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

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

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**Abstract**

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

## Introduction

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

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

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

The present study focuses on Senegal, where little previous research has evaluated biocultural determinants of overweight/obesity as body weight perceptions. The Senegalese region is experiencing a nutrition transition (Abubakari et al., 2008; Maire et al., 1992), with intensified urbanization associated with a rural exodus (Duboz, et al., 2012). Thus, overweight has become prevalent in urban areas, where the physical environment has become obesogenic as a consequence of economic development (Macia et al., 2010), increasing sedentary behaviors and consumption of cheap processed foods accessible for working-classes living in poor urban neighborhoods (Drewnowski, 2009; Sobal & Stunkard, 1989; Temple & Steyn, 2011). Nevertheless, for women living in the peripheral neighborhoods of Dakar, Senegal, this obesogenic physical environment could be compounded by the sociocultural environment since these women value stoutness and want to deliberately gain weight (Gning et al., 2007; Holdsworth et al., 2004). Indeed, traditional views of body size in Senegal promote stoutness in women as a symbol of a peaceful and wealthy household (Ndiaye, 2006), and this trend persists with the current rural exodus (Duboz et al., 2011) involving a valorization of

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

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

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

## Material and Methods

### *Scope of the study*

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

### *Qualitative study*

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

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

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

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

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

***Quantitative survey***

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

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

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

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

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

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

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

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

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

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

***Data analysis***

*Main analyses*

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

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

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

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

*Migration status*

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

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

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

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

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

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

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

## Results

### *Qualitative study*

*The social valorization of stoutness*

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

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

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

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

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

***[have weight]*** *and* ***khess [thinning skin]****, people said that Dakar is prosperous for you!" [Younger urban man, low educational level]*

*Diet perceptions and practices*

Devaluation of traditional food in young people. Intergenerational conflict has emerged between parents and youths concerning culinary practices. Parents condemn the use of modern foods based on rice, oil, "cube-maggi", meat and fast-food, whereas westernized youths no longer appreciate traditional diets mainly based on millet and vegetables. As illustrated by the following participant:

*"....in the current situation in many homes, if you cook* ***ngourban [millet seeds boiled and ground]****, children will not eat that. They will not even touch it because times are not the same. Children hardly know this diet. What they know is that you cook now to eat, and this is what causes endless damage to us. What would be safer for us are alternatives, but cooking with oil as we do for* ***ceebu jën [rice with fish]****, that's not good. With that, we cannot expect to have a healthy body." [Older rural man]*

Urban food pleasure. The urbanization process is perceived as the era of comfort and pleasure in lay norms. Therefore, it is not possible for westernized youth to accept eating "simple food" just to meet basic living needs, for example:

*"Many people flock to Dakar because there is the atmosphere there. The diet is different. In Dakar, the food is tasty, there are sandwiches, burgers, chawarmas. Here you can go six months without eating burgers or something like that. Here you eat couscous of millet and* ***foõdé [millet porridge with grains]****, that's all. Therefore many people prefer to go to Dakar for that. They flee the food here and also the hard work in the fields." [Younger rural man]*

*Physical activity*

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

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

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

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

***Quantitative survey***

*Perceptions of corpulence*

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

***Table 3***

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

***Figure 1***

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

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

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

***Figure 2***

*Dietary intake*

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

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

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

***Figure 3***

*Physical activity*

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

***Table 4***

*Anthropometry*

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

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

***Table 5***

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

*Migration and nutritional status*

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

***Figure 4***

*Health status perceptions*

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

*Analysis of overweight/obesity determinants*

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

***Table 6***

## Discussion

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

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

### *Social valorization of stoutness*

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

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

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

***High-calorie dietary intake***

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

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

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

***Lower physical activity***

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

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

***Comparison between determinants***

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

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

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

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

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

***Early stage of nutrition transition in Senegal***

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

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

***Intervention in specific subgroups***

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

***Recommendations***

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

## Conclusion

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

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*Authors' contribution:* All authors have read and approved the final manuscript. EC, GB, LG, PP and NCL developed the study concept and design. EC and PP developed the protocol of the field study. EC, AN, BF, SN, EHM and EG conducted the field study. EC, PP and MH analyzed and interpreted the data. EC, PJG, EM, PD and MH drafted the manuscript and MH provided critical revisions for important intellectual content. The study was supervised by GB, LG, PP and NCL.

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## Figures

**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.

**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.

**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.

**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).

## Tables

**Table 1.** Composition of urban focus group

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

P: Participant; F: Father; M: Mother, H: Husband.
[1]When applicable, we mentioned the work of each young participants. In general, women participant did not work and highly educated participants were students.
[2]For 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** |
|---|---|---|---|---|---|---|
| *Younger rural women, high educational level* | Dancer<br>F: farmer/artisan[1]<br>M: farmer/at home | Pupil<br>F: mechanic<br>M: farmer/at home | Pupil<br>F: farmer/artisan<br>M: farmer/at home | Pupil<br>F: farmer/taxi driver<br>M: farmer/at home | Pupil<br>F: farmer/artisan<br>M: dress maker/at home | Dancer<br>F: farmer<br>M: farmer/at home |
| *Younger rural men, high educational level* | Pupil<br>F: farmer/artisan[1]<br>M: farmer/at home | Pupil<br>F: farmer<br>M: farmer/at home | Farmer<br>F: farmer/artisan<br>M: dress maker/at home | Farmer<br>F: farmer/taxi driver<br>M: farmer/at home | Martial art teacher<br>F: Teacher<br>M: farmer/at home | Fisherman<br>F: farmer<br>M: farmer/at home |
| *Younger rural women, low educational level* | Household<br>F: farmer<br>M: farmer/at home | Farmer/at home<br>F: farmer/artisan<br>M: farmer/at home | Farmer/at home<br>F: farmer/merchant<br>M: farmer/at home | Dress maker/at home<br>F: farmer/taxi driver<br>M: farmer/at home | Farmer/at home<br>F: farmer/fisherman<br>M: farmer/at home | Farmer/at home<br>F: farmer/artisan<br>M: farmer/at home |
| *Younger rural men, low educational level* | Taxi driver[2]<br>F: farmer/artisan<br>M: farmer/at home | Farmer/artisan<br>F: farmer/artisan<br>M: farmer/at home | Skilled worker<br>F: farmer<br>M: farmer/at home | Mechanic<br>F: farmer/artisan<br>M: farmer/at home | Farmer/fisherman<br>F: farmer/merchant<br>M: farmer/at home | Taxi driver<br>F: farmer/taxi driver<br>M: farmer/at home |
| *Older rural women* | Primary school<br>H: farmer[3] | None<br>H: farmer/artisan | None<br>H: skilled worker | Primary school<br>H: farmer/artisan | Primary school<br>H: farmer/artisan | None<br>H: farmer |
| *Older rural men* | Secondary school<br>Farmer | Primary school<br>Farmer/artisan | None<br>Farmer/artisan | Primary school<br>Farmer/artisan | Primary school<br>Farmer | University<br>Teacher |

P: Participant; F: Father; M: Mother, H: Husband.
[1]In rural area, most of fathers were farmer and/or artisan (carpenter, mason…), and most of mothers were farmer and at home.
[2]When applicable, we mentioned the work of each young participants.
[3]For older women without occupation, we mentioned the occupational status of their husband.

**Table 3[1].** 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
[1]Post-hoc analyzes between the three samples: a <0.05; b<0.01; c<0.001
SD: Standard Deviation; NS: No Significant

**Table 4[1].** Physical activity means between Senegalese in urban, suburban and rural areas

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

[1]Age 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 5[1].** Biometric means between Senegalese in urban, suburban and rural areas

| | Urban area | Suburban area | Rural area | |
|---|---|---|---|---|
| ***Comparative analysis for men*** | | | | p |
| **BMI (kg/m$^2$)** (n= 96/103/82) | $21.8 \pm 3.5^{x\text{-}b}$ | $22.2 \pm 3.5^{x\text{-}c}$ | $20.3 \pm 3.5^{b\text{-}c}$ | ** |
| **Waist circumference (cm)** (n= 96/104/83) | $76.4 \pm 9.3^{x\text{-}x}$ | $78.4 \pm 9.3^{x\text{-}x}$ | $76.5 \pm 9.3^{x\text{-}x}$ | NS |
| **Hip circumference (cm)** (n= 96/104/83) | $92.5 \pm 8.3^{b\text{-}x}$ | $96.1 \pm 8.3^{b\text{-}c}$ | $91.5 \pm 8.3^{x\text{-}c}$ | *** |
| **Waist to hip ratio** (n= 96/104/83) | $0.83 \pm 0.07^{x\text{-}x}$ | $0.82 \pm 0.07^{x\text{-}a}$ | $0.84 \pm 0.07^{x\text{-}a}$ | NS |
| **Body Fat (%)** (n= 96/104/83) | $18.6 \pm 5.6^{x\text{-}c}$ | $18.3 \pm 5.6^{x\text{-}c}$ | $14.4 \pm 5.6^{c\text{-}c}$ | *** |
| **Mean Blood Pressure (mmHg)** (n= 96/104/82) | $94.3 \pm 14.2^{x\text{-}x}$ | $92.4 \pm 14.2^{x\text{-}x}$ | $92.7 \pm 14.2^{x\text{-}x}$ | NS |
| ***Comparative analysis for women*** | | | | p |
| **BMI (kg/m$^2$)** (n= 90/100/119) | $25.3 \pm 5.2^{x\text{-}c}$ | $24.8 \pm 5.2^{x\text{-}c}$ | $20.6 \pm 5.2^{c\text{-}c}$ | *** |
| **Waist circumference (cm)** (n= 91/101/120) | $83.4 \pm 12.0^{x\text{-}c}$ | $81.7 \pm 12.0^{x\text{-}b}$ | $76.6 \pm 12.0^{c\text{-}b}$ | *** |
| **Hip circumference (cm)** (n= 88/101/120) | $102.5 \pm 11.3^{x\text{-}c}$ | $100.1 \pm 11.3^{x\text{-}c}$ | $94.7 \pm 11.3^{c\text{-}c}$ | *** |
| **Waist to hip ratio** (n= 88/101/120) | $0.81 \pm 0.09^{x\text{-}x}$ | $0.81 \pm 0.09^{x\text{-}x}$ | $0.81 \pm 0.09^{x\text{-}x}$ | NS |
| **Body Fat (%)** (n= 91/101/120) | $33.9 \pm 6.2^{x\text{-}c}$ | $32.3 \pm 6.2^{x\text{-}c}$ | $27.5 \pm 6.2^{c\text{-}c}$ | *** |
| **Mean Blood Pressure (mmHg)** (n= 90/101/120) | $91.2 \pm 12.7^{x\text{-}x}$ | $91.5 \pm 12.7^{x\text{-}x}$ | $91.2 \pm 12.7^{x\text{-}x}$ | NS |

[1]Age 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

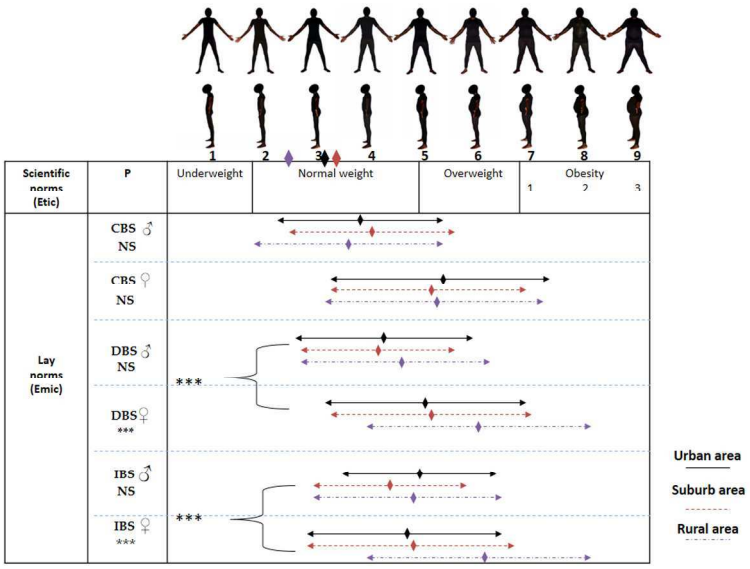


Figure 1. Perceptions of body size on masculine BSS. The diamonds just below the silhouettes corresponds to the BMI averages of the three populations (See table 2). CBS: Current Body Size, DBS: Desired Body Size, IBS: Ideal Body Size.

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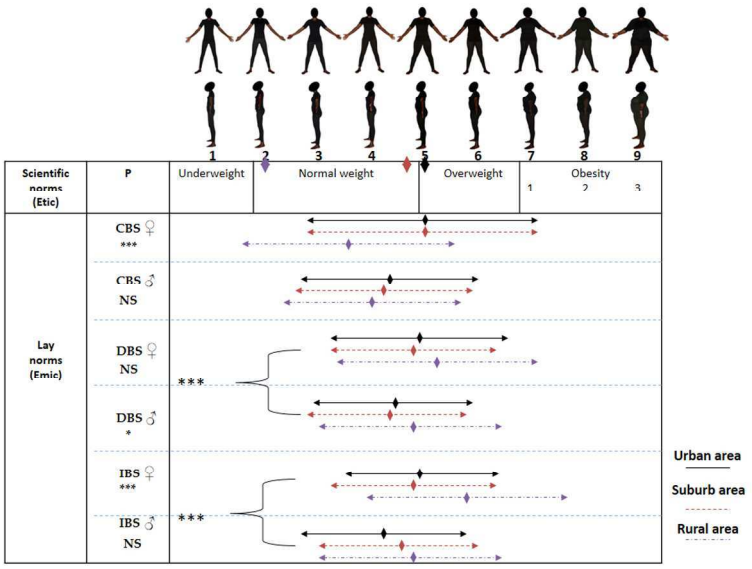


Figure 2. Perceptions of body size on feminine BSS. The diamonds just below the silhouettes corresponds to the BMI averages of the three populations (See table 2). CBS: Current Body Size, DBS: Desired Body Size, IBS: Ideal Body Size.

338x190mm (300 x 300 DPI)

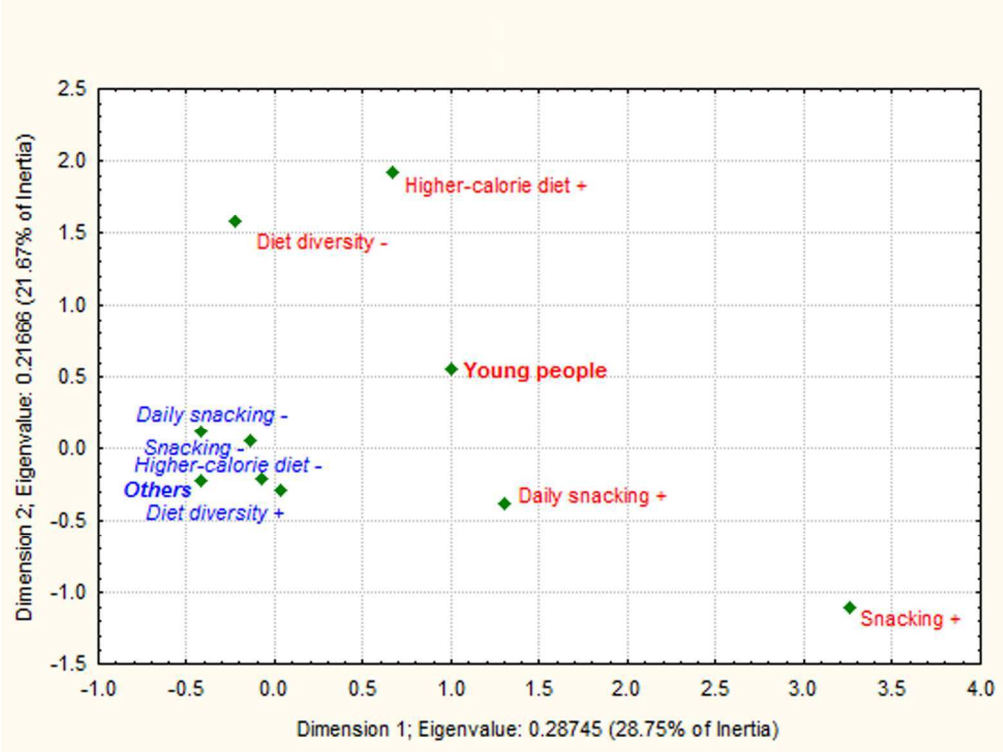


Figure 3. Obesogenic dietary intake depending on the age. FCA between diet consumption related to risk of overweight and the age (young ≤ 25 years; others > 25 years). The variables in italic followed by the sign – means a low risk while those followed by the sign + means a high risk.

139x104mm (300 x 300 DPI)

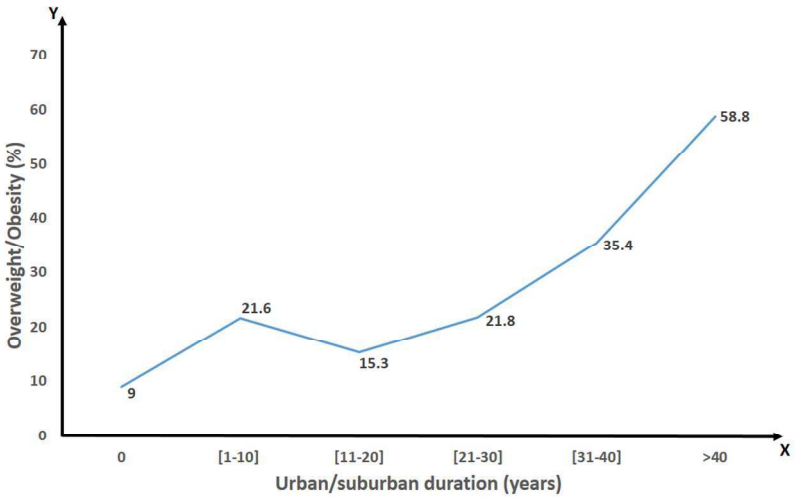


Figure 4. Prevalence of overweight and migration status. The respective original value of each prevalence was: 9% (n=17), 21.6% (n=8), 15.3% (n=9), 21.8% (n=22), 35.4% (n=28) and 58.8% (n=30).

338x190mm (300 x 300 DPI)