SUBOPTIMAL HEALTH AND CARDIOVASCULAR RISK: QUESTIONNAIRE-BASED ASSESSMENT USING SHSQ-25 AND SF-36

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ABSTRACT

Background. Suboptimal health is considered an intermediate state between complete health and the early manifestations of chronic diseases. Its detection at the preclinical stage is important for the prevention of cardiovascular disorders and other chronic pathologies.

Aim. To systematize and analyze subjective health indicators in apparently healthy individuals and determine their relationship with cardiovascular risk factors using the SHSQ-25 and SF-36 questionnaires.

Materials and Methods. A total of 509 individuals aged [34.31±13.79] years were examined. The SHSQ-25 and SF-36 questionnaires were used to assess suboptimal health status and quality of life. Body mass index, blood pressure, glucose and total cholesterol levels, smoking index, and endothelial function were measured using computer photoplethysmography. Multifactorial discriminant analysis was applied for health status classification, and mathematical models were developed to assess the risk of arterial hypertension. Statistical analysis included descriptive statistics, correlation analysis, and group comparisons based on different levels of risk factors. The research was conducted as a private initiative of the authors, did not receive funding from grant programs, and the research topic was not officially registered in the state register of scientific topics.

Research Ethics. The study was conducted in accordance with the ethical standards of the World Medical Association's Declaration of Helsinki (1964–2024) and European Community Directive 86/609 on the participation of humans in biomedical research.

Results. In the examined individuals, five health status clusters were identified: optimal health status, suboptimal health with low risk factors, suboptimal health with high risk factors, cardiovascular phenotype of suboptimal health with low risk factors, and cardiovascular phenotype of suboptimal health with high risk factors. Subjective health assessments obtained using the SHSQ-25 showed significant correlations with blood pressure (systolic and diastolic), endothelial function indicators, body mass index, total cholesterol, and glucose levels. High SHS scores were associated with reduced quality of life according to SF-36, particularly in the physical and mental health components, confirming the impact of suboptimal health on daily activity and psychological well-being.

Conclusions. The SHSQ-25 and SF-36 questionnaires are effective primary screening tools for identifying individuals with suboptimal health and increased risk of cardiovascular disorders. Their use in the clinical practice of physical therapists and occupational therapists allows timely identification of at-risk groups and planning of preventive or rehabilitative measures. Health status mathematical modeling improves the accuracy of risk assessment and can be integrated into the physiotherapy program.

Keywords: *physical therapy and rehabilitation, subjective health, cardiovascular risk factors, quality of life, chronic disease prevention.*

Introduction

Assessment of the CardioVascular System (CVS) is a vital step in physical and occupational therapy because it reflects the body's structural and functional reserves and helps determine the appropriate load for the patient [1–3]. Establishing a rehabilitation diagnosis is complicated because impairments are multifactorial, requiring the integration of data based on the International Classification of Functioning, Disability, and Health (ICF) [4; 5].

A modern, thorough patient evaluation includes standard clinical procedures such as medical history, symptom assessment, instrumental tests, and analysis of how impairments affect daily life, and also necessarily considers psychological and social factors, which are crucial for effective rehabilitation. The biopsychosocial model, introduced by Engel, stresses the importance of a holistic approach that goes beyond purely biomedical perspectives [6]. This framework is highly relevant to current rehabilitation practices.

A study by Oostendorp R.A. et al. showed that physical therapists tend to focus more on somatic factors, while psychological and social aspects are often less addressed, emphasizing the need for a more comprehensive history-taking approach [7]. Psychosocial factors, such as fear of movement, coping strategies, emotional state, and expectations for recovery, are remarkably influential on rehabilitation outcomes, especially in musculoskeletal injuries [8]. A comprehensive patient assessment involves taking a medical history, evaluating complaints, conducting clinical and instrumental examinations, and assessing how impairments affect daily activities. Modern approaches highlight the importance of considering not only physical deficits but also psychological and social dimensions, which significantly improve the effectiveness of rehabilitation programs [9].

Quality of Life (QoL) questionnaires, like Medical Outcomes Study 36-Item Short Form Health Survey (SF-36) and Suboptimal Health Status Questionnaire-25 (SHSQ-25), systematically assess the effectiveness of physical and occupational therapy by capturing physical, psychological, and social aspects of functioning. The SF-36 is a widely used generic questionnaire covering eight domains, such as physical functioning, pain, social functioning, and mental health, and provides two composite scores: physical and mental [10]. Its reliability, validity, and sensitivity to change are well documented across diverse clinical and general populations [11, 12]. The SHSQ-25 is a self-report tool with 25 items across five areas: fatigue, cardiovascular health, digestion, immunity, and psychosocial well-being [13; 14].

Psychometric testing confirms its reliability and structural validity in different groups, including populations in China, Ghana, and Korea [15; 16]. The SHSQ-25 serves as an effective screening instrument for the early detection of suboptimal health, which is associated with a higher risk of cardiovascular disease [17]. Combining general and specific tools provides a comprehensive CVS assessment in patients, aiding in the design of tailored physical and occupational therapy plans that enhance their effectiveness and improve patients' quality of life.

The **aim** of the study was to comprehensively assess suboptimal health status using the SHSQ-25 and SF-36 questionnaires and to establish its relationship with cardiovascular risks.

Materials and Methods

The study involved 509 individuals (222 men and 287 women) who were receiving treatment at rehabilitation centers and hospital departments in Ivano-Frankivsk, Poltava, Kharkiv, and Mykolaiv. The average age of participants was [34.31±±13.79] years. All individuals who considered themselves cardiologically healthy at the time of examination were included through a continuous sampling method. Exclusion criteria comprised the presence of chronic non-communicable diseases (except for patients with stage I arterial hypertension), comorbid conditions, medication use, and having sought medical care within the last three months.

In the present study, the 36-Item Short Form Health Survey (SF-36, Medical Outcomes Study) was used, which is one of the most widely used generic tools for assessing Health-Related Quality of Life (HRQoL). The questionnaire comes in two versions: the standard and the abbreviated form. The main difference is in the response scale for certain items, but both versions produce similar results. The standard version assesses health status over the past four weeks, while the short form is

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typically used for short-term assessments, usually covering one week [9].

The SF-36 includes 36 items organized into eight domains: physical functioning, role limitations due to physical problems, bodily pain, general health perceptions, vitality, social functioning, role limitations due to emotional problems, and mental health. Each domain is scored from 0 to 100, with higher scores indicating better health status. Additionally, the instrument provides two summary scores: the Physical Component Summary (PCS) and the Mental Component Summary (MCS) [18].

Scores are reported for each of the eight domains and the two composite scores, offering a detailed profile of HRQoL. Higher scores consistently reflect better self-rated health and functioning [19]. The scoring methods and calculation procedures are detailed in *Table 1*.

Values for items 6, 9a, 9d, 9g, 9i, 10, and 11 are reversed scored [4].

The calculation formula is as follows:

$$\text{Score} = \frac{\text{Actual item value} - \text{Minimum possible item value}}{\text{Possible score range}} \times 100 \quad (1).$$

The Suboptimal Health Status Questionnaire-25 (SHSQ-25) is a self-administered tool designed to assess subclinical health issues and early signs of cardiovascular and systemic dysfunction. It includes 25 items divided into five domains: fatigue, cardiovascular health, digestion, immune function, and psycho-emotional well-being (*Table 2*).

Higher total or domain scores indicate more severe suboptimal health, pointing to early functional changes that may come before clinically visible disease. Psychometric studies validate the SHSQ-25's reliability, internal consistency, and construct validity across various populations, supporting its use in screening for suboptimal health in otherwise healthy adults [15; 16].

Each item is rated on a 5-point Likert scale (0–4), where higher scores indicate worse health. Domain scores are calculated by summing responses within each domain, and the total SHSQ-25 score is obtained by adding all domain scores. For comparability and interpretation, scores can be converted to a 0–100 scale using the same formula as the SF-36.

All study participants completed the questionnaires. Some individuals were identified with arterial hypertension and underwent additional examinations for further analysis. The suboptimal health status was assessed in otherwise healthy in-

Table 1. Main principles of calculating the SF-36 scale scores

Scale	Items	Min–Max Value	Possible Score Range
Physical Functioning (PF)	3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, 3j	10–30	20
Role-Physical (RP)	4a, 4b, 4c, 4d	4–8	4
Bodily Pain (BP)	7, 8	2–12	10
General Health (GH)	1, 11a, 11b, 11c, 11d	5–25	20
Vitality (VT)	9a, 9b, 9c, 9d	4–24	20
Social Functioning (SF)	6, 10	2–10	8
Role-Emotional (RE)	5a, 5b, 5c	3–6	3
Mental Health (MH)	9e, 9f, 9g, 9h, 9i	5–30	25

Note: Items refer to the original numbering of the SF-36 questionnaire.

Table 2. Structure and scoring of the SHSQ-25 questionnaire

Domain	Items	Number of Items	Possible Score Range
Fatigue	1–5	5	0–20
Cardiovascular system	6–10	5	0–20
Digestion	11–15	5	0–20
Immune function	16–20	5	0–20
Psycho-emotional status	21–25	5	0–20
Total	1–25	25	0–100

Notes: Each item is rated on a 0–4 Likert scale. Domain scores are summed to obtain total and domain-specific scores, and can be transformed to a 0–100 scale for comparability.

dividuals, and their results were compared with those of participants with risk factors for arterial hypertension and those diagnosed with grade 1 hypertension.

Quality of life was evaluated using the SF-36 questionnaire for participants without hypertension and the SHSQ-25 for broader suboptimal health assessment. Endothelial function and biochemical parameters were examined in apparently healthy individuals, considering their overall health status. An Enzyme-Linked Immunosorbent Assay (ELISA) was performed to measure endothelin-1 levels, confirming endothelial dysfunction in participants with different health conditions. Cluster and discriminant analyses were used to develop a mathematical model for determining individual health status, integrating clinical, biochemical, and questionnaire data.

Study Design and Procedures

Stage 1: All participants completed a detailed questionnaire that included information about sex, age, occupation, and medication use. Based on this data, risk factors for arterial hypertension were assessed, including alcohol intake, smoking, overweight/obesity, sedentary lifestyle, and poor nutrition. Participants with arterial hypertension underwent further tests, including self-monitoring of blood pressure, ElectroCardioGraphy (ECG), EchoCardioGraphy (EchoCG), and Doppler or duplex scanning of the brachiocephalic arteries, as part of the initial and subsequent stages of routine health check-ups.

Stage 2: The suboptimal health status was evaluated in 509 participants, and a comparative analysis was carried out based on the presence of risk factors: healthy individuals without hypertension risk factors (n=200) and those with risk factors (n=288). These groups were also compared with participants diagnosed with grade 1 arterial hypertension (n=21). For SHSQ-25 validation, suboptimal health scores were correlated with the SF-36 quality of life index (n=82, excluding participants with hypertension).

Stage 3: Endothelial function and biochemical parameters (such as low-density lipoproteins and glucose) were measured in 348 apparently healthy individuals. Participants were then divided into two groups based on their total SHSQ-25 score (overall SHS): Group 1: total SHS less than 14 points; Group 2: total SHS of 14 or more points.

These groups' parameters were compared to those of participants with arterial hypertension. To confirm endothelial dysfunction, an Enzyme-Linked Immunosorbent Assay (ELISA) was performed to measure endothelin-1 levels (n=52) in healthy participants from both groups.

Final Stage: Cluster and discriminant analyses were used to create a mathematical model for determining individual health status (n=488, excluding participants with arterial hypertension).

Statistical Methods

Descriptive statistics (mean, standard deviation, median, interquartile range) were used for data analysis. The Shapiro-Wilk test was used to assess the distribution of variables. Quantitative indicators between groups were compared using Student's t-test or the Mann-Whitney U test (based on data distribution), while one-way ANalysis Of VAriance (ANOVA) was used for multiple comparisons. Spearman's correlation analysis evaluated relationships between variables. Cluster analysis identified suboptimal health status phenotypes, and discriminant analysis checked the accuracy of the classification. A p-value less than 0.05 was considered statistically significant. Data analysis was performed using SPSS software, version 26.0 (IBM, USA).

Results

Stage 1 – Questionnaire Survey and Risk Factor Assessment

During the initial phase of the study, several risk factors for arterial hypertension were identified among participants, including smoking, overweight/obesity, high blood cholesterol, unhealthy diet, elevated blood glucose levels, and insufficient physical activity. Analysis of these risk factors showed that nearly one-quarter of participants (71.8%, mostly men) were smokers. The proportion of smokers under 40 was 2.5 times higher than in those over 40. Overweight or obesity was found in one out of every four participants. Nutritional imbalances were present in 56.1% of participants, and 58.6% had insufficient physical activity. Nearly one-third of participants had elevated blood cholesterol, mainly women, with 32% showing total cholesterol levels above 5 mmol/L.

Almost all participants (99.6%) reported experiencing stress of varying levels; however, only a few, mostly office workers (n=6), reported constant stress. Among office workers, 38.5% experienced frequent or constant stress, compared to 48% of manual workers. Significant correlations were found between Blood Pressure (BP) and several variables: smoking index (r=0.36), age (r=0.49), Body Mass Index (BMI) (r=0.47), and Total Cholesterol (TC) (r=0.26), all with $p < 0.05$. No significant differences in BP were observed based on employment type. Two risk factors occurred together in 22.2% of participants, while three risk factors were present in 3.7%, demonstrating the prevalence of risk factors for arterial hypertension. Overall cardiovascular risk was low (<5%) in 96.3% of participants. Only nine male smokers aged 55–60 years were identified with high cardiovascular risk, with estimated probabilities of 7% and 11%, respectively. Grade 1 arterial hypertension was diagnosed in 21 participants.

Stage 2 – Suboptimal Health Status (SHS) Assessment

During the second stage of the study, the SHSQ-25 questionnaire was administered to the study sample (n=509) to determine the Suboptimal Health Status (SHS) score. Additionally, SHS scores were compared among participants with different risk factor profiles for arterial hypertension (Table 3).

The overall Suboptimal Health Status (SHS total) score was [14.34±5.74] points. Significant differences in the total SHS were observed among individuals with overweight or obesity (p=0.026) and among smokers (p=0.03). Correlation analysis revealed associations between the total SHS and total cholesterol (r=0.48, p<0.05), BMI (r=0.25, p<0.05), and BP (r=0.20, p<0.05).

Comparison of SHSQ-25 scores with quality of life indices measured using the SF-36 questionnaire (*Table 4*) demonstrated significant associations. Correlation analysis showed that the overall SHS score was significantly related to several SF-36 domains, including "fatigue", "mental health", "cardiovascular system", "digestive system", and "immune function", as well as to the physical health component (r=–0.65, p<0.05) and the mental health component (r=–0.54, p<0.05).

Among the study participants with a SHS score above 14 points (36.6%, n=30), a significant decrease in quality of life was observed compared to those with an SHS score below 14. Notably, declines were most evident in areas related to the cardiovascular system, role functioning, and mental health. These findings may suggest deviations in suboptimal health linked to impaired emotional well-being.

A comparative analysis of groups, considering the presence of risk factors and hypertension, showed that the total SHS score in patients with hypertension was significantly higher than in individuals without risk factors or with only risk factors (20.67±9.81 points vs. [11.65±5.78] points, p<0.001, and [16.2±6.45] points, p<0.05, respectively). This underscores notable differences in suboptimal health status among individuals with risk factors and hypertension, indicating potential health deviations. Additionally, the hypertension and risk factor groups displayed higher total cholesterol levels, lower High-Density Lipoprotein (HDL) levels, and elevated triglycerides compared to participants without risk factors (*Table 5*).

Table 3. Suboptimal Health Status (SHS) Score

Criteria	Overall Suboptimal Health Score, mean±SD	p
Age 18–40 years (n=304)	13.78±4.96	0.003
Age >40 years (n=205)	15.34±6.82	0.58
Men (n=222)	14.28±6.42	0.58
Women (n=287)	14.00±4.29	0.58
Smokers (n=124)	15.25±6.69	0.03
Non-smokers (n=385)	14.01±5.32	0.03
Office workers (n=374)	14.44±5.90	0.53
Manual workers (n=135)	14.07±5.26	0.53
BMI <25 (n=345)	13.76±5.32	0.026
BMI ≥25 (n=164)	14.93±6.09	0.026

Table 4. Quality of life indices in participants with different Suboptimal Health Statuses (SHS)

SF-36 Questionnaire Domains	Group 1 – total SHS <14, n=52, points	Group 2 – total SHS ≥14, n=30, points	t	p
Physical Health Component	54.29±14.48	29.82±8.46	2.816	0.018
Mental Health Component	45.35±18.87	22.00±7.54	2.740	0.023

Table 5. Comparative analysis of hypertension risk factor markers

Parameter	Individuals without risk factors, n=200	Individuals with risk factors, n=288	Individuals with arterial hypertension, n=21
SBP, mmHg	115.14±12.86	127.95±12.79*	142.14±5.14**
DBP, mmHg	75.51±8.51	79.78±12.28*	86.05±8.0**
BMI, kg/m²	20.74±2.07	26.80±6.72*	26.56±4.1
Glucose, mmol/L	4.52±0.82	5.01±0.87*	4.63±1.86
Total cholesterol, mmol/L	5.38±1.15^	5.95±1.20^	6.28±0.95**
LDL cholesterol, mmol/L	2.85±0.17	3.01±0.37*	3.26±0.12
Triglycerides, mmol/L	1.11±0.57	1.56±0.87	2.21±0.64**

Notes: * – difference between groups 1 and 2, p<0.01; ^ – difference between groups 1 and 2, p<0.05; ** – difference between groups 2 and 3, p<0.05.

Thus, the SHS was linked to risk factors for arterial hypertension. Endothelial dysfunction is seen as a primary mechanism that contributes to the development of cardiovascular diseases [19; 20]. In this study, arterial stiffness and endothelial function were measured using computer photoplethysmography. It was observed that vascular elasticity indicators, such as arterial stiffness and pulse wave velocity, increase with age [21]. Our results confirmed this, showing an age-related decline in endothelial function in both men and women (p<0.05). Smoking also negatively affected vascular elasticity, with endothelial function being lower in smokers compared to non-smokers ([6.4±8.1]% vs. [15.1±9.9]%, p<0.0001). Excess body weight likewise impaired endothelial function: the Full Factor Experiment (FFE) in overweight individuals was [7.8±9.6]%, significantly lower than in normal-weight individuals, who had an FFE of [16.6±8.6]% (p<0.0001).

Correlation analysis revealed an inverse relationship between endothelial function and both blood pressure (r=–0.44, p<0.05) and total cholesterol (r=–0.23, p<0.05). Significant correlations were also found between endothelial function and the overall suboptimal health status (r=–0.52, p<0.05), as well as specific SHSQ-25 domains: fatigue (r=–0.36, p<0.05), mental health (r=–0.29, p<0.05), and cardiovascular system (r=–0.36, p<0.05). Regression analysis further confirmed a strong link between overall suboptimal health status and endothelial function (*Table 6*).

The analysis included the following parameters: overall SHS, Smoking Index (SI), BMI, Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Endothelial Function (FFE), and age. The dependent variable was the overall SHS. The regression analysis revealed the strongest association to be between overall SHS and FFE. Specifically, individuals with higher SHSQ-25 scores (>14 points) had lower endothelial function.

Comparing groups divided by the mean SHS revealed significant differences in the following indicators: FFE ([16.4±8.6]% in Group 1 vs. [6.6±10.5]% in Group 2, p<0.0001), Cardiac Output Index (COI) ([71.7±12.4]% in Group 2 vs.

Table 6. Regression Analysis Results (Dependent Variable: Overall SHS)

Model	Unstandardized Coefficient		Standardized Coefficient	t	p
	B	Std. Error	Beta		
Constant	13.350	6.670	–	2.002	0.046
Smoking Index (SI)	0.034	0.085	0.026	0.398	0.691
BMI	0.139	0.145	0.079	0.958	0.339
Systolic BP (SBP)	0.069	0.054	0.102	1.288	0.199
Diastolic BP (DBP)	–0.040	0.049	0.052	–0.815	0.416
Endothelial Function (FFE)	–0.248	0.068	–0.284	–3.679	0.000
Age	–0.132	0.053	–0.209	–2.491	0.013

[68.1±12.2]% in Group 1, p<0.01), COI² ([59.1±±11.3]% in Group 1 vs. [63.3±10.7]% in Group 2, p<0.001), and Pulse Wave Velocity (PWV²) ([8.2±4.1] m/s in Group 1 vs. [9.3±3.3] m/s in Group 2, p=0.01), indicating higher vascular tone and stiffness in individuals with higher suboptimal health status. FFE significantly differed between groups across all age categories (p<0.001). Participants with arterial hypertension had lower FFE compared to both Group 1 and Group 2 (*Table 7*).

Thus, the group with an overall SHS ≥14 can be considered as representing a transitional stage between health and disease.

Among the primary biochemical markers of endothelial dysfunction, endothelin-1 plays a particularly crucial role. The level of endothelin-1 in Group 2 (overall SHS ≥14) was significantly higher than in Group 1 (overall SHS <14), measuring 4.79 (2.5; 9.13) fmol/mL versus 1.34 (0.94; 1.72) fmol/mL, respectively (Z=5.37, p<0.001). Endothelin-1 demonstrated a significant correlation with FFE (rs=–0.87, p<0.05), overall SHS (rs=0.83, p<0.05), the SHS subscale for "cardiovascular system" (rs=0.74, p<0.05), as well as with age (rs=0.40, p<0.05) and systolic blood pressure (rs=0.34, p<0.05).

The correlation between the SHS and endothelin-1 once again demonstrates the sensitivity of the SHS assessment method in identifying the risk of cardiovascular disease.

To investigate integrative relationships among overall SHS, FFE, and risk factors for arterial hypertension, a multifactorial statistical analysis was performed with the following variables: SHSQ-25 scores (overall and by subscales), SBP, DBP, BMI, smoking index, FFE, total cholesterol, and glucose levels. A cluster analysis was conducted based on these parameters, dividing all participants into five distinct clusters.

The first cluster comprised 114 individuals under 40 years of age (61 men and 53 women). This cluster most commonly exhibited low overall SHS values: [5.6±3.97] points (men – [4.68±3.46] points; women – [6.3±4.21] points). The "cardiovascular system" subscale of SHS also showed low scores: [0.38±1.0] points (men – [0.26±0.8] points; women – [0.47±1.13] points). Individuals in this cluster had normal BMI values ([22.6±±2.66] kg/m²), normal blood pressure ([110.6±±10.6] / [75.3±9.14] mmHg), and no endothelial dysfunction (FFE=[20.66±6.08]%). Glucose ([4.48±±0.67] mmol/L) and cholesterol ([4.7±0.66] mmol/L) levels were within normal ranges. Participants in this cluster can be characterized as "individuals with optimal health status".

The second cluster included 131 individuals (54 men and 77 women). This group also consisted predominantly of young participants under 40 years of age, with a mean age of [23.66±4.45] years (men – [24.7±5.07] years; women – [22.9±3.9] years). However, the overall SHS in this cluster was higher compared to Cluster 1, both for the group as a whole and separately for men and women, measuring [10.5±4.1] points (men – [10.5±4.4] points; women – [10.4±3.68] points). The "cardiovascular system" subscale score was also higher than in Cluster 1, reaching [0.93±1.07] points (men – [1.25±0.9] points; women – [0.74±±1.11] points). BMI ([21.6±2.95] kg/m²) and blood pressure ([109.0±11.3] / [71.1±8.6] mmHg) remained within normal ranges. A moderate decrease in FFE was observed ([17.29±7.77]%),

Table 7. Comparative characteristics of study groups

Parameter	Group 1 (overall SHS <14, n=181)	Group 2 (overall SHS ≥14, n=146)	Hypertensive individuals (n=21)
FFE, %	16.4±8.6*^	6.6±10.5	0.54±7.31
BMI, kg/m²	24.25±4.51*^	25.31±6.34	26.56±4.1
SBP, mmHg	121.19±11.22*	121.48±10.16**	142.14±5.14
DBP, mmHg	78.90±9.42*^	74.29±18.52**	86.05±8.0
Smoking index, pack-years	0 (0; 0.4)^	0 (0; 9.6)	1.13 (0; 20)
Glucose, mmol/L	4.55±0.82	4.86±0.92	4.63±1.86
Total cholesterol, mmol/L	4.87±0.74*^	5.78±1.24	6.28±0.95
Overall SHS	10.04±2.10*^	18.18±4.12**	20.67±9.81

Notes: *– significant difference between Group 2 and hypertensive individuals, p<0.05; ^ – significant difference compared to Group 2, p<0.05; **– differences between Group 2 and individuals with hypertension, p<0.05.

while glucose ([4.7±0.45] mmol/L) and cholesterol ([4.6±1.0] mmol/L) levels were within the reference range. This cluster can be characterized as "suboptimal health status with a low level of risk factors".

The third cluster comprised 102 individuals (36 men and 66 women), with a mean age of [26.0±8.77] years. This cluster was distinguished from the previous two by higher overall SHS values ([16.27±3.75] points). Elevated smoking index ([4.3±15.6] pack-years) and higher total cholesterol levels ([5.1±0.65] mmol/L) were also noted. A significant reduction in FFE was observed ([13.6±6.6]%). This cluster can be described as "suboptimal health status with a high level of risk factors".

The fourth cluster consisted of 89 individuals (46 men and 43 women), predominantly aged 35 years and older, with a mean age of [46.6±10.9] years. The SHS exhibited intermediate values, both for the overall score ([21.6±7.6] points) and for the "cardiovascular system" subscale ([1.1±±1.1] points). Participants in this cluster presented with 1–2 risk factors for arterial hypertension, primarily overweight or prolonged smoking history. BMI in this group was [26.9±4.19] kg/m² (men – [27.26±3.5] kg/m²; women – [26.4±5.06] kg/m²), and the smoking index was [15.6±29.9] pack-years (men – [22.2±32.0] pack-years; women – [6.6±23.2] pack-years). This cluster can be characterized as the "cardiovascular phenotype of suboptimal health with a low level of risk factors".

The fifth cluster included 52 individuals (13 men and 39 women), predominantly aged 40 years and older, with a mean age of [52.03±7.8] years. This group exhibited high overall SHS values ([27.4±5.45] points overall; men – [27.5±5.23] points; women – [27.38±5.6] points), and markedly higher scores on the "cardiovascular system" subscale compared to previous clusters ([3.07±2.01] points). Multiple risk factors for arterial hypertension were identified: smoking (mean smoking index [3.49±6.5] pack-years), overweight/obesity (BMI [31.5±4.8] kg/m²; men – [30.3±2.8] kg/m²; women – [31.9±5.3] kg/m²), and hypercholesterolemia (mean total cholesterol [6.5±1.8] mmol/L; men – [7.27±0.5] mmol/L; women – [6.3±1.1] mmol/L). Endothelial dysfunction was observed, with FFE values of [0.82±±7.4]% overall (men – [–0.15±5.81]%; women – [16±7.88]%), significantly lower than in the first four clusters. This cluster can be defined as the "cardiovascular phenotype of suboptimal health with a high level of risk factors".

Discriminant analysis demonstrated the validity of the chosen classification into five clusters. The results of this analysis enable the development of a mathematical classification model, which may facilitate the early, preclinical detection of functional changes in organs in individuals presenting only with nonspecific complaints that fall within the suboptimal health status spectrum.

This objective was achieved by having participants complete the "Suboptimal Health Status Questionnaire (SHSQ-25)". Risk factors were assessed, including calculation of the smoking index, body mass index, and measurement of arterial blood pressure, as well as determination of blood glucose and total cholesterol levels. Endothelial function was evaluated using computerized photoplethysmography with a reactive hyperemia test, followed by computational processing of the data according to established equations:

1. OHS (Optimal Health Status):

$$OHS = 535.2 \times Sex - 0.8 \times Age - 4.5 \times Fatigue - 22.9 \times PsychStatus + 12.5 \times CVS + 8.2 \times Digestive - 5.8 \times Immune + 6.3 \times SHS\_Sum + 3.2 \times SmokingIndex + 10.6 \times BMI + 2.8 \times SBP + 5.8 \times DBP - 2.5 \times EndothelialFunc + 6.7 \times AI - 4.4 \times AI2 - 0.6 \times SI - 4.7 \times SI2 + 46.3 \times Cholesterol + 22.8 \times Glucose - 28485.5 \quad (2).$$

2. Suboptimal Health Status with Low Risk Factors (SHS-LR):

$$SHS\text{-}LR = 534.2 \times G - 0.9 \times A - 4.9 \times F - 23.2 \times PS + 12.0 \times CVS + 7.7 \times DS - 16.1 \times IS + 6.8 \times TS + 3.2 \times SI + 10.5 \times BMI + 2.8 \times SBP + 5.8 \times DBP - 2.5 \times EF + 6.7 \times PI\ c4.5 \times PI2 - 1.1 \times AS - 4.8 \times AS2 + 47.5 \times TC + 23.2 \times GL - 28364.1 \quad (3).$$

3. SHS-HR (Suboptimal Health Status with High Risk Factors):

$$SHS\text{-}HR = 534.1 \times G - 0.9 \times A - 4.6 \times F - 22.5 \times P + 12.6 \times CV + 8.4 \times D - 15.7 \times IS + 6.7 \times TS + 3.2 \times SI + 10.5 \times BMI + 2.8 \times SBP + 5.8 \times DBP - 2.6 \times EF + 6.8 \times PI - 4.5 \times PI2 - 1.2 \times AS - 4.6 \times AS2 + 47.8 \times Ch + 23.4 \times Glu - 28366.7 \quad (4).$$

4. CV-SHS-LR (Cardiovascular Phenotype of Suboptimal Health with Low Risk Factors):

$$CV\text{-}SHS\text{-}LR = 534.48 \times G - 0.6 \times A - 5.2 \times F - 23.2 \times PSY + 12.1 \times CVS + 7.3 \times DIG - 16.3 \times IMM + 6.9 \times SUM + 3.3 \times SI + 10.9 \times BMI + 2.9 \times SBP + 5.5 \times DBP - 2.6 \times EF + 6.7 \times PI - 4.5 \times PI2 - 1 \times AS - 4.6 \times AS2 + 47.2 \times CHOL + 24.5 \times GLU - 28429.2 \quad (5).$$

5. CV-SHS-HR (Cardiovascular Phenotype of Suboptimal Health with High Risk Factors):

$$CV\text{-}SHS\text{-}HR = 536.3 \times Sex - 0.6 \times Age - 5.3 \times Fatigue - 23.1 \times MentalStatus + 13.3 \times CardioSystem + 7.1 \times DigestiveSystem - 16.6 \times ImmuneSystem + 7.2 \times SHS\_Total + 3.2 \times SmokingIndex + 11.3 \times BMI + 3 \times SystolicBP + 5.8 \times DiastolicBP - 2.9 \times EndothelialFunction + 6.8 \times PW\_Index - 4.6 \times PW\_Index2 - 1.1 \times ArterialStiffness - 4.4 \times ArterialStiffness2 + 49.6 \times Cholesterol + 25.6 \times Glucose - 28672.9 \quad (6).$$

Notes (Parameter Definitions):

OHS – Optimal Health Status.
SHS-LR – Suboptimal Health Status with Low Risk Factors.
SHS-HR – Suboptimal Health Status with High Risk Factors.
CV-SHS-LR – Cardiovascular Phenotype of Suboptimal Health with Low Risk Factors.
CV-SHS-HR – Cardiovascular Phenotype of Suboptimal Health with High Risk Factors.
Sex – sex.
Age – age.
Fatigue – fatigue symptoms.
PsychStatus – psychological status symptoms.
CVS – cardiovascular system symptoms.
Digestive – digestive system symptoms.
Immune – immune system symptoms.
SHS_Sum – total SHS-25 questionnaire score.
SmokingIndex – smoking index (pack-years).
BMI – body mass index.
SBP – systolic blood pressure.
DBP – diastolic blood pressure.
EndothelialFunc – endothelial function.
AI – reflection index of pulse wave.
AI2 – reflection index after pulse wave test.
SI – stiffness index.
SI2 – stiffness index after test.
Cholesterol – total blood cholesterol.
Glucose – blood glucose.

Based on the highest value obtained from the equations, the examined individual will be assigned to one of five clusters: 1) Optimal Health Status (OHS); 2) Suboptimal Health Status with a low level of risk factors (SHS-LR); 3) Suboptimal Health Status with a high level of risk factors (SHS-HR); 4) Cardiovascular phenotype of Suboptimal Health Status with a low level of risk factors (CV-SHS-LR); 5) Cardiovascular phenotype of Suboptimal Health Status with a high level of risk factors (CV-SHS-HR). This proposed approach enables the assessment of both the state of a healthy individual (OHS) and that of an individual with health deviations at the preclinical stage of disease (SHS).

Discussion

The results obtained confirm that subjective health assessment shows strong correlations with risk factors for arterial hypertension and indicators of endothelial function. This aligns with previous studies emphasizing the importance of SHS as an intermediate phase between health and disease, which may serve as an early marker for the development of chronic conditions [13; 15].

Using the SHSQ-25 questionnaire in our study enabled us to identify a close link between subjective complaints, risk factors, and quality of life. Similar findings were reported in international validation studies, demonstrating that the SHSQ-25 has good validity and reproducibility across different populations, including in Saudi Arabia and Ghana [14; 15]. This indicates the method's universality and its potential broad use in clinical practice.

Our study also confirmed that high SHS scores are associated with a reduced quality of life according to SF-36 results, especially in physical and mental health domains. This is consistent with prior research showing correlations between the SHSQ-25 and SF-36 measures in patients with cardiovascular diseases [11; 12]. Therefore, combining these scales can provide a more accurate assessment of patients’ status at the preclinical stage.

It is also important to highlight the identified link between suboptimal health status and traditional cardiovascular risk factors such as excess body weight, blood pressure, and cholesterol levels. Similar associations have been documented in studies involving the Chinese population, demonstrating that SHS is closely connected to cardiovascular risks and may predict their development [17].

Special attention should be given to the observed relationship between endothelial function and risk factors, including smoking, arterial hypertension, and dyslipidemia. This corresponds with existing literature emphasizing endothelial dysfunction as an early marker of cardiovascular problems [19; 20]. Therefore, evaluating endothelial function alongside SHS may improve the prognostic power of screening programs.

The mathematical model developed, which combines clinical, laboratory, and questionnaire data, provides a comprehensive assessment of health status and predictors of arterial hypertension even in practically healthy individuals. Similar multifactorial approaches have been successfully used by other researchers to predict cardiovascular complications [21–23]. This method could serve as a useful tool for primary screening in the general population and can be incorporated into annual preventive health check programs.

Our findings confirm the feasibility of using questionnaires and surveys as tools for initial cardiovascular risk screening in physical and occupational therapy settings [24]. Unlike complex lab or instrumental methods, these tools allow quick data collection regarding a patient's condition, help identify individuals with suboptimal health, and guide further diagnostics and interventions. However, it is crucial to recognize that data collected from questionnaires cannot fully substitute clinical examinations and should be viewed as a complementary approach. Integrating questionnaires into comprehensive rehabilitation programs is also vital.

Recent studies [25; 26] highlight that combining subjective patient assessments with objective biomarkers and functional tests significantly improves the accuracy of predicting cardiovascular event risk. Our results are consistent with this evidence and show that, even in a relatively small sample, meaningful associations between self-rated health and cardiovascular risk factors can be identified.

Consequently, questionnaires have great potential for early detection of at-risk patients in the practice of physical and occupational therapists. Further research with larger samples and multicenter studies will help clarify the diagnostic and prognostic value of these tools and support their integration into standardized medical-rehabilitation protocols.

Conclusions

1. Questionnaire-based assessment proved to be an informative and accessible method for distinguishing between optimal health status and suboptimal health conditions with varying levels of cardiovascular risk factors.

2. The applied cluster approach made it possible to identify five distinct health profiles, which may serve as a basis for differentiated strategies in physical therapy and occupational therapy.

3. The findings suggest that questionnaires can provide valid information on cardiovascular health already at the preclinical stage, thus supporting their use for early detection and preventive interventions.

4. Further integrating questionnaire data with clinical and functional diagnostic methods could improve predictive accuracy and support the development of personalized rehabilitation programs.

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Authors' Contributions

Authors \ Contribution	A	B	C	D	E	F
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Golovchenko I.V.			+			+
Morozenko D.V.				+		+
Aravitska M.G.				+		+
Shevchenko A.S.			+		+	+
Pertsev D.P.				+		+
Cherkova N.V.			+			+
Dushik L.N.				+		+

Notes: A – concept; B – design; C – data collection; D – statistical processing and interpretation of data;
E – writing or critical editing of the article;
F – approval of the final version for publication and agreement to be responsible for all aspects of the work.

Declarations

Conflict of interest is absent.

All authors have given their consent to the publication of the article, to the processing and publication of their personal data.

The authors of the manuscript state that in the process of conducting research, preparing, and editing this manuscript, they did not use any generative AI tools or services to perform any of the tasks listed in the Generative AI Delegation Taxonomy (GAIDeT, 2025). All stages of work (from the development of the research concept to the final editing) were carried out without the involvement of generative artificial intelligence, exclusively by the authors.

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