An Artificial Intelligence System to Predict Progression of Immune Dysfunction in Healthy Older Patients

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In 1983, forty nine participants returning for their annual HEALTH WATCH evaluation were assessed for immune function status and served as healthy controls in an early study of "normal" reference values for T_4 and T_8 lymphocyte counts and T_4/T_8 lymphocyte ratios, B lymphocyte counts, and other laboratory tests for immune function then available. Balascopy, a computer-assisted pattern recognition system for detection, quantification and cognition of multiple imbalances among clinical laboratory and health behavioral parameters, facilitates identification of otherwise healthy individuals with evidence of early immune dysfunction. When the T_4 and T_8 immunology tests were combined with 7 health index behavioral subscores, and 24 routine clinical laboratory tests, we are able to obtain a bodyprint unique for each patient, providing a comprehensive health status profile specific for that individual. These bodyprints serve as tools for the evaluation of otherwise undetectable metabolic, immunological and behavioral imbalances in a given patient in an unprecedented individualized manner. We show here a longitudinal look at a balascopic evaluation of one patient who has evidence of progressive immune dysfunction with development of only mild clinical symptoms.

MATERIALS AND METHODS

Health Watch is a longitudinal prospective study of healthy aging through which physicians and other health care providers can use person-specific data to monitor health and to identify interventions, while researchers continue to assess aging effects and determinants of healthy aging. The study uses a computer-based monitoring system for tracking the biochemical, hematological, physiological and behavioral parameters (n = 38) in men and women over their lifespan. This "person-specific" data has been studied in close to 3000 individuals for up to 23 years. Health Trend Charts summarize annual updates for biochemical *(n = 17)*, hematological *(n = 8)* and physiological *(n = 6)* parameters. A Health Profile Index, derived from a questionnaire updated by each patient annually, provides 7 subscores for health status. The **Health Watch** approach allows the primary care physician to observe early trends of unhealthy behavioral or laboratory patterns prior to signs or symptoms of disease, thereby permitting the active practice of primary preventive medicine, in partnership with the individual patient. The clinical parameters assessed annually as well as the seven health status and health behaviors subscores are listed in Table 1.

Balascopy (Balance + Scope) is a computer assisted methodology developed for the analysis of relationships between multiple immunological, hematological, biochemical, physiological and behavioral parameters. Balascopy utilizes a pattern recognition system for detection, quantification and cognition of imbalances in the above relationships. Generated balascopic patterns help to predict the presence or illustrate the development of immunodeficiencies in otherwise healthy individuals at the routine clinical laboratory or physician level office. Longitudinal analysis of balascopic interpretations of patientspecific data provides for

early, correct identification of progressive immune dysfunction and increased patient susceptibility to infectious diseases. Balascopic information, which is not available from any other existing modality, represents a new class of knowledge and opens up a new method for studying the mechanisms of disease and designing individualized therapeutic approaches.[1-5]

Table 1. Health Watch Clinical Parameters and Health Behavior Subscores

Hematology

White blood cell count	Mean cell volume
Red blood cell count	Mean cell hemoglobin
Hemoglobin	Mean cell hemoglobin concentration
Hematocrit	Platelets

Blood serum chemistry

Glucose	Urea nitrogen	Aspartate aminotransferase
Creatinine	Uric acid	Gamma glutamyltransferase
Calcium	Phosphorus	Triglyceride
Total protein	Cholesterol	Lactic dehydrogenase
Thyroxine	Alkaline phosphatase	High density lipoprotein
Total cholesterol	Low density lipoprotein	

Body physiology

Height	Systolic blood pressure
Weight	Diastolic blood pressure
Heart rate	Percent body fat

Health status and health behavior subscores (examples of 1340 variables)
Nutrition: Caffeine use, fat and fiber intake, nutritional adequacy
Tobacco: Cigarette, cigar, pipe use
Alcohol: Wine, beer, hard liquor consumption
Exercise: Aerobic benefit, flexibility, endurance, frequency and duration of workout, balance
Medical events: Aspirin use, accidents, exposures, illness, surgery, medication use
General well-being: Number of headaches and colds, subjective health, sleep pattern, number of sick days taken
Psychological well-being: Work performance and satisfaction, stress levels at work and at home, financial stress, stressful life events (marriage, death of a friend, etc.)

The charts and balascopic interpretations presented here represent a longitudinal evaluation of one of our active participants, an 85-year-old man of good health. This patient is part of a smaller cohort of **Health Watch** men and women who are assessed for immune function status along with the standard assessments described above. Although the patient's routine chemical and immunological parameters fall within established, healthy normal ranges, since 1984 he has experienced almost annual, prolonged (winter to spring) upper respiratory infection, demonstrated by dry coughs, sinus trouble, head and neck aches and other mild symptoms. Repeated laboratory tests and X-rays show no evidence of viral infection, and his current Health Watch profile shows nothing outside normal, healthy range values. The patient has also experienced a resurgence of allergies and other mild symptoms of progressive immune dysfunction commonly attributed to the vague processes of aging. Longitudinal balascopic evaluation of these parameters, however, pinpoints abnormal relationships among the varying, normal range parameters, providing a very different picture for the evaluation and treatment of the patient (see Table 2 and Figures 1a-1b, 2a-2b, 3a-3b, and 4).

DISCUSSION

From the patterns shown, it is clear that although this patient is maintaining healthy normal range values for chemical and immunological parameters as well as maintaining a "healthy zone" of behavioral practices, a progressive increase in abnormal relationships between these parameters is occurring. Analysis of these patterns and where new abnormalities arise helps the primary care physician to pinpoint problem areas within the myriad of healthy range values, thereby allowing for additional therapeutic approaches.

When considering those patterns shown in Figure 4, for example, it is possible to see that between the years 1986 and 1991, there is a trend towards an increasing number of immuno-metabolic abnormalities, while behavioral parameters appear to have played a much more important role in the patient's health during the earlier part of this seven year period. All of the patterns shown in this case study provide specific evidence of progressive immune dysfunction; more importantly, they provide additional clues as to where primary care intervention might be warranted and useful.

CONCLUSION

Early identification of immune dysfunction using person-specific data generated in longitudinal follow-up from patients returning for annual health status evaluation provides a basis for active intervention at all levels of preventive health care. As traditional pharmacological and less traditional psychoneuroimmunological interventions become available, balascopic analysis of trends in overall individual health status facilitates identification of otherwise healthy individuals with early immune dysfunction and may provide quantitative outcomes to monitor immune function and resistance to disease.

Table 2. Health Watch: Health Practices Index: Patient #15, year of Birth: 1907

Date Score	Danger zone			Risk zone			Healthy zone			
	0	10	20	40	50	60	70	80	90	100
Tobacco										
01/01/84 100										X
01/14/86 100										X
04/07/87 100										X
02/03/88 100										X
03/07/90 100										X
03/20/91 100										X
Medical events										
01/01/84 100										X
01/14/86 57					X					
04/07/87 69							X			
02/03/88 85								X		
03/07/90 63						X				
03/20/91 77								X		
Alcohol										
01/01/84 70							X			
01/14/86 86								X		
04/07/87 90									X	
02/03/88 90									X	
03/07/90 90									X	
03/20/91 90									X	
Nutrition										
01/01/84 84								X		
01/14/86 90									X	
04/07/87 80								X		
02/03/88 80								X		
03/07/90 84								X		
03/20/91 100										X
Exercise										
01/01/84 100										X
01/14/86 62						X				
04/07/87 100										X
02/03/88 100										X
03/07/90 100										X
03/20/91 100										X
Psychological well-being										
01/01/84 92									X	
01/14/86 81								X		
04/07/87 93									X	
02/03/88 92									X	
03/07/90 78								X		
03/20/91 93									X	
General well-being										
01/01/84 95										X
01/14/86 70							X			
04/07/87 85								X		
02/03/88 80								X		
03/07/90 88									X	
03/20/91 85								X		

CHEMISTRY

UR.	Uric Acid	5.8	MG/DL	(3.0-9.0)
BUN	Urea Nitrogen	14	MG/DL	(6-25)
GLU	Glucose	86	MG/DL	(70-110)
CHO	Cholesterol	221	MG/DL	(100-199)
TRI	Triglycerides	149	MG/DL	(35-200)
HDL	High Density Lipoproteins	46	MG/DL	(30-80)
LDL	Low Density Lipoproteins	144	MG/DL	(50-129)
SGO	Aspartate Amino Transferase	41	MU/DL	(3-45)
ALK	Alkaline Phosphatase	94	MU/DL	(30-128)

IMMUNOLOGY

WBC	White Blood Cells (x1,000)	4.9	K/UL	(3.0-10.0)
BC#	Total B Cells	152	#/CUMM	(100-600)
TC#	Total T Cells	760	#/CUMM	(800-2200)
T4#	Helper/Inducer T Cells	501	#/CUMM	(>400)
T8#	Supp./Cytotoxic T Cells	623	#/CUMM	(250-750)
4/8	T4#/T8# Ratio	0.76	Ratio	(>0.90)

BEHAVIOR

TOB	Tobacco	100	Danger Zone
M.E	Medical Events	100	(0-33)
ALH	Alcohol	70	
NUT	Nutrition	84	Risk Zone
P.A	Physical Activity/Exercise	100	(34-67)
PWB	Psychological Well-being	92	
GWB	General Well-being	95	Healthy Zone
			(68-100)

Figure 1a. 22 Parameters -patient #15: 1984.
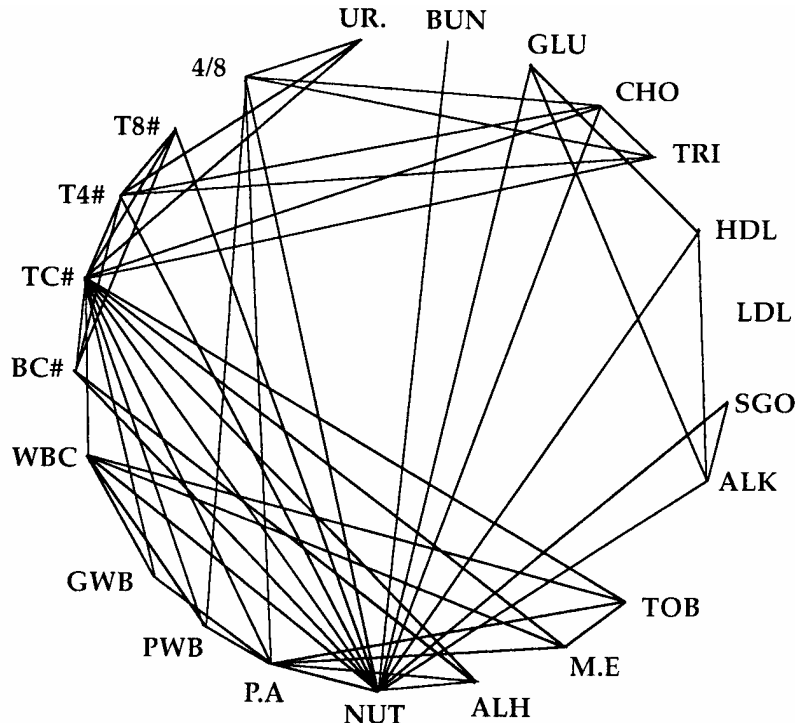
Figure 1b. Balascopic interpretation, Patient #15: 1984. Total abnormal = 54.

CHEMISTRY

UR.	Uric Acid	5.8	MG/DL	(3.0-9.0)
BUN	Urea Nitrogen	13	MG/DL	(6-25)
GLU	Glucose	91	MG/DL	(70-110)
CHO	Cholesterol	212	MG/DL	(100-199)
TRI	Triglycerides	143	MG/DL	(35-200)
HDL	High Density Lipoproteins	45	MG/DL	(30-80)
LDL	Low Density Lipoproteins	139	MG/DL	(50-129)
SGO	Aspartate Amino Transferase	35	MU/DL	(3-45)
ALK	Alkaline Phosphatase	99	MU/DL	(30-128)

IMMUNOLOGY

WBC	White Blood Cells (x1,000)	5.3	K/UL	(3.0-10.0)
BC#	Total B Cells	155	#/CUMM	(100-600)
TC#	Total T Cells	721	#/CUMM	(800-2200)
T4#	Helper/Inducer T Cells	438	#/CUMM	(>400)
T8#	Supp./Cytotoxic T Cells	412	#/CUMM	(250-750)
4/8	T4#/T8# Ratio	1.06	Ratio	(>0.90)

BEHAVIOR

TOB	Tobacco	100		Danger Zone
M.E	Medical Events	57		(0-33)
ALH	Alcohol	86		
NUT	Nutrition	90	}	Risk Zone
P.A	Physical Activity/Exercise	100		(34-67)
PWB	Psychological Well-being	81		
GWB	General Well-being	70		Healthy Zone
				(68-100)

Figure 2a. 22 Parameters -patient #15: 1986.
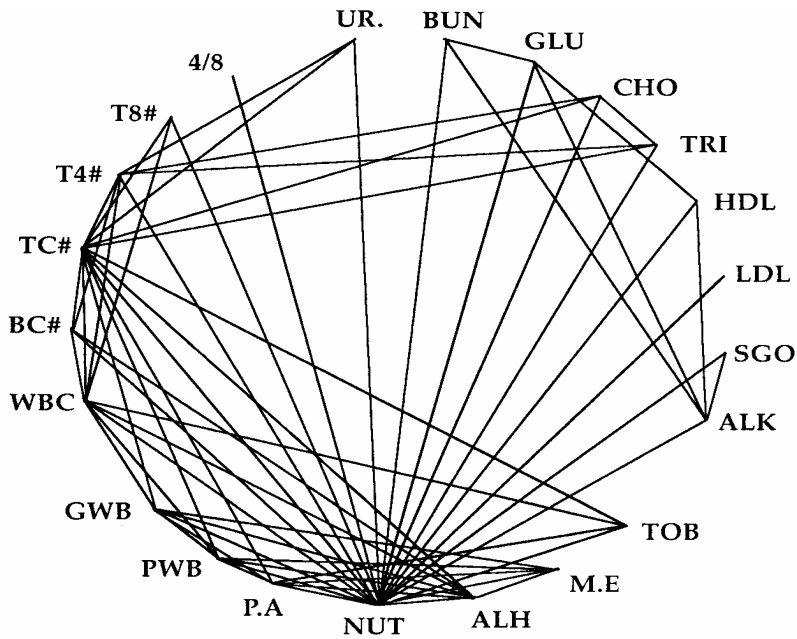
Figure 2b. Balascopic interpretation, Patient #15: 1986. Total abnormal = 63.

CHEMISTRY

UR.	Uric Acid	3.5	MG/DL	(3.0-9.0)
BUN	Urea Nitrogen	16	MG/DL	(6-25)
GLU	Glucose	88	MG/DL	(70-110)
CHO	Cholesterol	149	MG/DL	(100-199)
TRI	Triglycerides	61	MG/DL	(35-200)
HDL	High Density Lipoproteins	40	MG/DL	(30-80)
LDL	Low Density Lipoproteins	97	MG/DL	(50-129)
SGO	Aspartate Amino Transferase	24	MU/DL	(3-45)
ALK	Alkaline Phosphatase	109	MU/DL	(30-128)

IMMUNOLOGY

WBC	White Blood Cells (x1,000)	4.2	K/UL	(3.0-10.0)
BC#	Total B Cells	228	#/CUMM	(100-600)
TC#	Total T Cells	888	#/CUMM	(800-2200)
T4#	Helper/Inducer T Cells	420	#/CUMM	(>400)
T8#	Supp./Cytotoxic T Cells	444	#/CUMM	(250-750)
4/8	T4#/T8# Ratio	0.94	Ratio	(>0.90)

BEHAVIOR

TOB	Tobacco	100	Danger Zone
M.E	Medical Events	77	(0-33)
ALH	Alcohol	90	
NUT	Nutrition	100	
P.A	Physical Activity/Exercise	100	Risk Zone
PWB	Psychological Well-being	93	(34-67)
GWB	General Well-being	85	

Healthy Zone (68-100)

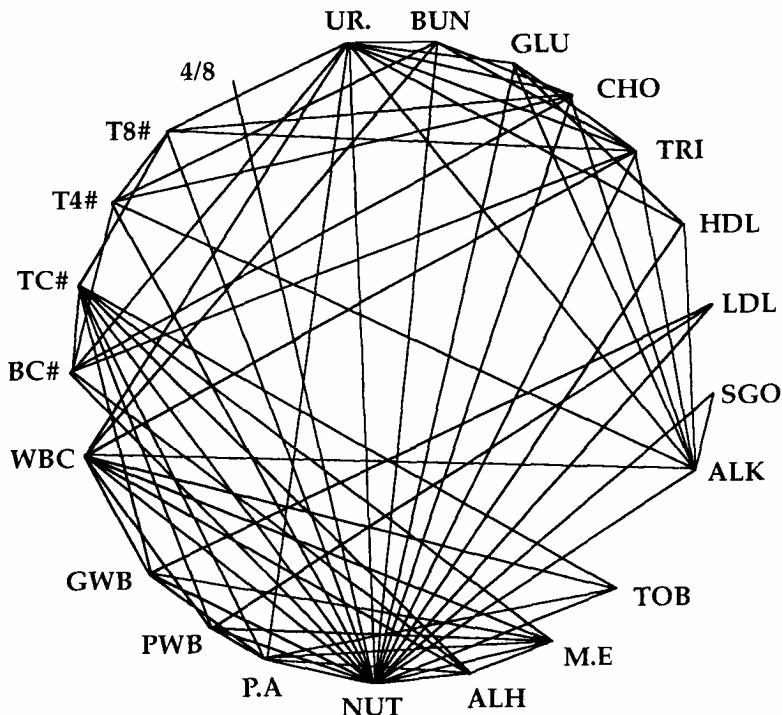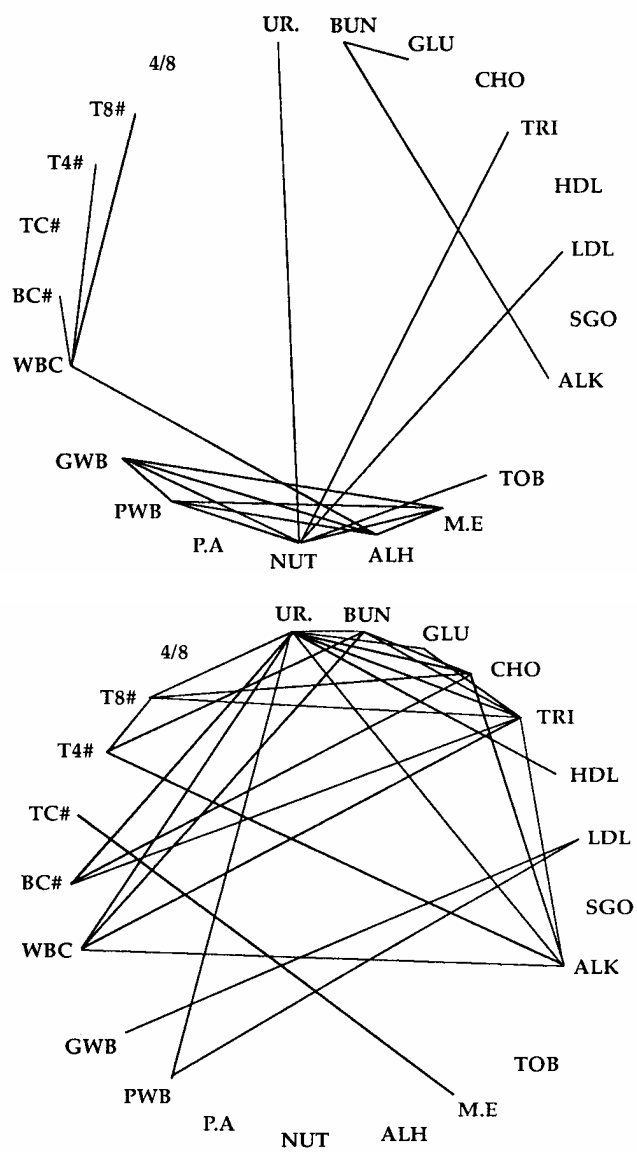**Figure 3a. 22 Parameters-patient #15: 1991.**

Figure 3b, Balascopic interpretation, Patient #15: 1991. Total abnormal = 76.

Figure 4. Balascopic patterns:
Total new abnormal relationships. Between 1984 and 1986, new abnormalities= 18;
between 1986 and 1991, new abnormalities = 27.

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