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Changes in indices of physical capacity, coordination, psychomotor activity and selected psychological traits in the driver after preparation to the Dakar Rally

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Abstract

Background & Study Aim: Extreme physical effort and psychical strain are observed during car rallies. Special training is necessary to improve the chances of a success in the sport. The aim of this study was monitoring of specified indicators from perspective of a possible correction of training during several months of driver preparation for the Dakar Rally.

Material & Methods: Individual case study involved characterization of a training of a driver before the 2014 Dakar Rally, repeated physiological tests (aerobic capacity, anaerobic capacity, reaction to thermal stress), psychomotor tests (coordination motor abilities), psychological tests (temperament, personality, motivation, fear). Analysis of competitive effectiveness was carried out based on official documents of the rally and structured interview with the participant.

Results: We found the desired improvement in capacity induced by the specific training. We also observed substantial improvement in balance and results obtained in visual-motor coordination tests performed with non-dominant limb, which caused equalization of the asymmetry occurring between the left and right limbs. The account of the rally's participant reveals the importance of psychological preparation for events with extreme character.

Conclusions: Since some weaknesses in physical fitness preparation of the driver were found during the first series of the examinations, the driver was administered a comprehensive training plan that improved important indices of aerobic capacity, aspects of coordination and psychological variables expected in racing drivers. From the practical standpoint, training and monitoring of its effectiveness in the next preparatory periods should be continued.

Key words: extreme sport, motor sport, post-training adaptations, training monitoring

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Extreme sport – "extreme form of physical activity are extreme sports, often classified according to the environment in which they are performed (water, land, air), extreme form of physical recreation as well as gainful activity or voluntary service, and all varieties of physical activity that meet at least one classification criterion of the feature associated either with extreme risk of injury or death, or extreme body burden with high level of effort, or extreme coordination difficulty" [33, p. 19]

INTRODUCTION

The Dakar Rally has been the challenge for many drivers for years. In 2014, the rally was organized in South America. It was comprised of 13 stages. The route started on 5th January 2014 in Rosario, Santa Fe, Argentina. The rally ended on 18th January 2014 in Valparaiso, Chile. Eighty percent of rally participants were amateur racers. Among 147 cars that took part in the rally, only 61 (41.5%) completed the route [1]. Participation in each rally is connected with extreme effort. After completion of the event, racing drivers have reported discomfort that occurs in the lumbar and cervical regions of the spine and in the shoulders [2]. It has been found that the problem of overload of different body regions can be reduced through good fitness preparation [3]. Psychological preparation for coping with difficult situations is essential in athletes [4-6].

Research concept

The problem of preparation of drivers and co-drivers cannot be ignored even if the car systems are continuously monitored over the race. It was assumed that training should cause adaptations in various body systems to rally demands. On the basis of scientific knowledge and coaching experience we assumed that to characterize the effects of post-training adaptations (expected changes) are important for racing drivers (indices of physical capacity, motor coordination and psychological characteristics).

The aim of this study was monitoring of specified indicators from perspective of a possible correction of training during several months of driver preparation for the Dakar Rally.

MATERIAL AND METHODS

Demographic profile of a driver and a car

The study examined a 39-year old racing driver (G.C.) with a master of pharmacy degree, with body height and mass at the level of BH = 170 cm and BM =66 kg, respectively. His work involved a frequent driving, with 80,000 km covered every year. The team of the Polish driver who had his debut in 2014 Dakar Rally was responsible for customization of the driver's clothes and tuning of Mitsubishi Pajero to the rally's demands. Multi-stage 2014 Dakar Rally was characterized by difficult land shape [7], which exposed the driver to mechanical overload in the sagittal axis, long axis and transverse axis, pointing to the necessity of inclusion of strength conditioning within the training plan in order to ensure that the driver maintains an optimal position for driving a car. Many hours of driving in a varied (especially sandy) and stony surface caused substantial vibrations that were transferred to the driver's body. Furthermore, thermal stress that accelerates body dehydration, decline in physical capacity and, consequently, deterioration in coordination and decision-making ability was also observed. The driver coped with these inconveniences. However, he was unable to complete the third stage of the rally due to the car breakdown. The study was approved by the local Ethical Committee.

Preparation for 2014 Dakar Rally

Preparation for 2014 Dakar Rally started in May 2013. During the first training session, personal trainer (R.P.) carried out pre-tests: the driver performed a test involving bar pull-ups from hanging position with palms facing down (n_{max}=4), push-ups (n_{max}=25) and the Cooper 12-minute run test (score = 2250 m). At the beginning of the preparatory period, the general development exercises with low intensity were used. The exercises were performed 3 times a week for 1.5 hours. Days and time of trainings had to be adapted to time available due to the professional responsibilities of the racer. Then the focus was on the training with stamina character (running alternated with walking and strength conditioning exercises, cycling and swimming). At the further stage of preparation, training sessions were for 6 weeks oriented to development of muscular strength. In the pre-competition training period (62 days before the rally), the focus was on the development of strength endurance and motor coordination. The method of circuit training was employed. The exercises that improve balance, visual-motor coordination and reaction time were also used. Training were carried out on average 4 times a week and each training session was 1.5 to 2 hours long.

The example training session during the direct pre-competition period.

Warm-up

- Cycling for ca. 15 min.
- Exercises using 3 kg medicine ball (exercises for all muscle groups) ca. 30 minutes.

Main part: circuits, ca. 30 minutes.

Barbell bench press, 2. Leg press, 3. Pull down, 4. Lying leg curl, 5. Barbell press behind neck, 6. Leg extension, 7. Standing dumbbell press, 8. Machine

Table 1. Training and testing the driver (31 weeks)

Pre-testing	Training block 1 (6 weeks)	Training block 2 (10 weeks)	Training block 3 (7 weeks)	Testing #1	Block 4 (weeks), including training in the thermal chamber	Testing #2	Travel to rally start point
Hand and arm strength	General workout outdoors	Runs alternated with walking, strength exercises, cycling, swimming	Exercises with external resistance Psychomotor tests and evaluation of psychological traits (16th September 2013)	Aspects of coordination (22th October 2013)	Circuit training	Aspects of coordination (12th December 2013) Psychomotor tests (18th December 2013)	Transport of the car to rally start point
Strength endurance in the muscles of upper limbs and chest	Endurance	Strength endurance	Strength	Endurance tests (30th October 2013)	Comprehensive training: Aspects of coordination + strength endurance	Endurance tests (19th December 2013)	Flight of the driver and co-driver
Running endurance	Continuous method	Variable method	Pyramid method	.	Circuit method	.	.
.	1.5 h	1.5 h	1.5 h	.	1.5-2 h	.	.
.	3 sessions / week	3 sessions / week	3 sessions / week	.	4 sessions / week	.	.
.	Driving a car = 9.2 thousand km	Driving a car 15.4 thousand km	Driving a car 10.8 thousand km	.	Driving a car 11.9 thousand km	.	Participation in the Rally (5th January 2014).

calf raise, 9. Cable triceps extension, 10. Incline bench sit-ups, 11. Hyperextension, 12. Standing torso twists with 10 kg disc weights held at the height of chest.

Exercises performed one after another, 15 repetitions. A 5-minute rest was used after completion of the circuit. The circuit was repeated for 3 times.

Special exercises performed at the end of the workout:

1. Squats on Bosu ball with simultaneous flexion of the arm with weight and catching the small bag thrown by the coach.
2. One leg standing with eyes closed (tree position).
3. Bosu ball press-ups.
4. Bosu ball squats with a ball handed in front of the chest.

Final part: Stretching exercises.

Sporadic exercises in a swimming pool were also used. Additionally, the driver also followed a driving training plan and a training that involved cycling on a cycle ergometer with the speed of 70 rpm in a hot environment with the temperature of 33°C and humidity of 70% with the load of 100W in a thermal chamber in the Department of Physiology and Biochemistry. Two weeks after completion of the preparation, the training program was extended with 60-minute thermal training sessions (passive overheating of body in a sauna room). Design of training and dates of examinations are presented in Table 1.

The driver also participated in the psychological examinations and was involved in psychological training sessions. In the period of between September and December, G.C. performed psychological training sessions, including exercises of relaxation (autogenic relaxation and progressive muscle relaxation), psychoregulation exercises in the form of biofeedback, respiratory exercises and visualisation. Other sessions were sacrificed to communication with co-driver and forms of social support that competitors should give to each other during the rally.

Research procedure

The research procedure consisted in aerobic capacity examinations and exercise performance of thermoregulation mechanisms [8], motor coordination and psychological variables. Biometric measurements, graded exercise test of maximum oxygen uptake performed on cycle ergometer and tests of coordination aspects were repeated twice at the last (4th) stage of training. At this time, the personal trainer (R.P.) administered stage 4 of the pre-race training (Table 1).

a) Physical capacity examinations

After a routine medical check-up before the exercise tests, body height (using Martin's anthropometer, USA) and body mass (using the F1505-DZA Sartorius scales, Germany) were measured. The results of these measurements were used to calculate body mass index (BMI in kg/m^2). Skinfolds over triceps and subscapular skinfolds were measured (GPM skinfold caliper with measurement range 0–45 mm ±0.2 mm, made in Switzerland). Fat per body mass and percentage fat were also recorded (FM in kg and PF%) [9]. Fat free mass (FFM) was calculated by subtraction of BM FM.

Graded exercise test was carried out using cycle ergometer (900E Jaeger, Germany). Prior to the main effort, the 12-minute warm-up was administered, with the load of 100W, followed by the increase in load by 30W every two minutes to exhaustion. The respiratory method was used to determine three metabolic zones: aerobic, mixed and anaerobic, which allowed the coach to customize physical load during preparation for participation in the rally. Measurement of maximal oxygen uptake (VO_2max in ml/kg/min) was used to determine the level of potential endurance exercise abilities of the competitor. Determination of the ventilatory thresholds VT-1 and VT-2 allowed for evaluation of current exercise abilities.

Two days after the graded exercise test, the driver performed the Kubica test that evaluates thermoregulatory mechanisms [8]. At first, the maximum values of work load (MWL) and heart rate (HR) were established during the graded exercise test on a cycle ergometer at room temperature until the subject decided to stop cycling. Then, the subjects performed a cycle exercise test at approximately 53% of the individual maximal work load in a thermal chamber. The ambient temperature and relative humidity were 30^{o}C and 70% respectively. The duration of the exercise test in minutes (DE) with rectal temperature (Tre) increased by 1.2^{o}C was assumed as an index of the efficiency of exercise thermoregulatory functions [8, 10]. Rectal (Tre) and skin temperatures was measured by electrotermometer MRV-A Elab (Dania) with the accuracy of ±0.05^{o}C. Skin temperature was measured in seven selected body points, with the weighted average (Tsk) calculated using the Hardy and DuBois formula:

*Tsk = 0.07forehead+0.35chest+0.14arm+0.05palm +0.19thigh+0.13calf+0.*007*foot*

b) Examinations of motor coordination

- Among various aspects of coordination, we carried out computer-aided testing of:
- ability to perform high frequency of movements,
- kinaesthetic differentiation of temporal movement indicatorss,
- speed, accuracy and precision of movements (muscle tremor in the labyrinth),
- time of simple reaction to visual and auditory stimuli and selective reaction time,
- spatial orientation,
- visual-motor coordination in the aspect of a moving object,
- rhythmization [11].

Balance, which was measured with the Unipedal Stance Test (UPST, with the longest/the best time of the three repetitions recorded in seconds). The UPST test might be used for detection of even insignificant neurological and vestibular defects in people at different age [12].

The results of measurement of 21 aspects of coordination in a driver were compared with the data from the control group, with 18 healthy untrained men at the age of 39.7±2.2 years (37-43 years) from the surroundings of the City of Krakow, Poland. The results obtained from the measurements with UPST test with eyes open and eyes closed were compared to the standards for 39-year old people [12]. Based on the results obtained from the first series of examinations, individual percentage differences were calculated for the driver compared to the untrained subjects = (1 measurement of the driver minus measurement in the control group)/1 measurement of the driver × 100.

c) Psychological examinations during driver's preparation to the rally measurements during the rally.

Psychological and psychomotor tests were also administered in order to propose the optimal form of mental training. The focus was on the characteristics of personality and psychomotor fitness which might represent the predictors for meeting the requirements imposed on participants of the Dakar Rally.

The questionnaire psychological survey was carried out in September 2013 using the following tools:

1. Eysenck Personality Questionnaire – Revised (SBG Eysenck, HJ Eysenck, P Barrret) with Polish adaptation by Piotr Brzozowski and Radosław Ł. Drwal [13].

This questionnaire examines the aspects of personality according to the Eysenck concept with three scales: extraversion-introversion, neuroticism, psychoticism. Additionally, the questionnaire contains the Lie Scale which measures the subject's need for social acceptance or tendencies for presenting the scores in a positive light.

An extrovert is a sociable person, oriented at action, with an optimistic outlook on the future. The introvert is more reserved, cautious when making a choice, and appreciates peace, quiet and order.

The aspect of neuroticism means a continuum started with emotional stability and neuroticism on the other end. Neuroticism is connected with anxiety and emotional instability. The moods of neurotics are varied and they have the tendencies for anxiety states.

The people with high results on the psychoticism scale are unsentimental, without empathy, suspicious and unhappy.

2. The Sport Motivation Scale (SMS-6) with Polish adaptation by Blecharz et al. [14].

The Polish adaptation of the Sport Motivation Scale (SMS 6), based on the Deci-Ryan concept, is composed of 24 items of which 6 subscales were separated. Minimum 4 points and maximum 28 points can be obtained on each scale. The structure of individual groups of motivations that affected the direction and dynamics of the behaviour of the subject.

3. Formal Characteristic of Behaviour – Temperament Inventory developed by Zawadzki and Strelau [15] measures temperament traits that refer to the formal characteristics of behaviour and includes 6 scales:

briskness (BR) – tendency to react quickly, to keep a high tempo of performing activities, and to shift easily in response to changes in the surroundings from one behaviour (reaction) to another,

perseverance (PE) – tendency to continue and to repeat behaviour after cessation of stimuli (situations) evoking this behaviour,

sensory sensitivity (SS) – ability to react to sensory stimuli of low stimulative value,

emotional reactivity (ER) – tendency to react intensively to emotion – generating stimuli, expressed in high emotional sensitivity and in low emotional endurance,

endurance (EN) – ability to react adequately in situation demanding long-lasting or high stimulative activity and under intensive external stimulation,

activity (AC) – tendency to undertake behaviour of high activity stimulative value or to supply of behaviour strong stimulation from surroundings.

4. State-Trait Anxiety Inventory (ISCL – STAI) by C.D. Spielberger with Polish adaptation by J. Strelau et al. [16].

The inventory is used to measure the anxiety understood in two ways: state anxiety the person perceives at the specific instant and as a relatively constant personal characteristic. The inventory contains 40 statements which are assigned numerical values by the respondent on a scale of 1 to 4 points, denoting: 1 – absolutely not, 2 – rather not, 3 – rather yes, 4 – absolutely yes. The results obtained allow for determination of the type of anxiety and its intensity which occurs in the subject as a general trait or state connected with a specific event.

5. The examinations of psychomotor ability using the computer tests included in the "Focus for Success" test battery developed according to the concept of attention by Robert Nideffer [17].

Simple reaction time in the case of the expected temporal sequence of stimuli, in the case of surprise and in the case of expecting the critical stimulus was measured. During the examinations, the type of stimuli was emitted in a random manner (impossible to be predicted by the subject), 6 stimuli of each type.

6. The structured interview was carried out after the return from the rally.

Statistics

In the analysis of temporal changes in the results, evaluation of the training effects was carried out by comparison of the results obtained by the driver (measurement2 minus measurement1)/ measurement1 × 100.

Table 2. Anthropometric measurements and indices and laboratory tests of physical capacity of the driver

Date of examination	30th July 2013 (1)	19th December 2014 (2)	Difference 2–1	Difference %
Body Height (cm)	170	170	0	0.0
Body Mass (kg)	65.523	64.67	–0.85	–1.3
Fat free mass	55.94	55.47	–0.47	–0.8
BMI (kg/m^2)	22.7	22.4	–0.3	–1.3
Fat percentage	14.6	13.9	–0.7	–4.8
Fat mass (kg)	9.56	9.00	–0.56	–5.9
Indices during graded exercise test (max)				
Duration of the effort (DE) (min)	10	10.50	0.5	5.0
Max load (Watt)	220	250	30	13.7
Work done (kJ)	96.0	103.5	7.5	7.8
V02max STPD (l/min)	2.30	2.43	0.13	5.7
V02max (ml/kg/min)	34.8	37.1	2.3	6.6
HRmax (bpm)	183	189	6	3.3
Pulmonary ventilation during exercise (VE) L) BTPS	87	83.6	–3.4	–3.9
Frequency of respiration (FR max)/min	47	45.8	–1.2	2.6
Maximal tidal volume (TVmax) (L) BTPS	1.83	1.82	–0.01	–0.1
Level of selected indices at aerobic-anaerobic threshold (AT – aerobic threshold)				
Time to reach the threshold (DE_{AT}) (min)	2	3	1	50.0
Load at the AT threshold (Watt)	100	130	30	30.0
Oxygen uptake ($V02_{AT}$) (l/min)	1.29	1.29	0	0.0
HR_{AT} (bpm)	117	129	12	10.3
%HR max at the AT threshold	64	68	4	6.3
%V02max at the AT threshold	56	53	–3	–5.4
Level of selected indices at the threshold of decompensated metabolic acidosis (TDMA)				
Time to reach the threshold (DE_{TDMA}) (min)	6	8	2	33.3
Load at the TDMA threshold (Watt)	160	190	30	18.8
Oxygen uptake ($V02_{TDMA}$) (L/min)	1.85	1.87	0.02	0.0
HR_{TDMA} (bpm)	157	165	8	5.1
%HR max at the TDMA threshold	86	88	2	2.3

Table 3. Individual metabolic zones of the driver with the range of physical exercise intensity in individual areas

Metabolic zones of the driver with the range of physical exercise intensity in individual areas (HR in bpm)				
Date	30th October 2013 (1)	19th December 2013 (2)	Difference 2-1	%
Zone of aerobic effort (bpm)	up to 116	up to 128	12	10.3
Zone of mixed efforts (aerobic/ anaerobic) (bpm)	from 118 to 156	from 130 to 164	12 – 8	10.2-5.1
Zone of anaerobic efforts	from 158	from 166	8	5.1
Aerobic threshold (AT)	117	129	12	7.6
Threshold of decompensated metabolic acidosis (TDMA)	157	165	8	5.1

RESULTS

a) Physical capacity

The racing driver analysed in the study was characterized by a proportional body build. The initial level of maximal oxygen uptake (VO_2max) of 34.8 ml/kg/min means a low aerobic potential of the human body (see Table 2). The level of exercise abilities represented by the level of ventilatory threshold VT-1 and VT-2 [18] was also low. VT-1 ventilatory threshold was obtained after 2 minutes of graded exercise test at the intensity of 100W, whereas the second threshold (VT-2), which reflects the onset of decompensated metabolic acidosis, was observed after 6 minutes at the intensity of 160W. In the first examination that evaluated exercise thermoregulation mechanisms [8, 10], based on the measurement of the increase in Tre by 1.2°C, the driver obtained the score of 32 minutes, which means low efficiency of exercise thermoregulation mechanism. The people with high efficiency of these mechanisms are adapted to work in a hot and humid environment obtain the results of over 60 minutes. In the last minute of test, the subject indicated the degree of fatigue of 18 points on a Borg's scale of 20 points [19] at the heart rate (HR) of 175 bpm and weighted average for the skin temperature (Tsk) of 32.2°C (Table 3).

The combined exercise and thermal training induced positive adaptations in the driver's body. These modifications were manifested in e.g. a reduction in fat mass (FM) by 5.9%, an increase in peak power by 13.7% and the amount of work done by 7.8% during graded exercise test and an increase in relative oxygen uptake by 6.6%. This reflects the increase in the efficiency of exercise mechanisms of oxygen uptake which determine athlete's endurance. Other manifestations of the improvement in exercise abilities were increments of power at the VT-2 threshold by 30% and time to obtain the VT-2 threshold by 33.3%.

b) Selected aspects of coordination

The results of the examinations were compared to the data obtained for men from the surroundings of Cracow at the age of 37-42 years (database base collected by J.J.). Based on the analysis of the percentage differences, we found that the person studied obtained, in almost all motor coordination tests, the scores better than in the control group. One exception was the results obtained for UPST balance test performed with eyes closed (Table 4).

The most beneficial differences were found for the driver in high frequency of movements (hand R=38%) and kinaesthetic differentiation of temporal indicator of movement (hand R=32.7% vs. hand L=67.3%). Other beneficial changes were observed in speed, precision and accuracy of movements (muscle tremor in the labyrinth). In this case, the time of test performed clockwise and counter-clockwise was shorter in the control group by ca. 26%. The driver studied performed the test faster than in the control group, with lower number of mistakes (by 13-20%). Simple reaction time and selective reaction time were substantially shorter (by 20%) than in the control group. Positive differences were also found in spatial orientation (24%) and visual-motor coordination with moving object (15%). Among all the analysed motor coordination abilities, only rhythmization demonstrated lack of variation. Interesting information was also provided by the analysis of percentage differences calculated between the upper non-dominant (left) limb of the driver with the results obtained for the right (dominant) limb in the control group. In the most of the tests, the driver obtained better results compared to controls who performed tests exclusively with the dominant limb.

The training effect size varied for different aspects of coordination. This effect for the left and right limb was: 100% vs. 0.0% for kinaesthetic differentiation, 48.5%

Table 4. Indicators that determine coordination motor abilities

Aspect of coordination	Test / unit	L1	R1	L2	R2	CON
Ability of differentiation of temporal parameters of movements	Kinaesthetic differentiation / pixel	16	33	32	33	49.0
Frequency of movements	Hand movements frequency (tapping) / n	33	49	49	60	35.5
Reaction time	Reaction time (visual stimulus) / ms	215	226	240	226	280.9
	Reaction time (auditory stimulus) / ms	231	191	195	186	235.2
	Complex reaction time / ms	407	355	305	363	451.9
Rhythmization ability	Movement rhythmization / ms	72	129	73	120	136.3
Speed, accuracy and precision of movements (muscle tremor in the labyrinth)	Labyrinth to the left / s	41	40	34	34	54.6
	Labyrinth to the right / s	43	35	44	35	47.6
	Labyrinth to the left / mistakes n	9	11	6	8	13.8
	Labyrinth to the right / mistakes n	10	8	8	7	9.3
Motor adjustment	Difference between the direction to the right and to the left / s	2	5	10	3	10.4
	Difference between the direction to the right and to the left / mistakes n	1	3	2	1	5.4
Visual-motor coordination	Free mode/n	39	37	48	36	43.9
Spatial orientation	Free mode/s	74	51	69	53	67.5
Balance	UPST O/s	60	60	120	120	44.4
	UPST C/s	5.8	16.9	16	34	16.9

Notes: L1 – result for the left upper limb during the first test; R1 – result for the right upper limb during the first test; L2 – result for the left upper limb during the second test; R2 – result for the right upper limb during the second test; CON – average result of the control group; O - open eyes; C - closed eyes

vs. 40.8% for movement frequency, 11.6% vs. 0.0% for the time of reaction to visual stimulus, 15.6% vs. 2.6% for time of reaction to auditory stimulus, 24.3% vs. 2.3% for selective reaction time (vision, hearing), 1.4% vs. 7.5% for movement rhythmization, 17.1% vs. 5.0% for time of labyrinth to the left, 2.3% vs. 0.0% for time of labyrinth to the right, 33.3% vs. 11.1% for mistakes in the labyrinth to the left, and 20.0% vs. 12.5% for mistakes in the labyrinth to the right, 400.0% vs. 40.0% for time difference in performance of the labyrinth, 100.0% vs. 66.6% for the difference in the number of mistakes, 23.1% vs. 2.7% for visual-motor coordination, 6.8% vs. 10.2% for spatial orientation, 0.0% vs. 0.0% for UPST with eyes open (exceeding the upper limit of 45s), 175.9% vs. 101.2% for UPST with eyes closed.

c) Psychological aspects: measurements performed in the pre-competition period before the rally

The results of the temperament inventory were illustrated in Figure 1. Temperament profile for G.C. allows the driver to take effective actions in the high stimulation situations, good tolerance to exposure to long-term load, adequate reaction in variable situations and emotional resistance. These temperament characteristics are conducive to meeting the requirements that participants of the Dakar Rally have to face.

Furthermore, the following results were obtained for the Eysenck Personality Questionnaire: neuroticism (2 points): 2 stens, extraversion (21 points): 9 stens, psychoticism (6 points): 4 stens, Lie Scale (10 points) 6 stens. The results obtained are consistent with the results obtained in temperament inventory. They point to the low level of neuroticism associated with anxiety-driven behaviours and tendencies for such behaviours. High result on the extraversion scale points to high demand for stimulation and easiness of entering into interpersonal contacts. The results for the Sport Motivation Scale 6 were as follows: Lack of motivation/amotivation: 4, external regulation: 4, introjected regulation: 14, identified regulation: 14, integrated regulation: 21, intrinsic motivation: 23.

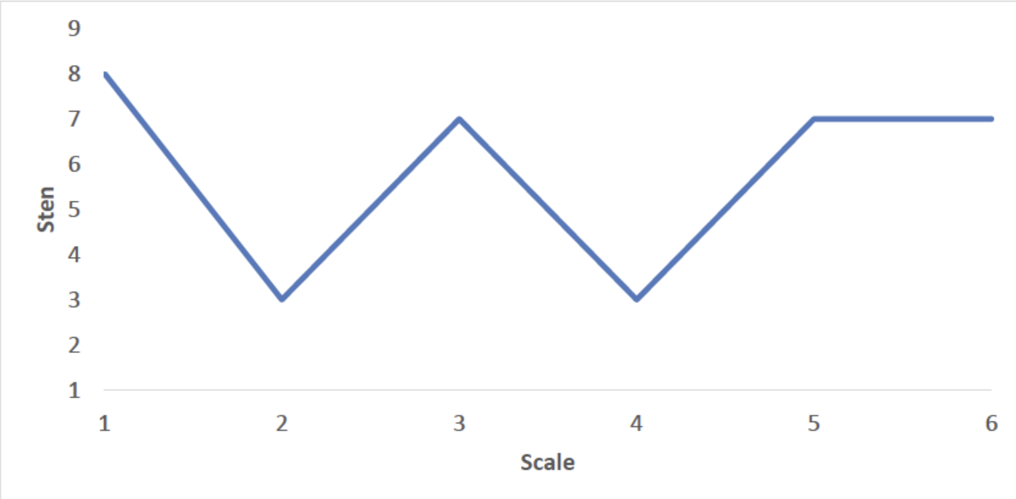

Figure 1. Individual profile of rally driver. Scale: 1-briskness, 2-perseverance, 3 – sensory sensitivity, 4-emotional reactivity, 5-endurance, 6-activity

Table 5. Measurement of reaction times and broad internal focus under laboratory conditions (Focus for Success)

Date	16th September 2013 (1)	18th December 2014 (2)	Difference 2–1	Difference %
By surprise (not ready) (ms)	0.26	0.23	–0.03	–11.54
Rhythmic (right on) (ms)	0.23	0.21	–0.02	–8.70
Expectation (too eager) (ms)	0.23	0.22	–0.01	–4.35
Mean reaction time (ms)	0.24	0.22	–0.02	–8.33
Broad external focus	51	58	7	13.72

The subject's behaviours connected with sports activity are stimulated primarily by the intrinsic motivation. This activity is at the amateur level in terms of the financial benefits that result from sport. Furthermore, the structure of motivation and the previously discussed personality traits cause that the driver studied presents entirely professional behaviour.

The examination carried out by means of the State-Trait Anxiety Inventory (STAI) revealed a low level of anxiety as a trait 3 stens according to Polish standards for athletes.

During the September examinations, the following average results were obtained for the "Focus for Success" tests [20]: time of reaction to stimuli with surprise: 0.26 sec; time of reaction to stimuli with rhythmic time sequence: 0.23 sec; time of reaction to stimuli in the case of waiting: 0.23 sec. Average time of all the reactions: 0.24 sec. In December 2013, before the trip to the Dakar Rally, the driver obtained the following results in the same tests: time of reaction to stimuli with surprise: 0.23 sec; time of reaction to stimuli with rhythmic time sequence: 0.21 sec, time of reaction to stimuli in the case of waiting: 0.23 sec. The percentage change in the results is presented in Table 5.

DISCUSSION

Physical capacity

As demonstrated in our study, many-hour driving a car by G.C. within his professional work was not stimulating in terms of the development of coordination motor abilities, with high level of these abilities being conductive to meeting the demands of the rally. First training-related examinations carried out by coaches revealed insignificant level of physical fitness in test results, local strength endurance and aerobic endurance. Therefore, a 31-week training program was started in order to improve fitness and coordination abilities. The results of this study are reduced to presentation of training-induced adaptations in the driver preparing for the 2014 Dakar Rally.

An increase in VO2max index of aerobic capacity from 34.80 vs. 37.10 ml/kg/min was observed after performing the specific training program of 8 weeks, which was at a low level, similar to the untrained men [21]. It was similar to the results reported in adult professional judo athletes (x=40.80±2.92, from 37.20 to 44.90 ml/kg/min) [22]. Heart rate (HR) at the VT-2 threshold was higher (165 bpm) compared to the group of judo seniors (150±10.67 bpm) [22].

Maximal heart rate (HRmax) obtained by the driver in the graded exercise test to exhaustion during the first and second examinations was 183 and 189 bpm, respectively. In the second examinations, the exercise and thermal tests found the increase in HRmax by 6 bpm and greater amount of work in the graded exercise test, which reflects the increased tolerance to the exercise-induced stress. This is important in motor sports where a number of stressors affect the activity of the driver. The psychical stressor (strong stimulation of the sympathetic division of the autonomous nervous system), exercise stressor (tolerance to overload) and thermal stressor (high temperature in the car cabin which often exceeds 50^{o}C) that cause a cardiovascular response at the level of nearly 90% HRmax [23]. One should realize the interactions of the factor of elevated temperature. The tests in the thermal chamber (physical training at elevated ambient temperature and Finnish sauna sessions) showed a tendency for improvement in efficiency of exercise thermoregulation mechanisms. This training strategy yields good effects [24]. In the second examinations, lower increases in Tre temperature and lower average weighted skin temperature (Tsk) were observed in selected segments of graded exercise and during passive and exercise-induced body heating during training sessions. This resulted from improved performance of sweat glands (intensive perspiration) and, consequently, better elimination of the excess heat from body through sweat evaporation. Body dehydration was determined with the accuracy of 1 g through measurement of body mass before and after tests or training sessions.

The results of other examinations indicate that the major physiological stressors experienced by a racing driver are elevated and long-term HR (bpm), elevated temperature and muscle tensions connected with G-force overload and the necessity of maintaining the position of the head with helmet [25]. The training was aimed at improvement in aerobic capacity, which determines endurance. With regard to the information that the driver would be driving a car under harsh land conditions at elevated temperature, the team strived for induction of adaptations to such extreme efforts. Other studies found the effect of both adaptation to elevated temperature and race simulation on psychomotor indices of test performance in racing drivers [26].

Aspects of coordination

We carried out multi-aspect examinations of coordination. The first series of our examinations revealed that the driver had an advantage over the untrained peers in the most of the aspects of coordination. Other studies, with the control group represented by the trained people, demonstrated that racing drivers were not distinguished by the selective reaction time nor by tapping test [3]. Other observations in this regard result from selection of the control group for the tests. At this stage of training control, we found that coordination aspects in the driver should be developed to the higher level. Comparison of the two series of the examinations revealed a particular improvement in the results of the tests of movement frequency, selective reaction time (vision, hearing), speed, accuracy and precision of movements (movement tasks in the labyrinth), visual-motor coordination, balance in the UPST test performed with eyes closed. In the UPST test performed with eyes open, the substantial exceeding of the normative values (a ceiling effect) were observed in both series of the tests. Some researchers [27] have found that eye movement speed, sense of position and directions of body movements (the neck and head), and vestibular organ efficiency are important for driving a vehicle. The contribution of these factors depends on road conditions. With a winding route, eyes movements explained 71% of variance of movement while driving [28]. During curving, the vestibular organ is engaged to a greater degree and the forces are generated to cause rotational movements of the steering wheel and the car [27]. These forces contribute to the greater degree to the discomfort in the hands and wrists in the driver (32%) compared to the co-driver (9%) [2]. Racing drivers with 10-year experience showed better results in measurements of isometric strength: hand grip with left and right hand, trunk extensors, arm flexors, left and right head flexors and dorsal flexors [3]. Trunk muscles in racing drivers should be strong since their abdominal muscles have to be contracted during braking and curving. Uneven surface and bumpy road cause the necessity of strong contraction of muscles of the back. Therefore, both muscle groups are used to stabilize trunk. Driving on uneven surface also causes substantial head swaying in the frontal plane, which can be partially prevented by the strong muscles of the neck. Hand grip strength and shoulder strength was greater than in the control group since they constantly use their hands during driving. Strength of dorsal flexors was also greater since feet have to be used in quickly changing conditions of the rally's environment [3].

Psychological aspects: retrospective analysis of competing in the rally

Personality traits of the driver analysed in our study, with particular focus on the temperament, make him suitable for participation in sports with high level of stimulation and elevated risk [30]. The Dakar Rally is very demanding in these terms. During the interview carried out after the rally, the driver said "The worst thing was the first 30 minutes of the rally, with substantial stress that manifested itself with muscular tension and dry mouth. I also felt the fear, especially watching the big and fast trucks (they were faster than personal cars!)". Natural aptitudes and acquired psychological skills helped the driver deal with difficult situations very fast: "... we soon realized that all and all we just started a rally".

The quick adaptation of the driver to this extreme situation was also noticeable; "We started from position 149 and in the beginning we were overtaken by 11 cars and then we overtook around 60 cars. After the first stage, we were at the position 98". The interview also showed how important is the role of co-driver and their support: "Bobik (co-driver) told me: Look, they are the same as YOU... and I realized: I came here to drive a little, that is, to race, and I thought that apart from training, we would be racing and it went quite well (as for us, obviously), we were able to cooperate very well, and, on top of that, there was this competition factor..." These words show that a co-driver has an important role not only through informational support but also through emotional support or boosting the driver's confidence. This type of support has an essential effect on function of the athlete in the situation of sports rivalry [31].

Multifaceted preparation for the race and quick coping with competitive stress caused that the team, despite rather mediocre car, coped with the race very well. However, they had to end their racing after the second stage of the rally due to car breakdown. The driver described this situation in the following way: "Our mistake was to race in the river's bed, with big stones. We should have been driving carefully and catch up on the time in other sections of the route. Our mistake was no strategy. We did not complete the rally due to the car breakdown, which was partially caused by faulty equipment, partially by neglected maintenance and partially by no experience, which resulted in no suitable strategy." Before the car breakdown that prevented the team from continuing to race, the team was at the 40th place, which was much beyond the expectations from before the race, and, according to the interview, was supposed to familiarize and prepare the drivers for future rallies in next years.

Apart from the comprehensive preparation (including psychological preparation), the great role was played by motivation, which, according to the results obtained, was of internal (autotelic) character. Through participation in rallies, the driver analysed in the study meets his needs for self-realization and autonomy.

Satisfaction from meeting three basic needs with over-cultural character (autonomy, competencies and good relationships with others) is conducive to maintaining the state of well-being and sense of internal balance [32]. The results obtained by G.C. in SMS 6 examination lead to the conclusion that this was the case during the driver's participation in the 2014 Dakar Rally. With the results obtained during testing of concentration of attention, it also shows that personality traits and psychomotor fitness represent the positive predictors for successful competition of the driver studied in similar sports events.

CONCLUSIONS

Since some weaknesses in physical fitness preparation of the driver were found during the first series of the examinations, the driver was administered a comprehensive training plan that improved important indices of aerobic capacity, aspects of coordination and psychological variables expected in racing drivers. The interview with the participant of the rally points to the importance of both the comprehensive and special preparation to the event with extreme character. From the practical standpoint, training and monitoring of its effectiveness in the next preparatory periods should be continued.

Practical implications

Based on the results of examination of respiratory exchange indices (VO_2, VCO_2, RER, FeO_2, $FeCO_2$, $V_E \cdot VCO_2^{-1}$, $V_E \cdot VO_2^{-1}$ and heart rate (HR) during graded exercise test, the metabolic zones were determined. The efforts that yielded the cardiovascular response of HR = 120±4.00 bpm were performed under conditions of individual aerobic comfort. With this effort intensity, oxygen consumption in the body was the highest. This load was used in continuous training with recovery and maintenance character. Ventilatory threshold VT-2 was observed in the first series of the examinations at HR=157 bpm. The optimum exercise intensity that developed endurance abilities was within the range of 145-150 bpm.

Our study also demonstrated that preparation of the driver for racing should involve the elements of thermal exo – and endogeneous training. They are conducive to the improvement in the effectiveness of exercise thermoregulation mechanisms which substantially delay fatigue processes. Thermal conditions in the car cabin (high temperature) might affect the racing driver's performance.

Equalization of the functional asymmetry of upper and lower limbs observed in coordination tests has essential practical implications for using the steering wheel, operating pedal in the car and maintaining the body position during the overload typical of the surprising conditions of car races. In the practice of training control, it would be also useful to monitor the level of muscle torques in static conditions.

The difficult attempt to participate in the rally revealed the braking system failure, which points to the necessity of even more precise preparation of the car for the route of the next rally.

COMPETING INTERESTS

Authors declare no conflicts of interest.

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