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Original Paper

A Comparison of Nutritional Habits, Physical Function and Psychological Constructs between Urban and Rural Costa Rican Older Adults

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Abstract

Purpose: *To compare nutritional habits, physical function and psychological constructs between Costa Rican older adults from urban and rural zones.*

Methods: *Male and female older adults aged ≥ 65 yr. from urban (n = 185) and rural (n = 109) Costa Rica were assessed on nutritional habits, physical function measures, and cognitive function by a face-to-face interview.*

Results: *Rural older adults consumed more daily carbohydrates, protein, and energy at breakfast and lunch (p < 0.05 for all), and more carbohydrates (p ≤ 0.001), fat (p = 0.002), protein (p ≤ 0.001), and energy (p ≤ 0.001) at dinner than urban elderly. Aerobic power (p = 0.044) was higher in urban compared to rural elderly. A correlation was found between aerobic power and global fatigue (r = -0.20, p = 0.014) in urban elderly. Lifetime cognitive activity correlated to total energy (r = 0.37, p = 0.003), carbohydrate (r = 0.37, p = 0.002), and protein (r = 0.34, p = 0.005) consumption in rural elderly. Higher depression scores (p = 0.048), and lower lifetime cognitive activity were observed in urban compared to rural elderly (p = 0.004).*

Conclusion: *The health profile is positive for either group depending on the variable analyzed, except for a higher aerobic power, which provides benefits to the entire cohort.*

Keywords

nursing, healthy aging, nutrition, healthy eating, cognition, gender, rural, urban

1. Introduction

According to The World Health Organization, 11% of the population in year 2000 was older than 60 years old (~605 million of older adults), a figure likely to triple by 2050, reaching 2 billion people in this age group (Joseph, Cole, Head, & Ingram, 2009; World Health Organization, 2017). Costa Rica has one of the highest life expectancies in America and one of the five "Blue Zones", where inhabitants live exceptionally long and nonagenarian males have the highest life expectancy of the world (Azofeifa, Ruiz-Narvaez, Leal, Gerlovin, & Rosero-Bixby, 2018; Rosero-Bixby, 2008). The aging society makes important to determine potential factors related to a healthy aging, impairment of basic tasks of daily living (e.g., feeding, dressing, toileting and bathing), unhealthy lifestyles, metabolic syndrome, mental disorders and chronic disease (Liang, Song, Du, Guralnik, & Qiu, 2015).

Theories concerning healthy nutritional behaviors suggest that people having a greater understanding of nutritional practices take more actions towards promoting healthy lifestyles (De Vriendt, Matthys, Verbeke, Pynaert, & De Henauw, 2009; Jovičić, 2015; Smith et al., 2006). Indeed, their actions depend on the concepts and theoretical knowledge they may have about "eating well"; not only in dietary content (i.e., foods that should and should not be consumed), but also in the dietary structure (e.g., number of meals, schedules) (Arcury, Quandt, & Bell, 2001; De Vriendt et al., 2009). Hence, it is argued that food ingested and diets followed by individuals are influenced by biological and genetic factors, as well as social, historical and cultural constructions, through which health, illness and healthy aging models are built (Arganini, Saba, Comitato, Virgili, & Turrini, 2012; Laditka et al., 2008; Smith et al., 2006).

Evidence suggest a link between metabolic dysregulation and brain function deterioration during senescence, showing for example, an association between cardiometabolic risk markers and compromised cognitive performance in healthy adults. As a result, diseases such as obesity, type 2 diabetes and high blood glucose levels are considered important risk factors to the incidence and severity of cognitive impairment (Kerti et al., 2013; Nilsson, Tovar, Johansson, Radeborg, & Björck, 2013; Wellman & Friedberg, 2002). It has been found that insulin resistance, essential fatty acids intake, oxidative stress, inflammatory and vascular alterations cause general changes in brain function (Talbot et al., 2012).

Dietary restriction has shown to be the most reliable strategy to extend longevity in animal research models. Although the precise mechanisms involved are still not fully understood, it is clear that animals fed with a specific diet not only live longer, but also to show a younger physiological profile. Caloric restriction in animals seems to delay the aging process and suffer similar changes and diseases as their non-caloric restricted counterparts; however, the overall process is delayed by several months (Kerti et al., 2013; Pérez & Sierra, 2009). A caloric intake reduction improved performance in memory-related tasks and prevented cardiac dysfunction, cancer and brain atrophy (Pani, 2015).

In humans, populations with higher caloric restriction have shown larger active centenarians (Hammar & Östgren, 2013). It is still unclear whether the effect is explained by the total percentage of reduced calories or due to a reduction of certain nutrients (e.g., specific proteins or some types of carbohydrates) (Le Couteur, Wilder, de Cabo, & Simpson, 2014). However, there is a significant correlation between a healthier nutritional status and improved performance on cognitive speed processing tasks (Ferdous, Cederholm, Kabir, Hamadani, & Wahlin, 2010). In addition, different specific nutrients interfere or contribute to the mental health in older adults; for example, protein-energetic malnutrition is associated with low muscle mass, immune system dysfunction, anemia, and reduced cognitive function (Donini, Savina, & Cannella, 2003). In addition, low levels of vitamin B12 are associated with neurological disorders, mood changes and cognitive impairment (Hammar & Östgren, 2013). Intake of acids (from fruits) and fatty acids (from nuts and fish) in adult life improve cognitive and motor abilities and overall wellbeing during old age (Joseph et al., 2009; Samieri et al., 2013; Samieri, Okereke, Devore, & Grodstein, 2013). Evidence also suggests that ingesting a multi-nutrient diet (i.e., zinc, melatonin, curcumin, piperine, eicosapentaenoic acid, docosahexaenoic acid, uridine and choline) over six weeks cause a neuroprotective and anti-inflammatory reaction, as well as an improvement in cognitive function in animals (Borre et al., 2014).

There is strong evidence about the beneficial role of the Mediterranean diet, which is largely based on vegetables, fruits, legumes, seeds, cereals, olive oil, fish, and low alcohol consumption, on cognitive impairment and healthy aging in general (Opie, Ralston, & Walker, 2013; Zbeida et al., 2014). Indeed, a strict adherence to the Mediterranean diet improves mobility and speed in older adults (Shahar et al., 2012). Criticism concerning the benefits of this diet are mostly based on results from cross-sectional studies; when attempting to replicate the results in non-Mediterranean populations, the findings coincide only if the food that is common to the region studied is included (Del Parigi, Panza, Capurso, & Solfrizzi, 2006; Tognon et al., 2011). Even so, all the studies concur that moderate and severe malnutrition increases the possibility of suffering illness at an older age (Del Parigi et al., 2006; Donini et al., 2003). These results provide relevant support for a diet targeting metabolic disorders and favoring a healthy aging (Donini et al., 2003; Freeman, Haley-Zitlin, Rosenberger, & Granholm, 2014; Le Couteur et al., 2014; Nilsson et al., 2013).

It has been speculated that the nutritional knowledge held by older adults, although relevant, is not enough to promote a healthy nutritional behavior in rural locations; functional limitations, limited resources and low accessibility to food supply, can have more bearing over their nutritional choices (Durazo et al., 2011). Similarly, food accessibility also seems to negatively affect older adults in urban areas, where the availability of acquiring food, alcoholic beverages and tobacco are higher (Navarro-Meza, Martínez Moreno, López-Espinoza, López-Uriarte, & Benavides Gómez, 2014). It is imperative to recognize that the social, economic and community resources that people have access to, in relation to their choice of diet, mediate nutritional quality (Naggan, 2015; Savoca et al., 2009). Even with the global awareness pertaining to the repercussions of an unhealthy diet—in rural as well as urban populations-, the intake of fats, animal products and sugar has increased due to industrialization processes in the last decades (Tucker & Buranapin, 2001).

Studies in countries such as the United States have proven that there is a generalized belief in the population of associating high salt consumption with rural areas and homes with socio-economic disadvantages. Evidence shows that within urban environments there is a consistent rejection to this particular nutrient; while in rural areas, even though the populace appears to know the risks involved with excessive salt intake, they don't seem to differentiate between "excessive" and "healthy" consumption (Smith et al., 2006). In Chile, older adults living in a rural environment and/or having a low socio-economic level are associated with high salt intake, fats and consequently the development of illnesses such as obesity and high blood pressure (Tucker & Buranapin, 2001). These data contrasts with results found in Mexico, where rural life is associated with healthier nutritional habits, as reported in studies in older adults who seem to have a lower energy intake than their counterparts from urban areas (Navarro-Meza et al., 2014). In addition, there is a higher percentage of tobacco use, alcohol and fatty food intake in adults located in urban environments. Both groups presented low levels of vitamin E, which has been associated to cognitive decline (Navarro-Meza et al., 2014).

Studies performed in China show that the high salt and fat intake, and coexisting diseases such as obesity and high blood pressure are also prevalent in urban environments and/or people who have a high socio-economic level (Tucker & Buranapin, 2001). The above, in conjunction with the fact that elderly people in rural environments from China are less prone to perform poorly in relation to basic activities of daily life, can be associated to the opening in 2000 of the Rural Cooperative Medical Care System, which may have affected the overall improvement of health habits and conditions in the population (Liang et al., 2015; Wagstaff, Lindelow, Jun, Ling, & Juncheng, 2009).

Studies in Costa Rica, showing the nutritional patterns of the population are somewhat rare; however, in 1999, there was a report indicating a high fat intake in the population (57 g in urban vs. 62 g in rural areas), mostly comprised of fats and oil groups, meat, milk and cheese (Ministry of Health, 2011). The top three sources of energy were rice, sugar, fats and oils, and there were approximately 25% households not meeting their daily protein needs (Ministry of Health, 2011). Clearly, there are equivocal findings concerning differences between urban and rural areas. These differences are partially influenced by gender, socio-economic and geographic conditions of the studied populations.

Gender differences have also found in food selection; women choose healthier foods (e.g., fruits, vegetables and fiber) and eat smaller portions of fat than men (Arganini et al., 2012; Wardle et al., 2004). Men seem to prefer higher fat foods and meat (McAfee et al., 2010; Velloso Missagia, Riveli Oliveira, & Carvalho Rezende, 2013). In southern towns of the US, it has been reported that men tend to identify their sense of belonging to a given region by adapting and dominating their diet according to the nutritional culture of their place of origin, characterized in this case by the intake of fats, carbohydrates and excessively seasoned food (Smith et al., 2006). Women tend to show better quality in their diet, even if there are few differences in the nutritional selection when evaluators compare the diets between genders (Ford et al., 2014). This is likely because women may be more concerned with eating healthy in order to be in better shape (Arganini et al., 2012). In contrast with these findings, studies made with the older adult population of Chile revealed that malnutrition due to deficit or excess is significantly higher in women than in men (Cannobbio & Jeri, 2008). In Costa Rica, obesity is a condition that appears to affect older adult females than males; however, the tobacco, alcohol, fat, and caloric levels are much higher in men (Mendez-Chacon, Santamaria-Ulloa, & Rosero-Bixby, 2008).

The educational level, more so than any other socio-economic factor, seems to be the most reliable healthy behavior and nutritional quality pattern predictor (McKay, Houser, Blumberg, & Goldberg, 2006). In Mexico, for example, malnutrition in older adults admitted to hospitals is related to low educational levels (Gutiérrez-Reyes, Serralde-Zúñiga, & Guevara-Cruz, 2007), and there is a direct association, in both urban and rural areas, between obesity in older adults and low education level (Navarro-Meza et al., 2014). In Colombia by the year 2012, the vast majority of deaths related to nutritional deficiencies only possessed a grade school education level and only 0.1% of the older adults had obtained a professional educational level (Cardona-Arango, Segura-Cardona, & Espinosa-López, 2012). It has been proposed that one of the reasons for the association between nutrition and education level is related to the fact that people that receive a higher education, obtain better nutritional information. People with a low educational level seem to depend more on physicians, neighbors and television programs for healthy nutrition advice than those with a higher educational level. Both groups use printed and electronic media as resources; however, their preferences and selections differ according to their educational level (McKay et al., 2006). Therefore, there is a postulated hypothesis that a higher socio-economic level entails better educational opportunities and, as a result, healthier nutritional behaviors (Sánchez Ruiz, de la Cruz Mendoza, Cereceda Bujaico, & Espinoza Bernardo, 2014).

The aim of the study was to compare nutritional habits, physical function and psychological constructs between Costa Rican older adults from urban (OAU) and rural (OAR) zones. The hypothesis was that OAR would have better nutritional habits, physical function and psychological health than OAU.

2. Methods

2.1 Participants

Participants were 294 Costa Rican older adults between the ages of 60 and 86. Volunteers were 185 from the Greater Metropolitan Area (GMA) while 109 resided in the rural areas of the Guanacaste province. The GMA is located in the central area of the country, where the largest group of habitants resides. Guanacaste is located some 200 km northeast of Costa Rica's capital San José towards the Pacific Coast.

The volunteers were recruited through organized groups of older adults such as the Institutional Program for the Older Adult of the University of Costa Rica (PIAM), the Costa Rican Gerontological Association (AGECO), the Program for Golden Citizens of the Costa Rican Social Security Bureau, and other groups of retired teachers, folk, cultural or community groups. The PIAM is an extension program directed by the University of Costa Rica, which promotes the participation of older adults within the university by biannual courses in different areas. The AGECO program is an institution that oversees older adult rights, inclusion and participation of the elderly within Costa Rican society, offering various services such as educational programs and volunteer work.

The recruiting process for this research was carried out directly through the groups and institutions by visiting and personally inviting any person interested in participating that signed up for the research project. The research team then contacted each interested party. Through a short phone interview, each subject was selected taking into account a previously defined inclusion and exclusion criteria, which was approved by the Scientific Ethics Committee of the University of Costa Rica.

The inclusion criteria were to complete an informed consent, have an age between 65 and 85 years, complete a cognitive screen and score on the "unimpaired" range, being from a community dwelling, have adequate visual and auditory abilities to perform all aspects of the cognitive and functional assessments, have stable doses of medications for at least 30 days prior to screening, and verbally assents to participate in all scheduled evaluations. Volunteers were excluded if showed moderate cognitive impairment as determined by a Mini-Mental State Examination score < 24 (Folstein, Folstein, & McHugh, 1975), had current clinically significant major psychiatric disorder (e.g., Major Depressive Disorder) according to DSM-IV (American Psychiatric Association, 1995) or significant psychiatric symptoms (e.g., hallucinations) that could impair the completion of the study, a history of clinically-evident stroke, clinically-significant infection within the last 30 days, history of drug or alcohol abuse or dependence within 2 yr.), current clinically-significant systemic illness likely to result in deterioration of the patient's condition or affect the patient's safety during the study, or significant pain or musculoskeletal disorder that would prohibit participation in fitness testing. As an example, any subjects reporting a history of brain trauma, stroke, symptoms of depression or any diagnosis of a neurocognitive disorder, were excluded from the study.

2.2 Procedures

2.2.1 Physical Assessment

The physical assessment included body height (m) and weight (kg), body mass index (BMI= kg/m^2), resting blood glucose (mmol/l), systolic (SBP) and diastolic blood pressure (DBP) (mm Hg), mean arterial pressure (MAP), 6-min walking test (6-MWT) (m) (Balke, 1963) and handgrip strength (kg) measures. Resting blood glucose was measured with a finger prick method using a digital glucometer True Result (Nipro Diagnostics, Inc., USA). Resting SBD and DBP were measured three times with a digital blood pressure monitor Citizen CH-302B (Premier Precision Ltd., Hong Kong). The lowest value of the three measurements was used for statistical purposes. The 6-MWT measures the distance an individual is able to walk over a total of six minutes on a hard, flat surface. The participant was required to walk as far as possible in six minutes. The individual was allowed to self-pace and rest as needed as traverse back and forth along a marked walkway. Peak aerobic power (VO_2peak) was estimated from a Costa Rican specific prediction equation: 17.59 + 0.028 (6-MWT)- 0.256 (BMI) -

2.567 (gender: 1 male, 0 female) ± 3.25 ml kg^{-1} min^{-1} (R^2 = 0.48) (Peralta-Brenes et al., 2018). Finally, handgrip strength was measured on the dominant hand with a Camry, model EH101 (Japan) handheld dynamometer with an accuracy of 0.1 kg.

2.2.2 Nutrition Habits

Nutrition habits were measured using an ad hoc interview. Questions included meal schedule, types of meals, use of food supplements, fats and added sugars. A registered nutritionist analyzed the food composition and computed carbohydrate (CHO), fat, protein, and total energy intake using a nutrition software (http://nutre.in/) (Colin de Jesús, 2015). The total energy intake was estimated from breakfast, lunch, dinner and energy from added sugars.

2.2.3 Cognitive Evaluation

Depression was assessed by the Geriatric Depression Scale (GDS) (Yesavage et al., 1982). The instrument allows scoring a point for each answer that indicates depression (usually bolded in the form). A score of above five suggests depression. Fatigue was assessed by the Multidimensional Assessment of Fatigue (MAF) (Belza, 1994). A Global Fatigue Index (GFI), is computed from the scale, where a higher score indicates more severe fatigue, fatigue distress, or impact on activities of daily living. The Lifetime Cognitive Activity (LCA) scale (Wilson, Barnes, & Bennett, 2003) was measured with a 25-item interview. During the interview, the frequency of common cognitively demanding activities, such as reading books, newspapers, and magazines, writing letters, going to the library, and playing games, was recorded across age epochs at year 6, 12, 18, and 40 (retrospectively), and at the current age. Responses are scored on a 5-point Likert scale ranging from 1 (once a year or less) to 5 (every day or almost every day).

The protocol was approved by the Scientific Ethics Committee of the University of Costa Rica. All participants were fully informed about the purpose of the study, and at any time had the right to withdraw. Confidentiality of the participants was fully respected. In addition, to increase reliability and power, the research protocol was designed a priori with a misplaced data design and multiple imputation of missing data, where participants answered two thirds of the items of the cognitive questionnaires to diminish attrition (Enders, 2010; Graham, Hofer, & MacKinnon, 1996; Graham, Taylor, Olchowski, & Cumsille, 2006; Valdivieso-Mora et al., 2018).

In San Jose, each participant attended two sessions of data collection; the first session included filling out questionnaires and performing a physical evaluation, and the second session included a neuropsychological evaluation. In Guanacaste, most of the participants attended an average of three sessions of data collection; the first two sessions were primarily used for filling out the questionnaires, and the third session included both the physical evaluation as well as the neuropsychological evaluation. This additional session was required since most of the participants had a low educational level or were not entirely familiar or comfortable with the evaluation methods, some either expressed fatigue due to the extensive nature of the questionnaires or required more clarification pertaining to the content. In some cases, during the Guanacaste trials the questionnaires could not be filled out in writing by the participants, instead they were answered verbally. This required additional time since the duly trained research assistants had to read out the questionnaires and write down the answers accordingly.

The duration of the first session in San José was over three hours and was carried out in groups of three to eight people. The sessions included programmed periods for rest and refreshments, a section for socio-demographic questionnaire forms and social psychological instruments, and by the end of the session, each participant performed the physical assessments individually. The nutrition questionnaires were given to each participant so they could be taken home and completed, so they could be returned by the second session. The second session consisted of the neuropsychological assessment, which was administered individually to each participant. During each session, research assistants were available to provide general directions for each of the questionnaires and assistance support to the participants. Any doubts or concerns were attended in an individual fashion. Each of the participants filled out five protocols and the informed consent form. The research team composed of a clinical neuropsychologist, a psychologist, a geriatric medical physician and six research assistants, accompanied them. These assistants were primarily psychology students from either the GM Area or Guanacaste area respectively, as they were more familiarized with each population group.

2.3 Statistical Analysis

The statistical analyses were performed with IBM-SPSS Statistics 23 (Armonk, NY, USA). Summary statistics are presented as mean (± SD) for continuous data and percentages for categorical data. Parametric two-way general linear-model ANOVA (gender by residency area) were computed on physical (body height and weight, BMI, resting blood glucose, SBP, DBP, MAP, 6-MWT, handgrip strength), and nutrition (CHO, fat, protein, energy) variables. ANCOVA were computed for cognitive (MMSE, GDS, GFI, LCA) variables using years of education and age as covariates. Pearson correlations were computed to determine associations between physical, nutrition and psychological variables. Non-parametric χ^2 tests were used to determine associations between categorical data by residency area and gender. The 95% confidence interval (95%CI) around the mean difference were computed when appropriate. Statistical significance was set *a priori* at $p \leq 0.05$.

3. Results

Participants were 294 Costa Rican older adults residing in urban and rural zones. Descriptive statistics on the sample demographics by gender and residency zone are presented in table 1. ANOVA main effects showed that regardless of gender, urban participants were older ($p = 0.003$, 95%CI = 0.9, 4.4) and completed more years of education ($p \leq 0.001$, 95%CI = 2.2, 5.3) than rural participants (Table 2).

Table 1. Percentage Statistics for Demographics for Costa Rican Urban and Rural Older Adults by Gender (n = 294)

Variable	Urban (n = 185)		Rural (n = 109)	
	Male (n = 47)	Female (n = 138)	Male (n = 20)	Female (n= 89)
Marital status				
Married	83.0	37.7	80.0	48.3
Single	0.0	14.5	0.0	8.0
Widowed	2.1	22.5	0.0	28.7
Separated	0.0	3.6	10.0	2.3
Divorced	10.6	18.8	5.0	11.5
Cohabitating	4.3	2.9	5.0	1.1
Sons living at home				
None	44.7	44.9	65.0	67.1
1	38.3	33.3	15.0	24.7
2	10.6	13.0	15.0	8.2
3	4.3	7.2	5.0	0.0
≥ 4	2.1	1.4	0.0	0.0
Retired				
Yes	95.7	80.3	100.0	73.9
No	4.3	19.7	0.0	26.1

Physical Assessment. ANOVA main effects showed that regardless of gender, urban participants showed higher MAP (p = 0.029, 95%CI = 0.8, 14.9), higher VO_2peak (p = 0.044, 95%CI = 0.0, 2.1), and lower blood glucose levels (p = 0.014, 95%CI = 0.1, 1.1) than rural participants (Table 2). Regardless of the residency zone, males were taller (166.9 ± 0.9 vs. 155.2 ± 0.5 cm, $p \leq 0.001$, 95%CI = 9.7, 13.7), heavier (77.3 ± 1.8 vs. 66.9 ± 0.8 kg, $p \leq 0.001$, 95%CI = 6.6, 14.3), and showed higher mean education (13.2 ± 0.4 vs. 11.3 ± 0.7 yr., p = 0.015, 95%CI = 0.4, 3.6) than females. Females showed lower DBP (70.7 ± 0.7 vs. 75.6 ± 1.4 mmHg, p = 0.002, 95%CI = 1.9, 8.0), handgrip strength (21.3 ± 0.3 vs. 35.1 ± 0.7 kg, $p \leq 0.001$, 95%CI = 12.3, 15.3), and walked a shorter distance (381.0 ± 6.9 vs. 443.2 ± 13.3 m, $p \leq 0.001$, 95%CI = 32.7, 91.7) than males.

Table 2. Descriptive Statistics Mean (±SD) on Physical, Physiological and Cognitive Variables of Costa Rican Male and Female Urban and Rural Older Adults (n = 294)

Variable	Urban			Rural		
	Male (n = 47)	Female (n = 138)	All (n = 185)	Male (n = 20)	Female (n= 89)	All (n = 109)
Education (yr.)	15.5 ±5.3	12.7 ±5.0	13.4 ±5.2	10.9 ±4.5	9.8 ±5.5	10.0 ±5.3
Family members	2.9 ±1.3	3.0 ±1.7	3.0 ±1.6	2.9 ±1.4	2.4 ±1.4	2.5 ±1.4
Age (yr.)	67.6 ±4.6	67.8 ±5.8	67.8 ±5.5	70.0 ±5.3	70.8 ±6.4	70.6 ±6.2
Height (cm)	167.6 ±7.8	154.8 ±6.5	158.0 ±8.8	166.1 ±7.1	155.5 ±5.5	157.5 ±7.1
Weight (kg)	75.4 ±14.7	66.6 ±11.1	68.9 ±12.7	79.3 ±15.0	67.1 ±12.6	69.3 ±13.8
BMI (kg/m^2)	26.9 ±4.9	27.9 ±4.7	27.6 ±4.7	28.6 ±4.9	27.9 ±5.4	28.0 ±5.3
SBP (mm Hg)	133.0 ±15.7	130.6 ±21.9	131.2 ±20.4	130.0 ±14.8	125.8 ±21.0	126.5 ±20.0
DBP (mm Hg)	78.5 ±11.4	73.7 ±9.7	74.9 ±10.3	72.7 ±10.3	67.7 ±10.4	68.6 ±10.5
MAP (mm Hg)	185.3 ±20.6	179.7 ±24.6	181.1 ±23.7	178.4 ±19.0	170.9 ±24.7	172.3 ±23.9
Blood glucose (mml/L)	5.7 ±1.7	5.3 ±1.2	5.4 ±1.4	6.0 ±1.1	6.1 ±1.8	6.1 ±1.7
Handgrip strength (kg)	35.3 ±6.1	22.3 ±4.5	25.6 ±7.5	34.9 ±6.0	20.4 ±4.6	23.0 ±7.4
6-MWT (m)	448.0 ±100.1	403.7 ±89.0	415.7 ±93.9	438.5 ±109.0	358.4 ±93.7	373.1 ±101.0
VO_2peak (ml ·kg^{-1} ·min^{-1})	20.7 ±3.2	21.6 ±2.9	21.4 ±3.0	19.6 ±3.4	20.6 ±3.2	20.4 ±3.3
MMSE (0-30 pts.)	28.8 ±1.4	28.9 ±1.6	28.9 ±1.6	28.4 ±1.8	27.1 ±2.4	27.3 ±2.3
GDS (0-15)	5.1 ±1.8	6.1 ±1.6	5.9 ±1.6	5.3 ±1.9	4.6 ±2.0	4.8 ±2.0
GFI (units)	4.4 ±4.2	5.2 ±5.8	5.0 ±5.4	2.9 ±3.7	5.7 ±6.7	5.3 ±6.4
LCA (units)	2.9 ±0.6	3.0 ±0.6	3.0 ±0.6	3.4 ±0.8	3.5 ±0.8	3.5 ±0.8

Note. SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; MAP = Mean Arterial Pressure; 6-MWT = 6-min Walking Test; VO_2peak = Peak aerobic power; MMSE = Mini-Mental State Examination; GDS = Geriatric Depression Scale; GFI = Global Fatigue Index; LCA = Lifetime Cognitive Activity.

Nutrition Habits. Differences regardless of gender were found in nutritional habits between older adults from urban and rural zones. Older adults from urban zone consumed more meals/day (p = 0.002, 95%CI = 0.2, 0.8), and more breakfast/week (p = 0.013, 95%CI = 0.1, 0.6) than older adults from rural zone (Table 3). However, older adults from rural zone consumed more daily energy ($p \leq 0.001$, 95%CI = 862.3, 1877.8) than urban older adults.

Older adults from rural zone consumed more CHO ($p \leq 0.001$, 95%CI = 13.0, 36.2) and protein ($p \leq 0.001$, 95%CI = 2.7, 8.5), and had a higher energy intake ($p \leq 0.001$, 95%CI = 307.5, 853.3) at breakfast than urban older adults. They also consumed more CHO (p = 0.033, 95%CI = 0.87, 20.8) and protein (p = 0.003, 95%CI = 1.5, 7.4) and had a higher energy intake (p = 0.006, 95%CI = 83.1, 484.2) at lunch than urban older adults. In addition, they consumed more CHO ($p \leq 0.001$, 95%CI = 10.1, 32.1), fat ($p = 0.002$, 95%CI = 1.0, 4.7) and protein ($p \leq 0.001$, 95%CI = 3.2, 10.0), and had a higher energy intake ($p \leq 0.001$, 95%CI = 339.3, 845.9) at dinner than urban older adults.

Table 3. Descriptive Statistics Mean (SD) of Nutritional Information on Costa Rican Male and Female Urban and Rural Older Adults (n = 294)

Variable	Urban			Rural		
	Male (n = 47)	**Female (n = 138)**	**All (n = 185)**	**Male (n = 20)**	**Female (n= 89)**	**All (n = 109)**
Meals/day	4.6 ±0.9	4.7 ±1.0	4.7 ±1.0	4.1 ±1.3	4.3 ±1.0	4.2 ±1.0
Breakfast/week (days)	7.0 ±0.0	6.9 ±0.6	6.9 ±0.5	6.5 ±1.6	6.7 ±1.2	6.7 ±1.3
Breakfast at home (days)	6.8 ±0.8	6.8 ±0.8	6.8 ±0.8	7.0 ±0.0	7.0 ±0.3	7.0 ±0.3
CHO (g)	58.3 ±41.8	50.7 ±35.8	52.6 ±37.4	82.6 ±41.6	75.7 ±39.9	77.0 ±40.1
Fat (g)	10.4 ±7.0	11.8 ±6.8	11.5 ±6.8	13.1 ±6.1	11.8 ±7.0	12.0 ±6.8
Protein (g)	14.9 ±10.2	14.8 ±9.1	14.8 ±9.3	21.5 ±8.3	19.4 ±10.4	19.8 ±10.0
Energy (kJ)	1620.7 ±987.1	1538.7 ±839.4	1559.2 ±876.3	2263.5 ±853.5	2056.6 ±971.2	2096.1 ±949.6
Lunch/week (days)	7.0 ±0.2	6.9 ±0.3	7.0 ±0.3	6.7 ±1.3	7.0 ±0.0	6.9 ±0.6
Lunch at home (days)	6.3 ±1.6	6.5 ±1.2	6.4 ±1.3	6.7 ±1.4	7.0 ±0.2	6.9 ±0.6
CHO (g)	77.1 ±30.8	66.4 ±36.7	69.1 ±35.5	85.5 ±30.0	79.6 ±28.2	80.8 ±28.5
Fat (g)	5.1 ±3.0	5.0 ±3.4	5.1 ±3.3	6.0 ±3.3	5.5 ±2.9	5.6 ±3.0
Protein (g)	24.4 ±11.0	23.3 ±10.2	23.6 ±7.1	28.7 ±7.1	28.0 ±8.7	28.1 ±8.4
Energy (kJ)	1901.8 ±638.2	1689.7 ±733.4	1743.3 ±714.6	2144.6 ±624.0	2014.2 ±567.3	2039.3 ±577.8
Dinner/week (days)	6.1 ±2.0	5.8 ±2.4	5.9 ±2.3	6.2 ±2.3	6.2 ±1.9	6.2 ±2.0
Dinner at home (days)	6.1 ±2.0	5.9 ±2.2	6.0 ±2.1	6.3 ±2.2	6.4 ±1.5	6.4 ±1.7
CHO (g)	54.3 ±37.2	44.3 ±29.0	46.6 ±31.3	70.7 ±42.2	70.1 ±38.8	70.2 ±39.3
Fat (g)	5.4 ±4.6	6.2 ±6.1	6.0 ±5.8	9.3 ±7.5	7.9 ±5.1	8.2 ±5.6
Protein (g)	14.3 ±10.5	13.7 ±9.5	13.8 ±9.8	21.7 ±13.6	19.6 ±11.5	20.0 ±11.9
Energy (kJ)	1356.7 ±845.2	1202.7 ±654.9	1239.1 ±704.5	1926.0 ±1092.4	1818.6 ±888.4	1840.3 ±927.8
Snacks/day	1.1 ±0.4	1.3 ±0.4	1.2 ±0.4	1.7 ±0.5	1.7 ±0.5	1.7 ±0.5
Daily added sugar (tsp.)	1.5 ±1.9	1.8 ±2.0	1.7 ±2.0	1.4 ±1.0	1.9 ±2.0	1.8 ±1.9
Total energy intake (kJ)	5132.5 ± 1543.9	4638.5 ± 1444.5	4761.0 ±1479.2	6505.8 ±1655.5	6005.2 ±1692.3	6117.1 ± 1687.4

Note. CHO = Carbohydrates; kJ = kilojoules (1 kcal = 4.1841 kJ)

The correlational analyses showed a consistent inverse association between VO_2peak and BMI in urban (r = -0.40, $p \leq 0.001$), rural (r = -0.58, $p \leq 0.001$), and the entire cohort (r = -0.47, $p \leq 0.001$), as well as a positive association between total energy intake and SBP in urban (r = 0.19, p = 0.031), rural (r = 0.21, p = 0.05), and complete cohort (r = 0.149, p = 0.04). In urban older adults, an inverse association was found between VO_2peak and MAP (r = -0.15, p = 0.05), and positive associations between total energy intake and DBP (r = 0.19, p = 0.035) and MAP (r = 0.23, p = 0.011).

A significant association was found between VO_2peak and GFI (r = -0.20, p = 0.014) in urban older adults, and in rural older adults LCA was associated to total energy intake (r = 0.37, p = 0.003). For the general sample, VO_2peak was associated to MMSE (r = 0.16, p = 0.011), GDS (r = 0.16, p = 0.015), and GFI (r = -0.15, p = 0.035). Total energy intake was associated to GDS (r = -0.19, p = 0.008) and LCA (r = 0.2, p = 0.001).

In rural older adults, significant associations were found between LCA and total energy (r = 0.37, p = 0.003), CHO (r = 0.37, p = 0.002), and protein (r = 0.34, p = 0.005) consumption. For the general sample, GDS was inversely associated to total energy (r = -0.19, p = 0.008), CHO (r = -0.20, p = 0.004), and protein (r = -0.17, p = 0.012) consumption. In addition, LCA was positively associated to total energy (r = 0.24, p = 0.001), CHO (r = 0.23, p = 0.001), and protein (r = 0.26, $p \leq 0.001$) consumption.

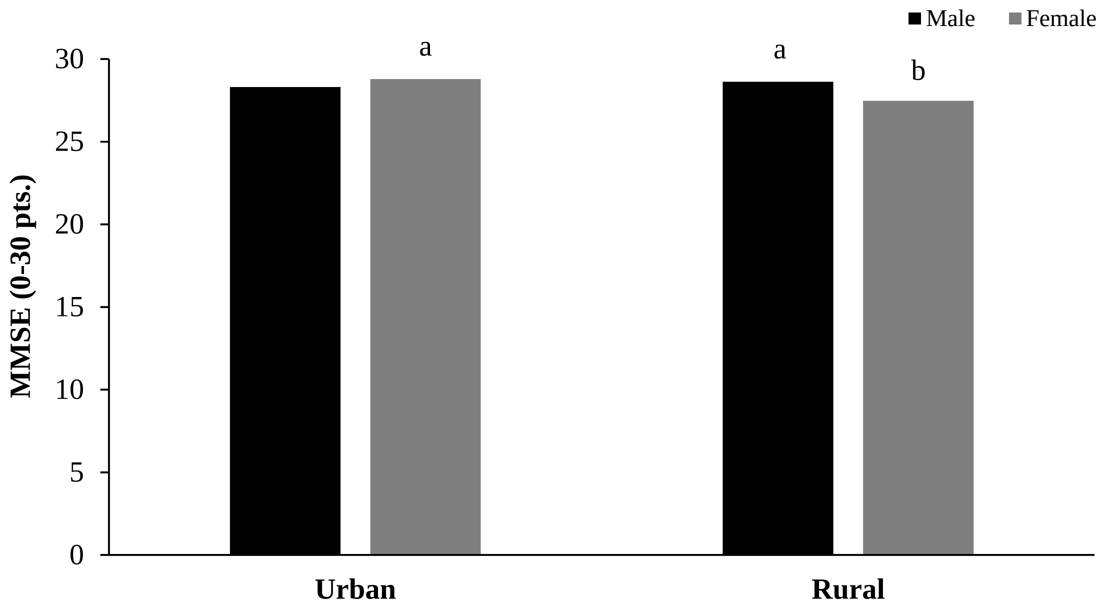
Non-parametric χ^2 tests showed no significant associations on supplement use, iron supplementation, and added salt to meals between older adults from urban and rural zones (p > 0.05). A significant interaction was found between gender and zone of residence on mean number of lunch meals per week (p = 0.009). Post hoc analysis showed that rural females eat more lunch meals per week than urban males (p = 0.004, 95%CI = 0.1, 0.5), and urban males eat more lunch meals per week than rural males (p = 0.014, 95%CI = 0.1, 0.6). Main effect zone on the mean number of lunch meals prepared at home showed that urban older adults prepared less meals than older adults from rural zone (p = 0.009, 95%CI = 0.1, 0.8). Main effect zone on the mean number of daily snacks showed that urban older adults consume less snacks than older adults from rural zone ($p \leq 0.001$, 95%CI = 0.4, 0.6, Table 3). The statistics on nutrition choices for urban and rural older adults by gender is presented in Table 4.

Table 4. Percentage Statistics on Nutrition Choices for Costa Rican Urban and Rural Older Adults by Gender (n = 294)

Variable	Urban (n = 185)		Rural (n = 109)	
	Male (n = 47)	Female (n = 138)	Male (n = 20)	Female (n= 89)
Supplements				
Ω-3 fatty acids	52.9	43.7	33.3	37.1
Selenium	5.9	4.2	0.0	0.0
Zinc	0.0	2.8	33.3	8.6
Calcium	11.8	36.6	33.3	45.7
Folic acid	5.9	9.9	0.0	0.0
Niacin	0.0	0.0	0.0	2.9
Other	23.5	2.8	0.0	5.7
Butter or Margarine use?				
None of them	82.1	69.7	75.0	69.5
Margarine	10.3	23.8	25.0	25.6
Butter	7.7	6.6	0.0	4.9
Frequency of fried meals at home				
Almost never	2.4	7.1	0.0	4.9
Sometimes	26.2	35.7	21.1	28.0
Regularly	54.8	46.0	52.6	54.9
Daily	16.7	11.1	26.3	12.2
How much added salt?				
Almost nothing	34.1	22.8	15.8	9.3
A little bit	29.3	20.5	21.1	18.6
A good amount	36.6	55.1	52.6	70.9
A lot	0.0	1.6	10.5	1.2
Use prepared sauces to flavor meals?				
Infrequent	8.1	24.2	15.8	19.8
Once a week	67.6	48.3	21.1	54.3
Few times per week	18.9	6.7	52.6	6.2
Daily	5.4	20.8	10.5	19.8

Cognitive Evaluation. An ANCOVA significant interaction was found between gender and zone of residency on MMSE (p = 0.003, Figure 1A) and GDS (p = 0.050, Figure 1B).

1A



1B

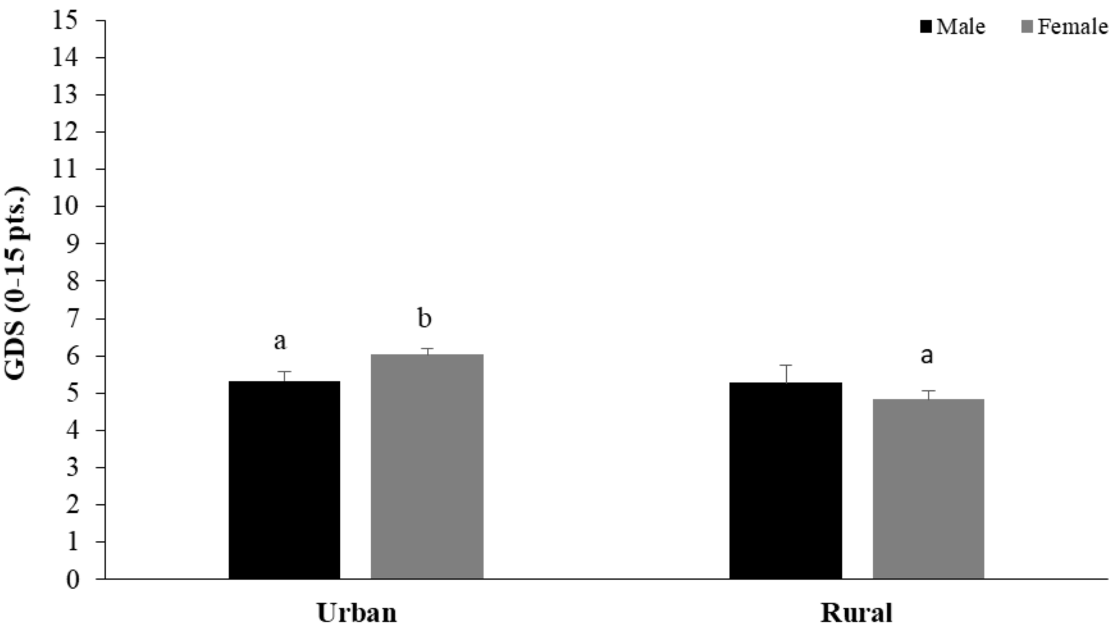


Figure 1. Interaction between Gender and Residency Zone on Cognitive Screening as Determined by the MMSE (Panel 1A) and Depression as Determined by the GDS (Panel 1B). Different Superscripts are Significant at $p \leq 0.05$

Regardless of gender, older adults from urban zone showed higher adjusted mean scores on GDS than older adults from rural zone (5.7 ±0.2 vs. 5.1 ±0.3, p = 0.048, 95%CI = 0.0, 1.3). Regardless of gender, older adults from urban zone showed lower adjusted mean scores on LCA than older adults from rural zone (3.0 ± 0.1 vs. 3.4 ± 0.1, $p = 0.004$, 95%CI = 0.1, 0.6).

4. Discussion

The aim of this study was to compare nutritional habits and psychological constructs between urban and rural Costa Rican older adults. Among the main findings of the study were the increased number of meals of older adults from urban zones and the high energy intake from CHO and protein of older adults from rural zones. Both groups of older adults with higher aerobic power also showed lower adiposity and fatigue. In addition, older adults from urban zone with higher aerobic power also showed better lifetime cognitive activity.

The need to determine general and inter-individual characteristics of older adults becomes relevant given the increasing number of this aging group in the population. A reduction in the biological capacities in older adults triggers the risk of geriatric syndromes accompanied by a decrease in cognitive function, depression, isolation, decreased physical abilities, as well as a disruption of nutritional habits and intake, a key element to prevent, attenuate and/or reverse some health conditions.

In this study, the differences by area of residence (i.e., urban vs. rural) of 254 older adults were evaluated, based on the importance that establishing differences could provide practitioners with a more precise intervention pattern for each one, which might contribute to developing better-suited strategic intervention plans for older adults. This type of research on nutritional, physical and psychological-cognitive comparison among older adults are poorly developed in the field of biomedical sciences.

The older adults living in urban areas in this study were older and completed more years of formal education than their counterparts living in rural zone. Naggan (2015), reported lower educational level in older adults from rural zones in Taiwan, and Navarro-Meza et al. (2014), found higher mean age in urban older adults from the city of Jalisco.

Female older adults in our study reported lower DBP, handgrip strength and walking performance than males. In a study on Spanish older adults, Bibiloni et al. (2018), reported that females had lower age-related physical fitness, educational level, as well as a greater weight than males.

In this study, the main nutritional findings by residence zone were those of the inhabitants of the rural zone. This group of older adults reported a higher daily total energy intake, CHO, protein and energy intake at each meal time (i.e., breakfast, lunch, dinner) than older adults living in urban areas. A higher fat intake was also reported by rural older adults only for dinner, and despite these results, in the older adults from urban zone reported a higher number of meals/day and total number of breakfast/week. Zulkowski and Coon (2004) and Chen, Cheng, Chuang and Shao (2015), evaluated the general nutritional status in an US and Taiwanese elderly population, respectively. In the US sample, the nutritional status for both rural and urban older adults was deficient; however, in Taiwan the nutritional status was worse in urban than in rural older adults. Madrigal-Leer et al. (2019), in a sample of Costa Rican centenarians from the Blue Zone of Nicoya (i.e., geographical zone with an uncommon concentration of people ≥ 100 yr. old), reported a higher prevalence of malnutrition and hypertension in the individuals evaluated. Nicoya, due to its colonial and cultural roots, could be considered a rural area.

A study by Xu, Byles, Shi and Hall (2015), reported higher protein and fat intake in older Chinese adults from urban areas; in contrast, those in the rural area showed a higher total energy and CHO intake, similar to the findings observed in the present study. In Brazil, Previdelli, Goulart and Aquino (2017), reported a high total energy intake in men, high protein intake in the rural zone, and high saturated fat intake in the urban zone. In Mexico, older adults from Jalisco had similar macronutrient intake by residence area; the only different finding reported was the total energy intake showing that in the urban zone there was a greater consumption of Kcal per day than in rural zone (e.g., higher intake of cereals and high-fat foods). We also find a similar result since the older adults from rural zone ingested more cereals. de la Cruz-Góngora, Martínez-Tapia, Cuevas-Nasu, Flores-Aldana and Shamah-Levy (2017), studied the Mexican Health and Nutrition Survey 2006 and 2012 and did not found significant differences in dietary intake of energy and nutrients in older adults from rural and urban areas.

In this study, higher LCA scores were related with lower fatigue in older adults from urban zone, a higher daily energy intake for the general population, as well as a higher total energy intake, protein and CHO in the total sample and in the rural zone. In the Costa Rican population, there was observed a greater dependence on the daily functions in older adults from the Nicoya area, where there was also a high prevalence of malnutrition as previously mentioned. This demonstrates congruence with both populations being evaluated in the same country and sharing similar characteristics.

5. Limitations

It is important to highlight the cultural, educational and lifestyle context of each population that is evaluated when comparing nutritional markers concerning macronutrients, energy or habits. Appropriate knowledge and information might positively influence in better nutritional practices and self-awareness regarding healthy eating and self-care guidelines, which certainly impact on healthy aging, resulting in better physical (e.g., increased VO_2max, strength, reduced fatigue), cognitive and psychological (e.g., reduced depression, higher functionality, lower risk of dementia or cognitive impairment) function (Arganini et al., 2012; De Vriendt et al., 2009; Jovičić, 2015; Laditka et al., 2008; Smith et al., 2006). Therefore, it is essential to design population studies and comparing these variables, which allows practitioners to generate a more comprehensive view regarding intake, not only of total energy, but also for each macronutrient, by gender, educational level, residence zone, and even by regions within a country.

6. Conclusion

Older adults from rural zone had a better energy and macronutrient intake for breakfast, lunch (CHO and protein) and dinner (CHO, protein and fat) than older adults from urban zone. There was a better nutritional intake in the rural zone and better performance in LCA. Older adults from urban zone had higher depression scores and reduced long-term cognitive function than older adults from rural zone. Therefore, differential nutrition, physical function and cognition is expected in urban and rural older adults from a small country in Central America. This finding has implications for local and national government agencies assessing the health of the elderly, and provides evidence of the need for creating tailored nutritional, physical activity and cognitive training recommendations for specific groups of the population.

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