more physically demanding daily subsistence tasks or continued employment through necessity, resulting in lower ratings of perceptions of general happiness. For example, previous research suggests that high rates of unemployment in South Africa delays the establishment of individual households by young adults, prolonging their reliance on aging parents who must continue to work to support their grown children (Klasen & Woolard, 2009). Thus, physical function measures may exhibit a negative relation with subjective well-being in these instances.

Still, as expected, higher grip strength was consistently associated with decreased risk of reporting poor subjective well-being (for each of the well-being variables) in all populations, including Russia and South Africa (which exhibits the highest average grip strength values; Table 1). Grip strength is strongly correlated with sarcopenia (an age-related decline in muscle mass), and therefore, represents an excellent measure of general strength at older ages (Cruz-Jentoft et al., 2010; den Ouden et al., 2011). Sarcopenia has been linked with an increased risk of future disability and functional impairment; decreased muscle mass and strength also typically restricts daily activities, inhibits ability to participate in social events, and limits independence (Cruz-Jentoft et al., 2010). Altogether, these detrimental health changes often compromise mental health and decrease self-reported well-being (Drewnowski & Evans, 2001).

Data on changes in physical function among older adults can be used to inform the design of interventions seeking to decrease sarcopenia risk and minimize its effects. Initiating regular, safely implemented moderate aerobic and resistance exercise programs at older ages has been shown to help manage pain levels and improve both physical strength and subjective perceptions of overall well-being in high-income countries, even in individuals with chronic conditions (Buman et al., 2010; Penninx et al., 2002). However, these programs must ensure that participants are physically able to safely complete the recommended exercises. Still, the results presented here suggest that resistance training to increase overall physical function and grip strength may represent a potential strategy to improve self-rated well-being. In fact, previous research in high-income nations indicates that even light physical activity for 30 min per day is positively related to both physical health and subjective well-being (Buman et al., 2010). The WHO has also suggested that adults aged 65 years and older engage in at least 150 min of moderate-intensity aerobic physical activity or 75 min of vigorous-intensity aerobic physical activity per week; in addition, muscle-strengthening activities are recommended at least twice a week (WHO, 2010).

Identifying these relatively simple interventions to improve long-term health outcomes is particularly essential given the rising number of functionally impaired older adults. Recent U.S. studies indicate that at least one physical impairment (difficulty in mobility, self-care, or independent living) was reported by 35% of men and 38% of women aged 65 years or older (U.S. Department of Health and Human Services, 2012). Substantially higher disability rates have recently been documented among the SAGE countries, with prevalence values ranging from 69.6% in China to 93.3% in India (Biritwum et al., 2016). Thus, simple strategies to improve physical function and prolong individual ability to perform daily tasks without assistance will become increasingly important as the proportion of older adults continues to rise worldwide.

Limitations

This study has important limitations. First, because the data in this study are cross-sectional, it is impossible to determine the causality between the variables assessed. For instance, previous research indicates that while physical disability increases the risk of poor perceived well-being, feelings of unhappiness also often result in a disengagement from daily activities and physical activity, thus accelerating physical decline (Lenze et al., 2001). Therefore, it is possible that poor subjective well-being and physical function may exhibit a positive feedback relation wherein each exacerbates the other. Longitudinal data following the progression of these trends over time is required to further parse out these complex interactions. SAGE Wave 2 was completed in 2015, providing another round of follow-up data on participants, which will help address this issue. These data will also facilitate the examination of other issues such as undiagnosed illness, which could affect physical function and mental well-being variables, but would only emerge over time.

Second, it is unclear how individual and cultural differences specifically influenced participant responses. One of the well-established difficulties of interpreting data on subjective well-being is that individuals may interpret the response categories differently (where one person's rating of "very good" is equivalent to another's rating of "good"), and that these interpretations can be influenced by cultural differences (Mathews, 2012). Therefore, it is possible that although there are shared experiences of subjective well-being that can be compared across cultures, the existence of culturally unique patterns decreases the utility of cross-cultural statistical measures; rather, each culture should instead be understood on its own terms (Mathews, 2012). Thus, although this study represents a novel examination of associations between physical function and subjective well-being in LMICs, additional work is also required to more explicitly determine the cultural factors driving the observed patterns in each country. This type of inquiry is needed not only among SAGE participants, but also in the field of global health as a whole. Still, despite these limitations, the results of this study provide a unique test of whether the positive relation between physical health and well-being documented in high-income nations is also evident among older adults living in LMICs.

Conclusion

These findings have important implications. Cross-cultural studies documenting the relation between physical and mental health among older adults are urgently needed, and more research is required to elucidate how these associations change over time and vary between populations. Data from these studies will help inform the design of more effective preventative programs to slow physical decline, thus maintaining independence and subjective well-being at more advanced ages. The identification of potential factors that can be targeted to preserve overall QOL at older ages has become increasingly important as the number of older adults continues to increase globally, especially in LMICs.

In conclusion, this study documented generally positive relations between physical function and subjective well-being among older individuals from six LMICs, as has been previously observed in high-income countries. These results suggest that physical function is generally related to perceptions of well-being in older adults living in both LMICs and higher income nations. Furthermore, uniform patterns were documented between grip strength and well-being in each country. Specifically, increased grip strength (a proxy of general physical function) was significantly predictive of higher well-being measures. Therefore, it appears that overall physical strength in particular exhibits a strong positive association with subjective well-being.

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