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# Biological Aging and Margalef Principle

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## Abstract

Considering that all living beings build their own structure with the energy they dissipate (Margalef Principle), it is necessary to understand the relationship between this principle and the aging process. To this end, we set the following objectives: To verify the correlation between the evolution of body mass and energy dissipation, and to verify the correlation between the evolution of body mass and the passage of time throughout human life. As a result of data analysis, we obtained a high degree of correlation between energy dissipation and body mass generation. No significant correlation was found between the passage of time and the evolution of body mass throughout life. These results confirm the Margalef Principle and support its consideration as a process independent of time elapsed.

## Keywords

Original Cycle, Self Organization, Body Weight, Energy Dissipation, Basal Metabolic Rate, Age

## 1. Introduction

Margalef's Principle can be expressed as follows: living beings are complex physical systems made up of a dissipative system that transforms energy, associated with a self-organizing system that recovers the dissipated (transformed) energy as information. And although Ramóm Margalef began his observations at the ecosystem level, he soon generalized them to all levels of biological organization [1] [2].

Humans, like all living beings, recover dissipated energy as information [3] [4]. In other words: they use the energy they transform to generate their own material structure; they self-organize [5]-[7].

This clarification is important. In the theoretical framework developed by Margalef, dissipated energy means transformed energy. We know that in thermody-

namics, heat is often referred to as dissipated energy. But Margalef never proposed that heat is the form of energy with which living beings self-organize.

Margalef knew the second law of thermodynamics. We do too. We all know that living beings can do very little with heat.

Complex organisms, such as humans, can be defined as systems of coupled oscillators [8] [9]. A physical system composed of a set of oscillatory variables that, while not synchronous, are in phase [10] [11].

The behavior of these variables throughout life depends on the system's geometry. It fundamentally depends on its shape, size, and dimension [12]. As these properties change during life, the behavior of their oscillatory variables also changes.

In previous publications, we analyzed the phenomenon of chronodisruption (the disturbance or alteration of the body's natural biological rhythms) associated with aging. We have emphasized that the passage of time is identical for all variables in a living being, so the mere passage of time does not explain chronodisruption [13] [14].

Until shortly after puberty (when growth ends), the system shows no chronodisruption. Once overall system growth concludes, gradual chronodisruption begins. Time passes identically for all variables, both before and after puberty. Chronodisruption does not depend on elapsed time, but on changes in the system's geometry when growth ceases [15].

Until puberty, a complex biological system like the human body grows significantly during a relatively short period (considering its total lifespan). It then continues to generate material structure within a space that no longer grows, a space that does not increase in size but increases in dimension. This causes geometric changes, leading to geometric phase transitions and the development of aging. Aging is the gradual loss of the capacity for self-organization and homeostasis, which occurs when the organism survives the end of its growth [16].

In these same publications, we noted that time behaves as a neutral operator during the evolution of a biological system. We believe it is time to quantitatively verify the degree of relationship between the generation of one's own structure (self-organization) and the passage of time.

Our objectives are:

Verify the relationship between material structure generation (estimated as total body mass/weight) and the passage of time.

Verify the relationship between material structure generation (total body mass/weight) and energy dissipation per unit of water-free mass (dry weight) throughout life.

## 2. Material and Method

Data processing complies with the Declaration of Helsinki and respects the conditions of the ethics committee (EX-2021-85190521) of its source (National Center for Elderly Care, Argentina). Data on the evolution of BMR/kg dry weight and

total body mass expressed in kg over the lifespan in humans come from tables in previous work [17].

A Pearson correlation test applied to the evolution of BMR/kg dry weight and total body mass expressed in kg over the lifespan provides insight into the degree of association between them.

The same Pearson test allows us to know the degree of correlation between the time elapsed (age) and the evolution of the total body mass expressed in kg throughout life.

When referring to a unit of body mass, we take the values for the unit of water-free body mass (dry weight). The reason is simple: this allows us to consider the metabolically active body mass as a reference. Dry weight was estimated taking into account the variation in the percentage of water found in the body according to age and sex. The percentage corresponding to water was subtracted from the total weight by sex and age.

In Table 1, we find data on the evolution of total body mass (weight), time elapsed (age), and BMR/kg dry weight. Taken and modified from previous papers by the authors. The design is unbiased, both in its cross-sectional and longitudinal formats (homogeneous distribution of the population by sex and age).

**Table 1.** Shows total weight values and BMR/dry kg for different ages. Sample demographic characteristics: Argentine population white (Hispanic) race. Sample size: n = 8920. Homogeneous distribution of the population by sex and age.

| Age (years) | Total Weight (kg) | BMR/dry kg |
|---|---|---|
| 1 | 9 | 172 |
| 3 | 13 | 160 |
| 6 | 20 | 125 |
| 10 | 28 | 103 |
| 14 | 46 | 68 |
| 18 | 55 | 56 |
| 24 | 58 | 50 |
| 50 | 63 | 45 |
| 76 | 65 | 39 |

## 3. Results

When comparing total body mass (weight) with BMR/kg dry weight, the Pearson test yielded a value of 0.98 ($p < 0.05$). This means that the probability that the results are due to chance is less than 5%.

Considering the critical values of Pearson's r for a test based on degrees of freedom, this result is statistically significant [18] (**Figure 1**).

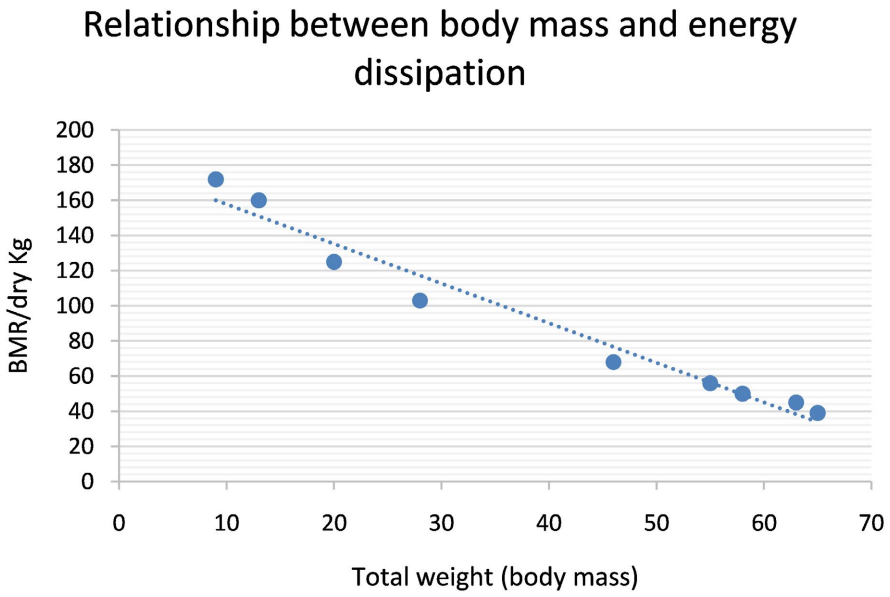


Figure 1. Total body weight and BMR/kg dry weight show a high correlation.

But when comparing age with total body mass, the Pearson test has a value of 0.80. Considering Pearson's critical r values for a test based on degrees of freedom, this result is not statistically significant.

It is not statistically significant because the probability that the results are due to chance is greater than 5% (following the same reference as in the previous case) (Figure 2).

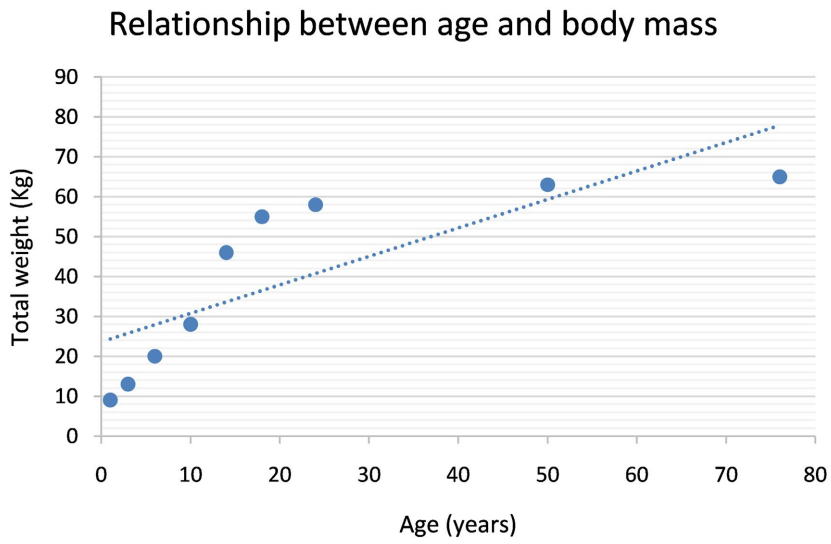


Figure 2. Total body weight and time elapsed (age) show no correlation.

The findings are robust: Energy dissipation (transformation) directly drives the generation of the material structure (confirming Margalef's Principle), while elapsed time does not show a statistically significant association with structural development.

## 4. Discussion

Within our proposed theoretical framework, these results can be expressed as follows: Energy dissipation is a determinant operator for the generation of material structure in living beings [19] [20]. This is a novel and necessary contribution to biology, as it confirms the Margalef Principle with concrete data.

It is equally important to emphasize that the mere passage of time is not a determinant operator for material structure generation in living beings.

We acknowledge this statement may seem simplistic, but it holds profound significance. The generation of a living being's material structure is directly related to energy dissipation. We also know elapsed time (age) does not determine structure generation. This assertion is nearly self-evident, and our study may appear extremely simple.

We therefore ask: If it is so obvious that structural development depends on energy dissipation (and not time), why do we continue quantifying lifespan in terms of elapsed time?

Quantifying lifespan via elapsed time is a logical inconsistency: A living being is defined by self-organization via dissipated energy. Dissipated (transformed) energy drives self-organization; time does not drive or determine structural generation. As this study shows, time has no relationship to it. Practical consequence: we should pay more attention to the physiological aspects of aging than to the chronological ones.

When studying oscillatory variables during aging, we previously proposed that time acts as a neutral operator. Since living beings are physical systems without relativistic distances or velocities (we consider them to be isolated systems), the passage of time (its metric) is identical for all variables. Thus, in terms of inter-variable relationships, affecting all equally is equivalent to no effect from time [21].

We maintain this interpretation but now go further: Nothing can occur in a living being without energy dissipation and its recovery as information to generate structure. Recovering dissipated energy as information is the "original cycle" of all living beings, expressed in all their variables [22].

Of course, when observing variables like the cardiac cycle (measured as heart rate), it is natural to consider "beats per unit time". But we must distinguish between the variable itself (cardiac cycle) and our measurement of it (beats/time).

A stronger example is the sleep-wake cycle or hormonal circadian rhythms. While such cycles appear time-related, they are actually tied to environmental light/dark alternations (not the passage of time itself) [23] [24].

Time's metric is identical for an Inuit in Lapland and a Fijian Islander. Yet the Fijian experiences consistent daily light/dark cycles, while the Inuit faces months of light or darkness [25] [26]. No Inuit stays awake for months or sleeps for months; sleep-wake cycles adapt [27] [28]. An hour is an hour in both Fiji and the Arctic. What changes with latitude is Earth's angular rotational velocity: Near poles, small distances are covered per unit time; near the equator, large distances.

Time's metric is identical, but angular velocity differs [29] [30]. At the equator, time dilation due to the Earth's rotation is canceled out by gravitational time dilation, meaning clocks at sea level, regardless of latitude, tick at the same rate. Crucially, the sleep-wake cycle is forged by light/dark cycles (not elapsed time).

These examples justify studying variables like BMR/dry weight and body weight to evaluate the "original cycle" (recovering energy as information): Facts must be studied as directly and simply as possible.

Thus, a simple study on BMR/dry kg and body weight evolution, with basic correlation analysis, is optimal. Exactly what we did.

There is a final reflection we wish to express: we know that Margalef's Principle does not explain the aging of living beings. But it does explain what defines living beings. And it defines them as physical systems (a type of physical system that recovers the energy it dissipates as information).

We also know that every physical system obeys the laws of physics. Therefore, the evolution of a physical system can be described from the perspective of the laws of physics that it must inevitably obey.

So, since living beings are physical systems, their evolution can be described from the perspective of the laws of physics (even with its most basic tools of mathematics and geometry).

Of course, this is not the only valid point of view, but it deserves respect, consideration, study, and development. We are working on that task.

## 5. Conclusions

We aimed to verify the relationship between material structure generation (total body mass/weight) and the passage of time. No statistically significant correlation was found.

We also aimed to verify the relationship between material structure generation and energy dissipation per unit water-free mass (dry weight) throughout life. A significant correlation between these variables was found.

Based on our results, we assert that the passage of time is not a determinant operator driving body mass/weight increase. Conversely, energy dissipation drives effective body mass/weight generation in living beings, confirming the Margalef Principle.

Without the Margalef Principle, there are no living beings (because all living beings comply with this Principle). And without living beings, there is no biological aging (because biological aging occurs in living beings).

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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