Stress and stress responses are issues of top research priority worldwide. Stress-inducing factors include not only large-scale natural and anthropogenic catastrophes, social and political perturbations, and major personal material or psychological losses. Quite ordinary life events or situations, such as academic examinations, can also act as stressors. Tight schedules, difficult syllabi, and chronic time pressure associated with the need to quickly assimilate large amounts of information are usual attributes of education in modern society and may lead to nervous breakdowns and maladaptive coping [1–3].

During examinations, as in any other situations bringing into play the adaptive mechanisms of the body, a range of physiological, autonomic, somatic, and psychological manifestations of stress are observed. The tonic action of stress on the homeostatic systems of the body upsets the harmony of intrasystem and inter-system relationships, causing them to deviate from the norm and even to develop into autonomic dysfunctions. It is generally accepted that adaptation to the emotional stress factor proceeds through an interaction of the sympathetic and parasympathetic divisions of the autonomic nervous system [4, 5]. Cardiovascular changes are an integral component of the general stress response. The most convenient and informative tool for studying the cardiovascular system is time series analysis of heart rate variability. This technique makes it possible to assess the shifts in neurohumoral balance; the relative roles of the sympathetic, parasympathetic, and humoral systems in controlling the heart rate; and the degree of its central regulation [5–7]. The time series of heartbeat intervals embodies information on the sinus node automaticity, processes involved in its control, and the overall level of body adaptation.

The literature data [3, 6, 8, 9] and the results of our previous studies [10–12] are limited to stress-induced alterations in the mechanisms of heart rate control and the psychophysiological characteristics of schoolchildren and college students during scheduled tests. Very few studies have addressed the state of the homeostatic systems of the body in adolescents facing competitive college entrance examinations, although this life event is extremely stressful.

Temperament and some specific personality traits have a bearing on the physiological functions and psych-emotional characteristics of individuals, shaping their behavior in difficult situations, including examinations [2, 6]. Therefore, the goal of this study was to assess the level of strain in the operation of mechanisms regulating the heart rate and the dynamics of psychological parameters in prospective post-secondary students during the period of competitive college entrance examinations.

METHODS

A total of 26 healthy 16- to 17-year-old adolescents of both sexes were studied. To assess the mechanisms of heart rate control, the electrocardiogram (ECG) was recorded in the first standard lead from the sitting subjects and fed directly into an IBM 486 computer for processing. In each ECG, a segment of 100 cardiac cycles was analyzed. Mathematical time series analysis of heart rate variability was performed as described by Baevsky et al. [13], using the Cardio computer program developed at the Laboratory of Mathematical Modeling of the Nervous System, Orbeli Institute of Physiology, National Academy of Sciences of Armenia. This program automatically determined and analyzed the RR intervals, constructing their time series (cardiointervalograms), which were further processed using the mathematical module of the program. This yielded various parameters of the dynamics of RR intervals (statistical estimates, parameters of histograms, autocorrelation functions, and spectral characteristics). Specifically, we determined the distribution mode Mo, or the most frequent RR duration (s), which served as an index of humoral regulation of the heart rate and thereby characterized the activity of the system; the sympathetic activity index called the mode amplitude AMo, which is the percentage of the total number of cardiac cycles in
PECULIARITIES OF THE HEART RATE CONTROL

which the RR duration equals \( \text{Mo} \); the variation range \( \Delta X \) (s), which was the difference between the longest and the shortest RR intervals in the sample under study and served as a parasympathetic activity index; and the coefficient of variation \( \text{CV} \). In addition, the following autonomic indices were calculated: the stress index \( \text{SI} \), defined as \( \frac{\text{AMo}}{2\Delta X \text{Mo}} \), which is informative as a measure of the stress-induced strain in the operation of the compensatory mechanisms of the body and of the activity of the central circuit in the regulation of the heart rate; the autonomic heart rate index \( \text{AHRI} \), defined as \( \frac{1}{\Delta X} \); the autonomic balance index \( \text{ABI} \), defined as \( \frac{\text{AMo}}{\Delta X} \); and the index of regulatory adequacy \( \text{IRA} \), defined as \( \frac{\text{AMo}}{\text{Mo}} \).

The heart rate data were analyzed for their statistical structure by constructing regression curves and scatter plots showing the variance of the RR interval sample under study (“autoregression cloud”). The autocorrelation function was calculated and plotted for each RR time series to reveal the periodicities contained in that series. The autocorrelation function makes it possible to assess how the central circuit of heart rate control affects the peripheral circuit. As the degree of central regulation in heart rate control depends on the individual personality type, psychological tests were computer-administered to the subjects before every ECG recording session. Spielberger’s State–Trait Anxiety Inventory was used to assess the anxiety level of a subject. His or her state was self-assessed using the Well-being–Activity–Mood (WAM) test. With the Eysenck Personality Inventory, we classified each subject as an extrovert or an introvert and determined the level of his or her neuroticism [14].

The subjects were studied on five occasions: 1.0–1.5 months before their entrance examinations (baseline data); 5–6 days before an examination; 1 day before the examination; 1 day after the examination; and 2.0–2.5 months after the examinations. Note that admissions examinations in Armenian colleges are written and the results of any examination become known thirty hours after its end. This timing determined our experimental schedule.

A total of 26000 cardiac cycles were subjected to statistical analysis. Student’s \( t \)-test was run on an IBM 486 computer.

RESULTS AND DISCUSSION

Testing of the prospective students 1.0–1.5 months before their entrance examinations indicated that 92.9% were extraverts and 7.1%, introverts. In this period, most (78.6%) of the subjects had an average neuroticism score (<12). The anxiety score was between 41.0 and 49.0 (44.36 ± 0.9), at the upper limit of the normal range. The self-rated well-being, activity, and mood (results of the WAM questionnaire) were 4.74 ± 0.19, 4.48 ± 0.19, and 4.94 ± 0.17, respectively, with the scale mean being 4.73 ± 0.15. Statistical analysis of the heart rate data demonstrated their high vari-