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Research Article

Human Biological Aging: A Vector Model

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Abstract: Keeping in mind the relationship between the basal metabolic rate and the change in weight in the aging process, we propose to generate a model of the same. As a result of data transformation, we obtained a graphic representation that is consistent with the original data. This representation manifested that after puberty, the parameter space loses its initial planarity. Thus, the model helps to sustain that the geometric phase changes that occur when the parameter space undergoes a gradual curvature, can contribute to explaining the biological aging process.

Keywords: After puberty, geometric phase, graphical representation, homeostasis decline, oscillatory physical systems, parameter space curvatures, self organization decline

INTRODUCTION

We know that living beings are physical systems that recover the energy dissipated as information (Pulselli *et al*., 2009; Matsuno, 1978). They self organize and develop (Wedlich-Söldner and Betz, 2018), but they finally age, presenting alterations of homeostasis (Koga *et al*., 2011; Campisi and Sedivy, 2009) and changes in their cellular and subcellular structure (Lauri *et al*., 2014; Gaziev *et al*., 2014).

In previous publications regarding the aging process in human beings, we have tried to understand this process as a consequence of the changes in the geometrics of the system (Barragán and Sánchez, 2015). We studied the relationship between the basal metabolism rate by unit of dry weight (BMR/kg DW) and the dry weight or the water-free weight DW in human beings. Then, we observed that until puberty the system presents increasing complexity and self-organization (Barragán and Sánchez, 2013). From the point of view of the geometric system, this implies a flat parameter space, in which cycle after cycle some variables resume their original values (Kauffman, 1991; Graudenzi *et al*., 2011).

After puberty, the capacity to self organize begins to slowly decline and from the point of view of the geometric system, this implies a gradual loss of the planarity thereof (Barragán and Sánchez, 2015). The parameter space suffers slow changes, which are seen in the behavior of the variables: cycle after cycle they no longer return to their original values. (Berry, 1988; Carollo *et al*., 2003).

Beyond the current theories of aging (Jin, 2010; Sergiev *et al*., 2015), we consider that, in a general mode, the same could be interpreted as the result of a geometric phase change that occurs in the system when it reaches a certain point in its evolution, that we identify as puberty (Barragán and Sánchez, 2015).

In the framework of the possible application of the concept of the geometric phase to understand the aging process, we must bear in mind that: although the parameter space is a virtual space of variables, it is in an environment, which is the real physical space in which these variables are defined. In real space, (not virtual space), planarity is also lost when a geometric phase change occurs, since it undergoes the same changes as the parameter space (Berry, 1988).

It has been accredited, by other authors, that changes in the geometric phase occur in living beings. (Tourigny, 2014). Our contribution only consists in proposing that such changes can contribute to explain biological aging. Developing a model (Sargent, 2013) of our proposal and contrasting it with data from clinical studies (Kersting *et al*., 1998; Choi and Pai, 2003), can contribute to its adequate formal expression and make its understanding clearer. The objectives are:

- Develop a vector model of the relationship between the BMR/kg DW and DW.
- Verify the goodness of fit of the model to the data observed in clinical studies.

MATERIALS AND METHODS

This study was developed under the supervision of "Universidad del Gran Rosario" (Rosario City,

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Table 1: DW and BMR/kg DW in men (Barragán and Sánchez, 2015)

Men (category)	Age (years)	Dry weight (kg)	BMR/DW (kcal/kg)
1 babies	0.0-0.5	1.4	228
2	0.5-1.0	2.9	172
3 boys	1-3	4.6	160
4	4-6	7.6	125
5	7-10	10.9	103
6 men	11-14	18.0	80
7	15-18	27.7	63
8	19-24	30.9	57
9	25-50	34.7	51
10	51 +	34.6	44

Table 2: DW and BMR/kg DW in women (Barragán and Sánchez, 2015)

Women (category)	Age (years)	Dry weight (kg)	BMR/DW (kcal/kg)
1 babies	0.0-0.5	1.4	228
2	0.5-1.0	2.9	172
3 girls	1-3	4.6	160
4	4-6	7.6	125
5	7-10	10.9	103
6 women	11-14	19.3	68
7	15-18	24.2	56
8	19-24	26.6	50
9	25-50	30.2	45
10	51 +	32.5	39

Argentina), since March 2018 to March 2019. We take from previous works, the data of evolution of the DW and the BMR/kg DW throughout life from men as well as women, to elaborate the model. Such data was considered as values of X and Y coordinates of a set of vectors, whose modules are calculated according to $\sqrt{x^2 + y^2}$.

The calculations of the modules were made for all possible relationships between the BMR/kg DW and the DW and not only for the effective relationships that occurred at each age. We tried to construct a model that would allow us to observe the real behavior of the system, within the framework of all the possible behaviors of the same.

To evaluate the goodness of fit of the model, the Hosmer Test (Chi square statistic) was used. The Tables with the data of DW and BMR/kg DW to build the model, are the following (Table 1 and 2).

RESULTS AND DISCUSSION

The calculations of the vector modules were made using the logarithm of the values in Table 1 and 2 for BMR/kg DW and DW. In the case of men, its representation in a surface graph is as follows (Fig. 1).

In the case of women, its representation in a surface graph is seen as follows (Fig. 2).

Regarding the evaluation of the goodness of fit of the model, online software was used (MacCallum *et al.*, 2001). The statistical analysis shows a Non-Significant (NS) difference between the results observed in clinical studies such as that of Kersting *et al.* (1998) and that of Choi and Pai (2003) with its respective logarithmic transformations and those expected according to the predictions of the model: Chi square 0.134 (NS) for men; and Chi square 0.086 (NS) for women. Data from the prior models to the year of life were not taken into account, because there was not enough data observed in the clinical studies to compare them with those expected by the model.

Bearing in mind that these are oscillatory systems (Tourigny, 2014; Cao *et al.*, 2016), with an initially flat geometry parameter space (Carollo *et al.*, 2003) and that such planarity is lost because it undergoes slow changes during puberty (Barragán and Sánchez, 2015). The concept of the geometric phase can be considered as a possible general explanation of the aging process. In the theoretical framework we propose, the changes associated with aging by genetic theories (Kuilman *et al.*, 2010; Salama *et al.*, 2014) and metabolic theories (Sun *et al.*, 2016; Gutiérrez-Salinas *et al.*, 2014),

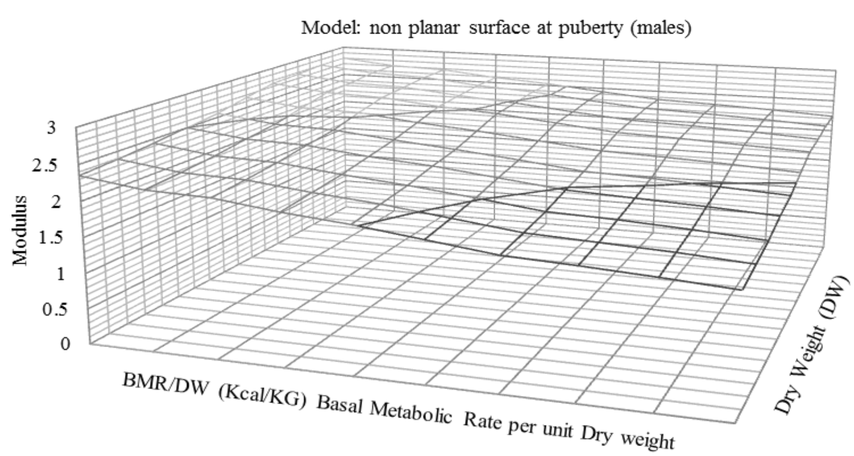

Fig. 1: The vectors go from the lower flat surface to the upper surface, according to the value of their modules. As arrows that go from the lower surface to the upper one. They are not represented in the graph, because the information overload would impede their observation

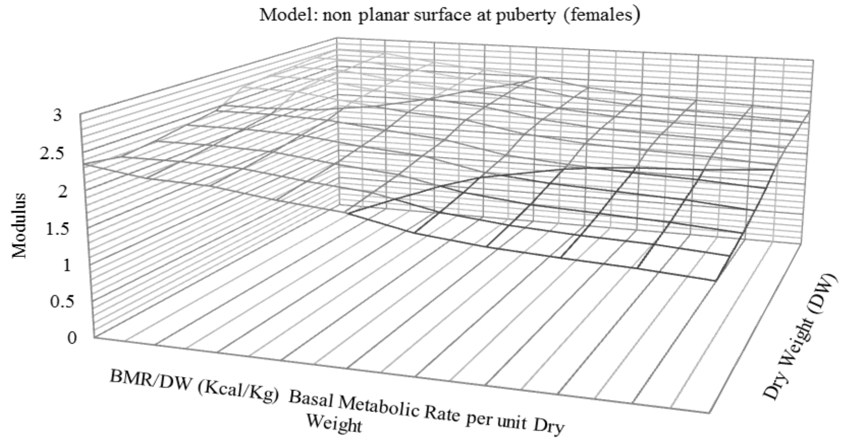

Fig. 2: As in Fig. 1, the vectors go from the lower surface to the upper surface according to their modules, as arrows that go from the lower surface to the upper one. They are not represented in the graph, because the information overload would impede their observation

would be epiphenomena of a physical process of general order: a geometric phase change.

Biological aging can be quantified based on the relationship between the DW and the BMR/kg DW. This exceeds the concepts proposed by other theories, from antagonistic pleiotropy (Blagosklonny, 2010) to the most current ones (McHugh and Gil, 2017). Finally, within the framework of our proposal, considering the existence of a "biological time space" (Maestrini *et al.*, 2018) it can be a real need and not just a logical necessity of certain mathematical models that describe the aging process.

CONCLUSION

Consistent with the proposed objectives, we have generated a model constructing vectors whose modules were calculated based on BMR/kg DW and DW values.

The goodness of fit of the model to the data observed in clinical studies was evaluated and is satisfactory. There are no differences between model predictions and clinical observations.

Our proposal to consider the aging process as a case of geometric phase, formalized in the developed model and can be considered a step forward in the way towards a general theory that explains the aging phenomenon beyond the classic genetic, metabolic, medical, or biochemical considerations.

CONFLICT OF INTEREST

Authors do not have conflict of interest or sponsors.

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