HOW DIFFERENT WE ARE IN TERMS OF HEART-LUNG INTERACTION: DISCOVERY AND DESCRIPTION IN QUANTUM BIOLOGICAL THERMODYNAMICS WITH FINITE SPEED

Stoian PETRESCU[1], Valeria PETRESCU[1], Romi BOLOHAN[2], Bogdan BORCILA[1*], Monica COSTEA[1], Silvia DANES[1], Michel FEIDT[3], Georgeta BOTEZ, Gabriela HUMINIC[4], Angel HUMINIC[4], Nicolae BORIARU[1], Gheorghe POPESCU[1], Nicoleta MANITIU[1], Nicoleta DUMITRASCU[5], Ema PANAITE[6], Teona LOZONSCHI[6], Adina GHEORGHIAN[1]

[1]University POLITEHNICA of Bucharest
[2]Clinical Centre of Emergency Medicine in Cardiovascular Disease
[3]University of Lorraine – LEMTA Nancy, France
[4]Transilvania University of Brasov
[5]University "Al. I. Cuza" of Iasi
[6]Technical University "Gheorghe Asachi" of Iasi

[*] Corresponding author: bbd1188@yahoo.com

ABSTRACT: Based on the new discovery/invention of *Quantum Biological Thermodynamics with Finite Speed* (QBTFS), we show in this paper how different we are, in terms of Stationary States, Interactions and Processes in Cardio-Pulmonary System, for different persons and in different positions. In order to do this, we have used the 4 new Diagrams invented in Quantum Biological Thermodynamics with Finite Speed as functions of F_H = *Heart Frequency*; F_L=*Lungs Frequency*; R_f = *Ratio between Heart and Lungs Frequency; N = Interaction Quantum Number* of a stationary-interaction-state between Heart and Lungs (a new fundamental concept-characterizing any Stationary State-introduced in QBTFS). These 4 Diagrams, build using the 4 parameters of Stationary States, F_H, F_L, R_f and N become in QBTFS extremely important tools for comparing the "performances" of the Cardio-Pulmonary System for any person: child, adolescent, young, mature and old persons (male or female).
Keywords: Quantum Biological Thermodynamics with Finite Speed, Stationary States, Cardio-Pulmonary System, Heart Frequency, Lungs Frequency, Interaction Quantum Number, Processes with Quantum Jump.

1. INTRODUCTION

Within the **Quantum Biological Thermodynamics with Finite Speed** (QBTFS) 4 new Diagrams were invented: $F_H = f_1(F_L)$; $F_L = f_2(F_H)$; $R_f = F_H/F_L = (2+N/4) = f_3(F_L)$; $R_f = f_4(F_H)$; where: F_H = *Heart Frequency*; F_L=*Lungs Frequency*; R_f = *Ratio between Heart and Lungs Frequency; N = Interaction Quantum Number* of a stationary-interaction-state between Heart and Lungs.

Each diagram has some advantages in comparison with the others, underlying some important aspects of the states and processes in different persons. The information obtained experimentally, measuring F_H and F_L for each person, used for building these diagrams, can show immediately if a person "is functioning" in the normal domain of the Heart Frequency = F_H = 60 - 90 oscillations/minute (as recently accepted by EU standards of health), in connection with the Lung Frequency F_L, and quantum number N of Stationary States. These diagrams become a "synoptic picture" in which we can immediately see how different we are from the point of view of or Cardio – Respiratory System, and how healthy or potentially ill we are or we could become in the near future.

From this point of view these 4 Diagrams are "*the mechanical equivalents*" of EKG diagrams, with some important advantages, or new information which cannot be obtained from EKG.

First of all, we can see in these diagrams immediately the differences between different persons, by age and sex, height and weight. We can see also if a person attains easy or not so ease, *stationary states*, which could be a very important indication of a potential illness in the future. These diagrams can be done by any person measuring the frequencies F_H and F_L, and drawing by themselves the points (*states*) and *processes* (lines which connect the points).

In this sense these diagrams are similar with the fundamental diagrams used in Classical Thermodynamics for studying and designing cycles of Thermal Machines (P-V, T-S, h-s, u-s). One of the main potential advantage of these diagrams is the fact that they can be used in the future (we hope) for design of "personalized artificial hearts", not only based on dimension (as is the case of different thoracic volume between men and women, or between children, young and adults), but also from the point of view of the **Domain of Heart–Lung Interaction**, characterized by $R_f = F_H/F_L$ or better by N. If a person can not at all, or easy (rapidly: in 2-3 minutes) to attain stationary states, this is a very "bad indication" of a present or potential illness (in the future-getting older).

2. STATIONARY STATES AND PROCESSES WITH OR WITHOUT QUANTUM JUMP IN CARDIO-PULMONARY SYSTEM REPRESENTED IN 4 DIAGRAMS FROM QUANTUM BIOLOGICAL THERMODYNAMICS WITH FINITE SPEED

The diagrams from Figures 1-6 offer a "synoptic picture" (similar with diagrams form Classical Reversible Thermodynamics: *P-V*, *T-S*, *U-S*, *h-s*) of the *stationary*, *quasi-stationary* and *non-stationary* (transitory) states for each person we do compare, from the point of view of ***Heart-Lung Interaction***. Looking for the points of one person we can see that some points are exactly on an Integer Quantum Number N Line (in Fig. 1 and 2) in the total domain from N=3 to N=30. This shows a "very interesting property" of the Heart-Lung Interaction. For several persons N oscillates between 3 to 7 (SP, VP, GH, NI, and EM). For another group the N is between 8 to 12 (Bi, AG, TE, and EM). For the next group N is in-between 9 to 17 (BB, TE, MF, and CR). One person covers the domain of N =12-22 (SD). Finally, there is a quite "special person" (in comparison with all the others from the figures 1 and 2, having an *extremely large domain* of N (GB) between 10 and 30, but with a *very narrow* domain for F_H =10-12. This "special person" has "special properties", namely: for a very large change of F_H = 57 to 103 the change of F_H is "very narrow" namely 10-12. This means that the "capacity of her lungs" assure a sufficient flux (flow-rate) of Oxygen "to satisfy" the necessary of all the muscles for any change of position and for internal functioning of all organs for a normal healthy state. This is obtained by the lungs with a very small change of the Frequency of oscillation, from 10 to 12. The "properties of the Lungs" offer to this person (GB) an extremely favorable opportunity to develop any kind of activities (with small to very large effort) without getting tired (despite of her age 75). If we are looking for an explanation for "this special property" of her Heart-Lungs Interaction we could find it in at list two possible explanations: 1-a large capacity (volume) of the lungs; 2-she did a lot of sport (tennis almost every day) for very many years. Probably other people practicing / playing tennis have similar properties of their "Heart-Lung Interaction". On the other hand she is left-handed, and she played tennis with left hand. In this way she developed the muscles on the left side of her chest, in the region of the Heart, in the same time with lungs and diaphragm development of these muscles. In Figure 2 we discover another person, MF (age 70) with the same F_L like GB equal to 10, with Rf = 7, and N = 20, in a *sitting position*, and with F_H = 70. Again this person has done and is still doing a lot of sport (bicycling). In comparison with two other persons who were doing the same measurement (in the train-coming from the NACOT Conference-Iasi) he has a "privileged position" in the figure 2. The second person is AG (age 30) with Rf = 4, and N = 8, F_H = 68, and F_L= 17. The third person is "very different" in comparison with both. Namely SP had Rf = 3, N = 4, F_H = 80, and F_L = 6.5 (at the age of 75).

All the other persons–except GB have a larger change of F_L in comparison with her (F=10-11). For example, MF has F_L=10-16; SP has F_L =22-28, SD has F_L=11-16; BB has F_L=*10-30*, VP has F_L=20-26, and GH has F_L=18-23. This fact explains why for these persons the change of Rf and respectively N it is not so great (in *processes with quantum jump* - determined by any effort; *changing the position, moving, doing work,*

running, etc.) in comparison with GB. This is why they get tired faster and "easier" in comparison with GB. Very interesting comparisons can be done, obtaining very interesting conclusions, in experiments of several persons in the same condition (the same room) and in the same position (*sitting, standing, laying*) and of course breathing the same air (at the same temperature and atmospheric pressure).

Such an experiment was done in train (travel from Iasi to Bucharest by MF, AG and SP, mentioned above). A similar experiment was done with 4 persons in the same conditions at a time moment (in the amphitheater in TU Iasi, during NACOT Conference, where S. Petrescu with M. Costea presented the paper [1]). Conclusions of this experiment are represented in figures 1-4 and are very interesting again, from the point of view of the topic of this paper, namely: "**How different are we from the point of view of Heart-Lung Interaction"**.

The four persons sitting in the last row of the Amphitheater, measured their own F_H and F_L in the same time. The results are the following (see Figures 1-4); For EM: R_f=5, N = 12, F_H = 65, F_L = 13. For TE: R_f = 4.5, N = 10, F_H = 78 and F_L = 17.5 and for SP: R_f = 3, N = 4, F_H = 80 and F_L=26.5; for NI: R_f = 2.75, N = 3, F_H= 71.5, F_L = 26. Again these four persons are "very different" from the Heart-Lung Interaction.

EM in comparison with SP and NI has a "quite small" F_L = 13; TE has F_L=17.5 and NI and SP have the same F_L = 25. We are saying that NI and SP are "similar", TE is "in between" them, and EM is "far from them" with a F_L = 13, and 'very favorable", as in the case of MF, and GB, from the point of view of Heart–Lung Interaction.

3. CONCLUSION AND PERSPECTIVES

The entire sort of information regarding "How different we are in terms of Heart-Lung Interaction" presented in this paper are obtained based on an essential and very important (fundamental) formula discovered/invented in **Quantum Thermodynamics with Finite Speed** by Petrescu et al [1-7]:

$$R_f = \frac{F_H}{F_L} = \left(2 + \frac{N}{4}\right) \qquad (1)$$

The 6 diagrams built based on the discovery of Eq. (1) could be used for **optimum design** of "personalized artificial hearts" [8] by optimizing them in such a way to permit a similar interaction with the natural-biological hearts of any person. If any person is doing his own experiments in different positions (*laying, sitting, standing, moving, doing work, running, eating*, etc.) can build by themselves such diagrams in the time they are healthy. These diagrams can show to some persons "some potential illnesses in the future" like: atrial and ventricular fibrillations, or pulmonary hypertension, fluttering, bradycardia, etc. For those persons who become really very ill, and at a moment in their life is necessary a surgery to implant an artificial heart, would be better to be used a "personalized artificial heart", in order to behave similar with the natural one of that persons. Mechanical engineers, Electrical engineers and Electronics engineers designing in cooperation with Medics and Physiologists, could design such artificial hearts, to be proper for different group of persons, by age, by sex, by height and the dimensions of the chest, and by their type of Heart-Lung Interaction, described in Figures like 1-4.

We believe that this is going to be the ***trend of design of artificial hearts***, helped by the recent discoveries made in what we called: **Quantum Biological Thermodynamics with finite Speed (QBTFS) as an Extension of Thermodynamics with Finite Speed (TFS)** [9, 10].

ACKNOWLEDGEMENTS

We want to thank to the 6 children who did the experiments used in the 4 Diagrams: Ema (11 years), Anna (13 years) Bianca (12 years), and Crista (12 years) from Azuga, and A. Huminic Jr. (12 years) from Brasov. These experiments made possible to compare children and young, mature and old people from the point of view of Heart-Lung Interaction.

We see in Figures 1-6 that the children have "another domain" in comparison with young, mature and old people, namely in the domain of *larger values* for F_L (this means that their frequencies of the Lungs oscillations are higher in comparison with mature people). In previous work [2, 3] we did discover and show that the children also have processes with quantum jump, when they change the position, similar with young, mature and old people, but this is happening in "another domain" of the 4 diagrams, as we also see in this paper in Figures 1-6.

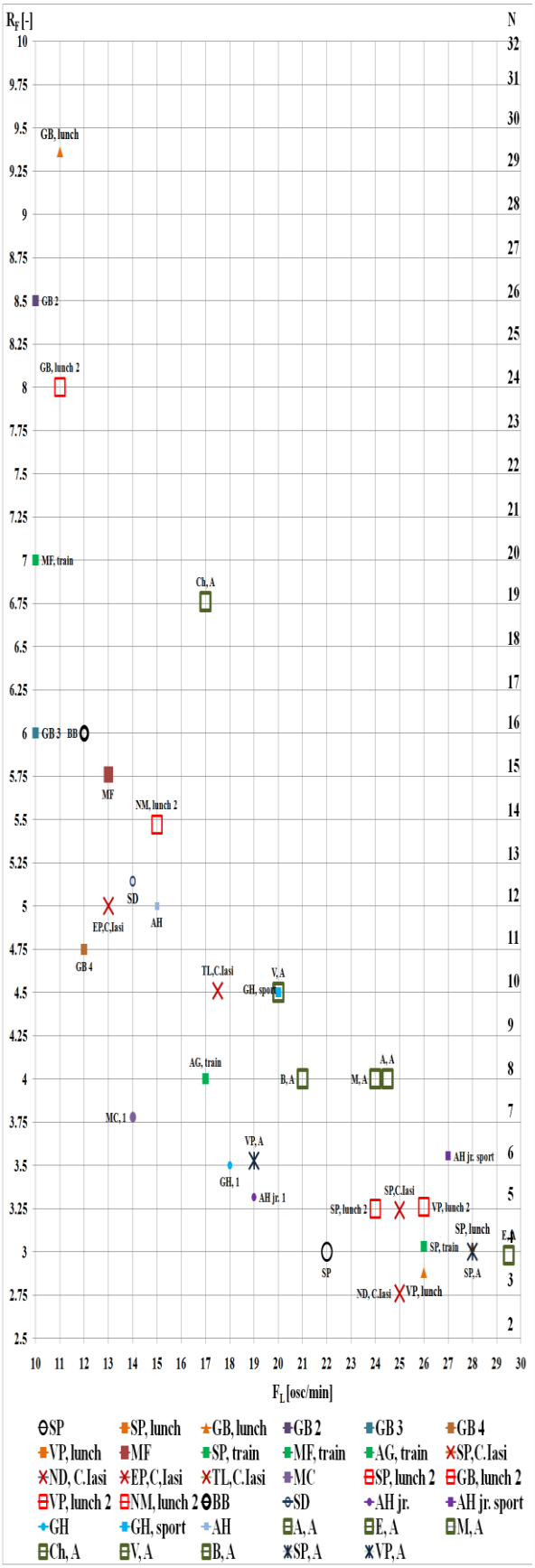

Fig. 1. Diagram *Rf* (F_L); *N = f*(F_L)

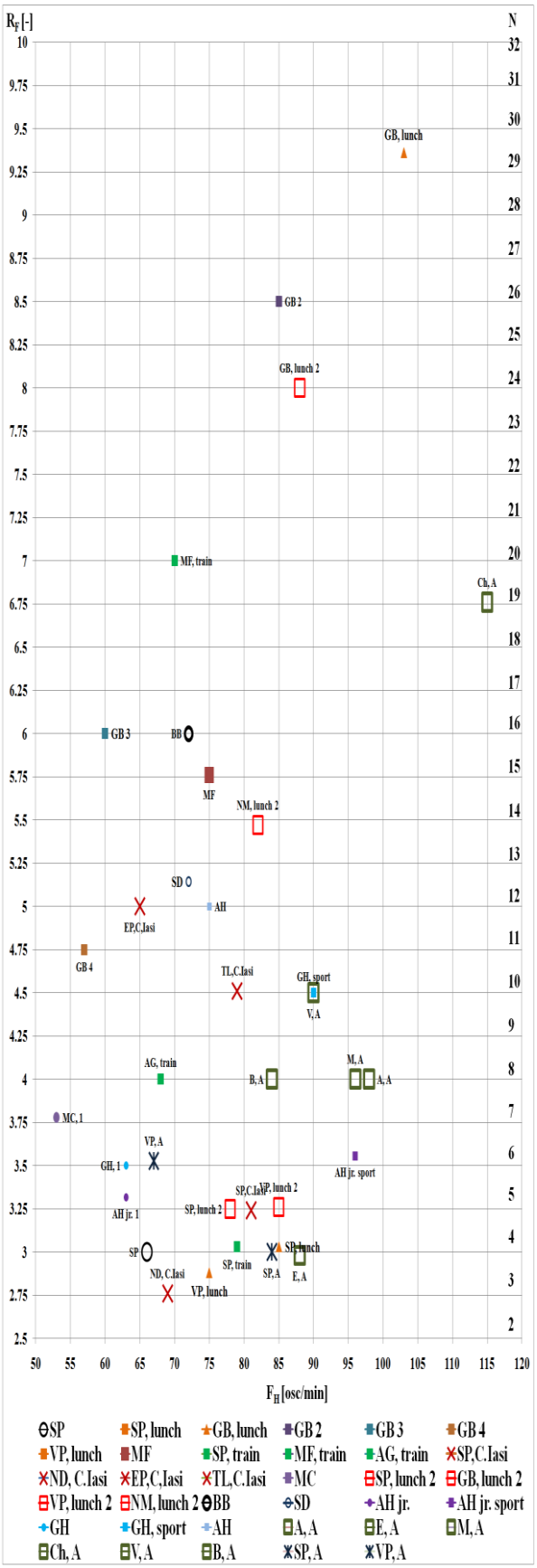

Fig.2. Diagram *Rf*(F_H); *N = f*(F_H)

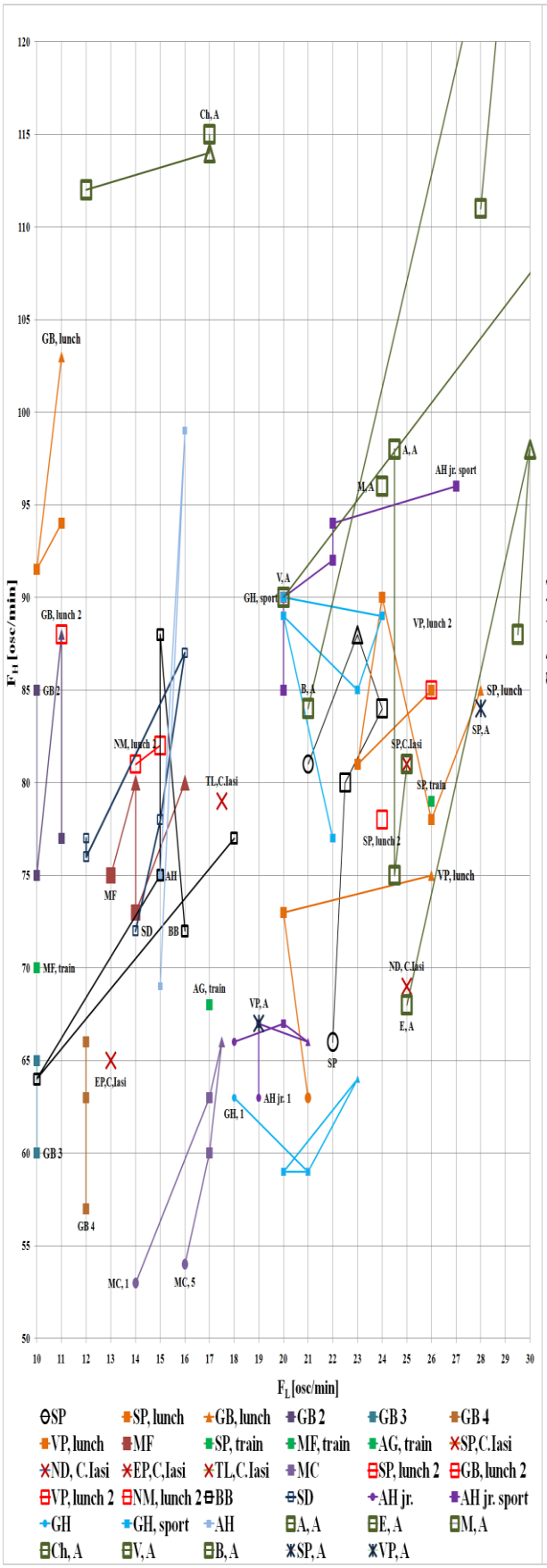

Fig. 3. Diagram $F_H = f(F_L)$

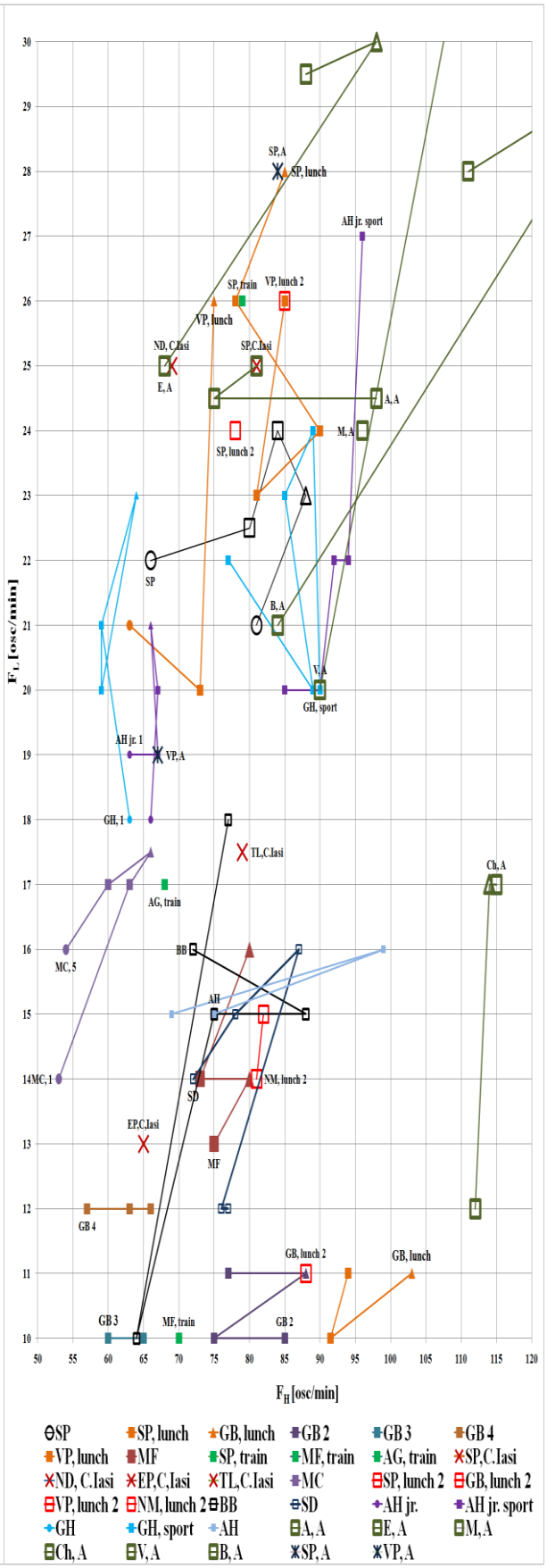

Fig.4. Diagram $F_L = f(F_H)$

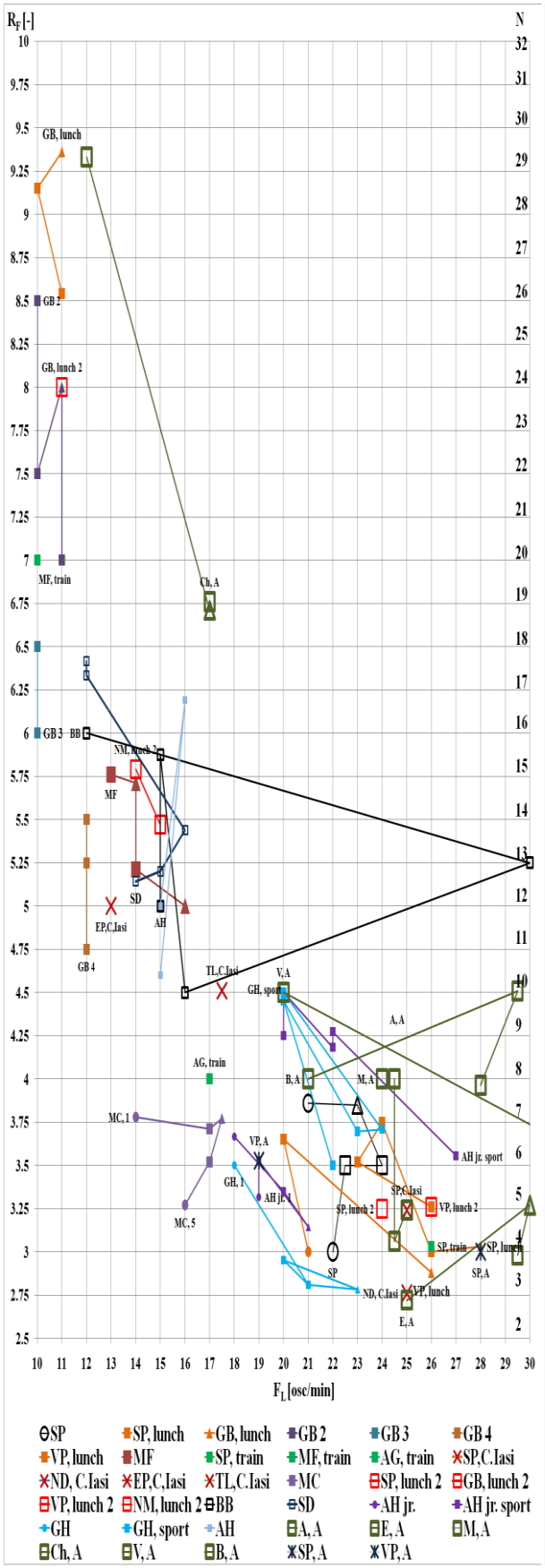

Fig. 5. Diagram *Rf(F$_L$), N = f(F$_L$)*

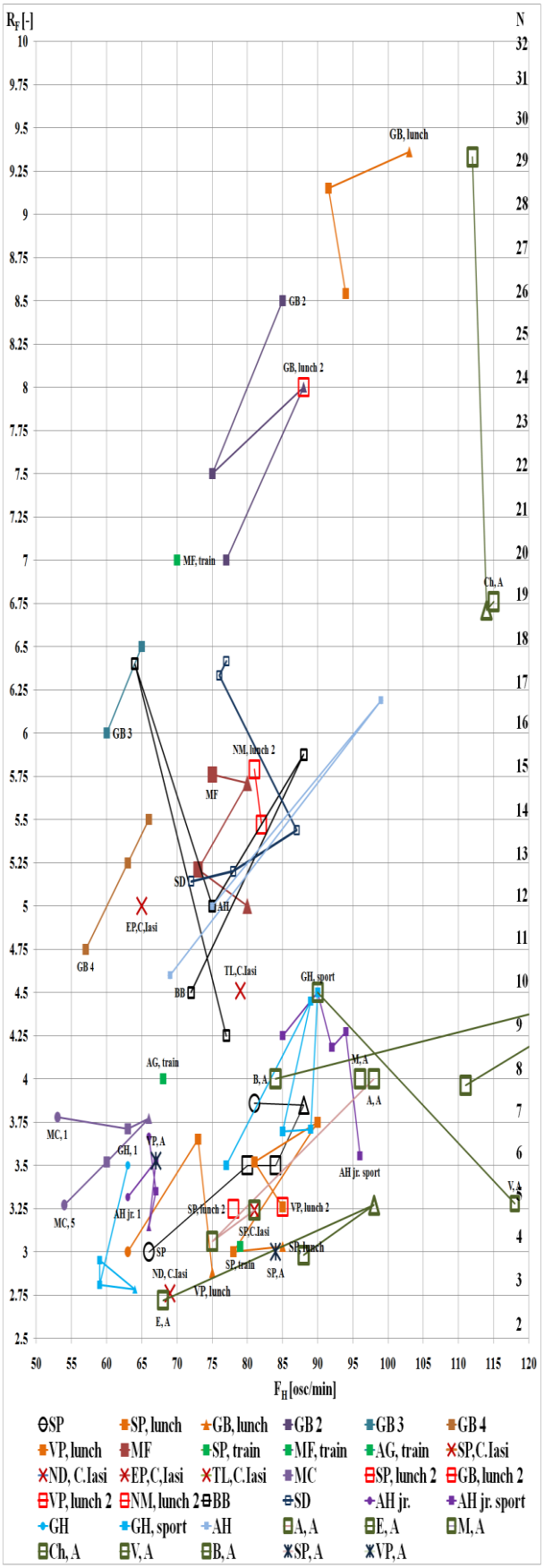

Fig.6. Diagram *Rf(F$_H$), N = f(F$_H$)*

REFERENCES

[1] 25Petrescu S., Costea M, Petrescu A.S., Petrescu V., *From Thermodynamics with Finite Speed toward Quantum Biological Thermodynamics with Finite Speed*, Proceedings of NACOT Conference, Iasi, 2015.

[2] 22 Petrescu S., Costea M., Timofan L., Petrescu V., Means for qualitative and quantitative description of the Cardio-Pulmonary System Operation within Irreversible Thermodynamics with Finite Speed, Proceedings of ASTR Conference, Sibiu, 2014.

[3] 23 Petrescu S., Petrescu V., Costea M., Timofan L. Danes S., Botez G., *Discovery of "Quantum Numbers" In the Cardio-Pulmonary Interaction studied in Thermodynamics with Finite Speed*, Proceedings of ASTR Conference, Sibiu, 6-7 November, 2014.

[4] 26 Petrescu S., Costea M., Petrescu V., Bolohan R., Petrescu A.S., Boriaru N. *Processes with Quantum Jumps in the Cardio-Pulmonary System*, Proceedings of ASTR Conference, Galati, 2015.

[5] 27 Petrescu S., Costea M., Petrescu V., Bolohan R., Petrescu A.S., Boriaru N. *Stationary Quantum States in the Cardio-Pulmonary System*, Proceedings of ASTR Conference, Galati, 2015.

[6] 29 Petrescu S., Costea M., Petrescu V., Bolohan R., Boriaru N., Petrescu A. S., Borcilă B., *Stationary Quantum States in The Cardio-Pulmonary System*, Buletinul AGIR, 2015.

[7] 30 Petrescu S., Costea M., Petrescu A. S., Petrescu V., Boriaru N., Bolohan R., Borcilă B., *Processes with Quantum Jumps in The Cardio-Pulmonary System*, Buletinul AGIR, 2015.

[8] 31 *SCIENCE&VIE*, **No. 1176**, 54-68, September 2015.

[9] 17 Petrescu S., Costea M., et al., *Development of Thermodynamics with Finite Speed and Direct Method*, Editura AGIR, Bucharest, Romania, 2011.

[10] 32 Petrescu S., Costea M., Feidt M., Ganea I., Boriaru N., *Advanced Thermodynamics of Irreversible Processes with Finite Speed and Finite Dimensions*, Editura AGIR, Bucharest, 2015.