Particularities of the changes in young swimmers' body adaptation to the stimuli of physical and mental stress in sports training process (#57290)

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Particularities of the changes in young swimmers' body adaptation to the stimuli of physical and mental stress in sports training process

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Background Identifying the particularities of the modification of young swimmers' body adaptation to physical and mental stress stimuli; determining the biochemical markers importance for assessing the body adaptive changes throughout sports training. **Methods** Six junior athletes of 12 - 16 years old specialized in 100 m in different styles participated in this study, conducted in 4 stages (E1 - basic, E2 – specific, E3 – pre-competitive and E4 – competitive). The investigation of distress occurrence during adaptation to training and competition stimuli was made in 3 levels: mental (perceived stress in training and competitions; competitive anxiety), motor (monitoring the workouts, planning the means on training areas, assessing the anaerobic threshold and calculating the average training speed) and biochemical (level of lactic acid concentration and blood glucose before and after effort - minutes 5 and 15; level of metabolic biochemical parameters, lymphocytes and blood glucose, and also hormonal parameters -norepinephrine, prolactin and cortisol- before and after competition effort– in specialized 100m event). **Results** Quantity results of the mental, motor and biochemical tests were analyzed in groups, while the quality results for each subject in dynamics were analyzed by comparison and correlation, for monitoring objectively the individual response to training and competition stimuli. The psychological tests showed increases and changes in athletes' mental behavior by 40 % at CWT ($p < 0.05$), by 17 % at CPST ($p < 0.05$), average level of stress at SCAT and 75 % of stress in self-confidence at CT ($p < 0.01$). The biochemical tests revealed an ascending dynamics of La accumulated after specific effort, with peaks in period E2 ($p < 0.05$) and decreases in E3 compared to E2 ($p < 0.05$), which reflected an adaptation to the specific effort and an increase in anaerobic capacity. The highlighted values of Glu decrease in pre-effort and increase in minute 5 and 15 post-effort ($p < 0.05$) in E2; as for E3, the values had decreases in pre-effort and post- effort - 5 and 15 min ($p < 0.05$), which highlighted the effort impact on body and ability to recover after effort. Athletes' individual metabolic results were 50 % above the maximum values, mainly post-effort (42 %); the hormonal results were 17 % over maximum values, mainly post-effort (14 %). Spearman's correlative analysis of the induced-stress stimuli during workouts revealed 5 % significant correlations at $p < 0.05$ and 9.1 % strong connections while in competitions there are 4.67 % significant correlations at $p < 0.05$ and 6.4% strong connections. **Conclusion** The research demonstrated that the correlation of the mental and biochemical tests results with the specific motor ones facilitated the correct individualization of effort orientation in training and recovery and contributed to the knowledge of the particularities of young swimmers' body adaptation to training and competition effort.

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Abstract

Background

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Methods

Six junior athletes of 12 - 16 years old specialized in 100 m in different styles participated in this study, conducted in 4 stages (E1 - basic, E2 – specific, E3 – pre-competitive and E4 – competitive). The investigation of distress occurrence during adaptation to training and competition stimuli was made in 3 levels: mental (perceived stress in training and competitions; competitive anxiety), motor (monitoring the workouts, planning the means on training areas, assessing the anaerobic threshold and calculating the average training speed) and biochemical (level of lactic acid concentration and blood glucose before and after effort - minutes 5 and 15; level of metabolic biochemical parameters, lymphocytes and blood glucose, and also hormonal parameters - norepinephrine, prolactin and cortisol- before and after competition effort– in specialized 100m event).

Results

Quantity results of the mental, motor and biochemical tests were analyzed in groups, while the quality results for each subject in dynamics were analyzed by comparison and correlation, for monitoring objectively the individual response to training and competition stimuli. The psychological tests showed increases and changes in athletes' mental behavior by 40 % at CWT ($p < 0.05$), by 17 % at CPST ($p < 0.05$), average level of stress at SCAT and 75 % of stress in self-confidence at CT ($p < 0.01$). The biochemical tests revealed an ascending dynamics of La accumulated after specific effort, with peaks in period E2 ($p < 0.05$) and decreases in E3 compared to E2 ($p < 0.05$), which reflected an adaptation to the specific effort and an increase in anaerobic capacity. The highlighted values of Glu decrease in pre-effort and increase in minute 5 and 15 post-effort ($p < 0.05$) in E2; as for E3, the values had decreases in pre-effort and post-effort - 5 and 15 min ($p < 0.05$), which highlighted the effort impact on body and ability to recover after effort. Athletes' individual metabolic results were 50 % above the maximum values, mainly post-effort (42 %); the hormonal results were 17 % over maximum values, mainly post-effort (14 %). Spearman's correlative analysis of the induced-stress stimuli during workouts revealed 5 % significant correlations at $p < 0.05$ and 9.1 % strong connections while in competitions there are 4.67 % significant correlations at $p < 0.05$ and 6.4% strong connections.

Conclusion

The research demonstrated that the correlation of the mental and biochemical tests results with the specific motor ones facilitated the correct individualization of effort orientation in training and recovery and contributed to the knowledge of the particularities of young swimmers' body adaptation to training and competition effort.

Introduction

The adaptation and permanent readaptation of human body systems to the training stimuli is the functional spring of progress in sports performance, provided that they are optimal individually. Otherwise, the stress makes adaptation impossible, the overtraining occurs leading to performance decrease and the stimuli, which are below the individual ability to adapt, do not produce the expected effects (*Mellalieu et al., 2009; Mihăilescu, 2018*).

The specialists of this field - *Bompa* (2002), *Dragnea & Teodorescu-Mate* (2002), *Platonov (2015), Şalgău* (2005) - state that it is a biological necessity to reach the overcompensation after performing a number of training sessions, because the processes of body adaptation are superior to the ones in the previous training. During the preparatory period, the chronic fatigue syndrome is caused by successive overloaded microcycles, with insufficient recovery periods that influence three major areas: the neuromuscular system, the metabolic system and the neuro-endocrine system. The practice of the modern sports training highlights that the optimization of the sports results achieved by the athletes adapted to intense efforts is determined by the training method based on the relationship between effort-fatigue-stress; this method is the basis of the training. Depending on the sports branch and the sports event, two categories of training sessions are needed: endurance training to improve the aerobic metabolism and sprint training to improve the anaerobic metabolism and strength (*Maglischo, 2003; Şalgău, 2005*). In swimming, the workouts are dominated by the aerobic ergogenesis; the water in the swimming pool imposes a series of adaptive processes. There is a correlation between the anaerobic power and the sports performance regarding the heart rate and respiratory rate, where the connections between them are lower after effort in water, compared to the effort on land. After maximum efforts, changes in different organs and systems such as high systolic blood pressure and low diastolic pressure, decreased blood pH, increased lactic acidemia and weight loss may occur immediately.

Numerous genetic qualities are observed in valuable swimmers: the so-called sense of water, willpower, toughness, motor endurance to stress, ability to overcome unpleasant subjective states, ability to concentrate on the background of fatigue (e.g. *Drăgan, 2002*).

From a psychological point of view, stress can be often confused with emotions that become a source of stress in the interpersonal relationships (*Godoy-Izquierdo et al., 2011*). In general, on the one hand, the stress is the negative side of distress, which causes decreased performances, decreased efficiency and the onset of disease (*Grosu et al., 2015; Ware &Matthay, 2000*); on the other hand, a positive side is described – the eustress which manifests itself as a pleasant, dynamic, stimulating and exciting experience; people feel able to cope successfully with the demands they face and they put themselves in challenging situations that they know how to control. In this case, the stress works for us to improve our achievements (e.g. *Šarotar-Žižek et al., 2013*).

The stress hormone – prolactin increases in acute and rapid stress; at another occurrence of stress, the prolactin decreases or is even refractory. In chronic stress, prolactin is low and cortisone is increased. Stress hormones include: catecholamines, glucocorticoids, growth hormones, prolactin, vasopressin and endogenous opioids (e.g. *Drăgan, 2002*).

The interdisciplinary approach in the fields of sports training theory, swimming, medicine and psychology has made valuable contributions to the identification of the parameters that determine the occurrence of stress and has revealed its relationship with performance capacity both in training and competition (*Anshel, 2001; Smith et al. 2002; Matthews et al., 2005; Salgau et al., 2008; Papadopoulos et al. 2014; Whdan, 2014; Lee et al., 2015; Mrakic-Sposta et al., 2015; Platonov, 2015; Souglis & Travlos, 2015; Vovkanych & Penchuk, 2015*). Thus, *Niemana & Wentz (2019)* describe the influences that physical activity has on the immunity system of the body but also their metabolic aspects; *Carrasco, et al. (2007) and Stroud, et al. (2009)* analyzed the neuroendocrine and cardiovascular responses to stress induced in the course of swimming training sessions and competitions. The authors *Kanaley et al. (2001), Crewther et al. (2013) and Soria et al. (2015)* determined and analyzed the variation of stress hormones during the elementary physical exercises but also in performance sports; they consider that physical exercises of high intensity are a powerful stimulant for cortisol secretion.

However, we have not identified studies that address the use of a complex assessment system able to measure the mental and biochemical parameters relevant in determining the individual reactivity of swimmers to the effort in training and competitions and able to facilitate the correct management of swimmers' individual preparation depending on stress level.

The aim of the research was to identify the particularities of young swimmers' body adaptation to the stimuli of stress produced by the physical and mental efforts in training and competitive activities.

Materials & Methods

Participants

Six athletes aged 12 to 16 years specialized in 100 m event - different styles (3 juniors: 2 boys – butterfly, breaststroke and one girl – backstroke; 3 cadets: one boy – backstroke and 2 girls - crawl), with a swimming experience of more than 6 years, selected from the entire group on performance criterion (they ranked in the top 10 in the finals of the National Swimming Championships. The sportsmen (S) had the height of 162.9±3.78 cm, weight 50.8±4.24 kg, arm span 167.6±4.40 cm and active mass 86.08 ±1.00%. The individual competitive tests included in the competition calendar of the Romanian Swimming and Modern Pentathlon Federation depend on the age category: cadets 12 years (girls and boys) and 13-14 years(boys), 13 years (girls) and juniors 15-16 years (boys) and 14-15 years (girls).

The experimental study was approved by University of Pitesti Ethics Committee for the Doctoral School "Science of Sport and Physical Education" in accordance with the Ethical Standards of the Helsinki Declaration (ecbr5-03-2020). The subjects gave written consent to the study in accordance with the recommendations of the Ethical principles of psychologists *(e.g. Meyer, 1988)* and Biomedical Research Ethics Committees *(e.g. WHO Regional, 2000).* Given their age, the subjects had also a written consent signed by their parents regarding their participation to the research.

Methods

The scientific documentation on the researched matter allowed the presentation of studies from the specialized literature at national and international level, which facilitated the establishment of the research scientific approach and training methodology.

The evaluation of athletes' mental state following up the training and competition stimuli was made by means of four standardized tests taken over from the specialized literature (*Cohen et al., 1988; Levenstein et al., 1993; Lee, 2012; Judge et al., 2016; Britton et al., 2017*).

Two tests were used to measure the perception of stress regarding the stimuli associated to workouts and competitions: Test 1 (TΨ1), Cohen & Williamson Test (CWT, 1988) formed of 14 items with 5 response scales: low level < 25 points; average level 26-50 points; high level > 50 points. Test 2 (TΨ2), Cohen Perceived Stress Test (CPST), formed of 10 items with 5 response scales: low level < 13 points; average level 13-20 points; high level >20 points.

The following tests were given to determine the competition anxiety: Test 3 (TΨ3), Sport Competition Anxiety Test (SCAT) – a questionnaire specific to the competitive activity, which assesses the anxiety and includes 15 items with 3 response scales: low level < 17 points; average level 17-24 points; high level > 24 points (e.g. *Riddick, 1984*). Test 4 (TΨ4), Crăciun Test (CT) specific to the competitive activity, evaluates the competitive anxiety; this test is formed of 9 items with 4 response scales: low level < 4 points; average level 4-8 points; high level >8 points.

The test highlights the cognitive anxiety (questions (Q) - 3, 6, 8), somatic anxiety (Q - 2, 4, 7) and self-confidence (Q – 1, 5, 9) (e.g. *Crăciun, 2012*).

The method of determining the stress level by means of biochemical analyses was applied during workouts, in different periods of preparation, but also in competitions. The biochemical assessment by the technique of blood collecting from the arm was performed in basal period and in the competitive period (before and after effort). Venous blood was collected directly in special vacutainers for each type of analysis. The amount of blood collected for each parameter was: hematological parameters (VSH – 1.6 ml), blood count (2 ml); biochemical parameters (Blood glucose and Total serum cholesterol - 6 ml); hormone/endocrine markers: plasma catecholamines (epinephrine, norepinephrine, dopamine - 4 ml), prolactin and cortisol (6 ml). The amount of blood collected from an athlete before effort was 19.6 ml and the same amount was collected after effort (total amount of 39.2 ml/ athlete). The basal biochemical analyses were performed at the Sante Clinical Laboratory in Pitești (Romania); the analyses during competition were made - on an outpatient basis - at the Olympic Swimming Pool of Pitești and Hunedoara (Romania); the plasma catecholamines were processed at the Cerba laboratory (France). The basal analyses and the analyses during competition determined the metabolic parameters - lymphocytes (%) and blood glucose (mg/dl) – and the endocrine parameters: norepinephrine (mmol/l), prolactin (ng/ml) and cortisol (µg/dl) before the effort made in competition and immediately after effort, in minute 5. These biochemical parameters were selected because they showed changes above normal values after the competition effort *(Soultanakis and Platanou, 2008; Papadopoulos et al., 2014; Zacca et al., 2019).*

To determine the anaerobic capacity in training, the capillary blood test was used for measuring the lactic acid (mmol·L^{-1}) and blood glucose (mmol·L^{-1}) before effort and in minutes 5 and 15 after effort. The athletes swam 8x100 m in the specialized style (motor test - MT1), start at 150 sec, with a break of about 1 min; the competition events were split 2x50 m (MT2), with 5 sec break. The Lactate Pro portable analyzer with Lactate Pro Test Strips was used to determine the lactic acid level in the blood; the blood glucose was determined by means of the portable analyzer Accu-Chek Performa Nano glucometer with Accu-Chek Performa test strips (*Șalgău, 2017; Ferreira et al., 2019; Arsoniadis et al., 2020*). The time in the motor tests was measured with the help of the Professional Timer Stopwatch, Digital Sports Stopwatch with Countdown Timer, 100 Lap Memory, 0.001 Second Timing (water resistant, multi-functional stopwatch for swimming, running, training) (*Maglischo, 1993; Zacca et al., 2019*).

The level of secretion of these hormones was investigated, following the effort and the stimuli of the mental and physical stress in training and competitions, in order to objectively analyze the performance of athletes related to their individualized level of training. (e.g. *Dimitriou et al., 2002*).

Experimental Design

The research was carried out throughout a training macrocycle formed of 4 mesocycles. The basic values of stress perception were measured using the psychological tests 1 and 2 (TΨ1 and TΨ2); biochemical tests were used by collecting metabolic and hormonal venous blood tests at the beginning of the training (T1), after two weeks of holiday. Given that the subjects correspond to the two categories of competitive age (juniors and cadets), the planning of the effort volume was made differently (table 1):

Insert here table 1

- *stage I (E1), basic:* 4 weeks - junior and 5 weeks - cadets. The perception of stress in training was measured at the end of the basic preparatory period (T2), using TΨ1 and TΨ2 tests and biochemical analyses by collecting capillary blood tests (La and Glu) before and after effort in the minutes 5 and 15, in parallel with the motor tests of training 8x100m (B&MT1).
- *stage II (E2), specific:* 3 weeks - junior and 5 weeks - cadets. The perception of stress was measured at the end of the period (T3); biochemical analyses were made by collecting capillary blood tests (La and Glu) before and after effort in the minutes 5 and 15 (B&MT1), in parallel with the motor tests of training 8x100m.
- *stage III (E3), precompetitive* (2 weeks). Capillary blood biochemical analyses (La and Glu) were collected before and after effort in the minutes 5 and 15 (B&MT2), in parallel with the motor tests of training 2x50m.
- *stage IV (E4), competitive* (1 week). Measurement of stress perception (tests 1 and 2) and competitive anxiety (tests 3 and 4) (T4), biochemical analyses were made by collecting venous blood tests (La and Glu) before and after competitive effort in the minutes 5 and 15, 100 m event, the specialized style.

Based on the results of motor tests, biochemical analyses and the physical training model recommended by *Maglischo, (1993),* weekly models and individualized training models were developed per effort zones, at the beginning and the end of the research.

Analysis data

Statistical analysis of the study results was performed using the IBM KyPlot, version 5.0, Data Analysis & Visualization software package (*KyensLab Inc.,* Japan). Descriptive statistics methods were used to calculate the arithmetic mean and the standard error of the mean (SEM). Wilcoxon Signed Rank Test for Paired Data and Friedman Test with Replication were used to compare the means of the parameters studied between tests *(*e.g. *Yoshioka, 2002).* Pearson's correlation coefficient was used to examine relations between variables. Statistical significance was set at $p < 0.05$ (e.g. *de Winter et al., 2016*).

Results

The quantitative results recorded by the subjects during the research are presented, in their dynamics, in the following tables and figures, systematized on the three levels of the research: mental, motor and biochemical, in training and competitions. The qualitative aspects of the results were analyzed at the level of group of subjects (highlighting the common aspects and individual differences of the reactivity of the six subjects) but also at the individual level, interpreting the significance of the dynamics of each monitored indicators.

The dynamics of individual stress perception in training was studied by means of Cohen-Williamson Test (CWT) and Cohen Perceived Stress Test (CPST) and the competition anxiety was assessed using Sport Competition Anxiety Test (SCAT) and Crăciun test, 2012 (CT).

The results of the psychological particularities of stress perception in young swimmers under the influence of stimuli from training and competition are shown in table 2.

Insert here table 2

The results analysis of the stress perceived at CWT presented the distribution of the individual values on a three-level scale related to the low level value. At the beginning of the research at basic level (T1), the athletes recorded a perception of stress 10 % over the low level. The analysis of the dynamics of the individual values at each stage revealed that all athletes had progressive increases of the perceived stress in training by 18% at T2 and significant differences at $p < 0.05$ and by 25% at T3 with insignificant differences $p > 0.05$. At the end of the research, at T4 compared with T1, the athletes showed an increase by 40% in the perception of stress and insignificant differences at $p > 0.05$. Regarding the adaptation of athletes' body to stress stimuli in training and competitions, there are significant differences at $p < 0.05$, which confirms the effectiveness of planning the effort parameters in training.

The dynamics of the perception of the individual stress in training was made with the help of CPST. The distribution of the individual values was achieved on a three-level scale. When the research started (T1), the athletes presented o perception of the stress by 13 % up to the average level of stress. The dynamics of the individual values at each stage showed that all athletes have progressive increases of stress perception in training sessions by 6% in T2 and insignificant differences at $p > 0.05$ and by 13% in T3 with insignificant differences $p > 0.05$. At research ending, the athletes presented – in T4 compared with T1 - an increase by 17% of the perceived stress and insignificant differences at $p > 0.05$. It refers to the concerns and feelings of the last month regarding the passing of the middle school graduation national exam. As for the athletes' body adaptation to the stimuli of stress in workouts and competitions, significant differences are observed at $p < 0.05$, which validates the proper management of effort parameters in training.

The assessment of the competitive anxiety was performed by using SCAT and CT (*Crăciun, 2012*), in the Junior National Championships, approximately one hour after the end of the event. The analysis of the results regarding the perceived stress in competition (SCAT) showed the distribution of the individual values on a three-level scale. The competitive anxiety values reveal an average level of anxiety. Comparing the individual results, it was observed that 2 athletes had low values of anxiety, other 2 athletes had a medium level and the other two – high anxiety.

The CT test was used as a basis for improving and detailing the criteria of assessment of the modern diagnosis regarding the competitive anxiety. Detailing the anxiety assessment scale in three levels, at each criterion, made possible a more in-depth knowledge of the competitive anxiety of young swimmers. The results of the analysis highlighted a competitive anxiety increased by 75 % at self-confidence, medium level - the cognitive one increased by 71% and the less affected by the competition was the somatic anxiety with 54%, at the low level. The comparative analysis between the indicators of SCAT and CT tests reveals significant differences at $p < 0.05$ and $p < 0.01$ within the tests. The correlation of the individual values between the test indicators shows that at the low level of anxiety SCAT corresponds more to the self-confidence sphere, at medium level to the cognitive and somatic sphere; at high level –to the cognitive sphere (e.g. Woodman and Hardy, 2003). These strong connections show the influence of the competitive stress stimuli on the adaptation of athletes' body (e.g. *Butt et al., 2003; Blásquez et al., 2009.*).

Figure 1 presents the volume of training means per effort zones of the young swimmers at the beginning (initial) and the end (final) of the research in the specific period. The comparative analysis highlights the motor particularities related to the content of the individual training plans. It was noticed the decrease of the volume by 5-6 % except for the cadet athletes specialized in crawl style who had a volume of 26% of warm up at the beginning of the research and 6% at the end of the research. In the research final part, it was found out that 11-13 % technique exercises (TE) for backstroke swimmers and 6% for crawl style were included in the content of the training means; these exercises were not necessary for the butterfly and breaststroke swimmers, given the style characteristics. The workouts for legs were increased by 1-3 %; the increase for the cadet athletes in final period was by 21 %, although they did not have these workouts initially. The means of relaxation had 6 % in both stages, with small changes by ± 1-3 % at the end.

Insert here figure 1

Concerning the distribution of the specific volume per effort zones in training, it was observed that the backstroke style swimmers (IM and MR) were specialized in the medium and long events (400 m and 800 m crawl and 200 m backstroke). At the beginning of the research, the athlete IM (junior) worked with 65% of the training volume, namely 12 % on S2 zone (lactate production) and 53% on R1 zone (basic endurance) with a decrease of 10 % at the end (S2 – 25 % and R1 – 31 %). The athlete MR (cadet) worked 62 % initially, with 31% on R1 and R2 zones (threshold resistance) and a decrease of 6 % at the end (R1 and R2 – 28%) (fig. 1a and b). The junior athletes (PA - butterfly and CD - breaststroke) were specialized in 100 m and 200 m events. Both athletes worked with 66 % of the training volume at the beginning and the end of the research, namely with 23 % on R1 and 43 % on R2 at the beginning and 29% on R1 and 37 % on R2 at the end (fig. 1c). The cadets (PAJ and BK) were specialized in the 50 m, 100 m, 200 m events - crawl and backstroke. Both athletes worked with 68 % of the training volume at the beginning of the research, namely 3 % on S1 (lactate tolerance), 13 % on S2 and 52 % on R1; at the end their decrease was by 7 %, namely 12 % on S1, 25 % on S2 and 24 % on R1 (fig. 1d). (e.g.*Maglischo, 1993*).

The results achieved by athletes in the motor tests that included standardized training exercises are shown in table no 3.

Insert hear table 3

The lactic acid (La) and blood glucose (Glu) were the metabolic biochemical indicators monitored during training sessions in order to highlight the relationship between effort- fatigue - recovery. The blood tests were collected in three distinct moments (pre -effort, 5 min post-effort and 15 min post-effort) in the stages of basic training (E1), specific training (E2) and pre-competitive one (E3). The anaerobic capacity was monitored by the value of La (lactate). At the level of the group, an ascending dynamics of the La accumulated following the specific effort was observed, with peaks in E2 period, when both volume and intensity of the effort were high.

In this period, it was programmed to increase the resistance to La accumulations, in pre-effort by 0.04 mmol·L^{-1}, after 5 min post-effort by 3.8 mmol·L^{-1} and after 15 min post-effort by 2.63 mmol·L^{-1} ($p < 0.01$). In E3 there are decreases compared to E2, which reflects an adaptation to the specific effort, an increase of the anaerobic capacity by 0.09 mmol·L^{-1} in pre-effort, by 1.48 mmol·L^{-1} after 5 min post-effort and by 1.11 mmol·L^{-1} ($p < 0.01$) at 15 min post-effort. The values of Glu showed the following values in E2: decreases by 2 mmol·L^{-1} in pre-effort, increases by 21.2 mmol·L^{-1} in 5 min post-effort and by 11.3 mmol·L^{-1} in 15 min post-effort ($p < 0.05$). There are also decreases in E3 by 5.83 mmol·L^{-1} in pre-effort, by 19.2 mmol·L^{-1} in 5 min post- effort and by 12.8 mmol·L^{-1} in 15 min post-effort, which showed the impact of the effort on the body and on the ability to recover after effort ($p < 0.05$). The results of the training speed calculations highlight the increase by 0.03 m·s^{-1} (1.24 sec) at the 8x100m fitness test between E1 and E2 and by 0.16 m·s^{-1} (7.29 sec) at 2x50m test in E3. The performances of the motor tests (fitness tests) were compared to the biochemical parameters, which allowed on the one hand the recording of the biochemical reactivity to the specific effort, respectively the adaptation of the body to effort, and on the other hand the establishment of the aerobic threshold speed and the calculation of the individualized training speeds in order to optimize the performance capacity from one training period to another.

The results of the metabolic and hormonal biochemical indicators during competition are listed in table no 4. The analysis was based on the premise that any disturbance in hormones functioning causes the diminution of energy efficiency and the decrease of body resistance to stress, which has a negative impact on the elite athletes. The metabolic and hormonal parameters were investigated in basal period (T1), depending on effort (pre and post-effort) (T4) and mental stress of the competition for analyzing objectively the efficiency of athletes in relation to their individualized training level.

Insert hear table 4

The comparative analysis of the metabolic biochemical parameters in Lymphocytes (%) highlights an increase by 4% in pre-effort and by 13% post-effort ($p > 0.05$). In terms of Glu (mg/dl), the parameters in basal stage and in pre-effort are within the normal reference limits; the glucose concentration in post-effort increases by 35% related to the basal level ($p < 0.05$). Regarding the hormonal biochemical indicators in Norepinephrine (mmol/l), both in basal and pre-effort period, they have normal values with a decrease by 46% related to the basal stage and an increase by 93% over the normal reference limit in post-effort ($p < 0.01$). The Prolactin hormone shows an increase by 37% in pre-effort and by 117% in post-effort; all measured values are within the normal reference limits ($p < 0.05$); the Cortisol hormone (µg/dl) has a decrease by 12% in pre-effort and an increase by 27% in post-effort ($p < 0.05$).

The individual results of the athletes showed that 50% of the metabolic results are above the maximum values at the 2 indicators, mainly post-effort (42%), which determined an individualized carbohydrate recovery and a new approach to effort and recovery, through changes in training intensities, in line with the demands of the competition, associated with intensifications of the post-effort recovery meant to reduce the risk of exceeding the maximum values. The individual results of the athletes showed that 17 % of the hormonal results are over the maximum values at the 3 indicators, mainly post-effort (14%). This fact determined the rethinking of the training based on the premise that the effect of the stress on the brain depend on the stress hormones (cortisol, catecholamines, prolactin), which have the ability to cross the blood-brain barrier and impair the cognitive processes: attention, memory, decision making. The results of the correlation between the anthropometric, metabolic, biochemical, mental and motor indicators in training are shown in table no 5.

Insert hear table 5

Spearman's correlative analysis of the stimuli of the stress induced in training sessions highlighted 5 % significant correlations at $p < 0.05$ as follows: at E1 - body mass with V.A. and TΨ2 with Glu (post-effort, 5 min); at E2 - MT1 with Glu (pre-effort) and TΨ1 with La (post-effort) at 5 and 15 min. Regarding the association of the correlation degree between variables at each tested stage, it is observed that 99 correlations were made, in which 80.8% have poor connections (37.4%), moderate connections (34.3%) and strong ones (9.1%). Thus, we find out that there is an interdependent relationship between the correlated variables determined in the training sessions and the efficiency of the implemented technology. At the level of the individual values analyzed by us, the correlations of this type determined the correct management of the effort for the permanent adaptation and readaptation of the athletes in various periods of training.

Insert hear table 6

Regarding the Spearman's correlative analysis of the competition-induced stress (table 6), a percentage of 4.67 % significant correlations were highlighted at $p < 0.05$, in E4: TΨ3 with TΨ4(A) and TΨ1 with Norep. (basal); between Glu in pre-effort with Glu (basal); between Norep. with TΨ4 (C) and the performance in competition; Cortisol with Limf. (basal); between Limf. post-effort with Prolac. (basal) and Limf. post-effort with Limf (basal). As for the association of the correlation degree between the competitive stress perception variables, the result of the competition performance and the biochemical parameters in basal, pre-effort and post effort stages, one can notice that 171 correlations were made, out of which 70.2% have poor connections (43.3%), moderate (20.5%) and strong ones (6.4%). From the perspective of the effort-fatigue-recovery relationship, the significant correlations highlight the interdependence between the mental and physiological stress in competition and the biochemical data of the hormonal and metabolic parameters, justifying their use to determine the physiological stress induced by the competition set as a goal; thus objective premises are created for the individualization of the post-competitive recovery (e.g. *Smith, 2007*).

Discussion

One of the fundamental problems of the contemporary training is the monitoring and modeling of the training process, in all aspects, especially at the level of high performance. The importance of athletes' complex evaluation and training process increases along with their level of performance (*Dormehl et al., 2016; Nicolas et al., 2019*). The main indicators of monitoring the young swimmers' training, which highlighted the particularities of the changes in body adaptation to stress stimuli in workouts and competitions, were the individualized planning of their effort volume in training macrocycle and the mental, motor and biochemical tests. The interdisciplinary approach to the quantitative results of the mental, motor and biochemical tests of each subject led to a qualitative analysis in dynamics, by comparison and correlation of the tests; their values were the benchmarks of the objective monitoring of the individual response to training and competition stimuli. Thus, based on them, the individualized training was oriented and the ameliorative interventions were carried out in the training plan.

The built and used methodology proposes 4 mental tests given depending on the particularities of different training periods, two categories of biochemical indicators - metabolic (25) and hormonal (5) - and motor tests specific to different training periods in order to highlight the level of stress recorded by athletes in a training macrocycle.

An important feature in the evaluation of stress was the evaluation of the mental state following the stimuli from training and competition (*Cohen et al., 1988; Crăciun, 2012; Ebstrup et al., 2011; Godoy-Izquierdo et al., 2011; Lee, 2012; Levenstein et al., 1993; Nikseresht et al., 2017; Polman et al., 2007; Riddick, 1984; Stroud et al., 2009*), but also the avoidance of stress occurrence (*Grosu et al., 2015; Iurea & Safta, 2018; Ware & Matthay, 2000*).

An important indicator in the physical effort orientation in training was the distribution of the specific volume on effort zones in different periods of training, depending on the results of the mental, motor and biochemical tests and on the observation protocols performed. Thus, corrections were made to the training plan for each athlete, at motor, biochemical and mental level. For example, in the case of the athlete MR (butterfly style) with low lactic acid level (5.3 mmoli/l in the preparatory period) and good results obtained, a well-developed aerobic system was reached. Because high values of lactic acid of 10.3 mmol/l were recorded after the motor tests performed during the specific training period and a value of 10.9 mmol/l in the pre-competitive period, the swimming was performed in effort zones of low intensities with short breaks (aerobic effort) but using mainly the backstroke style. On the basis of the notes included in the observation protocol, two weekly training sessions on Ergosim Conditions Simulator were introduced to correct errors because technical ones were identified in the movement of arms in backstroke style. At mental level, psychological counseling was introduced once a week because the athletes manifested average values of stress caused both by family problems and demands of the specific and competitive training. In order to be able to restore energy reserves, the glucose values were measured after effort because the athlete may also have decreases in the reserves of glycogen (which produces energy); so, if necessary, a hyperglycemic diet was recommended to the athletes.

According to the individual results of the biochemical indicators, the distribution of the 6 effort zones in the weekly training plan was made as follows: R2 and R3 training zones were planned so that the swimmers have 34-56 hours for recovery before using again the same zones. A series of S1 (lactate tolerance) and 2 series of S2 (lactate production) were placed at least 24 hours of recovery after the Resistance series R2 and R3. The S3 (Power) was positioned before the training day in the R2 effort zone so that enough glycogen could be found in the muscles to support the fast swimming speed (e.g. *Maglischo, 1993*).

While carrying out the research, it was taken into account the observance of the four fatigue stages as presented in the vision of the physiologist Ulmeanu FC, (1967): oscillating fatigue (incomplete recovery), harmonious fatigue (specific to athletes), discordant fatigue (physical and mental fatigue), pathological fatigue (exhaustion) (e.g. *Sargent et al., 2014*). In the experimental methodological approach regarding the optimization of sports performance, it was taken into consideration the observance of the four phases of overcompensation as presented in the specialized literature (e.g. *Bompa, 2002*).
The results of the mental tests were in a functional relationship with the biochemical ones, which showed large accumulations of lactic acid in the specific period and decreases in the pre-competitive period. The dynamics of the lactic acid levels along different periods reflected the functional stress, corresponding to mental one. Regardless of the type/nature of the test used (motor, mental or biochemical one) similar validity criteria must be ensured, so that the test provides useful and associative information on the current or future performances (*Mihăilescu & Dubiț, 2015; Smith et al., 2002; Rodríguez-Zamora et al., 2012; Whdan N. 2014*).
Performing an effective endurance training requires an exact monitoring of the changes in the aerobic and anaerobic capacity, as well as a careful evaluation of the training speeds by means of some biochemical blood tests. The blood tests can be used to improve the training in four ways: establishing the training speeds, recording the training progress, diagnosing the weaknesses of the training programs and comparing the potential of an athlete with that of another athlete to achieve high performances. The training volume in swimming is usually very large compared to the relatively short competition time. The training at high intensity intervals has been shown to improve the performance in a rather brief period (*Sperlich et al., 2010; Arsoniadis et al., 2017*; *Șalgău, 2017; Moser et al., 2020*).
The anaerobic threshold tests measure the concentration of lactic acid in timed repetitions series, swiming at progressive speeds. The lactate concentration depending on the swimming speed shows the results of one of the most used blood tests (*Bitang and Dulceanu, 2014; Nikitakis et al., 2019; Arsoniadis et al., 2020*).
In terms of results of the metabolic parameters determined in this period, they reflected the same trend. After effort, the blood glucose had the highest values in the pre-competitive period and the lowest values in the specific training period. In dynamics, the glucose had lower values after effort in all three training periods, which meant that the athletes needed reserves of carbohydrates. In the minute 15 after effort, the values of blood glucose did not return to the values recorded before effort; the glycogen restoration was difficult. Training and recovery were reoriented to achieve an optimum performance (*Soultanakis & Platanou, 2008*; *Bădescu and Galeru, 2009; Afshari et al., 2014; Souglis & Travlos, 2015*; *Jones, et al., 2018*).
Physical effort with an intensity over 80% can increase blood glucose level by discharging epinephrine (adrenaline), which causes the elimination of glucose from the liver. The results of the biochemical tests in workouts in parallel with the motor tests performances show that swimming training causes increases of blood glucose due to the intense efforts and stress to which the body is subjected. As for the results of the hormonal parameters determined before the

competitive effort, they have lower values than the ones recorded in basal conditions for noreprinephrine but after the effort made in competition they increased, which showed that stress and intense effort cause increases in norepinephrine, without exceeding the normal values. Prolactin increased compared with baseline conditions and before or after competition, without going beyond normal maximum values. As for cortisol, before the competitive effort the subjects had lower values of cortisol than the ones recorded in baseline conditions; after the effort made in competition, there were increases without exceeding the values recorded in basal conditions,which highlights the fact that the stress and intense effort led to increases in this indicator (*Caracsso et al., 2007; Crewther et al., 2013; Kanaley et al., 2001; Soria et al., 2015*).

The dynamics of the motor tests and competition results confirm the correctness of the methodological orientation of the effort based on the results of the biochemical and mental tests of the elaborated methodology (*Maglischo, 1993; Smith et al., 2002*). That is why the results of each subject were analyzed in dynamics from the first up to the last test, correlating the results of the 3 planes (mental, motor and biochemical) and the anthropometric parameters measured in workouts, highlighting 5 % significant correlations at $p < 0.05$. Correlations were also made in which there were 4.7% significant connections at $p < 0.05$ between competitive anxiety, performances in competition and the metabolic and hormonal biochemical indicators (*Crăciun, 2012; Parnabas et al., 2015; Kalinin et al., 2019*).

The methodology used at this age and in this sport, at the level of the individual values, was validated on the basis of the quantitative and qualitative analysis of the research results, opening opportunity windows for larger studies conducted nationally and internationally on swimming and other sport branches too.

Conclusions

The research results enable us to state that at least at the level of the individual values analyzed, creating and using an interdisciplinary monitoring/investigation algorithm can facilitate the measurement and objective assessment of swimmers' individual reactivity to effort in training and competitions. The effort in training and competition, depending on characteristics, determines the occurrence of mental and physiological stress.

Monitoring the training and establishing the swimming speeds, consistent with the individual physiological impact and the psychological profile of the athlete, can optimize the management of the training process in accordance with the specific character of the event, the preparation period and the training level of the swimmers.

Swimming training sessions cause an increase in blood glucose as a result of the intense efforts and stress to which the body is submitted, stress induced by the training and competition stimuli on the one hand and by the environment in which specific training sessions and competitions take place on the other hand. The swimming competition induces the release of norepinephrine, prolactin and cortisol following the physical and mental stress to which the body of the swimmer is subjected.

The corroboration of the information obtained by biochemical investigations with the psychological profile of the athlete can reflect the level of biological adaptation of the swimmers to training effort and can represent an objective benchmark in the guidance of the effort for optimizing the specific physical training and increasing the competitive performance. Based on blood lactic acid and blood glucose levels, measured in different training periods, it is possible to assess the level of stress induced by the training stimuli for each swimmer and to take appropriate recovery measures.

Limitations of the study

The research is experimental type but was operationalized by analyzing the individual results, which is a limit of the research. The results obtained have relevance and scientific significance only at the level of the research subjects and cannot be generalized. However, they have a great practical applicability for both swimming and other sports, where ensuring the effort –fatigue-recovery relationship is decisive in achieving sports performance. The research analyzed the individual particularities of training and the adaptive changes to the training and competition effort of the young swimmers in different styles. The low number of subjects participating in the research is caused by the impossibility of individualized monitoring and recording of the data that were methodologically operated by other coaches during training. That is why we appealed to only one coach of the club, who worked directly with the respective athletes. Because there is no data base with values of the two categories of biochemical parameters that we used, the analysis of the research results was made only against the basic benchmarks of laboratories and related to the individual dynamics of those values, throughout a training macrocycle, without reference to particularities of the values in elite athletes generally and swimmers particularly.

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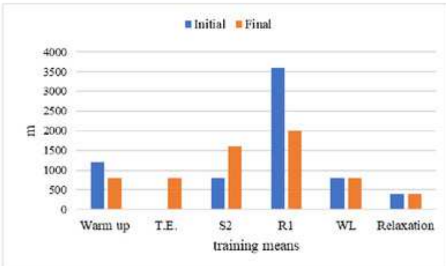
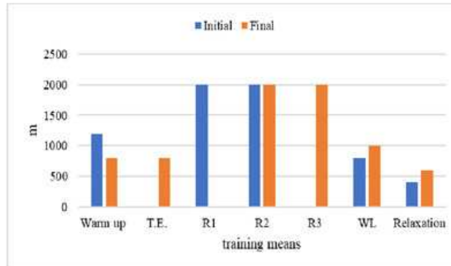
Figure 1

Volume of training means per effort zones at the beginning and the end of the research

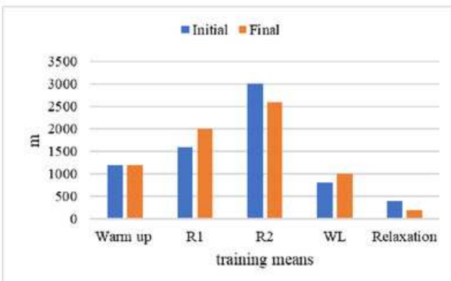
T.E. - technique exercises; WL - workouts for legs; R1 zone - basic endurance; R2 zones - threshold resistance; S1 - lactate tolerance; S2 zone - lactate production



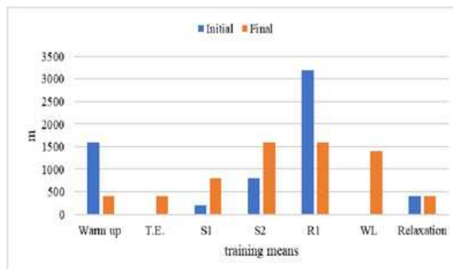
a) Athlete – IM (backstroke)



b) Athlete – MR (backstroke)



c) Athletes – PA (butterfly) and CD (breaststroke)



d) Athletes PAJ and BK (crawl)

Table 1 (on next page)

Graph of mental, motor and biochemical indicators monitoring in macrocycle 2, 2015-2016 plan

Ψ – psychological testing; B- biochemical testing; B: MT&C – biochemical testing in training and competition; T1- basal; T2 – end of basic period; T3 – end of specific period; T4 – competitive period; MT – motor test; ***Jr.*** *- Junior athlete – I.M.;* ***Cd.*** *- Cadet athlete – M.R.; B&MT1 – testing of La and Glu in motor test 8x100m; B&MT2 – testing of La and Glu in motor test 2x50m*

Month		Jan.			Feb.				March				April				Total
Indicators	Week	08 15	18 24	25 31	01 07	08 14	15 21	22 28	29 06	07 13	14 20	21 27	28 03	04 10	11 17	18 24	25 01	
Periods	Jr.		Preparatory				Specific			Pre-Cp.		Cp.	Transition		Specific			
Ψ	Ψ_{T1}		Ψ_{T2}				Ψ_{T3}					Ψ_{T4}						
B: MT&C	B_{T1}		B&MT1				B&MT1			B&MT2		B&C						
Periods	Cd.		Preparatory					Specific					Pre-Cp.		Cp.	Pre-Cp.		
Ψ	Ψ_{T1}		Ψ_{T2}					Ψ_{T3}							Ψ_{T4}			
B: MT&C	B_{T1}		B&MT1					B&MT1					B&MT2		B&C			
Days of training	Jr.		6	6	6	6	6	6	6	6	7	3	5	5	6	6	6	**86**
	Cd.		6	6	6	6	6	6	6	6	6	6	6	6	7	6	7	**92**
Days of rest	Jr.		1	1	1	1	1	1	1	1	0	0	2	2	1	1	1	**15**
	Cd.		1	1	1	1	1	1	1	0	1	1	1	1	0	1	0	**12**
In water training	Jr.		8	9	9	9	9	9	9	9	9	4	5	5	9	9	9	**121**
	Cd.		8	9	9	9	9	9	9	8	8	9	9	9	8	8	8	**129**
Off water training	Jr.		5	5	4	4	4	4	3	2	0	0	0	0	3	3	3	**40**
	Cd.		5	3	3	3	2	2	3	2	2	2	2	2	2	0	0	**33**
Total training	Jr.		13	14	12	12	13	13	12	11	9	4	5	5	12	12	12	**159**
	Cd.		13	12	12	12	11	11	12	10	10	11	11	11	10	8	8	**162**
Hours in water	Jr.		16	18	22	22	20	20	18	18	18	8	8	8	20	22	22	**260**
	Cd.		10	18	22	24	22	24	26	24	28	24	24	15	8	16	10	**295**
Hours off water	Jr.		3	2.3	2	2	2	2	2	1	0	0	0	0	1.30	1.30	1.30	**41.2**
	Cd.		5	3	3	3	2	2	3	2	2	2	2	1	1	0	0	**31**
Total of hours	Jr.		19	20.3	24	24	22	22	20	19	18	8	8	8	21.3	23.3	23.3	**280.2**
	Cd.		15	21	25	27	24	26	29	26	30	26	26	16	9	16	10	**326**
Volume km	Jr.		42	45	50	55	55	53	45	30	30	12	20	20	45	50	55	**607**
	Cd.		40	45	45	50	45	50	55	50	60	50	44	34	12	35	24	**639**

1

Table 2(on next page)

Psychological particularities of stress perception of the young swimmers under the influence of stimuli from training and competition (n=6)

*T1 – beginning of the baseline research; T2 – end of the preparatory period, basic stage; T3 – end of the preparatory period, specific stage; T4 – end of the competitive stage (end of research); A – cognitive; B – somatic; C – self-confidence; Z - Wilcoxon Signed Rank Test for Paired Data; X^2 - Friedman Test With Replication; T1# - comparison with T4; T4# - comparison with A, B, C; * - $p < 0.05$; ** - $p < 0.01$*

Psychological indicators			Athletes						Mean; ±SEM	Z; p-value	X^2; p-value
			PA	IM	CD	MR	PAJ	BK			
CWT (points)	T1#		27	26	22	28	28	34	27.50 ±1.58	2.032; .057	10.12; .018*
	T2		28	28	24	31	31	36	29.66 ±1.64	2.232; .033*	
	T3		36	29	28	30	35	30	31.33 ±1.35	0.843; .461	
	T4		40	34	30	38	28	40	35.00 ±2.11	1.632; .208	
CPST (points)	T1#		16	16	15	19	16	22	17.33 ±1.08	1.992; .059	9.54; .023*
	T2		24	21	18	23	19	22	21.16 ±0.94	2.032; .057	
	T3		25	22	21	21	22	24	22.50 ±0.67	1.479; .169	
	T4		24	26	24	23	22	21	23.33 ±0.71	0.812; .498	
SCAT (points)	T4#		26	15	22	13	28	21	20.83 ±2.41	-	
CT (points)	T4	A	10	4	9	8	12	8	8.50 ±1.08	2.213; .035*	13.17; .004**
		B	7	5	5	6	9	8	6.66 ±0.66	2.207; .035*	
		C	8	7	12	10	8	9	9.00 ±0.73	2.201; .036*	

Repeated Measures ANOVA (Non-parametric)

Friedman

χ^2	df	p
10.1	3	0.018

Pairwise Comparisons (Durbin-Conover)

			Statistic	p
T1	-	T2	2.333	0.034
T1	-	T3	2.644	0.018
T1	-	T4	4.355	< .001
T2	-	T3	0.311	0.760
T2	-	T4	2.022	0.061
T3	-	T4	1.711	0.108

Descriptives

	Mean	Median
T1	27.5	27.5
T2	29.7	29.5
T3	31.3	30.0
T4	35.0	36.0

Here as an example Anova calculated for CWT, so it is visible that only between T1-T2, T1-T3, T1-T4 significant differences exist and possibly between T2-T4 a tendency.

Table 3(on next page)

Results of the biochemical tests during training sessions in parallel with the performances of the motor tests (n = 6)

stage I (E1), basic; stage II (E2), specific; stage III (E3), precompetitive; SEM – standard error of mean; X^2 *- Friedman Test with Replication; * p < 0.05; ** p < 0.01*

Stage, no weeks	Fitness Test	Statist. Ind.	mean times (sec)	Lactic acid (mmol·L^{-1})			Blood glucose (mmol·L^{-1})		
				pre-effort	post-effort 5 min	post-effort 15 min	pre-effort	post-effort 5 min	post-effort 15 min
E1	8x100 m	Mean; ±SEM	80.21; ±1.66	1.88; ±0.24	6.9; ±1.16	5.35; ±0.83	107; ±3.81	118; ±9.57	106; ±6.69
		X^2	-	12.00			4.00		
		p-value	-	.002**			.135		
E2	8x100 m	Mean; ±SEM	78.97; 1.49	1.92; 0.30	10.7; 0.94	7.98; 0.78	105; 5.94	139.2; 15.11	117.3; 11.8
		X^2		12.00			6.33		
		p-value		.002**			.042*		
E3	2x50m	Mean; ±SEM	71.68; 2.38	1.83; 0.18	9.22; 0.58	6.87; 0.34	99.17; 5.79	120; 7.41	104.5; 6.67
		X^2		12.00			7.00		
		p-value		.002**			.03*		

Table 4(on next page)

Dynamics of the metabolic and hormonal biochemical parameters in competitions (n = 6)

*SEM – standard error of mean; X^2 - Friedman Test with Replication; * $p < 0.05$; ** $p < 0.01$*

1
2

Biochemical parameters	**Mean; ±SEM**			X^2	p-value
	Basal	Pre-effort	Post-effort		
Lymphocytes (%)	44.62; ±3.24	46.27; ±3.34	50.45; ±2.43	1.333	.513
Blood glucose (mg/dl)	89.83; ±4.00	93.01; ±6.22	121.56; ±3.90	9.000	.011*
Norepinephrine (mmol/l)	2.78; ±0.49	1.28; ±0.31	7.70; ±2.06	10.33	.005**
Prolactin (ng/ml)	7.07; ±0.58	9.67; ±1.64	15.39; ±3.76	7.000	.03*
Cortisol (µg/dl)	12.58; ±0.98	11.11; ±0.97	15.92; ±1.38	8.333	.015*

Table 5(on next page)

Correlation of the variables of research indicators in training (n=6)

*Rho - Spearman coefficient correlation; * - $p < 0.05$, $r_s = 0.886$; poor correlation – 0.2; moderate correlation – 0.5; strong correlation – 0.8; BMI – Body mass index; MT – motor test; V.E.Z – volume of effort zones; T.V. – training volume;TΨ1 - Cohen-Williamson Test (CWT) and TΨ2 - Cohen Perceived Stress Test (CPST)*

Variables			MT1 (sec)		MT2 (sec)	V.E.Z. (km)		T.V. (km)		TΨ1 (points)		TΨ2 (points)	
		Stage	E1	E2	E3	E1	E3	E1	E3	E1	E2	E1	E2
Body mass (kg)		E1	-.257			.500		.912		-.677		-.143	
		E2		-.257							-.725		-.441
		E3			-.143		.794		.618				
Stature (cm)		E1	-.314			.088		.618		-.353		.2	
		E2		-.314							-.493		-.559
		E3			-.2		.618		.795				
BMI (kg/m^2)		E1	-.314			.177		.883		-.706		.2	
		E2		-.314							-.289		.088
		E3			-.086		.353		.118				
Blood Lactate (mmol·L^{-1})	Pre-eff	E1	-.174			.313		.224		-.089		-.058	
		E2		-.086							-.783		-.147
		E3			-.058		.851		.612				
	5 min post-eff	E1	-.029			.559		.500		-.383		-.314	
		E2		-.143							-.928		-.412
		E3			-.086		.795		.500				
	15 min post-eff	E1	-.086			.677		.736		-.589		-.371	
		E2		-.289							-.912		-.358
		E3			.203		.806		.627				
Blood Glucose (mmol·L^{-1})	Pre-eff	E1	.657			.294		.059		-.294		-.657	
		E2		.886							.145		-.441
		E3			.493		.045		-.343				
	5 min post-eff	E1	.486			.765		.294		-.412		-.943	
		E2		.486							-.638		-.736
		E3			-.2		.442		.147				
	15 min post-eff	E1	.543			.441		-.088		-.088		-.771	
		E2		.6							-.638		-.736
		E3			.232		.493		.313				

Table 6 (on next page)

Correlation of the induced stress variables in competition (n= 6)

** - $p < 0.05$, $r_s = 0.886$; poor correlation – 0.2; moderate correlation – 0.5; strong correlation – 0.8; TΨ1 - Cohen-Williamson Test (CWT); Cohen Perceived Stress Test (CPST) Sport Competition Anxiety Test (SCAT); Crăciun test (CT); Limf. – Lymphocytes; Glu – Blood glucose level; Norep. – Norepinephrine; Prolac. – Prolactin; Cort. – Cortisol.*

Variables		Stage 4 (E4)							Basal stage (T1)				
		TΨ1	TΨ2	TΨ3	TΨ4			Times	Limf.	Glu	Norep.	Prolac.	Cort.
					A	B	C	100m (s)	(%)	(mg/dl)	(nmol/l)	(ng/ml)	(µg/dl)
Var-s	E4	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1			-.132	-.319	-.308	.088	-.015	.493	-.464	.058	-.928*	.174	.377
2				-.174	-.294	-.808	-.308	-.464	-.116	-.203	.319	-.551	.841
3					.899*	.551	-.174	.086	.371	-.429	.257	.2	-.143
4	A					.588	.088	.116	.667	-.580	.203	-.029	-.232
5	B						.088	.116	.667	-.580	203	-.029	-.232
6	C							.667	.029	.406	-.319	-.551	-.232
8	Pre-effort	-.348	-.145	.029	.174	.406	-.464	-.771	.714	-.6	.543	.257	-371
	Post-effort	-.087	-.493	.371	.174	.754	-.638	-.257	.029	-.086	.2	.943*	-.543
9	Pre-effort	-.058	-.174	-.257	-.551	-.116	-.029	.2	-.771	.886*	-.029	.486	-.314
	Post-effort	.290	.058	-.086	-.464	-.174	-.174	.371	-.943*	.714	-.314	.428	.143
10	Pre-effort	.209	-.348	-.086	.058	-.116	.928*	.886*	-.257	.543	-.543	-.371	-.143
	Post-effort	-.551	-.348	-.143	-.029	.319	-.174	-.6	.486	-.086	.6	.314	-.714
11	Pre-effort	.435	-.087	.086	-.290	.231	-.580	.143	-.714	.314	-.314	.771	.086
	Post-effort	-.348	-.116	.486	.174	.464	-.754	-.429	-.029	-.086	.486	.771	-.314
12	Pre-effort	.426	.412	-.406	-.735	-.485	-.309	.116	-.928*	.551	-.319	.203	.493
	Post-effort	-.319	.116	.314	.232	.377	-.841	-.829	.486	-.657	.6	.429	-.086