Body Mass Index, Performance of Activities of Daily Living and Cognition: Analysis in Colombian and Korean Older Adults

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Abstract

Background: With this study, we aim to describe the associations of the different categories of the Body mass index (BMI) with ADL and cognitive performance in Colombian and South Korean older adults living in the community.

Methods: A cross-sectional analysis of two surveys were analyzed; Survey on Health, Well-Being, and Aging in Colombia (SABE) (n= *23448*) and Korean Longitudinal Study of aging (KLoSA) (n=*4501*). Participants older than 50 years were selected from rural and urban areas achieving a representative sample. Here we investigate the association between BMI categories with function, using zero-inflated negative binomial regression, and cognition, using a logistic regression model.

Results: In Colombia, underweight was associated with an impaired score on the MMSE and worse performance in the IADL. Being overweight was associated with better scores on the MMSE and the IADL. For both outcomes education was highly influential. In Korea, after adjustments, there were no significant associations for any of the outcomes.

Conclusions: In Colombian population, underweight, in particular, seems to be negative to preserve both cognitive and daily functioning. Additionally, being overweight but not obese was associated with less cognitive impartment and better daily functioning.

Introduction

Due to health and social advances, older adults are living longer, and the population older than 60 is increasing [1]. This is one of the greatest human achievements. However, to keep older adults living longer but also healthy and free of dependency represents several challenges to societies. Independence in activities of daily living is an important marker of health in older adults[2]. Autonomy is the ability of a person to satisfy their needs, independently and satisfactorily. Functional deterioration in older adults is becoming more relevant as a major public health problem since functional decline is a common endpoint of multiple comorbidities and is directly associated with frailty, poor quality of life, dependency, and high costs to health systems[3].

Another important component of older adult's health is cognition. Cognitive impairment, including dementia, is a very important risk factor for dependence, poor quality of life, and death[2,4,5]. Therefore, maintaining normal cognition and performance in Activities of daily living (ADL) should be priorities in health systems[6,7].

Maintaining an adequate nutritional status has been pointed out as an important intervention to preserve well-being and health in older adults, and several studies have related nutrition with cognition and function[8,9]. Studies in younger populations have generally shown that overweight and obesity predispose to unfavorable conditions such as cardiovascular diseases, mobility issues, depression, anxiety, dementia, and poor quality of life and death[10]. However, recent studies show that this may be different in older populations, where undernutrition is the main factor associated with negative outcomes. Particularly, evidence has shown that a "U shaped " relationship exists between nutritional status and unfavorable outcomes, where the people in the extremes (i.e. underweight and obesity) represent the groups with a higher risk of mortality[11,12]. Similar associations have been found for other frequent geriatric conditions such as frailty [013]. However, most of these studies are performed in developed western countries, and there is a lack of evidence regarding performance in activities of daily living.

This study describes the associations of Body mass index (BMI) categories with ADL and cognitive performance in Colombian and South Korean older adults living in the community. Korea and Colombia are countries with very different diets and cultures, thus we included both populations to evaluate if the effect of the BMI could be different.

Materials And Methods

2.1 Setting and participants

This is a secondary analysis of two national studies: The Health, Well-Being, and Aging (SABE) Colombia study and the Korean Longitudinal Study of Aging (KLoSA). The studies were designed to determine the factors that characterize aging in these countries.

In both studies, face-to-face interviews were conducted, and subjects were given sets of questionnaires, concerning sociodemographic characteristics, health-related issues, lifestyle habits, and cognitive function. Participants with incomplete data or those who refused follow-up could not be included in the analysis.

SABE was performed in 2015 with a representative sample of community-dwelling Colombian older adults (age ≥ 60 years). As of 2020, this is the largest database available regarding Latin American older adults. A set of questionnaires on different topics (socio-demographic characteristics, health-related issues, access to health services, cognitive performance, functional status, and financial resources) was applied to all the participants by interviewers at the older adult's household. A total of 3,694 older adults were surveyed for an effective national response rate of 66%. Complete methodology, processes, and objectives are available elsewhere [14].

KLoSA started in 2006, with follow-up every 2 years. A stratified multistage probability sampling was used to obtain a representative sample. The analysis was made on wave 2016. The recruitment of participants and methods used in KLoSA has been described in detail elsewhere [15,16].

2.2 Variables

2.2.1 Body mass index

In Colombia, BMI was determined by anthropometrical data. Bodyweight and height were measured with the patient wearing light indoor clothing, using a Kendall graduated platform scale and a SECA 213® stadiometer (Hamburg, Germany), and BMI was calculated using the formula BMI = weight (kg)/height (m2). Four weight status categories were determined: < 18.5 underweight, 18.5 – 24.9 normal, 25 – 29.9 overweight, ≥ 30 obese[17,18]. In Korea, BMI was measured using self-reports of height and weight (unit: kg/m2). It was based on the Asia-Pacific BMI classification and four categories were determined: underweight (BMI <18.5kg/m2), healthy weight (18.5 BMI <23.0kg/m2), overweight (23.0 BMI <25.0 kg/m2), and obese (BMI ≥25.0kg/m2)[17].

2.2.2 Basic Activities of Daily Living:

The basic activities of daily living (BADL) refer to self-care and mobility, and their deterioration is closely related to clinical complications, geriatric syndromes, frailty, and dependency [19].

In SABE, BADLs were assessed using the Barthel scale (0-100) [20]. The KLoSA adapted existing BADL and IADL instruments to assess the functional status of the community-dwelling adult population. The KLoSA consists of 7 BADLs items, including dressing, washing the face, bathing, eating, getting out of bed, toileting, and bladder/bowel management. All BADLs variables from KloSA were dichotomized (not need any help = 0 and any kind of help =1) and summed[21,22].

2.2.3 Instrumental Activities of Daily Living:

The instrumental activities of daily living(IADLs) refer to the individual's ability to carry out actions that link the person to the environment, allowing the use of community resources to supply their own needs.

In SABE, IADLs were assessed through the question: “Can you perform the following activities?: 1) Able to manage own finances, 2) Capable of making daily purchases (especially food) 3) Able to prepare food, 4) Able to manage own medications, 5) Use of public transportation or taxi, 6) Telephone use. Answer options were codified as binary: 0. capable of performing the tasks alone (including both those who perform the activities alone without no difficulties and those who

perform the activities alone with difficulty); and 1. not able to do it alone (including both those who perform the activities with any kind of help and those who cannot perform the activity).

In KloSA 10 IADLs items were evaluated, including grooming, housekeeping, preparing meals, laundering, going out, using public transportation, shopping, money management, phone use, and medication management. IADLs were further codified as 0 if the individual was able to perform the task alone (either with or without difficulty) and as 1 if he/ she was not able to perform the task by her/himself [22].

A summary score was created, ranging between 0 and 6 for SABE and 0 to 10 for KLosa; a higher score reflected a greater impairment in IADLs. For the IADL analysis, those persons with any problems in BADLs were excluded, this to assess only those that have problems in IADL and has not progressed to having limitations on BADL.

2.2.4 Cognitive function:

In SABE the Mini-Mental State Examination test (MMSE) in its validated Spanish version was used to determine the cognitive status (score ranging from 0-30)[23].

KLoSA subjects were screened using the Korean Mini-Mental State Examination (K-MMSE). The K-MMSE is a validated measure with a score ranging from 0-30[24].

For both populations, the MMSE was dichotomized as normal (> 24) and cognitive impairment ($\leq$ 24).

2.2.5 Confounding variables

We included sociodemographic factors (age, sex, and years of schooling) and chronic diseases (hypertension, diabetes, COPD, stroke, myocardial infarction, arthritis, and cancer). To further capture the burden of chronic disease, a summary score was created, summing up each disease. Evidence suggests that multi-morbidity accounts more efficiently for the impact on global health in older adults than individual entities [25].

2.3 Statistical analysis

The descriptive analyses were performed by estimating percentages for categorical variables, and means and standard deviations for quantitative variables, and groups were compared using the Pearson chi-square test and t-student test, respectively. For BADL and IADL scores, we fitted a zero-inflated negative binomial regression model to evaluate the differences between nutritional levels, due to the high frequencies of zeros in the datasets (i.e. subjects without decline on BADLs or IADLs). We inverted the Barthel test score in the SABE dataset to allow the correct estimation of the model. Moreover, we fitted a logistic model for the MMSE score dichotomizing its values to normality (> 24) and cognitive decline (<= 24). Based on the literature review, we adjusted the models for the following covariates: sex, level of education, number of comorbidities, and age. We considered significance at $P < .05$ to evaluate the variables in the model. R software was used to perform all statistical analyses.

Results

The final sample from Colombia was n=23448 and Korea n= 4501. For Colombia, the means of the MMSE was 23.08 ± 7.75, in IADL 0.88 ± 1.55, and BADL 3.41 ± 10.54; for Korea the MMSE 25.49 ± 5.38, IADL 0.63 ± 2.04, BADL 0.2 ± 1.04. In both samples, there were significant differences concerning sex, comorbidity, and education. More detailed characteristics of the sample can be found in Table 1.

3.1. BMI associations with cognition and function

3.1.1. Colombia

- Cognition: Underweight was associated with cognitive impairment (Est 0.475, SE 0.089 p-value <.00.) On the other hand, being overweight was associated with normal scores in the MMSE (Est -0.345, SE 0.041 p-value <.00.) Figure 1.
- IADL: Underweight was associated with an impaired score in the IADL (Est 0.213, SE 0.089 p-value 0.02.) Being overweight was associated with normal scores in the IADL (Est -0.193, SE 0.049 p-value <.00.) Figure 2.
- BADL: Underweight (Est 0.137, SE 0.038 p-value <.00.) and obesity (Est 0.683, SE 0.029 p-value <.00.) were,both associated with impaired scores in the BADL.
- For IADL and BADL education was highly associated, a graphical representation of this is shown in Figure 3.

3.1.1. Korea

- After adjustment for confounding variables, there were no significant associations for cognition, IADL, or BADL, table 2. For complete bivariate information, see table 1.

Discussion

BMI and *Cognition*

In Colombia, we found that underweight was associated with an impaired score at the MMSE. This is in line with studies that relate malnutrition with cognitive deterioration and as a risk factor for frailty and dementia (11,14–16). On the other hand, being overweight was associated with normal scores in the MMSE. Previous studies have reported the existence of an "obesity paradox"[26]. Some studies have found that even though the risk of certain diseases increases as the BMI rises (including cardiovascular diseases, cancer, arthritis, etc.), people tend to live longer, and in older adults being a bit on the higher side appears to give an extra protective reserve[27].

In Korea, we did not find any significant associations. Kim G. et al. have studied this association longitudinally, finding that those who were underweight exhibited faster deterioration in cognitive functioning, compared to those with a normal weight. However, overweight or obese older adults presented a slower cognitive decline than those with normal weight[28]. As shown in Figure 2, the tendency of our data goes in the same direction. Even so, our study differs in many aspects. First, our study was cross-sectional and the directionality of any association therefore could not be determined**.** Second, their study used a longitudinal model to evaluate the relationship between cognition and age, assuming that measurements were equidistant over time**.** Finally, we used MMSE as a dichotomic variable, we could not fit a normal distribution in the MMSE score analysis, even though we employed the usual linear transformations recommended in the literature.

BMI and *IADL*

In Colombia, being underweight was found to be associated with impaired performance in the IADLs. Also, overweight was associated with better scores in the IADLs. The explanation for this could be that when weight is lost, there is also loss of muscle mass[29]. Research has shown that muscle volume protects against many kinds of negative outcomes and this might be one of the reasons why being overweight (balance between fat and muscle mass) but not obesity (too much fat and low muscle mass) may protect against the unfavorable outcomes assessed in this paper[29].

It is important to highlight that people with difficulties in IADL are usually at a point that can either revert or progress to having problems in BADL. Older adults with limitations in performing BADL require more assistance from a caregiver and have more health problems related to these limitations. Especially regarding IADL, BMI values show a U-shaped curve where extremes are related to the worst performance in IADL. This, when people are losing their instrumental functional capacities but still preserve the basic, might be a crucial point of intervention, where targeting nutritional status could modify functional prognosis and prevent progression to further dependency.

BMI and *BADL*

In Colombia, we found significant associations between both underweight and obesity with high impairment in BADL. Although this is a cross-sectional analysis, these results might be explained in the first place by the disease(s) responsible for the functional impairment and in second place by the lack of mobility which is associated with both sarcopenias, physical wasting, undernutrition, and obesity.

Education and Functional status

It worth highlighting that in Colombia, education was a very significant confounder. In Figure 3, we show a graphical representation of the big difference between those with the highest education vs. illiterates. The worst status for those with a higher educational (>high school) is much better than the best status for those with low education (< high school or no education).

Education in the context of a country such as Colombia does not refer only to the knowledge acquired at school; it also refers to opportunities since early life, economic situation, and living environment.

Limitations and strengths

This study has some limitations. First, this is a cross-sectional study; therefore, causality cannot be determined. Second, this study is based on self-reported measurements of functional status, allowing memory bias. Third, we performed a secondary analysis which means that the variables were not collected for the specific purpose of this paper. Fourth, IADL and BADL were categorized differently and measured using different methods in the studied populations. BMI in KLoSA was determined by self-report, which may have led to memory bias. Thus, due to several differences between the measurement methods used in the surveys, we did not intend to compare the two cohorts directly and all analyses have been performed separately. BMI is a widely-used instrument, useful for important health-related outcomes that become more likely when a person is underweight or obese. However, as with most measures of health, BMI is not a perfect measure, especially when referring to older adults; mainly due to the changes related to aging of the musculoskeletal system. Thus, a complete nutritional and anthropometric assessment would be the best way to approach body composition and nutrition in further studies.

This study encompasses several strengths. The data were collected from a representative sample of old adults from two countries, one in Latin America (the biggest population-based study adults to date), and the other in South Korea in Asia. Also, this study provides relevant information for health care providers and future strategies for the prevention of disability[13,28].

Conclusion

In Colombian older adults underweight, in particular, seems to be negative concerning the preservation of both cognitive and daily functioning. Additionally, being overweight but not obese was associated with less cognitive impartment and better daily functioning.

Declarations

Ethics approval and consent to participate:

Ethics committees of the both University of Caldas and the University of Valle in Colombia reviewed and approved the SABE study protocol. The Korean Longitudinal Study of Ageing was approved by the Research Ethics Committee of the Korea Labor Institute. Data from both surveys are publicly available with personal information removed. All study participants signed informed consent to participate and to have their data used for research purposes. Both studies adhered to the ethical guidelines of the Declaration of Helsinki.

Consent for publication: Not applicable

Availability of data and materials: KLoSA dataset analysed during the current study is available in an online repository: https://g2aging.org/?section=page&pageid=18 and SABE is available by request to the ministry of health of Colombia.

Competing Interest: The authors declare no competing interests.

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Author´s contribution

Miguel Germán Borda: Conception of work, Formal analysis, Methodology, Visualization, Writing- Reviewing and Editing.

Luis Carlos Venegas-Sanabria: Preparation of the initial draft, manuscript writing, review and approval

Elkin Garcia-Cifuentes, Alberto Jaramillo-Jimenez: Conception of work, Methodology, Visualization, Writing- Reviewing and Editing.

Dag Aarsland: Methodology, Visualization, Writing- Reviewing and Editing, supervision.

Ronald Camilo Gomez, Carlos Alberto Cano-Gutierrez: Methodology, Visualization, Writing- Reviewing and Editing.

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Vera Aarsland, Khadija Khalifa: Visualization, Writing- Reviewing and Editing

Hogne Soennesyn: Methodology, Visualization, Writing- Reviewing and Editing, supervision.

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Tables

Table 1. Description of the variables according Body mass index categories. Colombian and South Korean population

n (%) or mean ∓ sd	Body Mass Index classification					
	Underweight	**Normal**	**Overweight**	**Obese**	**Total**	P-value
	Korea (n = 4501)					
Sex						<.001
Female	105 (56.76)	939 (54.69)	567 (49.35)	860 (59.31)	2471 (54.90)	
Male	80 (43.24)	778 (45.31)	582 (50.65)	590 (40.69)	2030 (45.10)	
Age	74.31 ∓ 11.28	70.17 ∓ 9.76	68.69∓ 9.12	68.34 ∓ 10.05	69.37 ∓ 9.85	<.001
Comorbidity	1.06 ∓ 1.02	0.97 ∓ 1.06	1.04 ∓ 1.07	1.35 ∓ 1.19	1.12 ∓ 1.12	<.001
Education						<.001
No Education	27 (9.89)	118 (4.99)	51 (3.20)	89 (6.13)	285 (6.33)	
< high school	79 (42.25)	651 (37.91)	372 (32.43)	534 (38.15)	1636 (36.35)	
> high school	40 (15.02)	289 (11.82)	194 (12.19)	394 (15.34)	910 (20.22)	
high school	39 (14.65)	666 (27.95)	532 (33.42)	633 (19.60)	1670 (37.10)	
BADL	0.68 ∓ 1.92	0.19 ∓ 0.99	0.14 ∓ 0.87	0.18 ∓ 0.99	0.19 ∓ 1.02	<.001
IADL	1.63 ∓ 3.35	0.64 ∓ 2.05	0.46 ∓ 1.70	0.54 ∓ 1.90	0.61 ∓ 2.00	<.001
MMSE	22.74 ∓ 7.20	25.45 ∓ 5.29	26.18 ∓ 4.85	25.61 ∓ 5.27	25.58 ∓ 5.30	<.001
	Colombia (23448)					
Sex						<.001
Female	380 (53.52)	3464 (46.33)	4295 (55.74)	5306 (70.21)	13445 (57.34)	
Male	330 (46.48)	4012 (53.67)	3410 (44.26)	2251 (29.79)	10003 (42.66)	
Age	73.11 ∓ 8.72	71.17 ∓ 8.14	69.61 ∓ 7.32	71.46 ∓ 8.86	70.81 ∓ 8.19	<.001
Comorbidity	0.93 ∓ 1.03	1.03 ∓ 1.06	1.3 ∓ 1.11	1.56 ∓ 1.18	1.29 ∓ 1.13	<.001
Education						<.001
No Education	234 (32.96)	2111 (28.24)	1810 (23.49)	1958 (26.91)	6113 (26.07)	
< high school	385 (54.23)	4075 (54.51)	4289 (55.67)	4158 (55.02)	12907 (55.05)	
> high school	71 (10)	958 (12.81)	1205 (15.64)	1059 (14.01)	3293 (14.04)	
high school	20 (2.82)	332 (4.44)	401 (5.20)	382 (5.05)	1135 (4.84)	
BADL	96.79 ∓ 8.23	98.23 ∓ 5.68	98.47 ∓ 4.68	93.09 ∓ 16.22	96.61 ∓ 10.50	<.001
IADL	1.35 ∓ 1.81	0.82 ∓ 1.43	0.57 ∓ 1.18	1.19 ∓ 1.86	0.87 ∓ 1.55	<.001
MMSE < 24	19.98 ∓ 8.93	22.90 ∓ 7.67	24.57 ∓ 6.54	22.10 ∓ 8.48	23.10 ∓ 7.73	<.001

BADL: Basic activities of daily living. IADL: Instrumental activities of daily living. MMSE: Mini-mental state Examination.

Table 2. Association between BMI categories with function (BADL/IADL) and Cognition. Colombian and South Korean population

	BADL			IADL			MMSE < 24		
	Estimation	**Standard Error**	p-value	**Estimation**	**Standard Error**	p-value	**Estimation**	**Standard Error**	p-value
	Colombia								
Underweight	**0.137**	**0.066**	**0.04**	**0.214**	**0.089**	**0.02**	**0.476**	**0.090**	**< .01**
Overweight	-0.045	0.035	0.19	**-0.193**	**0.049**	**< .01**	**-0.346**	**0.041**	**< .01**
Obese	**0.683**	**0.029**	**0.00**	-0.056	0.052	0.28	0.080	0.041	0.05
Sex vrs women	**0.124**	**0.025**	**0.00**	-0.081	0.042	0.06	**-0.306**	**0.034**	**< .01**
< high school	-0.016	0.026	0.54	**-0.305**	**0.045**	**< .01**	**-1.198**	**0.035**	**< .01**
high school	**0.154**	**0.070**	**0.03**	-0.216	0.134	0.11	**-1.781**	**0.096**	**< .01**
> high school	-0.002	0.043	0.96	**-0.571**	**0.099**	**< .01**	**-2.325**	**0.070**	**< .01**
Comorbidities	**0.082**	**0.009**	**< .01**	**0.043**	**0.018**	**0.02**	-0.014	0.015	0.33
Age	**0.027**	**0.001**	**< .01**	**0.050**	**0.002**	**< .01**	**0.090**	**0.002**	**< .01**
	Korea								
Underweight	0.201	0.182	0.27	0.201	0.241	0.40	0.332	0.206	0.11
Overweight	0.056	0.166	0.73	-0.110	0.139	0.43	-0.105	0.111	0.34
Obese	0.013	0.143	0.93	-0.073	0.135	0.59	0.002	0.104	0.99
Sex vs. women	0.037	0.137	0.79	-0.041	0.148	0.78	**-0.404**	**0.094**	**< .01**
< high school	-0.131	0.151	0.39	-0.089	0.159	0.58	**-1.636**	**0.189**	**< .01**
high school	0.015	0.210	0.94	-0.156	0.208	0.45	**-2.465**	**0.206**	**< .01**
> high school	-0.074	0.225	0.74	-0.099	0.230	0.67	**-2.539**	**0.226**	**< .01**
Comorbidities	-0.029	0.052	0.58	-0.059	0.048	0.21	**0.202**	**0.040**	**< .01**
Age	0.004	0.007	0.54	**0.018**	**0.006**	**< .01**	**0.089**	**0.006**	**< .01**

BADL: Basic activities of daily living. IADL: Instrumental activities of daily living. MMSE: Mini-mental state Examination.

Figures

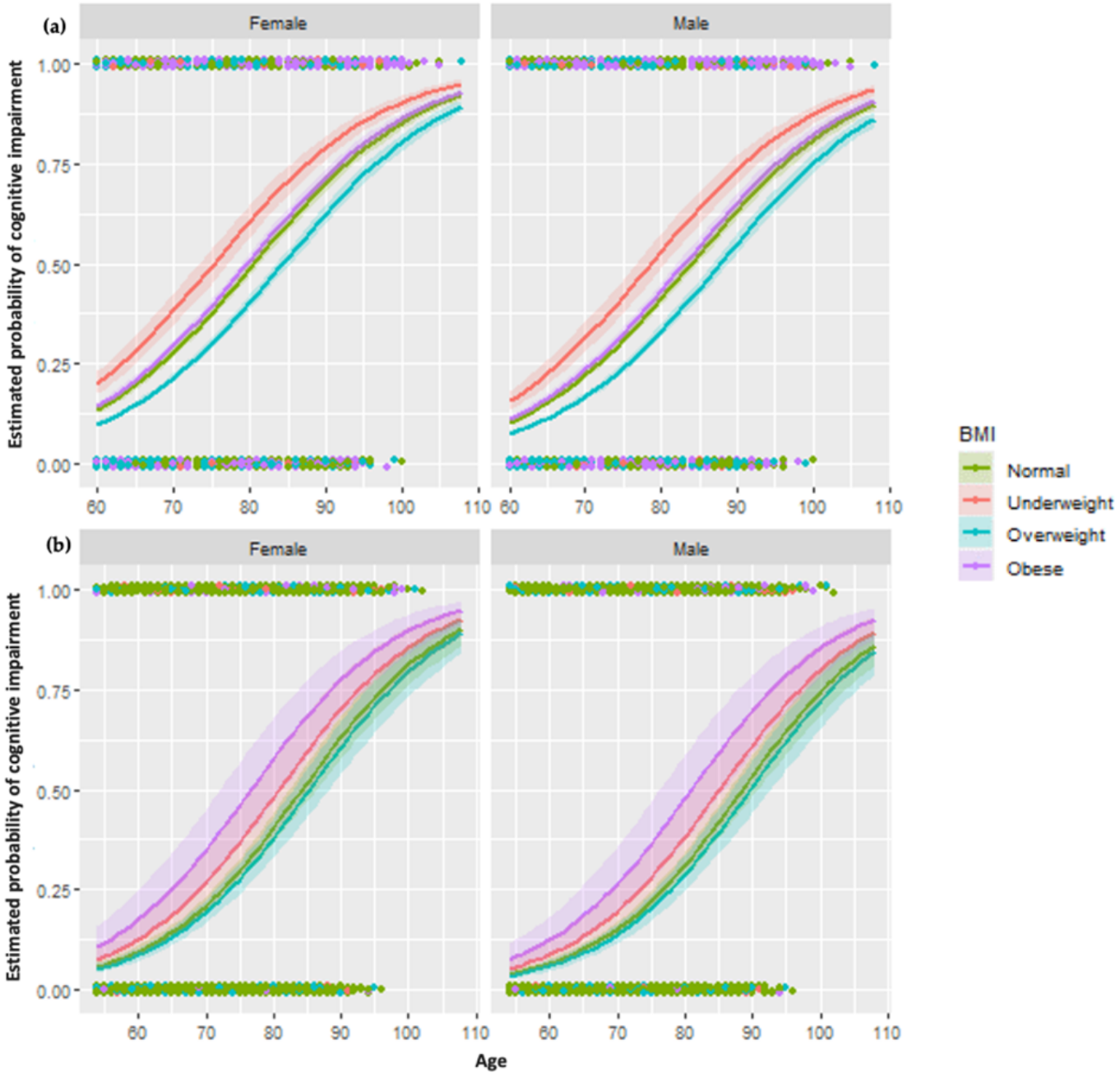

Figure 1

Impairment in the MMSE for the different BMI levels for (a) Colombia and (b) Korea. Higher IADL indicates more impairment. BADL: The basic activities of daily living, IADL: The Instrumental activities of daily living, BMI: Body mass index. Y-axis shows predicted values for IADL and BADL

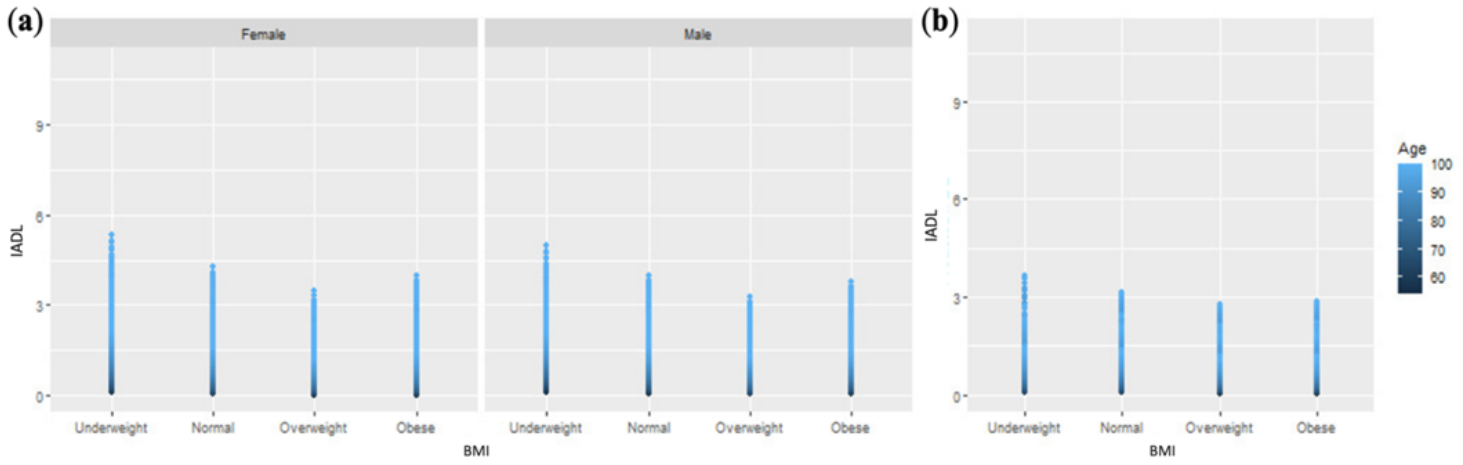

Figure 2

Score of IADL for the different BMI levels for (a) Colombia and (b) Korea. Higher IADL indicates more impairment. BADL:The basic activities of daily living, IADL: The Instrumental activities of daily living, BMI: Body mass index. Y-axis shows predicted values for IADL

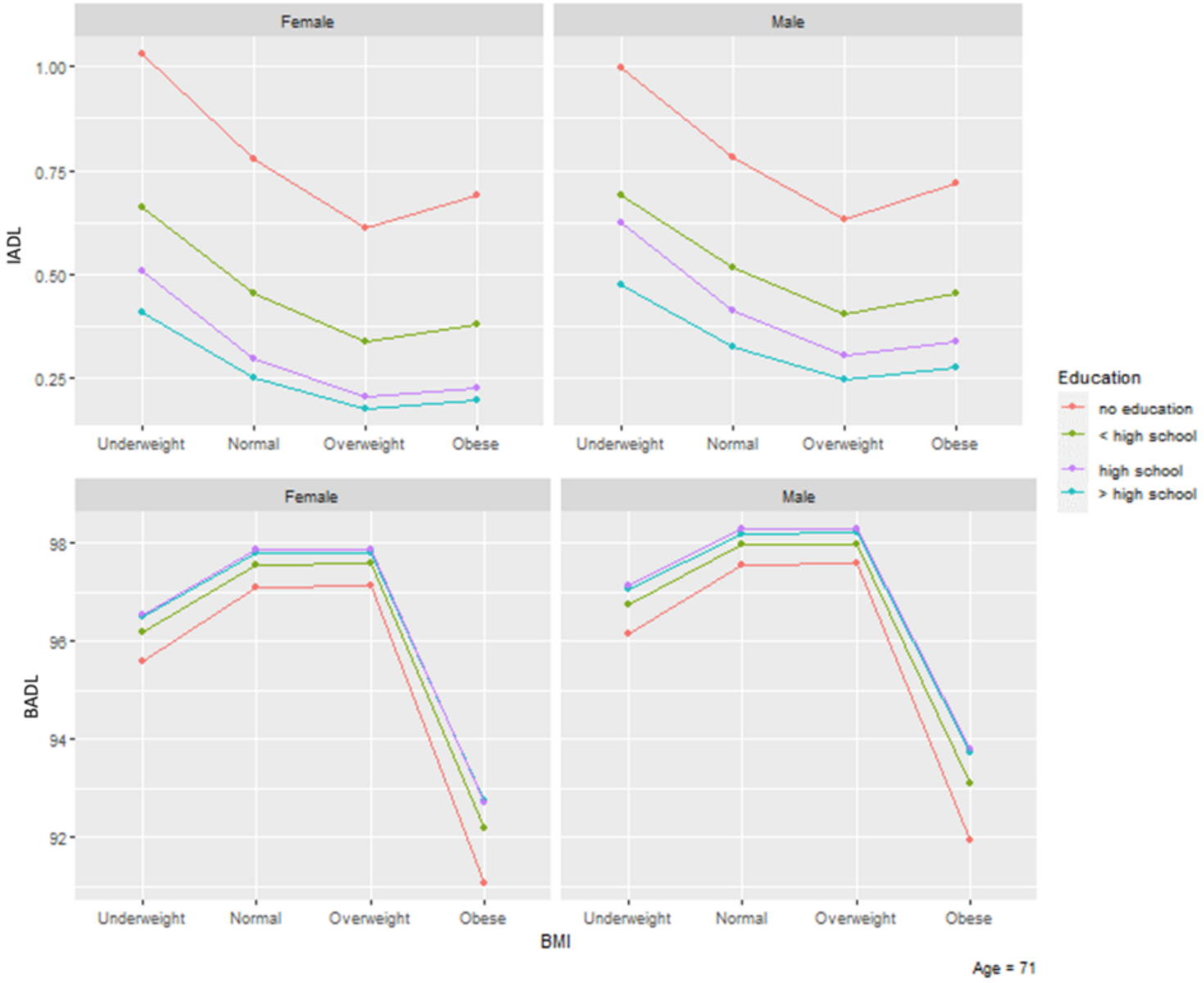

Figure 3

Functional status in IADL and BADL according to BMI and education BADL: The basic activities of daily living, IADL: The Instrumental activities of daily living, BMI: Body mass index. Y-axis shows predicted values for IADL and BADL