RESEARCH ARTICLE

Relationships between metabolic factors and Heart Rate Variability parameters. Prevention in occupational health.

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Abbreviations and other definitions used:

HR	heart rate
HRV	heart rate variability
TP	total power
VLF	very low frequency
LF	low frequency
HF	high frequency
LF/HF ratio	(LF ms^2/HF ms^2)
SD1, RMSSd	HRV time domain parameters
SBP/DBP	systolic/diastolic blood pressure
RRs	systolic blood pressure
KOL	cholesterol
HDL-C	“good” cholesterol
LDL	“bad” cholesterol
TRIG	triglyceride
BG	blood glucose
Ti	body mass index: Ti=body weight (kg) / 0.79 x body-height (cm) – 0.607
CHD	coronary heart disease
CAD	coronary artery disease
S	smoker
Hyp	hypertensive
Ym	service years, years in mine

Abstract
The rhythmic functioning of the human body is influenced by many factors. The development of innovation in recent decades has made it possible to study heart rate variability.
Objectives: (1) obtaining more accurate information than previously available to understand the complex effects on the human body, (2) logical exploration of the directions and magnitudes of variations in the metabolic factors and HRV parameters, (3) drawing attention to the importance of understanding these complex effects and to use them for prevention in occupational health.
Methods: Using non-invasive methods of the HRV analysis, physiological measurements were taken at workplaces with the participation of people at work, both at rest in lying position and during work. In the present study, we focused on analysing the measurement data from groups where, due to the workplace conditions (e.g. chemical safety regulations), clinical laboratory test results were also available. Measurement results were evaluated using the SPSS software system and other advanced mathematical methods.
Results: Of the more than 5,000 physiological measurements carried out at the workplace over nearly 20 years, 571 had measurement results that could be used to analyze changes in the individuals' metabolism and heart rate. These analyses enabled us to assess the reported relationships, by taking into account (1) the combined changes in heart rate, blood pressure, blood glucose, cholesterol, triglyceride, body weight and HRV parameters, (2) the effects of age, years of service and life characteristics, and (3) the mathematical reliability criteria. On the basis of the available sample size and individual characteristics, groups with favorable and unfavorable conditions were formed. Differences in the data of these groups compared to each other and to the mean demonstrate the striking nature of the results. The reliability of the results was ensured by the mathematical methods used in the analysis.
Conclusion: The simultaneous variations of metabolic syndrome factors and HRV parameters highlight the potential and the importance of using new methods developed through innovation.

Keywords: physiological measurements; HRV parameters; metabolism factors; prevention programs

1. Introduction

The continuous development of innovation has an impact on scientific research into the micro and macro systems, development of instruments, informatics and complex ways of understanding the functioning of the human body. One part of this research is the method of HRV analysis, the results of which have been published in over 16,000 peer-reviewed publications in the international literature - unfortunately, only 3-5% of these deal with topics of occupational health, work hygiene and work safety.

Health is the most valuable, irreplaceable basic value in a person's life. As early as in 1946, WHO defined health as a state of complete physical, mental and social well-being. According to the Fundamental Law of Hungary, "everyone has the right to safe and healthy working conditions". According to the Hungarian Occupational Safety and Health Act, "the employer is responsible for the implementation of safe and healthy working conditions".

The human body functions in a complex way and, in addition to the generally adverse effects of age, factors of work (working circumstances, working conditions) and private life (leisure, family, housing conditions) affect the individuals' health.

In the interest of people, all methods must be used to ensure fitness for work and health protection.

Both international and national data show that cardiovascular diseases are the leading contributors of mortality rate.

Due to the development of innovation, utilization of the results of scientific research has increased in the field of health protection, too; implementation of modern methods of investigation has also increased, and all these make it possible to detect and prevent health disorders. This makes it possible to use the heart rate variability method. [1, 2, 3]

Such a combined method of research may include the option of a joint investigation of metabolic factors and changes in HRV parameters, and the state of the cardiovascular system.

In this publication, we provide novel information on the results of a coupled study of HRV parameters and metabolic factors collected in physiological measurements aimed at understanding the working environment and the work strain of the person doing the work.

The tables based on a combined assessment of the results of physiological measurements in the workplace and the clinical laboratory tests, together with the constructed figures, illustrate the novel nature of the links.

2. Methods

2.1.Study population

Workers from seven extractive and processing plants participated in our research aimed at understanding work strain of the human body between 2005 and 2017. The clinical laboratory tests included in the present paper are only required by Hungarian regulations when chemicals are present in the workplace, therefore they were available only for 571 individuals. The effect of chemicals is harmful to health, and therefore - presumably - their presence can be detected in changes of HRV parameters. It is important to note that the number of chemicals entering the industrial field is constantly increasing through innovation, and therefore continuous monitoring of their adverse health effects warrants new kinds of activity. The combined study of metabolic syndrome factors (blood pressure, blood glucose, TRIG., KOL, and Ti) and changes in HRV parameters could provide novel information for the modernization of occupational health regulation. It will also enhance the understanding of the impact of primary prevention data in the workplace on the detection of harms from chemical exposure in the general population.

Of the 571 laboratory records available to us, all the individuals included in this paper were men with the required 'fit for work' qualification. The workplace physiological measurements were carried out under the auspices of the National Public Health Center. Before the measurements, after being informed of the purpose of the study, the workers gave their written consent to participate in the instrumental measurements and to the use of their clinical laboratory findings for research purposes. The study was conducted in accordance with the requirements of the Helsinki Declaration of 1983 and 1989, with the permission of the Scientific and Research Ethics Committee of the Medical Research Council. The data were processed in accordance with the regulations on personal data protection.

2.2.Execution of the workplace measurements

The measurements were performed at the plants using a POLAR S 810 heart rate monitor, which is suitable for recording HR beat-by-beat and storing the data. The tests were conducted by measuring blood pressure (OMRON M3) and by interviewing the workers to record individual data (age, years of service, height, weight, smoking habits, health complaints). This was followed by mounting the sensor of the measuring instrument on the chest and starting the instrument set to beat-to-beat. The 10-minute measurements at rest in supine position were performed in the occupational physicians' office or in other separated, noise-free room of the plant, supplied with clean air, using camp beds. The POLAR instruments were worn by the workers throughout the work period, were shut down and dismantled at the end of the shift, and the data were stored on a portable computer. Observation and recording of work processes during the shift was carried out in the traditional way by recording points of time. Between 6 and 12 people participated in the measurements who were working simultaneously at the same workstation. Measurements were taken during all three parts of the day (morning, afternoon, night) and on each working day of the shift (1-7 working days). A significant number of the workers who participated in the workplace measurements also took part in ergometric tests (Jaeger Oxycon Champion treadmill) at the National Institute of Occupational Health.

2.3. Statistical analysis of measurement data and clinical laboratory findings

The HRV parameters stored on the computer and the clinical laboratory findings were sorted in Excel tables according to the European Society of Cardiology and the North American Society of Pacing and Electrophysiology HRV Standards of Measurement, Physiological Interpretation, and Clinical Use guideline[4] using time domain (error measures) and frequency domain (TP domains: VLF, LF, HF and LF/HF) values and laboratory findings.

The statistical analysis included descriptive details (mean values, 95% confidence intervals, variance, standard deviation, max / min, skewness) and details of the dependence of parameters on life characteristics (hypertension, smoking, Ti) using standard SPSS Version 13.0, (SPSS Inc., Chicago, IL)[5] and version 23 (IBM). Comparisons included analysis of individuals, groups, shifts as parts of the day, and work processes. SPSS is one of the most widely used tools for multivariate analyses, and the SPSS Linear Models and Linear Regression procedures were used in the analyses. Linear models allow the analysis of relationships between a continuous dependent variable and one or more so-called predictor variables.

Although more than 25 variables were used to describe the phenomena, fewer variables were used in the detailed analyses of the modelling of individual phenomena, taking into account the closeness of the correlation relationships.

We note that functioning of the human organism is eurhythmic and the relationship between physiological variables is stochastic. However, linear analyses with close regression relationships and two or more factors correctly reflect the nature of the changes and there is no significant difference in the extent, either.[6]

The dependence of HRV parameters and metabolism factors on age and years of service was analyzed by the ANOVA method of linear regression analysis. The closeness of the correlations between each of the influencing factors and the HRV parameters and metabolism factors was tested. We examined the normality of the variables in the data set and the results of each regression relationship were checked by sensitivity analysis.

Our paper is based on the use of the data set measured in supine-resting state.

3. Results

According to the literature, [7, 8] HRV analysis is an important method to understand the state of the cardiovascular system in both healthy and ill individuals. Literature[9] analyzes the relationship between acute and chronic effects on the cardiovascular system and HRV parameters. The relationship between heart rate (HR), blood pressure (SBP/DBP) and metabolic factors is also discussed. [10, 11]

Metabolic syndrome can lead to a number of health problems such as diabetes and therefore primary prevention in the workplace is also important. [12]

We compared the results of our workplace physiological measurements (HR, SBP/DBP and HRV) and the analysis of the relationship between clinical-laboratory findings, considering the subsequent cardiovascular events, to the findings published in the literature.[11]

3.1. Correlation relationships

The relationships between the physiological characteristics (age, Ti, HR), HRV parameters (TP, LF, HF, LF/HF, RMSSD) and clinical laboratory findings factors

(blood glucose, KOL, HDL-C, LDL-C, TRIG) of the 571 available samples (where correlation>+/-0.2, significance = 0.000) are presented in Table 1.
Table 1 shows that there was a strong relationship between age and HRV parameters and between years of service and changes in HRV parameters for the 571 samples. The same was true for the relationships between HRV parameters, but the closeness of the relationship between metabolic factors and HRV parameters exceeded +/- 0.3 only for TRIG, age, LF/HF and HR. According to the data in the table 1, LF/HF and HF (11 times) and TP (10 times) appeared most frequently.

3.2.Effects of lifestyle characteristics on metabolic syndrome factors and HRV parameters [13, 14, 15]

Tables 2 to 8 illustrate the characteristic data of the different groups formed according to different life characteristics (non-smoking: nS, smoking: S, and non-hypertensive: nH, hypertensive1: H1; H_{incr} factor, and TRIG I., II., III.; KOL I., II., III.), as well as the characteristics of the participants belonging to the favorable (92 samples) or the unfavorable (48 samples) groups and present the results in graphs.
Table 2 shows the mean values for the 571 samples analyzed. The data show that the mean values of blood glucose and KOL, LDL, HDL were high, while TRIG levels were within the acceptable range.
Changes in lifestyle characteristics (such as smoking, blood pressure groups) and metabolic factors and their effects on HRV parameters were analyzed.
The data for nS (64.8%) and S (35.2%) groups are shown in Table 3 and the changes in HRV parameters are illustrated in Figure 1.
The data in Table 3 and Figure 1 show that smoking reduced the magnitude of the HRV domains (TP, VLF, LF and HF) and modified their % proportion. The lower TP, VLF, LF values of smokers reflect the adverse physiological effects (as reflected by the values relative to the mean of the 571 samples).
Figure 2 shows a decrease in the LF of the HRV parameters and an increase in the TRIG factor of metabolism as a function of age, based on the mean values of the 571 samples. As shown in the figure, the value of the selected HRV parameter LF decreases with increasing age, but the TRIG factor of metabolism moves in the opposite direction. The relationship between the two variables is illustrative, given the different directions of change, and makes a joint study of the two different factors possible.[16]
Table 4 shows the distribution of the 571 samples by blood pressure groups and the different data of metabolism factors and HRV parameters.
Figure 3 illustrates the magnitude of blood pressure and TRIG values as a function of age and the nature of changes in the relationships.
Figure 4 shows the typical values of the TRIG level by blood pressure groups.
During the analysis of the measurement data, so-called "favorable" and "unfavorable" groups were formed, the details of which are presented in Table 6 and the HRV parameters different from the average and the formed groups are illustrated in Figures 5.
Table 6 shows the different data regarding the favorable, average and unfavorable (high) KOL, TRIG levels and HRV parameters, which are useful for the co-evaluation and for outlining the occupational health assessment criteria.
Table 7 shows the relationships between KOL groups, age, body mass index data and changes in HRV parameters. It can be seen that cholesterol levels increase with age and body mass index - as do blood glucose and TRIG levels - but the levels of TP, VLF, LF and HF parameters decrease (most notably for HF).
The TRIG/HDL-C ratio deserves particular attention, because, according to the literature [13], a value of ≥ 3.5 leads to cardiovascular disease (CHD, CVD) and death. Based on our example, the average value of TRIG/HDL-C for the 30 samples was 4.4, which justified a separate and immediate analysis of the

subjects in this group. Table 8 shows the life characteristics and HRV parameters of the 30 samples.

Comparing the data series of our 'unfavorable' group in Table 6 (48 samples) and the TRIG/HDL-C group (30 samples) in Table 8, we can conclude that the life characteristics of the individuals in both groups and the HRV parameters alike justify a complex examination of both the individuals and the working conditions.

Figures 6/1 and 6/2 show the relationship between HRV parameters and the TRIG/HDL ratio as a function of age, which raises awareness and may provide grounds for conducting future studies.[17]

Figure 7 illustrates the strong connection between HF and age. Age has the largest effect (> 70%), followed by hypertension with 21-22%.

4. Discussion

The results presented in this paper are based on the evaluation of 571 measurements carried out in 5 plants with the participation of 215 people, in conformity with the plant's working schedule. The individuals studied worked on a shift system (2-7 day shift).

The instrumental measurements were performed in isolated rooms under undisturbed conditions in a supine resting position for 10 minutes before the start of work. HRV parameters measured with POLAR S 810 type instruments were evaluated using the SPSS software system, taking age, years of service, life characteristics (blood pressure, smoking, body weight and their combination) and metabolism factors into account. Of particular note, we formed "favorable" and "unfavorable" groups to detect differences and to substantiate justified interventions.

The correlations between the individual physiological conditions and the measured HRV parameters and metabolism factors were determined and the cases considered as close are summarized in Table 1. It can be concluded that the relationship between HRV parameters (time domain and frequency domain) is generally close, as well as between metabolism factors, but the relationship between HRV parameters and metabolism factors is weaker, except for blood glucose and TRIG. The associations with strength >+0.4 between TRIG and age, and between TRIG and LF/HF and HF deserve special attention.

Among the life characteristics, the effects of smoking on HRV parameters are illustrated in Table 3 and Figure 1. Compared to the mean values, in smokers the TP domain decreased by 28.6% and the LF% decreased by 6.5%.

Figure 2 illustrates the variation of the LF parameter of HRV and the TRIG factor of metabolism as a function of age. The different nature of the variation of the two factors points to the possibility of a joint assessment.

The data in Table 4 and Figure 3 show the change in TRIG and blood pressure (RRs=SBP) as age progresses. The data in the table and the figure with the values over the age group of 40-50 years and their impact on the circulatory system highlight the importance of a combined assessment of these two factors.

Table 4 shows the TRIG values by blood pressure group (normal: ≤130 mm Hg; acceptable: 140-150 mm Hg, and elevated: ≥151 mm Hg), as illustrated in Figure 4. The combined assessment of Figures 3 and 4 shows that not only age but other factors (e.g. years of service, KOL level), also influence the values, as shown by the variation in HRV parameters.

To highlight the relationship between the effect of physiological characteristics and the change in HRV parameters of the study population, we formed a "favorable" (≤39 years, n's, nH, TRIG-I) and an "unfavorable" (≥40 years, S, H, TRIG-III) group, the effects of which are shown in the different TP, VLF%, LF%, HF% changes in Figure 5. The data reflect that the pulsation domain of the heart in the "unfavorable" group is lower than that reported in heart failure patients in the literature.

Table 7 shows the relationships between ages, years of service, metabolic factors and changes in HRV parameters. The KOL groups were formed according to the instructions for reference ranges. According to the instructions, if total cholesterol levels are >5.3, it is necessary to determine HDL-C levels, as well. As shown in Table 7, an increase in KOL levels resulted in a decrease in HRV parameters. The optimal level of LDL-C is <3.4 mmol/L with a high limit of 3.6-4.1 and a very high limit of >5 mmol/L. Based on our sample data, 9.4% of the cases studied fell into this latter group, which is informative for coronary artery diseases. Of particular interest is the TRIG/HDL-C ratio, which, according to the literature, is a predictor of coronary artery disease when >3.5 mmol/L.

According to the data in Table 8, in the case of 30 samples, the TRIG/HDL-C value was 4.4 (and HDL-C barely exceeded the critical value of 1.0).

As for the formed groups, in both the unfavorable (48 samples) and TRIG/HDL-C (30 samples) groups the data of HRV parameters are noteworthy and warrant monitoring of the working conditions and the health status of the individuals studied. [17, 18]

Figures 6/1 and 6/2 show the variation of the critical factor of metabolism TRIG/HDL-C and some HRV parameters as a function of age. It could be concluded that, with increasing age and years of service, the HRV parameters decreased and the metabolism index increased.

Figure 7 illustrates the order and magnitude of life characteristics that influenced the change in the HRV parameter reflecting parasympathetic effects, with age being the dominant determinant (>70%).

Based on our results, it can be concluded that the simply performable method of HRV measurements and assessment provides additional information about the complex effects affecting the human body, which are manifested in changes of metabolic factors, and can be used as a basis for timely action to prevent or moderate health impairments.

Limitations

The data collection prior to the workplace measurements did not include a more detailed questioning about smoking habits (e.g. how long people have been smoking and how much they smoke per day) - this information could have enriched the results of the analysis. Also, the data collection did not cover drinking habits and leisure activities, because - based on our initial experience - the reliability/validity of this information is unverifiable and would have distorted the evaluation of the results.

Conclusions

The present paper covers only the determination and assessment of the parameters measured at rest in the supine position out of the full-time period measurements carried out at the workplace. The findings reveal that the method of HRV analysis, through a combined understanding of the determinant effects of age, life characteristics, and metabolic factors can provide essential information for the establishment of modifications in occupational health and safety activities and regulations.

The results of measurements performed in the supine resting state based on changes in HRV parameters, and the evaluation of their relationships with age, years of service, life characteristics and metabolic factors, as well as their specific groupings support the possibility of understanding the logic of the joint variation of HRV parameters and metabolic factors. This requires a large number of measurements to be made at the units under study, taking into account the multitude of influencing factors.

By using the HRV method, in addition to examining the effects of age and life characteristics, it is possible to explore the effects of working conditions and to introduce a physiologically more favorable work variant.

The results of workplace physiological measurements involving individuals with unfavorable conditions may justify the need for special medical examinations for the

individuals concerned, for which regulatory and technical conditions should be created.
Innovation can help to improve the accuracy of test results by developing more modern measurement tools and assessment methods. These developments are multi-disciplinary and complex: they require the collaboration of doctors, psychologists, engineers, mathematicians, computer scientists - all working to preserve the working capacity of the workers and protect their health.

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Tables

Table 1 Correlation relationships (n=571; corr>+/-0.200; sign=0.000;)

Characteristics	1	2	3	4	5	6
Age	LH/HF: + 0. 809	Service years: + 0.569	HF: -0.564	LF: -0.479	TP: -0.453	TRIG: + 0.418
Service years	age: + 0.569	LF/HF: +0.497	HF: -0.419	RMSSD: -0.386	LF: -0.376	TP: -0.361
Ti	HR: + 0. 258	TRIG: + 0. 249	RMSSD: -0.235	SD1:-0.229	HF: -0.224	LF/HF:+0.197
KOL	LDL: + 0. 930	HDL: +0. 299	BG: + 0.221	TRIG : + 0.195		
HDL	KOL: + 0.299	TRIG: -0.288	RMSSD: +0.193			
LDL	KOL: + 0.930					
TRIG	LF/HF: + 0.424	age: + 0.410	HF: -0.372	RMSSD: -0.356	HR: +0.305	Service years: +0.294
BG	SD1: -0.279	LF/HF: +0.253	RMSSD: -0.229	VLF: -0.229	TP: -0.221	KOL : +0.221
HR	RMSSD: -0.631	VLF: -0.599	TP: -0.586	HF. -0.549	LF/HF: +0.412	TRIG: +0.305
RMSSD	SD1: +0.971	HF: +0.764	TP: +0.763	LF: +0.755	VLF: -0.751	HR: -0.586
SD1	RMSSD: + 0.971	HF: +0.772	TP: + 0.764	LF: +0.756	HR: - 0.625	LF/HF: -0.513
TP	VLF: +0.994	LF: +0.993	HF:: +0.973	RMSSD: +0.763	HR: -0.586	LF/HF: -0.478
VLF	TP: +0.994	LF: +0.978	HF: +0.949	RMSSD: +0.755	HR: -0.599	LF/HF: -0.449
LF	TP: +0.993	HF: +0.982	VLF: +0.978	RMSSD: +0.755	HR: -0.563	LF/HF: -0.480
HF	LF: +0.982	TP: +0.973	VLF: +0.949	SD1: +0.772	LF/HF: -0.574	age: -0.564
LF/HF	age: +0.809	HF: -0.574	RMSSD: -0.529	Service years: +0.497	LF: -0.480	TP: -0.478

Table 2 Mean values of the analyzed parameters of 571 samples

Parameter	Age (years)	Service years	Ti	KOL	HDL	LDL	TRIG	BG	HR	SD1	RMSSD	TP	VLF/%	LF/%	HF/%	LF/HF
mean values	44.7	17.7	1.11	5.62	1.31	3.67	1.8	4.91	71.9	16.1	22.1	1263	770/62.1	352/27.5	141/10.4	2.75

Table 3 Characteristic parameters of the smoker (S) and the non-smoker (nS) groups

Groups	Age (years)	Service years	Ti	SBP	KOL	HDL	LDL	TRIG	BG	HR	RMSSD	TP	VLF/%	LF/%	HF/%	LF/HF
nS	44.2	17.3	1.11	136	5.41	1.32	3.58	1.75	4.85	69	24.3	1427	866/61.6	309/27.7	161/10.7	2.67
Mean	44.7	17.7	1.11	139	5.62	1.31	3.67	1.85	4.97	71.9	22.1	1263	770/62.1	352/27.5	141/10.4	2.75
S	45.7	18.4	1.11	144	6.02	1.29	3.87	2.09	5.18	77.3	17.9	962	593/63.9	266/27.2	105/9.9	2.90

Table 4 Characteristic parameters of the various blood pressure groups

BP groups	Age (years)	Service years	Ti	KOL	HDL	LDL	TRIG	BG	HR	SD1	RMSSD	TP	VLF/%	LF/%	HF/%	LF/HF
nH: 62.6%	42.8	16.2	1.06	5.43	1.33	3.57	1.53	4.78	68.7	19.1	26.0	1501	907/61.3	420/27.8	173/11.0	2.61
H1: 23.0%	47.3	19.9	1.18	5.79	1.27	3.81	2.04	4.94	74.1	12..0	16.4	943	587/63.2	260/27.1	96/9.8	2.91
H_{incr}:14.4%	48.8	21.2	1.23	5.91	1.31	3.85	2.29	4.94	81.3	9.1	13.0	730	463/64.2	200/26.8	68/8.5	3.12
Mean	44.7	17.7	1.11	5.62		3.57	1.8	4.91	71.9	16.1	22.1	1263	770/62.1	352/27.5	141/10.4	2.75

nH: SBP ≤ 139 mmHg; H1: SBP = 140-159 mmHg; H_{incr}: SBP ≥ 160 mmHg

Table 5 Characteristic parameters of the TRIG groups

Groups	Age (years)	Service years	Ti	KOL	HDL	LDL	TRIG	BG	HR	SD1	RMSSD	TP	VLF/%	LF/%	HF/%	LF/HF
TRIG-I	44.6	17.9	1.08	5.25	1.37	3.42	1.16	4.74	69.5	17.6	23.8	1344	813/61.7	376/27.7	152/10.7	2.69
TRIG-II	43.4	16.8	1.15	5.91	1.26	3.93	1.95	4.94	73.0	15.9	22.2	1303	794/61.9	363/27.5	146/10.6	2.71
TRIG-III	46.5	18.1	1.13	6.23	1.31	3.98	3.25	5.52	76.9	12.6	17.3	1007	628/63.1	276/27.1	103/9.6	2.94
571 samples	44.7	17.7	1.11	5.62	1.31	3.67	1.8	4.97	71.9	16.1	22.1	1263	770/62.1	352/27.5	141/10.4	2.75

TRIG – I (53.3%): ≤ 1.69 mmol/L
TRIG – II (25.9%): 1.7 – 2.3 mmoL/L
TRIG – III (20.8%): ≥ 2.31 mmoL/L

Table 6 Typical parameters of the "favorable", the average and the "unfavorable" groups

Groups	Age (years)	Service years	Ti	SBP	KOL	HDL	LDL	TRIG	BG	HR	RMSSD	TP	VLF/%	LF/%	HF/%	LF/HF
"favorable"	35.8	10.7	1.06	127	5.09	1.36	3.25	1.3	4.78	67.7	30.6	1892	1098/58.4	545/28.8	243/12.8	2.27
Average	44.7	17.7	1.11	139	5.62	1.31	3.83	1.80	4.97	71.9	22.1	1263	770//62.1	352/27.5	141/10.4	2.75
"unfavorable"	49.9	21.0	1.18	159	6.76	1.33	4.50	2.51	6.07	84.7	11.6	661	422/64.4	181/27	59/8.6	3.24

"favorable" group (92 samples): ≤ 39, nS, nH, TRIG-I

"unfavorable" group (48 samples): ≥ 40, S, H, TRIG-III

Table 7 Typical parameters of the KOL groups

Groups	Age (years)	Service years	Ti	KOL	HDL	LDL	TRIG	BG	HR	SD1	RMSSD	TP	VLF/%	LF/%	HF/%	LF/HF
571 samples	44.7	17.7	1.11	5.62	1.31	3.67	1.80	4.97	71.9	16.1	22.1	1263	770/62.1	352/27.5	141/10.4	2.75
KOL-I	43.7	16.2	1.08	4.61	1.27	2.99	1.53	4.91	70.3	17.5	23.7	1329	799/51.1	374/27.9	153/10.9	2.64
KOL-II	44.6	19.1	1.11	5.94	1.30	3.83	1.87	4.95	72.8	15.5	21.3	1244	775/62.3	341/27.4	128/10.3	2.67
KOL-III	49.9	16.9	1.14	8.23	1.51	5.36	2.60	5.33	73.9	13.7	18.8	1080	688/63.8	289/26.7	103/9.5	2.81

KOL-I (41% of the samples): ≤ 2.7 mmol/L

KOL-II (49.6% of the samples): 2.8 – 5.2 mmol/L

KOL-III (9.4% of the samples): ≥ 5.3 mmol/L

Table 8 Mean values of the various parameters of the group TRIG/HDL-C ≥ 3.5

Group	Age (years)	Service years	Ti	SBP	KOL	HDL	LDL	TRIG	TRIG/ HDL	RMSSD	HR	TP	VLF/%	LF/%	HF/%	LF/HF
30 samples	49.5	18.5	1.19	145	6.18	1.05	3.83	4.55	4.4	13.2	77.6	793	499/83.4	212/27.5	73/9	3.06

TRIG/HDL-C: ≤ 1.5: no risk

TRIG/HDL-C: 1.51 – 3.4: moderate risk

TRIG/HDL-C: ≥ 3.5: high risk

Figures

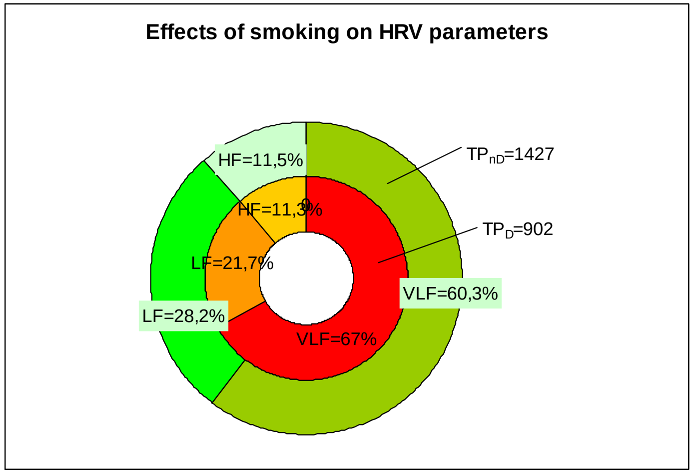

Figure 1 Effects of smoking on HRV parameters

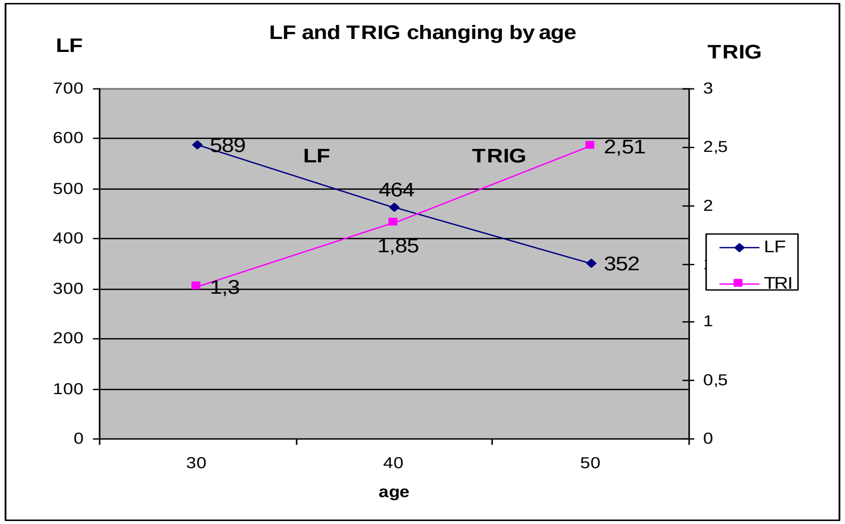

Figure 2 LF and TRIG changing by age

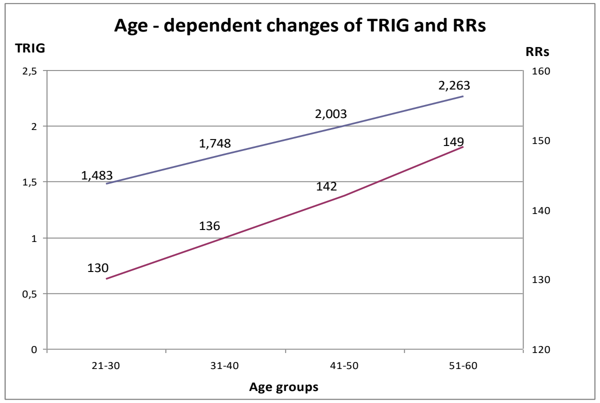

Figure 3 Age-dependent changes of TRIG and blood pressure

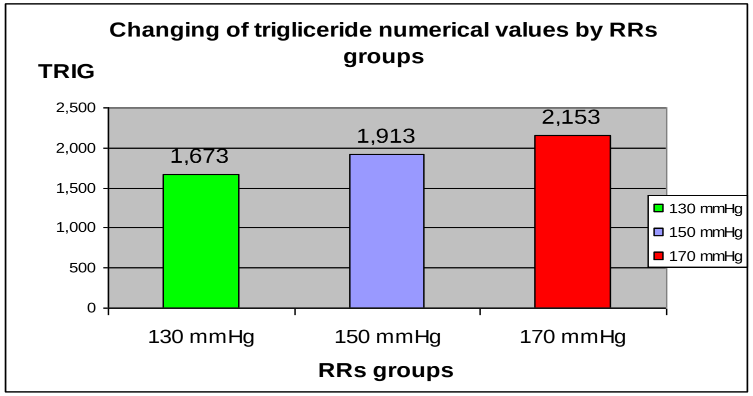

Figure 4 Mean triglyceride values by blood pressure groups

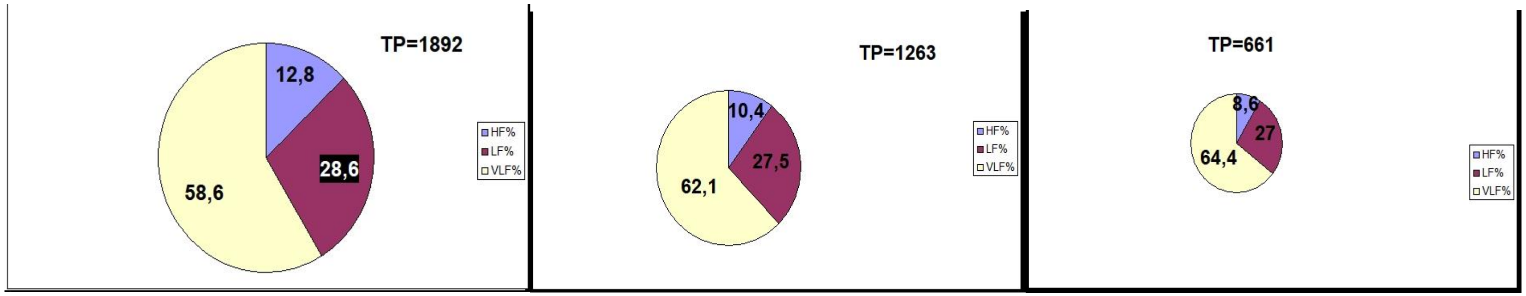

Figure 5: "Favorable" group (Age ≤ 39 years, nS, nH, TRIG I.) Average of the 571 samples (mean age: 44.7 years, S: 35%, H: 47%, TRIG=1.85) "Unfavorable" group (Age ≥ 40 years, S, H, TRIG III.)

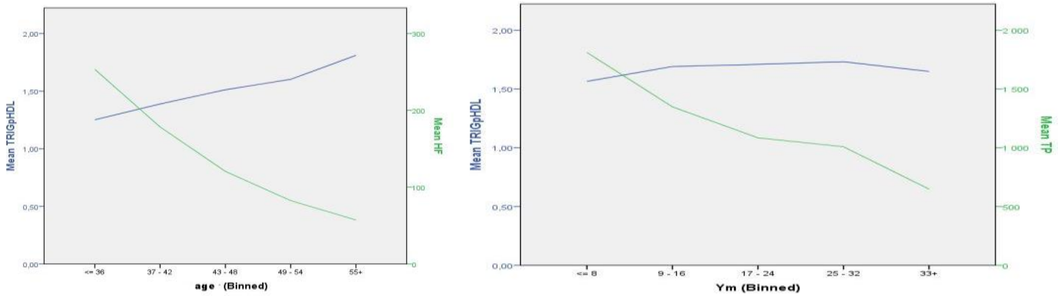

Figure 6/1 **Figure 6/2**

Figure 6 TRIG/HDL vs. time functions

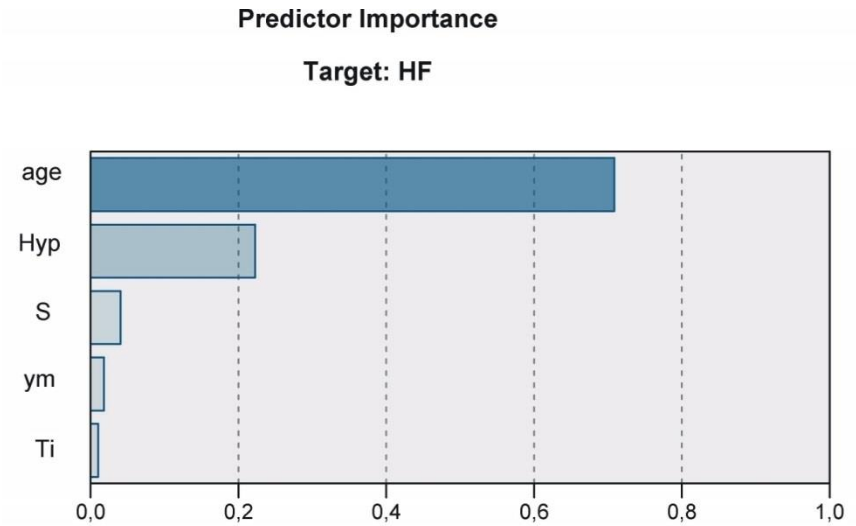

Figure 7. Predictive power of lifestyle variables on HF value

