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**Biocultural determinants of overweight and obesity in the
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1 **Biocultural determinants of overweight and obesity in the context of**
2 **nutrition transition in Senegal: a holistic anthropological approach**

3

4 Running title: **Determinants of overweight and obesity in Senegal**

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27 **Keywords:** Ecohealth, Obesity, Population Health.

28 Abstract

29 Senegal is experiencing a rising obesity epidemic, due to the nutrition transition occurring in
30 most African countries, and driven by sedentary behavior and high-caloric dietary intake. In
31 addition, the anthropological local drivers of the social valorization of processed high-calorie
32 food and large body sizes could expose the population to obesity risk. Hence, this study aimed
33 to determine the impact of these biocultural factors on the nutritional status of Senegalese
34 adults. A mixed-methods approach was used, including qualitative and quantitative studies.
35 Fourteen focus-groups (n=84) and a cross-sectional quantitative survey (n=313 women;
36 n=284 men) of adults in three different socio-ecological areas of Senegal (rural: n=204;
37 suburban: n=206; urban: n=187) were conducted. Dietary intake (Dietary Diversity Scores),
38 physical activity (International Physical Activity Questionnaire), body weight norms (Body
39 Size Scale), weight and health statuses (anthropometric measures and blood pressure) were
40 measured. We found that middle-aged and older Senegalese women valued
41 overweight/obesity more than younger Senegalese in all regions. In addition, young
42 urban/suburban adults had a tendency for daily snacking whilst urban/suburban adults tended
43 to be less physically active and had higher anthropometric means. A binary logistic regression
44 model showed that being female, older, living in urban/suburban areas and valuing larger
45 body size were independently associated with being overweight/obese, but not high-calorie
46 diet. Univariate analyses showed that lower physical activity and higher socioeconomic status
47 were associated with being overweight/obese. Finally, overweight/obesity, which is low in
48 men, is associated with hypertension in the total sample. To conclude, the nutrition transition
49 is currently underway in Senegal's urban/suburban areas, with older women being more
50 affected. Since joint effects of specific biocultural factors contribute to this phenomenon, the
51 study's findings suggests the need for local public health interventions which target women
52 and account for anthropological specificities of the Senegalese population.

53 Introduction

54 Obesity is widely known to be a global pandemic problem (Popkin et al., 2012), and is largely
55 caused by the continuing nutrition transition (Morris, 2010). Low and Middle Income
56 Countries (LMICs) are now facing a faster transition than in High Income Countries (HICs)
57 caused by high urbanization rates which involve rapid short-term adaptive strategies
58 potentially obesogenic (Downey, 2016; Olszowy et al., 2015). Indeed, the nutrition transition
59 is characterized by changing dietary habits and sedentary lifestyles within on-going
60 urbanization exposing to obesity and cardiometabolic diseases (Delpeuch, 2013). In sub-
61 Saharan African populations, the level of obesity continues to increase more aggressively than
62 in HICs (Stevens et al., 2012; Steyn & Mchiza, 2014; Connor Gorber et al., 2007). In
63 addition, the prevalence of diet-related non-communicable diseases (NCDs) such as
64 hypertension and type 2 diabetes are increasing in these settings (Ebrahim et al., 2013).

65 In the context of urbanization in Africa, which is characterized by a rural exodus and
66 intensification of internal migration, new migrants are progressively exposed to NCDs
67 (Oyebode et al., 2015). Nevertheless, their traditional preference for stoutness
68 (overweight/obesity) seems to remain in these obesogenic areas, as observed in Ghana,
69 Cameroon and Nigeria (Akindele et al., 2017; Appiah et al., 2016; Cohen et al., 2017).
70 Indeed, the propensity towards stoutness is strengthened during the internal migration,
71 particularly as this paradigm is viewed as a sign of successful integration into the modern
72 urban lifestyle associated with abundance. In comparison, if the social valorization of
73 stoutness is established in the rural setting where food insecurity is higher, this appreciation is
74 moderate due to the high physical strength necessary for manual labor (De Garine, 1962; Sear
75 & Marlowe, 2009). Thus, in urban obesogenic settings, this sociocultural phenomenon
76 becomes pronounced as migrants from rural settings still believe in increasing fat stores to
77 lower the risk of extreme undernutrition during times of seasonal adversity.

78 Urban migrants are therefore proud to flaunt their larger body size (Agyemang et al., 2009;
79 Brown & Konner, 1987; De Garine, 1990). Accordingly, a social valorization of high body fat
80 (Blocker & Freudenberg, 2001; Mvo et al., 1999) seems to be spreading in African
81 populations and become a risk factor for excess fat accumulation, as observed in urban
82 Cameroon (Cohen et al., 2013). This valorization of stoutness usually involves high-calorie
83 food consumption (Bricas, 2008; Ndoye & Diop, 2001) and fattening practices associated
84 with deliberate low physical activity practices to gain weight (Rguibi & Belahsen, 2006;
85 Warnier, 2009). Therefore, this factor could be considered as a biocultural determinant of the
86 obesity pandemic (Brewis, 2011), especially in African populations and the African diaspora
87 (Flynn & Fitzgibbon, 1998; Krauss et al., 2012).

88 The present study focuses on Senegal, where little previous research has evaluated biocultural
89 determinants of overweight/obesity as body weight perceptions. The Senegalese region is
90 experiencing a nutrition transition (Abubakari et al., 2008; Maire et al., 1992), with intensified
91 urbanization associated with a rural exodus (Duboz, et al., 2012). Thus, overweight has
92 become prevalent in urban areas, where the physical environment has become obesogenic as a
93 consequence of economic development (Macia et al., 2010), increasing sedentary behaviors
94 and consumption of cheap processed foods accessible for working-classes living in poor
95 urban neighborhoods (Drewnowski, 2009; Sobal & Stunkard, 1989; Temple & Steyn, 2011).

96 Nevertheless, for women living in the peripheral neighborhoods of Dakar, Senegal, this
97 obesogenic physical environment could be compounded by the sociocultural environment
98 since these women value stoutness and want to deliberately gain weight (Gning et al., 2007;
99 Holdsworth et al., 2004). Indeed, traditional views of body size in Senegal promote stoutness
100 in women as a symbol of a peaceful and wealthy household (Ndiaye, 2006), and this trend
101 persists with the current rural exodus (Duboz et al., 2011) involving a valorization of

102 processed and high-calorie food from populations with a lower socioeconomic status (SES) in
103 Dakar (Bricas, 2008; Ndoye & Diop, 2001).

104 Senegalese urban areas present both ecological and sociocultural obesogenic components, i.e.
105 a physical and sociocultural environment that facilitates obesity (Macia et al., 2017), as
106 observed in other African countries (Cohen et al., 2017). This dynamic social-ecological
107 context (Saarloos et al., 2009) has its own anthropological specificities involving a complex,
108 unique and potentially obesogenic lifestyle (Ulijaszek & Lofink, 2006). Nevertheless, the
109 impact of the social valorization of stoutness on weight gain is uncertain. Although this
110 biocultural factor i.e. between physical and sociocultural environments, may have
111 implications for physical activity and eating behaviors, this interaction is rarely studied.

112 The literature has identified many determinants which play a major role in the development of
113 obesity, caused by both heredity and social-ecological environment (Popkin & Gordon-
114 Larsen, 2004). Nevertheless, each human population could be exposed simultaneously to
115 several determinants of obesity. The knowledge on the interaction between these determinants
116 to accurately characterise the nature of the obesogenic exposure in different contexts remain
117 relatively unknown by multiple scientific approaches, except holistic anthropology (Parkin &
118 Ulijaszek, 2007). An anthropological global investigation using an integrative approach is
119 relevant to understand complex human interdisciplinary phenomena such as obesity (Dufour,
120 2006), and was used in this study to identify how ecological and sociocultural environments
121 within this lifestyle change interact with each other to expose the population to overweight,
122 obesity and hypertension in Senegal (Saarloos et al., 2009). Therefore, this study's innovative
123 aims were to (1) determine the joint influence of biocultural factors (body weight perceptions,
124 eating behaviors, physical activity) on the nutritional status of Senegalese migrating from a
125 rural to urban/suburban area in Dakar, and (2) to provide a holistic understanding of the
126 Senegalese nutrition transition to identify its stage experienced by the country.

127 **Material and Methods**

128 *Scope of the study*

129 Two contrasting areas were compared: the agglomeration of Dakar (city center and suburb)
130 and a rural area of the Wolof region (inside three villages of the Kaolack region: Diamaguene,
131 Keur Ndary Ndiaye and Gandiaye) where the socioeconomic conditions of inhabitants are one
132 of the lowest of the country (AG/GRN-GTZ, 2004). Using this framework we conducted (i) a
133 qualitative study to identify biocultural determinants of overweight/obesity including body
134 weight norms; physical activity and diet practices; (ii) a quantitative study to assess the
135 respective effects of these determinants using specific African photographic stimuli (Body
136 Size Scales, BSS) associated with a body image assessment guide (BIAG) and a questionnaire
137 assessing diet and physical activity, and (iii) anthropometric measurements. Overall, the
138 results from these integrated analyses facilitated a comparison between the cultural reality of
139 Senegalese adults and their urban physical environment, to (1) determine the joint influence
140 of biocultural determinants of obesity as the valorization of stoutness, high-calorie eating
141 practices and sedentary behaviors on their nutritional health status, in order to (2) globally
142 understand the nutrition transition and identify its progress in Senegal.

143

144 *Qualitative study*

145 *Study design.* The aim of this analysis was to define the biocultural determinants of
146 overweight/obesity by: (i) describing the different vernacular conceptions associated with
147 body weight: fertility, power, well-being, good health and beauty (Mvo et al., 1999), (ii)
148 identifying the different culinary local practices that characterize the Senegalese diet, (iii)
149 analyzing their relationship with physical activity, and (iv) detecting whether acculturation is
150 occurring. This process was also integral for the completion of the quantitative study, since
151 the variables tested by our measurement tools (BSS, BIAG and questionnaire) cannot be

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152 isolated from their sociocultural context. The results of this qualitative study were important
153 to: (i) identify the local norms of body weight, diet and physical activity, and (ii) interpret
154 results of the quantitative study. Indeed, we used the qualitative data on the diet, physical
155 activity and body weight norms to test for causal links between these aspects and weight gain,
156 which would have been impossible to establish based on quantitative data only. We used the
157 combination of qualitative and quantitative approaches to (i) demonstrate the effect of social
158 valorization of stoutness, diet and physical activity on the development of overweight/obesity,
159 and to (ii) assess how these phenomena are impacting a specific population.

160 *Sampling and process.* To determine these local norms and identify the influence of modern
161 lifestyle on it, a qualitative study using focus-groups explored in-depth local representations
162 of overweight/obesity determinants (Stewart & Shamdasani, 1990). Fourteen focus groups
163 were conducted, composed of 6 participants per group recruited from various neighborhoods
164 of the two areas according to three criteria (Tables 1 and 2). Firstly, '**age**' (< 25 years, and >
165 45 years); secondly '**sex**', thirdly '**educational level**' (< high school level: non-completion of
166 high school, \geq high school level: completion of high school), or fourthly '**occupational**
167 **category level**' (low occupational level, e.g. manual trades, small shopkeepers; high income
168 occupational level, e.g. senior executive level, healthcare professional). We could not
169 consider only educational level since it does not cover the total population in rural and urban
170 areas as the percentage of highly educated people is low, especially in elders. It was replaced,
171 when necessary, by the occupational category level, the two indices being positively
172 correlated in Dakar. We conducted 6 focus-groups in a rural area (Kaolack region) and 8 in an
173 urban area (Dakar agglomeration) since the socioeconomic and educational gradients among
174 rural middle-aged and elderly people were very low (ANSD-ICF, 2015).

175 We selected participants inside a network of relationships from local interviewers with
176 experience conducting local anthropological studies. Contrary to the quantitative study, the

177 subjects' study participation was somewhat arbitrary as (i) their acceptance to participate in
178 the detailed protocol may have depended on their inclusion in our network, and (ii) our study
179 required participants with sufficient knowledge and interest regarding the research. These two
180 criteria were simultaneously assessed while screening candidates for study participation. Even
181 though this sample aimed at covering the Senegalese point of views on our topic, our
182 qualitative study was not fully representative of the population as participants (key
183 informants) were selected via their relationship with some of the research assistants.
184 Nevertheless, the sample presented a balanced sex ratio and all participants belonged to the
185 Wolophone group. Focus groups were performed in neighborhoods to allow each participant
186 to express themselves in a familiar context without exterior pressure, and recorded with a
187 handheld recorder. Focus groups (and all other methods) were conducted in Wolof, the main
188 vernacular language of the participants, and then translated into French and transcribed.
189 Finally, data saturation for the focus groups was reached after all participants had the
190 opportunity to express their point of view for each discussion point.

191

192 ***Quantitative survey***

193 *Perceptions of corpulence.* To accurately assess body weight perceptions and identify the
194 potential social valorization of overweight/obesity, we used the Body Size Scale (BSS). This
195 validated tool presents real human body sizes photographs of both sexes, covering the total
196 gradient of the body mass index (BMI) (Cohen et al., 2015). Then, we built a body image
197 assessment guide (BIAG) to contrast local Senegalese norms with scientific norms of body
198 weight measured by the BSS, as already employed in one of our previous studies (Cohen &
199 Pasquet, 2011). The BIAG consists of three questions about current body size (CBS), desired
200 body size (DBS) and ideal body size (IBS) for oneself as well as one's partner (for polygamist
201 households, we included the first wife). We compared the responses for these items between

8

202 participants living in urban, suburban and rural areas, to assess possible changes in corpulence
203 norms with the urbanization process. In addition, a *social valorization of overweight/obesity*
204 *index* was constructed from the BSS to accurately assess the desire to gain weight.

205 *Dietary intake.* To assess dietary intake, we firstly used the Dietary Diversity Score (DDS), a
206 qualitative 24-hour recall, to assess the diversity of food group composition (Savy et al.,
207 2006). The Food and Agriculture Organization developed the DDS, based on 16 main food
208 categories (e.g. cereals, green vegetables, oils, meats), and we used this tool to assess the
209 dietary diversity in Senegal (FAO, 2011). The DDS is observed to be a good indicator of
210 global diet changes in the context of the nutrition transition (Oldewage-Theron and Kruger,
211 2008). Precisely, the DDS and BMI are positively correlated in the context of staple food
212 accessibility (Savy et al., 2006; Karimbeiki et al., 2018). Secondly, we also evaluated whether
213 urbanization in Senegal involves obesogenic eating practices by assessing (1) the frequency of
214 snacking in the last 24 hours through this question: “Have you nibbled yesterday? If so, how
215 often?”; (2) the daily frequency of snacking – the snacking average perceived by subjects –
216 through this second question: “How many times have you nibble a day?: less than once [1],
217 once [2], twice [3], three times [4], continuously [5]”; and (3) the desire to adopt a high-
218 calorie diet through this last question: “What does it mean "eat well" for you?”.

219 *Physical activity.* To assess the duration of physical activity, we used four items from the
220 International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003). The daily averages
221 (in hours) of intensive physical activity level (digging, carrying heavy loads, make efforts
222 intensely, etc...), moderate physical activity level (wear light loads, yields, cycle quietly,
223 etc...), walking and sedentary behavior levels were calculated from the number of days and
224 the duration of physical activity in the last seven days prior to completing the questionnaire.

225 *Health status perception.* Using the BSS, a *body self-satisfaction index* was calculated to
226 identify subjects as either satisfied with their body weight, wanting to gain or lose weight.

227 This BSS index was compared with BMI categories to assess the body self-satisfaction of
228 participants according to their body weight status.

229 *Anthropometry.* A set of anthropometric measurements was taken by trained fieldworkers,
230 using standardized procedures (Weiner & Lourie, 1981). Height was measured to the nearest
231 mm using a portable stadiometer (Siber Hegner, Zurich, Switzerland). Weight was measured
232 with participants in very light clothing, to the nearest 100g, using a digital beam scale (Tanita,
233 Tokyo, Japan). Overweight was defined as $BMI \geq 25$ and $<30 \text{ kg/m}^2$ and obesity by a $BMI \geq$
234 30 kg/m^2 . Hip circumference (HC) and waist circumference (WC) were measured to the
235 nearest mm in a standing position using a non-stretchable tape measure, according to standard
236 procedures. The waist-to-hip ratio (WHR) was calculated to assess body fat distribution
237 (WHO, 2000). Skinfold thickness measurements (mm) were taken at four sites: biceps,
238 triceps, suprailiac, and subscapular using a Harpenden skinfold caliper (Holtain Ltd.,
239 Crymych, UK). Fat mass (percentage of fat) was derived from the sum of the four skinfold
240 measures (Durnin & Womersley, 1974).

241 In addition, two diastolic and systolic blood pressure (BP) measurements (mmHg) were taken
242 with an electronic tensiometer (Omron France, Rosny-sous-Bois, France) at each arm, with
243 the subjects in a seated position and after 15 minutes rest. Means between the two systolic and
244 diastolic BP taken at each arm were calculated. Mean BP between systolic and diastolic BP
245 means was defined as: $(\text{diastolic BP} + 1/3) \times (\text{systolic BP} - \text{diastolic BP})$. Hypertension was
246 defined as: diastolic BP ≥ 90 and/or systolic BP ≥ 140 mmHg. This biometric protocol
247 allowed us to assess the respondents' nutritional status and its association with hypertension.

248 *Samples.* We assembled a sample in the agglomeration of Dakar (city center and suburb) of
249 393 adults (200 men/193 women; 187 urban and 206 suburban subjects) and a sample of 204
250 adults in the Kaolack region (84 men/120 women). For both areas, we used a quota sampling
251 strategy, according to three criteria (age, sex and neighborhood) from the 2002 National

252 Senegalese Census. Data for the regions investigated were provided by the Senegalese
253 National Institute of Statistics and Demography. In Dakar agglomeration, participants were
254 selected from all parts of the city and its peripheral region (e.g. Sacré Coeur, Cambérène).
255 Rural area subjects were strictly inhabitants of the three villages cited above. Pregnant women
256 and confused elders were excluded in order to collect reliable biological and cultural data.

257

258 ***Data analysis***

259 *Main analyses*

260 For the qualitative study, analyses were performed from thematic groupings to identify
261 relevant emerging themes for each potential determinant of overweight/obesity (Mason,
262 2002). After the identification of main themes (e.g. for social valorization of stoutness:
263 idealization of urban abundance; for diet: urban food pleasure; and for physical activity:
264 valorization of idleness), we summarized the main information from each theme and
265 compared the social representations and practices related to these in our three subsamples.

266 For the quantitative study, we used analysis of variance and covariance (ANOVA/ANCOVA),
267 and t-test (post-hoc analyses) to assess anthropometric characteristics and body size standards;
268 Chi² and Fisher Exact test to assess the prevalence of overweight/obesity and hypertension.
269 The average comparisons between CBS and DBS/IBS were implemented by paired t-test. We
270 also used two Principal Component Analyses (PCA) and one multiple Factorial
271 Correspondence Analysis (FCA) to respectively construct proxy socio-economic and high-
272 calorie diet indices and analyze the food consumption. Finally, a binary logistic regression
273 model was carried out to assess the risk factors for overweight/obesity.

274 *Socioeconomic status.* A proxy index of household wealth was constructed using a PCA from
275 a set of variables: e.g. owner/tenant, type of house, car/truck, mobile phone, electricity. In the
276 total sample, the first principal component explained 40.1% of the variance with an Eigen

277 value of 19.7 (5.3 for the second principal component). Households were classified into three
278 distinct groups: 'low', 'middle' and 'high' SES levels according to tertiles of the calculated
279 variable from the first principal component.

280 *Migration status*

281 The migration profile of subjects was deduced through the creation of one variable, the
282 "duration of residence in urban/suburban areas" coded into six categories: 0 years; 1-10 years;
283 11-20 years; 21-30 years; 31-40 years; >40 years. This urban/suburban length of residence
284 was investigated to see whether it was associated with nutritional status.

285 *Body image.* The BSS was treated as a metric value, each human picture ranging from 1 to 9
286 according to increasing BMI categories. The *social valorization of overweight/obesity index*
287 was constructed as: 4 minus DBS; since the fifth silhouette on the scale corresponds to
288 overweight. Then, the *body self-satisfaction index* was calculated by subtracting the CBS and
289 DBS (CBS-DBS) (Williamson et al., 1993).

290 *Dietary intake.* Dietary diversity was coded by: lower DDS (< 7 different categories of food
291 groups); or higher DDS (≥ 7 different categories of food groups). Snacking frequency was
292 coded as: lower snacking (< 3 times/day), or higher snacking (≥ 3 times/day). The item on the
293 desire to adopt a high-calorie diet was coded as "higher-calorie diet" for modalities suggesting
294 an obesogenic diet (e.g. eating filling food, eating at irregular times, eating high-calorie food)
295 and as "lower-calorie diet" for the other modalities (e.g. eating a balanced diet, eating at
296 regular hours, eating fruits and vegetables, etc.). A multiple FCA of the different items of
297 dietary intake allowed the analysis of food consumption in the context of urbanization. In
298 addition, a proxy high-calorie diet index was constructed using a PCA from the different
299 items of questionnaire suggesting obesogenic dietary intake (high DDS, snacking in the last
300 24 hours, daily snacking, and craze for high-calorie foods). The first principal component
301 explains 31.9% of the variance with an Eigen value of 1.3 (1.0 for the second principal

302 component). Caloric diet was classified into three distinct groups: ‘low’, ‘middle’, and ‘high’
303 levels of caloric intake from the first principal component which synthesized snacking
304 practices.

305 *Physical activity.* Finally, a physical activity index was constructed for moderate and high
306 intensity physical activity defined in the IPAQ. Physical activity was coded as: lower physical
307 activity (0 days of moderate and intensive physical activities practiced during the last week);
308 and higher physical activity (≥ 1 days of moderate and/or intensive physical activities
309 practiced during the last week).

310 *Relationships between beliefs, practices and body weight.* The relationships (adjusted odds
311 ratios (OR), 95% confidence intervals (CI)) between overweight/obesity and their plausible
312 determinants (sex, age, area living, proxy index of household income, level of education,
313 dietary intake, social valorization of overweight/obesity index, high intensity physical
314 activity) were assessed with a binary logistic regression model.

315 For the qualitative analyses, we used the NVivo 7 software (QSR International, Melbourne,
316 Australia) to synthesize the main outcomes of focus-group. For the quantitative analyses we
317 used the Statistica 13 software (Statsoft Inc, Tulsa, OK, USA) for conducting descriptive
318 statistics and PCA(s) and FCA; and MyStat 12 software (Systat Software Inc, San Jose, CA,
319 USA) for the logistic regression. Finally, qualitative and quantitative approaches were
320 assigned equal weight in the interpretation of the findings.

321

322 **Results**

323 ***Qualitative study***

324 *The social valorization of stoutness*

325 Idealization of urban abundance. The development of urban areas in Senegal involves an ideal
326 conception of a modern lifestyle, where success is seen as possible for rural and migrant

327 populations who idealize western culture. Integrating into an urban lifestyle is associated with
328 weight gain, scarce in the village setting, as a symbol of integration into the city, taking
329 advantage of its abundance. But in rural areas, only a limited corpulence is valued, since high
330 fatness is not adapted to rural labor. Hence, this social valorization of stoutness increases
331 alongside the emerging modern lifestyle, seen as a symbol of wealth and prosperity. For
332 example, one participant explained:

333 *“According to my vision of the two eras, everyone knows that at present, women intentionally*
334 *overeate high-calorie food and use medication (corticosteroids); especially for us, women..., it*
335 *differs from the grandparents’ eras when they spoke of **am yaram [have weight]**. If you're too*
336 *rey [stout] in the village, you will not be able to work or cultivate; it's not valued... But*
337 *women today in the city, no one knows they are taking medications (corticoids) that increase*
338 *their overweight.” [Older urban woman, high SES]*

339 Manifestation of urban success in rural area. Improvements in SES which accompany
340 urbanization, expressed through weight gain is especially the case for middle-aged and elderly
341 married women, living in suburbs of Dakar with a low SES, who are less receptive to modern
342 representations of body size. They generally maintain regular contact with the rural universe
343 through traditional celebrations (weddings, etc.) in which it is important to present a
344 “beautiful body”: corpulent and dressed with smart traditional loose clothes. The experiences
345 of younger people are different, as illustrated by this young man:

346 *“People in villages are ignorant. If you are **am yaram [have weight]**, automatically they think*
347 *that you are in good health but it is not always true! If you come back to the village after*
348 *urban living, people will say: “You eat your money!” People in the regions do not see like*
349 *Dakar people, they all want to come in Dakar. For them, if you migrate to Dakar, you have*
350 *no more worries, you have everything you want; whereas in Dakar, firstly we do not always*
351 *eat well, secondly, times get tough. Thus, a woman who returned to the village **am yaram***

352 *[have weight] and khess [thinning skin], people said that Dakar is prosperous for you!"*

353 *[Younger urban man, low educational level]*

354

355 *Diet perceptions and practices*

356 Devaluation of traditional food in young people. Intergenerational conflict has emerged

357 between parents and youths concerning culinary practices. Parents condemn the use of

358 modern foods based on rice, oil, "cube-maggi", meat and fast-food, whereas westernized

359 youths no longer appreciate traditional diets mainly based on millet and vegetables. As

360 illustrated by the following participant:

361 *"...in the current situation in many homes, if you cook ngourban [millet seeds boiled and*

362 *ground], children will not eat that. They will not even touch it because times are not the same.*

363 *Children hardly know this diet. What they know is that you cook now to eat, and this is what*

364 *causes endless damage to us. What would be safer for us are alternatives, but cooking with oil*

365 *as we do for ceebu jën [rice with fish], that's not good. With that, we cannot expect to have a*

366 *healthy body."* [Older rural man]

367 Urban food pleasure. The urbanization process is perceived as the era of comfort and pleasure

368 in lay norms. Therefore, it is not possible for westernized youth to accept eating "simple

369 food" just to meet basic living needs, for example:

370 *"Many people flock to Dakar because there is the atmosphere there. The diet is different. In*

371 *Dakar, the food is tasty, there are sandwiches, burgers, chawarmas. Here you can go six*

372 *months without eating burgers or something like that. Here you eat couscous of millet and*

373 *foõdé [millet porridge with grains], that's all. Therefore many people prefer to go to Dakar*

374 *for that. They flee the food here and also the hard work in the fields."* [Younger rural man]

375

376

377 *Physical activity*

378 Valorization of idleness in older women. The social value of overweight also involves a desire
379 to decrease daily physical activity, i.e. the practice of idleness, based on reclusion at home,
380 regular sleep and moreover achieving “peace of mind”: the avoidance of worries, social
381 pressures. The obsession to ostentatiously demonstrate household economic success in poor
382 urban neighborhoods, through spouses’ weight gain, involves a real change in lifestyle to
383 become fat: the search of a simple life without stress, unnecessary actions and desire to gain
384 an “authentic weight”:

385 *“During the day I closed my door and I quietly and sufficiently slept. That's how I gained*
386 *weight. The aim, it is above all to be **xel mu dal [have peace of mind]**. If you take the most*
387 *appropriate diet to gain weight while you are not **xel mu dal**, it does not work. You have to be*
388 *comfortable in your head ... Sleeping the day, it's also great to gain weight. At a certain point,*
389 *all I could not have, I did not care anymore. I was trying not to break my head. Everything*
390 *that could give me peace of mind, I did.” [Older urban woman, high socioeconomic status]*

391 Frequent physical activity in young people. However, young people exposed to western media
392 and medical discourse value physical activity, especially sport, e.g. jogging or bodybuilding
393 for men. The most westernized young people want to practice regular physical activity to
394 avoid weight gain during their life:

395 *“Modern clothes require a thin body! From 6pm, young people are at the beach doing sport*
396 *to fight against the phenomenon of weight gain. Young people, especially in Dakar, tend to*
397 *not want to gain weight, even for a wedding. It is old-fashioned.” [Younger urban man, high*
398 *educational level]*

399

400

401

402 ***Quantitative survey***403 *Perceptions of corpulence*

404 In all groups, men overestimated their body size (Table 3; Figure 1), and perceived
405 themselves as being in the normal weight category. Those living in urban and rural regions
406 showed a significantly greater desire to increase body weight to become overweight (CBS vs
407 DBS: $p < 0.01$ and $p < 0.001$). Further, participants from all regions selected DBS and IBS in the
408 normal weight category, while the suburban group had the lowest DBS and IBS averages and
409 the highest CBS average. We observed in the urban and rural groups that IBS were
410 significantly higher than CBS ($p < 0.001$), but not in the suburban group.

411 ***Table 3***

412 All women perceived their partners to be in the overweight category (Table 3; Figure 1);
413 however only rural women indicated that they wanted them to gain weight to be overweight
414 ($p < 0.01$). Both urban and suburban dwelling women showed a slight preference for their
415 partner to lose weight. Rural women preferred both DBS and IBS in the overweight category,
416 whereas urban/suburban women had a preference for DBS and IBS in the normal weight
417 category ($p < 0.001$). The masculine IBS of the urban women group was significantly lower
418 than the CBS for their partner ($p < 0.05$) and lower but not significantly in the suburban group.
419 Conversely, masculine IBS was significantly higher than the CBS for the partner of rural
420 women ($p < 0.001$). Finally, the DBS and IBS of men for themselves were significantly lower
421 than those of women for men ($p < 0.001$).

422 ***Figure 1***

423 Concerning **women's** perceptions (Table 3; Figure 2), we observed that only suburban and
424 rural groups overestimated their weight. Women in the urban and suburban groups perceived
425 themselves as being in the overweight lower threshold, whereas rural women perceived
426 themselves in the normal weight category ($p < 0.001$), and were observed to have a desire to

427 gain weight ($p<0.001$). The DBS and IBS averages were similar to those of women's
428 perceptions for men: in the overweight threshold, except for rural women who clearly
429 preferred the overweight category ($p<0.001$). In addition rural women had an IBS
430 significantly higher than their DBS ($p<0.05$) and their CBS ($p<0.001$).

431 All men perceived women to be in the normal weight category (Table 3; Figure 2), and rural
432 men desired their partner to gain weight ($p<0.001$). The IBS for women was the lowest in the
433 urban men group and the highest in the rural men group. Rural men had a preference for
434 feminine IBS significantly higher than their partner's CBS ($p<0.01$), whereas IBS and CBS
435 were not significantly different in urban/suburban groups. Finally, the DBS and IBS of
436 women for themselves were significantly higher than those of men for women ($p<0.001$).

437 **Figure 2**

438 *Dietary intake*

439 The multiple Factorial Correspondence Analysis (FCA 1, Figure 3) of dietary intake related to
440 risk of overweight/obesity (high DDS, high snacking level, desire for high-calorie foods)
441 showed that middle-aged and elderly subjects adopted a lower-calorie diet than young
442 Senegalese, even though they had a higher DDS and the dietary intake pattern of this second
443 group seemed undetermined ($p<0.001$; $n=597$). Indeed, no point cloud was observable
444 between youth and dietary intake variables. No dietary intake pattern was found with either
445 nutritional status or region.

446 Univariate analyses showed a significant association between lower DDS and the rural
447 lifestyle (49.5% vs 27.2% in urban/suburban areas, $p<0.001$). Adjusted with age, we found
448 significant DDS mean differences between urban/suburban and rural areas (8.7 ± 1.8 in urban
449 area, 8.6 ± 1.8 in urban area and 7.5 ± 1.8 in rural area, $p<0.001$). In addition, we found a
450 significant association between higher daily snacking and urban/suburban lifestyle (28.0% vs
451 16.2% in rural area, $p<0.01$), and younger age (39.0% vs 17.7% in older subjects, ≤ 25 years

452 old; $p < 0.001$). However, higher daily snacking was not associated with overweight/obesity
453 among young subjects (≤ 25 years old). Finally, higher daily snacking was associated with
454 young (48.6% vs 20.0% in older subjects, ≤ 25 years old) and young/middle-aged subjects
455 (34.8% vs 0.07% in older subjects, ≤ 45 years old) living in both urban/suburban areas
456 ($p < 0.001$ for both groups).

457 *Figure 3*

458 *Physical activity*

459 Durations of moderate and high intensity physical activities were lower in suburban than in
460 rural areas (Table 4, $p < 0.001$). Moderate physical activity was higher in rural than urban area
461 ($p < 0.001$), and high intensity physical activity was higher in urban than suburban area
462 ($p < 0.05$), and close to the level of the rural average. The level of sedentary behavior was
463 highest in the urban area and the lowest in the rural area ($p < 0.001$). There was no significant
464 difference for the walking average. Then, univariate analyses showed a significant association
465 between younger age (≤ 25 years old) and the regular moderate and/or intensive physical
466 activities ($p < 0.01$) in both urban and suburban areas. We found the same pattern of results in
467 young and middle-aged subjects (≤ 45 years old; $p < 0.001$) since 61.1% of them practiced these
468 types of physical activities whereas only 30.9% of older subjects (> 45 years old) practiced
469 moderate and/or high intensity physical activities in urban/suburban areas.

470 *Table 4*

471 *Anthropometry*

472 In urban/suburban areas, women were fatter and had lower mean BP values than men (Table
473 5). In both sexes, groups from both urban and suburban areas had higher anthropometric
474 indices than those from rural area, except for mean BP in both sexes. HC was significantly
475 higher in men living in suburban areas compared with those living in urban settings. Similar

476 trends were found for BMI and WC but not significantly. No significant differences were
477 found for mean BP between areas in both sexes.

478

Table 5

479 The prevalence of overweight and obesity in the total sample were significantly higher in
480 urban/suburban than rural areas: respectively 29.6 vs 8.5% for overweight (Chi2, $p < 0.001$)
481 and 11.8 vs 2.0% for obesity (Fisher Exact, $p < 0.001$). In addition, 5.8% of young subjects
482 (≤ 25 years old) were overweight/obese, 23.0% of middle-aged subjects (25-45 years old) and
483 40.5% of older subjects (Chi2, > 45 years old; $p < 0.001$); and 2.9% of young subjects (≤ 25
484 years old) were obese, 7.4% of middle-aged subjects (25-45 years old) and 16.9% of older
485 subjects (Chi2, > 45 years old; $p < 0.001$). For hypertension, we only found a significant
486 difference between urban/suburban and rural areas in young people (≤ 25 years old): 15.6 vs
487 6.1% (Fisher Exact, $p < 0.05$). Finally, significant associations were observed between
488 overweight/obesity (aggregated) and hypertension (48.9% in overweight/obese vs 19.3% in
489 underweight/normal weight subjects, Chi2, $p < 0.001$).

490

Migration and nutritional status

492 We observed a significant association between overweight/obesity and the length of residence
493 in urban/suburban areas (Chi2, $p < 0.001$). The percentage of overweight subjects strongly
494 increases after 30 years of urban/suburban duration (Figure 4). No association between
495 urban/suburban length of stay and overweight/obesity in rural Senegalese were found since
496 none of them lived in a city.

497

Figure 4

498

Health status perceptions

499

500 Using the *body self-satisfaction index*, we observed that 52% of overweight/obese subjects
501 were satisfied with their weight status versus 13.5% in underweight/normal weight subjects
502 ($p<0.001$). Then, we observed that the majority of subjects who wanted to gain weight were
503 >25 years old (62.0%; $p<0.05$). Finally, using the *social valorization of overweight/obesity*
504 *index*, we observed that the majority of subjects who valued overweight and obesity were
505 women (60.2%; $p<0.001$) and those aged >25 years (74.1%; $p<0.05$). However, the difference
506 in overweight valorization between age groups was only significant in women (younger/older
507 women: 44.6% vs 65.5%, $p<0.01$; and younger/older men: 43.0% vs 42.4%).

508

509 *Analysis of overweight/obesity determinants*

510 In the binary logistic regression model, the comparison of overweight/obese subjects (BMI
511 ≥ 25 kg/m²) with non-overweight (BMI <25 kg/m²) (Table 6) revealed an independent
512 negative effect of the caloric diet, and independent positive effects of gender, age, living area
513 and the social valorization of overweight/obesity. The risk of being overweight/obese was 3.6
514 times higher in women than in men ($p<0.001$). Overweight/obesity increased with age
515 ($p<0.001$) and urbanization ($p<0.001$). Indeed, we observed that the risk of being
516 overweight/obese was 6.5 times higher in both urban/suburban areas than in the rural area.
517 Overweight/obesity increased with the social valorization of overweight/obesity ($p<0.05$): the
518 risk of being overweight/obese was 1.7 times higher among subjects who valued
519 overweight/obesity than those who did not. Finally, univariate analyses showed that high SES
520 was more likely to be associated with being overweight/obese ($p<0.05$), and the more likely
521 that participants participated in moderate and/or high intensity physical activity, the less likely
522 they were to be overweight/obese ($p<0.001$).

523

Table 6

524

525 Discussion

526 This study conjointly investigated the biocultural determinants of overweight and obesity in
527 Senegal to globally understand, through a holistic view, the physical and sociocultural
528 environmental aspects – i.e. the biocultural aspects – of the Senegalese nutrition transition and
529 clearly identify its stage experienced by the country. Overall, despite the relative low
530 prevalence of overweight and obesity in Dakar agglomeration, we observed that Senegalese
531 have experienced health consequences related to this lifestyle transition highlighted by our
532 mixed-methods study. More precisely, the internal migration from rural to urban/suburban
533 areas was associated with a dynamic social-ecological obesogenic context: (1) a higher
534 urban/suburban prevalence of overweight/obesity and hypertension, and (2) a valorization of
535 stoutness, sedentary behaviors and higher SES exposing to overweight/obesity according to
536 our qualitative and quantitative findings.

537 For urban/suburban Senegalese, the urbanization and specific biocultural factors involve a
538 higher exposure to overweight/obesity identified in the binary logistic regression model.
539 These findings have been observed in other populations who migrated to urban areas of
540 LMICs as in Gambia and Botswana (Letamo, 2011; Siervo et al., 2006). In addition, the
541 nutrition transition seems to be more evident in urban/suburban Senegalese women, who had
542 mean BMI around 25 kg/m^2 , as the findings of Macia et al. (2016). Our data supports the
543 hypothesis that women in LMICs are more sensitive to the obesogenic effects of nutrition
544 transition in urban areas as observed in other African countries, even though the Senegalese
545 prevalence of overweight/obesity remains still low (Fezeu et al., 2008; Monteiro et al., 2004).

546 *Social valorization of stoutness*

547 In spite of the social valorization of stoutness in traditional Senegalese culture, accentuated by
548 the current lay portrayal of Dakar as an Eldorado, which seems to strengthen this process, this
549 cultural trait tends to decrease in Dakar (urban/suburban areas), particularly in young women.

550 The Senegalese population seem to adapt their body size norms to the obesogenic urban
551 environment and modern perceptions of body size, like other African populations
552 experiencing internal migration in South Africa and external migration to Western countries
553 (Renzaho et al., 2012; Szabo & Allwood, 2006). Indeed, the younger study participants
554 devalued overweight and obesity unlike the older subjects, as identified in a Cameroonian
555 rural-urban study (Dapi et al., 2007). Thus, in Dakar agglomeration, both DBS and IBS were
556 approximately around overweight, especially in the middle-aged and older women, as
557 observed in other African urban areas such as Kumasi, Ghana (Appiah et al., 2016); whilst the
558 prevalence of overweight, obesity and hypertension were higher than in the rural area, as
559 shown in South Africa (Steyn & Mchiza, 2014).

560 A preliminary recent Senegalese study on body image showed this women valorization of
561 stoutness (Cohen et al., 2018), but our further analyses demonstrated that particularly women
562 valued also overweight and obesity in men while most of participants overestimated their
563 weight, a trend probably linked to the traditional depreciation of thinness (Ndiaye, 2006).
564 Hence, in the binary logistic regression model, the social valorization of overweight and
565 obesity was as an independent risk factor for overweight and obesity, as observed in previous
566 studies conducted in Cameroon (Cohen et al., 2017; Cohen et al., 2013), since the majority of
567 overweight/obese subjects did not want to lose weight. A phenomenon already identified in
568 urban middle-aged Senegalese women (Holdsworth et al., 2004).

569 ***High-calorie dietary intake***

570 Then, even though Senegalese culture in the central Wolof region involves traditional culinary
571 habits based on a low-calorie diet, essentially composed of frugal dishes of vegetables and
572 millet, these culinary practices is being unappreciated today according to the qualitative study.
573 Firstly by young people which want to discover the food pleasures in the city (Holdsworth et
574 al., 2006; Ndoye & Diop, 2001), and also by older women in suburban area who intentionally

575 overeat and use corticosteroids to rapidly gain weight, as observed by Rguibi & Belahsen
576 (2006) in Morocco. Thus, we observed that the DDS is higher in both suburban and urban
577 areas, as well as the frequency of daily snacking. However, in the binary logistic regression
578 model, this desire for food pleasure was not associated with overweight and obesity among
579 young and middle aged subjects living in both suburban and urban areas.

580 The DDS measuring the quality of the dietary intake is not systematically associated with
581 BMI (Salehi-Abargouei et al., 2016). Indeed, the literature attests that the DDS and BMI are
582 positively correlated during times of guaranteed access to staple high-calorie food, a condition
583 which is not in all Senegalese regions (Savy et al., 2006; Bosu, 2015; Karimbeiki et al., 2018).
584 Furthermore, this result could also be explained by the ambivalent lifestyle experienced by the
585 population. Young people exposed to a global consumer society are caught between food
586 hedonism and the valorization of thinness (Hesse-Biber et al., 2006), while some older people
587 maintain a traditional diet not obesogenic (Ndoye & Diop, 2001). Hence, the FCA showed
588 that the dietary patterns of middle-aged and older subjects were associated with lower-calorie
589 dietary practices, especially in rural area where daily snacking was the least frequent.
590 Moreover, the high-calorie diet index had an independent inverse association with
591 overweight/obesity in the binary logistic regression model because snacking practices were
592 mainly used by younger people.

593 ***Lower physical activity***

594 In addition, we observed that moderate and high intensity physical activities were higher in
595 the rural area, whilst sedentary behavior was higher in urban/suburban areas. In addition,
596 lower intensity and/or moderate physical activities were associated with overweight and
597 obesity, as observed by Sodjinou et al. (2008) in Cotonou, Benin, even though this association
598 was only univariate, since no significant in the binary logistic regression model. The
599 qualitative study showed that middle-aged and older women value sedentary behaviors, as a

600 symbol of peace of mind and prosperity, to ostentatiously gain weight, as observed in other
601 studies conducted in Africa as Morocco (Rguibi & Belahsen, 2006; Warnier, 2009). However,
602 young people valued physical activity more, especially sports such as jogging, since an urban
603 lifestyle does not make regular physical activity easy, mainly caused by the office work time
604 and the decreased need for agricultural manual activities (Besharat Pour et al., 2014).

605 ***Comparison between determinants***

606 As for many African populations, the Senegalese who have migrated have a greater risk of
607 developing overweight/obesity (Agyemang et al., 2009), even if they are receptive to etic
608 standards (scientific norms) of corpulence, questioning the emic (lay norms) valorization of
609 stoutness (Morris et al., 1999). Urban/suburban Senegalese seem to have an increased risk for
610 hypertension related to higher overweight/obesity prevalence (Guh et al., 2009), caused by
611 biocultural factors. We observed (i) a cultural component: the social valorization of
612 overweight/obesity involving sedentary and eating behaviors to deliberately gain weight
613 (Puoane et al., 2005), and (ii) an ecological component: lower moderate and intensive
614 physical activities and higher-calorie dietary intake related to the urbanization process through
615 a decrease in any form of daily activity (frequent walking, manual work for men; intensive
616 housework and caring for children/elders for women) and the increase of daily-snacking, food
617 portion sizes and energy density of diets (Duffey & Popkin, 2011; Popkin & Gordon-Larsen,
618 2004).

619 ***Urban lifestyle, symbol of abundance***

620 In recent history in HICs, obesity mainly affects lower SES groups (Popkin et al., 2012),
621 particularly those living in urban areas, even though it touches all socioeconomic groups
622 (Drewnowski, 2009). The reasons for this are complex, but include the tendency to consume a
623 cheaper and more monotonous high-calorie diet (Drewnowski, 2009; Sobal & Stunkard,
624 1989). Indeed, besides greater accessibility of this food for working-classes living in poor

625 urban neighborhoods, there is some evidence of a cultural explanation, the phenomenon of
626 ‘social revenge’, i.e. a desire for the working-classes to discover ‘the pleasures of the city’,
627 including ‘good food’ (Corbeau, 1995). In some ways, our data supports other studies of
628 African populations as Cameroonians and South Africans (Cohen et al., 2013; Puoane et al.,
629 2005) since (i) the valorization of overweight, especially among middle-aged and older
630 subjects, persists in both suburban and urban areas, whilst (ii) the desire for daily snacking
631 was associated with these areas.

632 For instance, we observed some practices of fattening and idleness in middle-aged and older
633 women, to gain weight and symbolize peace and success in a household. These practices are
634 not ritualistic, nor implemented in specific venues or times as observed in rural Mauritania
635 and Cameroon (Sylla, 1985; De Garine, 1990; Warnier, 2009), because these strategies to gain
636 weight are modern and not linked to a collective rural lifestyle, to express economic success
637 in an urban area (De Garine, 1962). This can be interpreted as a “social revenge” for new
638 migrants originally exposed to undernutrition in a rural area (Doak et al., 2005), who want to
639 discover the nutritional abundance of Dakar. Nevertheless, this phenomenon does not have
640 the same consequences in all ages. Young people value a processed high-calorie diet but not
641 body fat, unlike middle-aged and elderly subjects. Besides eating an obesogenic diet, young
642 people, unlike older age groups, tend to practiced regular moderate and/or high intensity
643 physical activities as observed in other Senegalese qualitative studies conducted in Senegal
644 (Baller, 2007; Neveu Kringelbach, 2007), to maintain a thin body.

645 *Early stage of nutrition transition in Senegal*

646 The study found evidence (association between higher SES and overweight/obesity, low BMI
647 means, low rural DDS, and no association between higher DDS and overweight/obesity) that
648 Senegal remains in an early stage of nutrition transition compared to other African countries,
649 such as South Africa and Gabon. This partially contradicts the findings of Abrahams et al.

650 (2011) which consider Senegal in an advanced stage of nutrition transition. Indeed, the
651 socioeconomic model of nutrition transition attests that during the emergence of
652 industrialization, rural populations have low socioeconomic conditions and suffer from
653 undernutrition, unlike urban populations which improve their socioeconomic status, adopt a
654 higher-calorie diet, sedentary behaviors and therefore gain weight (Sobal & Stunkard, 1989).
655 However, inside urban/suburban areas, higher SES was not associated with
656 overweight/obesity, implying that the advanced stage of nutrition transition in Senegal is not
657 specifically associated with wealth but rather the industrialization of lifestyle and the
658 valorization of stoutness (Ziraba et al., 2009). Urban Senegal allows access to a more
659 abundant, energetic and diversified diet, which are essential conditions of the nutrition
660 transition (Popkin & Gordon-Larsen, 2004), less accessible in villages inside the Sahel, and
661 can be positively perceived by rural and migrant populations as the ‘lifestyle of abundance’.

662 ***Intervention in specific subgroups***

663 The Senegalese living in Dakar are exposed to both physical and social obesogenic
664 environments. Duration of urban residency is a risk factor for overweight and obesity, as
665 observed in other non-African and African populations (Cohen et al., 2017; Olszowy et al.,
666 2015), leading to the adoption of high-risk behaviors for overweight and obesity influenced
667 by cultural values. Indeed, urban Senegalese still (i) value inappropriate overweight which is
668 ill-adapted to the urban ecosystem, (ii) adopt a higher-calorie diet and (iii) seem to abandon
669 regular physical activity required to obtain energy balance within an obesogenic environment.
670 More precisely, urban-dwelling middle-aged and older women tend to value overweight and
671 have lower physical activity levels compared with younger people who nibble more
672 frequently – an obesogenic diet practice if they are to reduce their physical activity in the near
673 future.

674 ***Recommendations***

675 We observed that the diet of urban middle-aged and older women is also influenced by the
676 nutrition transition even though the DDS only captured this dietary intake change in young
677 adults. Other tools such as frequency food questionnaires, 24-hour recalls, or food portion
678 guidelines could better assess the changes in dietary patterns and its association with
679 nutritional health status (Amougou et al., 2016; Dop et al., 2003). Even though the assessment
680 of food consumption is limited, our study findings suggest that public health policies for
681 overweight/obesity prevention need to be adapted to the specificities of migrant populations
682 (Delavari et al., 2013; Delavari et al., 2015). Precisely, these policies should account for
683 evolving biocultural determinants of overweight and obesity in different socio-ecological
684 areas in Senegal and other African countries (Abraido-Lanza et al., 2006; Himmelgreen, et al.,
685 2004).

686

687 **Conclusion**

688 Although the nutrition transition is currently underway in Senegal's urban/suburban areas,
689 this study demonstrates that migration can modify the joint influence of biocultural drivers on
690 overweight and obesity during the shift from rural to urban areas accelerated by the
691 urbanization process. Comparative studies of migrants in other African countries experiencing
692 urbanization and the nutrition transition are required to provide more evidence to support how
693 generalizable this trend is. Local and global health policies need to account for the
694 anthropological specificities of migration pathways, to identify the exposure levels of rural-
695 urban migrants to risk of overweight and obesity.

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703 analyzed and interpreted the data. EC, PJG, EM, PD and MH drafted the manuscript and MH
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706

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715

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956 **Figures**

957 **Figure 1.** Perceptions of body size on masculine BSS. The diamonds just below the
958 silhouettes corresponds to the BMI averages of the three populations (See table 2). CBS:
959 Current Body Size, DBS: Desired Body Size, IBS: Ideal Body Size.

960

961 **Figure 2.** Perceptions of body size on feminine BSS. The diamonds just below the silhouettes
962 corresponds to the BMI averages of the three populations (See table 2). CBS: Current Body
963 Size, DBS: Desired Body Size, IBS: Ideal Body Size.

964

965 **Figure 3.** Obesogenic dietary intake depending on the age. FCA between diet consumption
966 related to risk of overweight and the age (young ≤ 25 years; others > 25 years). The variables
967 in italic followed by the sign – means a low risk while those followed by the sign + means a
968 high risk.

969

970 **Figure 4.** Prevalence of overweight and migration status. The respective original value of
971 each prevalence was: 9% (n=17), 21.6% (n=8), 15.3% (n=9), 21.8% (n=22), 35.4% (n=28)
972 and 58.8% (n=30).

Tables

Table 1. Composition of urban focus group

<i>Focus groups</i>	P1	P2	P3	P4	P5	P6
<i>Younger urban women, high educational level</i>	F: engineer M: small merchant	F: merchant M: small merchant	F: high official M: at home	F: employee M: small merchant	F: employee M: employee	F: high official M: dress maker
<i>Younger urban men, high educational level</i>	F: engineer M: teacher	F: skilled worker M: at home	F: senior executive M: accountant	F: high official M: at home	F: employee M: small merchant	F: teacher M: small merchant
<i>Younger urban women, low educational level</i>	F: senior executive M: nurse	F: employee M: at home	F: senior executive M: at home	F: taxi driver M: at home	F: taxi driver M: at home	F: taxi driver M: at home
<i>Younger urban men, low educational level</i>	Electrician ¹ F: employee M: at home	Mechanic F: employee M: at home	Mason F: high official M: nurse	Electrician F: accountant M: at home	Mason F: merchant M: at home	Electrician F: taxi driver M: traditional healer
<i>Older urban women, low SES</i>	Primary school H: merchant ²	Secondary school H: mechanic	Secondary school H: taxi driver	Secondary school H: merchant	None H: taxi driver	None H: skilled worker
<i>Older urban men, low SES</i>	None	Primary school	None	None	Primary school	None
<i>Older urban women, high SES</i>	High school H: employee ²	Secondary school H: carpenter	Primary school H: no married	Secondary school H: official	Secondary school H: employee	Primary school H: employee
<i>Older urban men, high SES</i>	University	University	University	University	University	University

P: Participant; F: Father; M: Mother, H: Husband.

¹When applicable, we mentioned the work of each young participants. In general, women participant did not work and highly educated participants were students.

²For older women without occupation, we mentioned the occupational status of their husband.

Table 2. Composition of rural focus group

Focus groups	P1	P2	P3	P4	P5	P6
<i>Younger rural women, high educational level</i>	Dancer F: farmer/artisan ¹ M: farmer/at home	Pupil F: mechanic M: farmer/at home	Pupil F: farmer/artisan M: farmer/at home	Pupil F: farmer/taxi driver M: farmer/at home	Pupil F: farmer/artisan M: dress maker/at home	Dancer F: farmer M: farmer/at home
<i>Younger rural men, high educational level</i>	Pupil F: farmer/artisan ¹ M: farmer/at home	Pupil F: farmer M: farmer/at home	Farmer F: farmer/artisan M: dress maker/at home	Farmer F: farmer/taxi driver M: farmer/at home	Martial art teacher F: Teacher M: farmer/at home	Fisherman F: farmer M: farmer/at home
<i>Younger rural women, low educational level</i>	Household F: farmer M: farmer/at home	Farmer/at home F: farmer/artisan M: farmer/at home	Farmer/at home F: farmer/merchant M: farmer/at home	Dress maker/at home F: farmer/taxi driver M: farmer/at home	Farmer/at home F: farmer/fisherman M: farmer/at home	Farmer/at home F: farmer/artisan M: farmer/at home
<i>Younger rural men, low educational level</i>	Taxi driver ² F: farmer/artisan M: farmer/at home	Farmer/artisan F: farmer/artisan M: farmer/at home	Skilled worker F: farmer M: farmer/at home	Mechanic F: farmer/artisan M: farmer/at home	Farmer/fisherman F: farmer/merchant M: farmer/at home	Taxi driver F: farmer/taxi driver M: farmer/at home
<i>Older rural women</i>	Primary school H: farmer ³	None H: farmer/artisan	None H: skilled worker	Primary school H: farmer/artisan	Primary school H: farmer/artisan	None H: farmer
<i>Older rural men</i>	Secondary school Farmer	Primary school Farmer/artisan	None Farmer/artisan	Primary school Farmer/artisan	Primary school Farmer	University Teacher

P: Participant; F: Father; M: Mother, H: Husband.

¹In rural area, most of fathers were farmer and/or artisan (carpenter, mason...), and most of mothers were farmer and at home.

²When applicable, we mentioned the work of each young participants.

³For older women without occupation, we mentioned the occupational status of their husband.

Table 3¹. Body perception averages

Men				Women for men				Women				Men for women			
	CBS	N	P		CBS	N	P		CBS	N	P		CBS	N	P
Urban area	3.8±1.5	86		Urban area	5.3±2.1	63		Urban area	5±2.2	82		Urban area	4.3±1.7	81	
Suburban area	4±1.6	94		Suburban area	5.1±1.9	84		Suburban area	5±2.2	92		Suburban area	4.2±1.7	91	
Rural area	3.6±1.7	78		Rural area	5.2±2.1	76		Rural area	3.6±2	95		Rural area	4±1.7	72	
All	3.8±1.6	258	NS	All	5.2±2	223	NS	All	4.5±2.2	269	***	All	4.2±1.7	244	NS
	DBS	N	P		DBS	N	P		DBS	N	P		DBS	N	P
Urban area	4.2±1.6	91		Urban area	4.9±1.9b1	61		Urban area	4.9±1.7	88		Urban area	4.2±1.6a1	83	
Suburban area	4.1±1.4	101		Suburban area	5.0±1.9b2	85		Suburban area	4.8±1.6	97		Suburban area	4.1±1.5a2	92	
Rural area	4.5±1.8	78		Rural area	6.0±2.2b1-b2	76		Rural area	5.2±1.9	110		Rural area	4.7±1.7a1-a2	71	
All	4.3±1.6	270	NS	All	5.3±2	222	***	All	5±1.8	295	NS	All	4.3±1.6	246	*
	IBS	N	P		IBS	N	P		IBS	N	P		IBS	N	P
Urban area	4.7±1.5	86		Urban area	4.5±1.6c1	83		Urban area	4.9±1.6c1	85		Urban area	4.2±1.5	86	
Suburban area	4.2±1.4	100		Suburban area	4.8±1.8c2	91		Suburban area	4.8±1.6c2	97		Suburban area	4.5±1.5	98	
Rural area	4.6±1.7	81		Rural area	5.9±2c1-c2	105		Rural area	5.8±1.9c1-c2	113		Rural area	4.7±1.7	80	
All	4.5±1.6	267	NS	All	5.1±1.9	279	***	All	5.2±1.8	295	***	All	4.5±1.6	264	NS

Analysis of variance between the three area: * p<0.05; ** p<0.01; *** p<0.001

¹Post-hoc analyzes between the three samples: a <0.05; b<0.01; c<0.001

SD: Standard Deviation; NS: No Significant

Table 4¹. Physical activity means between Senegalese in urban, suburban and rural areas

	Urban area n=187	Suburban area n=206	Rural area n=204	p
Intensive physical activity (h)	0.9 ± 1.9 ^{a-x}	0.5 ± 1.9 ^{a-c}	1.2 ± 1.9 ^{x-c}	**
Moderate physical activity (h)	0.6 ± 1.9 ^{x-c}	0.6 ± 1.9 ^{x-c}	2.6 ± 1.9 ^{c-c}	***
Walking (h)	1.1 ± 1.6 ^{x-x}	0.8 ± 1.6 ^{x-x}	0.9 ± 1.6 ^{x-x}	NS
Sedentary behavior (h)	5.6 ± 3.7 ^{x-c}	5.1 ± 3.7 ^{x-c}	3.3 ± 3.7 ^{c-c}	***

¹Age adjusted by covariance analyses

Ancova between the three samples: * p<0.05; ** p<0.01; *** p<0.001

Post-hoc analyses between the three samples: a<0.05; b<0.01; c<0.001; x: No Significant (NS) for each side-by-side comparison

Table 5¹. Biometric means between Senegalese in urban, suburban and rural areas

	Urban area	Suburban area	Rural area	p
Comparative analysis for men				
BMI (kg/m²) (n= 96/103/82)	21.8 ± 3.5 ^{x-b}	22.2 ± 3.5 ^{x-c}	20.3 ± 3.5 ^{b-c}	**
Waist circumference (cm) (n= 96/104/83)	76.4 ± 9.3 ^{x-x}	78.4 ± 9.3 ^{x-x}	76.5 ± 9.3 ^{x-x}	NS
Hip circumference (cm) (n= 96/104/83)	92.5 ± 8.3 ^{b-x}	96.1 ± 8.3 ^{b-c}	91.5 ± 8.3 ^{x-c}	***
Waist to hip ratio (n= 96/104/83)	0.83 ± 0.07 ^{x-x}	0.82 ± 0.07 ^{x-a}	0.84 ± 0.07 ^{x-a}	NS
Body Fat (%) (n= 96/104/83)	18.6 ± 5.6 ^{x-c}	18.3 ± 5.6 ^{x-c}	14.4 ± 5.6 ^{c-c}	***
Mean Blood Pressure (mmHg) (n= 96/104/82)	94.3 ± 14.2 ^{x-x}	92.4 ± 14.2 ^{x-x}	92.7 ± 14.2 ^{x-x}	NS
Comparative analysis for women				
BMI (kg/m²) (n= 90/100/119)	25.3 ± 5.2 ^{x-c}	24.8 ± 5.2 ^{x-c}	20.6 ± 5.2 ^{c-c}	***
Waist circumference (cm) (n= 91/101/120)	83.4 ± 12.0 ^{x-c}	81.7 ± 12.0 ^{x-b}	76.6 ± 12.0 ^{c-b}	***
Hip circumference (cm) (n= 88/101/120)	102.5 ± 11.3 ^{x-c}	100.1 ± 11.3 ^{x-c}	94.7 ± 11.3 ^{c-c}	***
Waist to hip ratio (n= 88/101/120)	0.81 ± 0.09 ^{x-x}	0.81 ± 0.09 ^{x-x}	0.81 ± 0.09 ^{x-x}	NS
Body Fat (%) (n= 91/101/120)	33.9 ± 6.2 ^{x-c}	32.3 ± 6.2 ^{x-c}	27.5 ± 6.2 ^{c-c}	***
Mean Blood Pressure (mmHg) (n= 90/101/120)	91.2 ± 12.7 ^{x-x}	91.5 ± 12.7 ^{x-x}	91.2 ± 12.7 ^{x-x}	NS

¹Age adjusted by covariance analyses

Ancova between the three samples: * p<0.05; ** p<0.01; *** p<0.001

Post-hoc analyses between the three samples: a<0.05; b<0.01; c<0.001; x: NS for each side-by-side comparison

Table 6. Odds ratio and 95 % confidence limits for subjects who are overweight or obese, adjusted by binary logistic regression analysis, and compared to subjects who are not.

Determinants	Categories	Overweight/Obesity		
		Odds ratio	Confidence intervals	
Gender**	Men†			
	Women	3.8	2.2	6.4 c
Age***		1.1	1.0	1.1 c
Living area***	Rural area†			
	Urban/suburban areas	7.3	3.4	15.5 c
Educational level	None/primary†			
	Secondary/University	1.3	0.8	2.2
Socioeconomic level*	Low/Middle†			
	High	0.9	0.5	1.5
Caloric diet***	Low/Middle†			
	High	0.6	0.3	1.0 a
Physical activity***	Higher physical activity†			
	Lower physical activity	1.2	0.7	2.1
Stoutness valorization**	No overweight valorization†			
	Overweight valorization	1.7	1.0	2.7 a
N=561				

*, **, ***, Crude analysis significant effect (p<0.05 ; p<0.01 and p<0.001 respectively)

In bold, binary logit analysis significant effects (a, b, c): p<0.05, p<0.01, p<0.001 respectively

†Category taken as reference

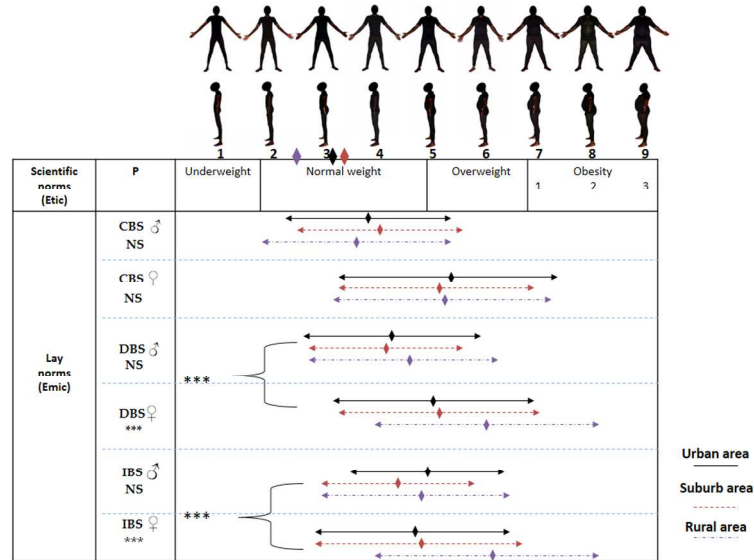


Figure 1. Perceptions of body size on masculine BSS. The diamonds just below the silhouettes corresponds to the BMI averages of the three populations (See table 2). CBS: Current Body Size, DBS: Desired Body Size, IBS: Ideal Body Size.

338x190mm (300 x 300 DPI)

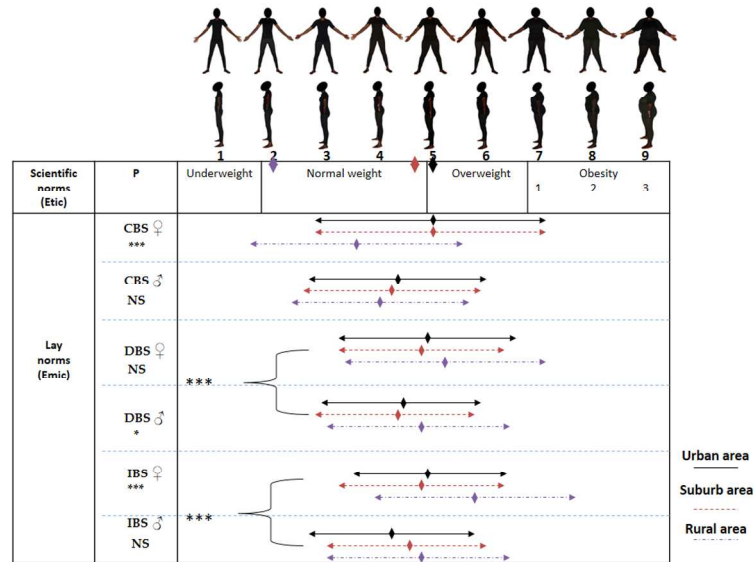


Figure 2. Perceptions of body size on feminine BSS. The diamonds just below the silhouettes corresponds to the BMI averages of the three populations (See table 2). CBS: Current Body Size, DBS: Desired Body Size, IBS: Ideal Body Size.

338x190mm (300 x 300 DPI)

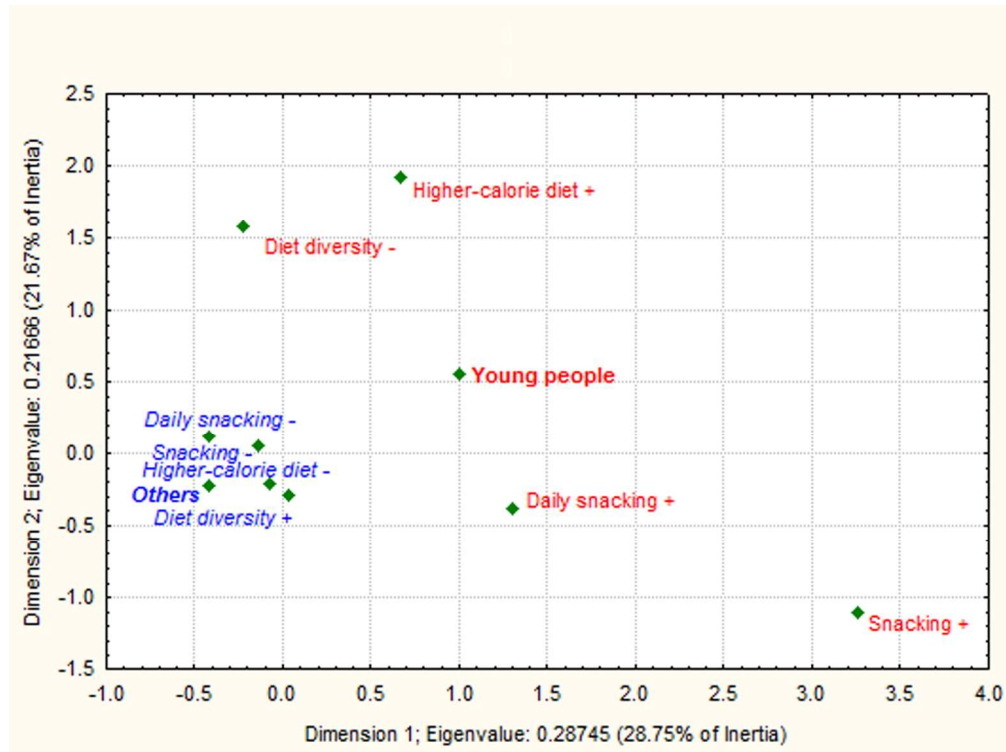


Figure 3. Obesogenic dietary intake depending on the age. FCA between diet consumption related to risk of overweight and the age (young ≤ 25 years; others > 25 years). The variables in italic followed by the sign - means a low risk while those followed by the sign + means a high risk.

139x104mm (300 x 300 DPI)

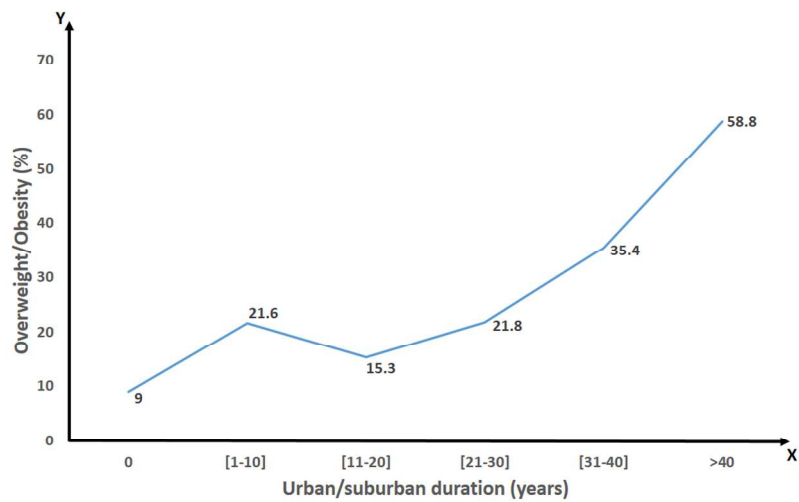


Figure 4. Prevalence of overweight and migration status. The respective original value of each prevalence was: 9% (n=17), 21.6% (n=8), 15.3% (n=9), 21.8% (n=22), 35.4% (n=28) and 58.8% (n=30).

338x190mm (300 x 300 DPI)