Reaction time and stress tolerance of police officers in specific and non-specific tests in professional self-defence training

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Abstract

Introduction: The police forces performance is demanding on well-timed and quick reaction. Single reaction time and choice reaction time are crucial when the jeopardy appears. Performing under stress in life-threatening situations needs a good level of stress tolerance. In our study, we used two non-specific, and two specific (shooting) tests to analyse the reactivity of police officer under different conditions. *Material and methods*: The research sample consisted of n=18 male Czech police training instructors. The group is unique as these police officers are specialised in the professional self-defence with focus on the coercive means use and shooting skills. Two standardized non-specific tests administrated with the Vienna Test System (VTS) by Schuhfried GmbH were used for data gathering. Single reaction time (SRT) was measured by the Reaction test, stress tolerance and choice reaction time (CRT) was measured by the Determination test. Two practical non-standardized shooting tests were used for the reactivity analysis in the goal oriented environment (shooting range). *Results:* The single reaction time among police training instructors was M=261.56±33.60 ms, which corresponds to the 66.28 percentile of age norm. Performance in the stress tolerance test also matches the average performance in population (M=45.56 percentile of correct reactions, M=61.67 percentile of incorrect reactions, M=51.44 percentile of skipped signals). According to the Pearson correlation coefficient, there is no correlation between single reaction time in the Reaction test and choice reaction time in the Determination test (r=-0.03). There is no correlation between single reaction time in the non-specific Reaction test and performance in the specific Shooting test 1 (r=0.06) and Shooting test 2 (r=-0.01). *Conclusions:* There is no relation between the results in the specific and non-specific reaction tests. Nonspecific tests of single reaction time and choice reaction time are suitable for a general assessment of motor abilities. Specific tasks need specific training and specific evaluation methods.

Keywords: response time, stress, self-defence, police, law enforcement training, shooting

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INTRODUCTION

Professional self-defence for law enforcement units is a highly demanding process both from the physiological and psychological point of view. The police forces performance involves a wide range of activities including use of force in the case the order is to be enforced. Therefore, the use of coercive means, arresting techniques, shooting and physical fitness is an integral part of law enforcement training. There is still a need to search for new methods and evaluation of such training [1,2]. Police officers regularly engage with citizens, which can result in the use of force against the perpetrator. These situations evolve in rapid, dynamic, and stressful conditions [3]. The well-timed and quick reaction is needed when the jeopardy appears. For that reason, police officers are trained to be well prepared to use all available means in the right time. Single reaction time (SRT) is vital at the beginning of the defensive action when all recourses should be activated. The more complex the situation, the longer the reaction time. That is why choice reaction time (CRT) is critical when more options are available. The defending person must react vigorously and energetically enough to stop the attack, but by using reasonable force. Otherwise, the defensive action will be considered not lawful [4]. In life-threatening situations, where the correct reaction is critical for survival, the effective decision-making process is vital [3,5]. The reaction may be inhibited by increasing anxiety, fear and stress [6,7]. Therefore, stress tolerance (ST) of police officers is essential when the task is ongoing in the middle or extended period (e. g. when defensive and offensive actions alternate during the more protracted fight or shootout).

Reaction time (RT), both SRT and CRT, were researched in many studies, especially in anthropometrics and sports sciences [3,5,8–10]. RT is a vital motor ability in daily life, when driving a car, catching a falling object and so forth. RT is the indicator of human ability to start a movement on a given (simple or complex) stimulus in the shortest possible time [10]. In other words, RT is the time elapsing from the transmission of the stimulus to commence the motion. This delay between the perception of the signal and the start of movement is also called latent time [11] (processes in the nervous system are not visible). During this time receptor (eye, ear, skin) receives the information, the signal is guided by the nerve fibres, the information is processed by the nervous system (decision-making process), and then a motor reaction command is sent to the effectors. The time from movement initiation to its termination is called the motor time (MT). For some motor acts, the reaction time is longer than the MT (e.g. in the boxing punch). Resulting response time is a sum of reaction time (SRT or CRT) and motor time. The reaction time affects the resulting response time (movement) as it is part of it.

Měkota and Novosad [10] state that 100 ms is the physiological limit below which the SRT cannot drop. SRT of 200 ms is the typical value among adults and 500 ms in children. According to anthropometric measurements, the shortest SRT is for tactile stimulus (150-140 ms), mean for the acoustic stimulus (160-150 ms), and slower SRT was registered for visual signal (210-190 ms) [9,12]. CRT values are higher than SRT. According to Hick's law increasing the number of choices will increase the decision time logarithmically [11]. The Delay is due to processing information in the central nervous system (decision-making process). When selecting from two alternatives, the RT is extended from 200 ms to approximately 300 ms, with the choice of seven alternatives, the RT is extended to approximately 600 ms. With the increasing complexity of the situation, the correlation between SRT and CRT decreases. Individuals with fast SRT may not be quick in complex situations (e.g. in sports games, combat sports and others).

Reaction ability is highly genetically determined [12]. Dovalil [13] claims, that reaction time can be influenced by up to 10-15% of its original level. Balkó [14] provided the evidence that 9-week training intervention (in total 350 minutes) can significantly improve the SRT and CRT among young fencers (n=12 boys,16±1.1 years, n=7 girls, 16.4±0.9 years) in comparison with the control group n=5). In the research group, average SRT was 274 ms in the pretest and 257,5 ms in the posttest, CRT 423 ms in the pretest, 393 ms in the posttest (5 choices). Reactivity may not be necessary critical for some task accomplishment (e.g. gymnastics, sporting rifle shooting), in others it seems to be opposite (boxing, defensive shooting). That is why in combat sports and self-defence training routine lots of reaction drills are commonly in use (e.g. blocking of attacking hand, escaping from the attack, catching a ball, drawing a gun and other exercises). Self-defence has similar features with combative sports

since the essence of the activity is to overcome the enemy over a short distance using combat techniques. That is why martial arts and combat sports (MA&CS) research can be applied in the field of personal and professional self-defence conveniently. MA&CS are highly demanding on the athletes' reactivity [14-16]. Grushko et al. [8] provided a review study of motor reaction in various sport, including MA&CS. The shortest SRT values were following. In the judo&sambo group observed SRT 211.578±14.75 ms in males and 199.67±11.59 ms in females. In the taekwondo group, was observed SRT 230.69±26.09 ms in males, 214.73±22.64 ms in females. In the kickboxing sample were observed shortest SRT values 150±0,007 ms in males. Such a short reaction time in non-combat sports was observed just among swimmers 154.02±0.02 ms in this study. All tests were administrated using reacting by hand. Quel and Bennett [17] draw attention to the fact that RT is not a predictor of competition in karate. Significantly higher importance than RT is the ability to anticipate an opponent's action. More specifically, participant skill level in karate kumite does not predict CRT or response accuracy in a task requiring a non-specific response to non-specific stimuli. Therefore, CRT does not predict potential talent for karate kumite. Perceptual-cognitive expertise is a crucial factor to achieve sporting success in karate, along with physiological characteristic [18]. In our study, we have investigated the reaction time and the ability to resist cognitively demanding reaction task among police officers in two non-specific test using the Vienna Test System in comparison with two specific shooting tests.

METHODS

The research sample consisted of n=18 male Czech police training instructors between 27-44 years (average age: 36.37±4.69 years) with the length of practice of 6.28±4.11 years. The group is unique as these police officers are specialised in the professional self-defence with focus on the coercive means use and shooting skills. The length of practice varies from 0.5 to 13 years on the position of police instructor. That means, all involved tested person have undergone specialized training and the length of practice is related to their teaching period (not training period). Instructors are responsible for the training of "regular" policeman. The research team had the opportunity to measure the sample at the beginning of specialised training (without fatigue).

Data gathering procedure

We used two non-specific tests (Reaction test, Determination test) administrated with the Vienna Test System (VTS) by Schuhfried GmbH. The Reaction test (variant S1) detects the SRT by using yellow light stimulus. The stimulus is presented on the computer screen. The reaction is provided by one finger on the reaction panel connected to the computer. The use of a rest key and a reaction key makes it possible to distinguish between reaction and motor time. The age norm is based on the sample n=139 tested persons.

Determination test (variant S1) assesses reactive stress tolerance, attention and reaction speed in the respondent. Complex multi-stimuli reaction test involving the presentation of both coloured stimuli and acoustic signals (use of earphone) to which the respondent reacts by pressing the appropriate buttons on the response panel and using the foot pedals. The stress element of the DT arises from the need to sustain continuous, rapid and varying responses to rapidly changing stimuli. Because test presentation is adaptive, any individual can be confronted with stimuli at a frequency sufficiently high to place him in a situation in which he is over-challenged and can no longer execute the necessary responses. For the performance analysis, we used data on correct, incorrect a skipped reactions. The age norm is based on the sample n=1179 tested persons.

Afterwards, we used two specific shooting test for quickness and accuracy evaluation among police officers. These specific shooting tests are regularly used in law enforcement training. Both tests record single reaction (SRT) time and motor time (MT). Recorded time is a sum of SRT+MT. In the 1st Shooting test, a gun with a magazine and one cartridge in the magazine is in the case on the belt with locked safety-catch. As soon as the acoustic signal appears on the timer, the policeman pulls the gun, charges and shoots the target in distance 10m. The test detects the policeman SRT and the ability to hit the target by quick pulling and to charge the gun. In the 2nd Shooting test, a gun with a magazine and one cartridge in the chamber (gun is already is loaded) is in the case on the belt. As soon as the

acoustic signal appears on the timer, the policeman pulls the gun, and shoots the target in distance 10m. The test detects the policeman SRT and the ability to hit the target by quick pulling and to overcome the trigger resistance. The time was recorded by the standardized shooting timer.

Data analysis procedure

Descriptive statistics and Pearson correlation coefficient was in use for correlation calculation between tests.

RESULTS

We provide results of police officers in all four tests. In the Reaction test and Determination test, raw scores and are displayed first. The percentile calculated from the raw scores related to the Vienna Test System age norm are following. Table 1 contains the interpretation of the percentile range.

Reaction test (VTS)

The main result of the Reaction test is the mean SRT value, which is calculated from n=28 signals displayed on the screen for approximately 4 minutes. In the research sample was the SRT M=261.56±33.60 ms. According to the Vienna Test System, age norm corresponds this result to the 66.28±24.44 percentile. The second value observed in the Reaction test is the motor time, which was M=117.83±27.11 ms. This result corresponds to the M=68.17±20.40 percentile of the age norm. Both results in the Reaction test (SRT, MT) fit the average performance of most of the reference population. Results of the whole research sample are displayed in Table 2.

Determination test (VTS)

In the determination test, three central values were evaluated according to age norm. Correct reactions score indicates the correct response to a given signal (visual or acoustic, hand or foot reactions). Incorrect reactions score indicates mistaken responses (e.g. pressed pedal by foot instead of a the button pressed by hand). Skipped reactions score indicates that the person did not respond to the signal in any way. Percentiles were calculated from the raw scores according to the age norm of the Vienna Test System. As the presentation of signals in the Determination test is adaptive, a different number of the signals was presented to each tested persons during approximately 6 minutes. That is why raw scores are needed for percentiles calculations, which express reaction and attention performance under stress. The research sample displayed the following results in the Determination test. In the correct reactions was the performance M=45.56±23.37 percentile, in incorrect reactions M=61.67±28.96 percentile, in skipped signals M=51.44±28.77 percentile. All results in the Determination test fit the average performance of most of the reference population. Results of the whole research sample are displayed in Table 3.

Shooting tests 1, 2

In the specific 1st shooting test, the performance was M=2177.77±358.91 ms, in the 2nd specific shooting test M=1730.00±351.71 ms. The response time is a sum of reaction time and motor time. There are no population norms for these tests. These tests are repeatedly used in the law enforcement training for the tactical population. That is why we have investigated if there is a correlation with non-specific Reaction and Determination tests (Table 4).

Table 1. Vienna Test System percentile range interpretation

PCTL range	Interpretation
0 – 16	Significantly below average
16 – 24	Slightly below average
25 – 75	Average - performance of most of the reference population
76 - 84	Slightly above average
84 – 100	Significantly above average

PCTL - percentile

Table 2. Result of the Reaction test (results in ms).

Tested person	Mean SRT	Mean MT	SRT PCTL	MT PCTL
TP 1	277	149	63	56
TP 2	253	115	65	60
TP 3	234	123	89	73
TP 4	261	125	77	72
TP 5	224	102	91	72
TP 6	205	80	99	99
TP 7	260	91	60	82
TP 8	249	121	82	74
TP 9	232	114	91	78
TP 10	258	94	80	94
TP 11	231	80	92	99
TP 12	271	116	51	59
TP 13	298	94	24	77
TP 14	308	167	20	18
TP 15	273	172	70	40
TP 16	356	155	17	51
TP 17	262	98	58	77
TP 18	256	125	64	46
Mean	261.56	117.83	66.28	68.17
Median	259.00	115.50	67.50	72.50
SD	33.60	27.11	24.44	20.40
Min	205.00	80.00	17.00	18.00
Max	356.00	172.00	99.00	99.00

PCTL – percentile; SRT – single reaction time; MT – motor time

Table 3. Result of the Determination test (results in ms).

Tested person	Correct	Incorrect	Skipped	Correct PCTL	Incorrect PCTL	Skipped PCTL
TP 1	266	18	8	78	21	63
TP 2	267	1	4	64	97	89
TP 3	224	22	7	36	16	71
TP 4	219	5	7	31	75	71
TP 5	264	30	22	61	7	14
TP 6	194	6	19	13	69	19
TP 7	282	7	3	76	68	94
TP 8	223	0	15	34	99	29
TP 9	248	5	7	61	75	71
TP 10	240	10	24	54	47	8
TP 11	242	9	7	56	53	71
TP 12	292	4	5	82	86	83
TP 13	196	5	21	7	81	16
TP 14	202	28	21	10	10	16
TP 15	225	4	18	37	81	21
TP 16	253	8	7	66	58	71
TP 17	242	4	7	34	86	70
TP 18	225	5	11	20	81	49
Mean	239.11	9.50	11.83	45.56	61.67	51.44
Median	241.00	5.50	7.50	45.50	72.00	66.50
SD	27.50	8.65	6.91	23.37	28.96	28.77
Min	194.00	0.00	3.00	7.00	7.00	8.00
Max	292.00	30.00	24.00	82.00	99.00	94.00

PCTL – percentile

Table 4. Results of Shooting tests 1, 2 (shoot 1,2 results in ms).

Tested person	Shoot 1	Hit 1	Shoot 2	Hit 2
TP 1	2830	1.00	1900	1.00
TP 2	2330	1.00	1980	0.00
TP 3	1690	1.00	1230	1.00
TP 4	2150	0.00	1830	0.00
TP 5	2500	0.00	2210	1.00
TP 6	1910	1.00	1540	1.00
TP 7	1740	1.00	1310	1.00
TP 8	2560	1.00	1910	1.00
TP 9	1790	1.00	1290	1.00
TP 10	1670	1.00	1310	1.00
TP 11	2470	1.00	2300	1.00
TP 12	1820	1.00	1260	0.00
TP 13	1910	1.00	1610	1.00
TP 14	2370	0.00	2270	1.00
TP 15	2200	0.00	1970	1.00
TP 16	2290	1.00	1750	1.00
TP 17	2180	1.00	1490	0.00
TP 18	2790	1.00	1980	1.00
Mean	2177.77	0.78	1730.00	0.78
Median	2190.00	1.00	1790.00	1.00
SD	358.91	0.42	351.71	0.42
Min	1670.00	0.00	1230.00	0.00
Max	2830.00	1.00	2300.00	1.00

Explanatory notes: SHOOT 1 – 1st shooting test, SHOOT 2, 2nd shooting test, HIT 1.2 – hit (1.00) or missed target (0.00)

Correlations between tests

Following relationships were observed in the non-specific tests using Pearson correlation coefficient. In the Reaction test, we found the correlation between SRT and MT r=0.56. The correlation is not high, but the relationship between values is directly proportional. That means that tested persons with better reaction time were also better in the speed of task accomplishment. In the Determination test, there is no correlation between CRT and the number of mistakes (r=-0.08). That means that the speed of the task accomplishment is not correlated with accuracy, attention and ability to resist demanding situation is more important than the reaction time. There is no correlation between SRT in the Reaction test and CRT in the determination test (r=-0.03).

Following relationships were observed in the specific tests. In the specific Shooting tests 1&2 there is no correlation between SRT and accuracy (SHOOT 1 and HIT 1 r = -0.21; SHOOT 1 and HIT 2 r = 0.10; SHOOT 2 and HIT 1 r = -0.46; SHOOT 2 and HIT 2 r = 0.14). That means that police officers with faster reaction were not more inaccurate.

Following relationships were observed between specific and non-specific tests. There is no correlation between SRT in Reaction test and performance in the Shooting test 1 (r=0.06) and Shooting test 2 (r=-0.01), which is a sum of SRT and MT. That means that there is no relationship between performance in the non-specific and specific reaction tests.

DISCUSSION

Background of our study is based on the police officers performance analysis [3,5,6] and anthropometrics findings [8–10]. These sources confirmed two premises. Firstly, police performance is demanding on well-timed and quick reaction, when responding to the sudden action by a citizen not respecting the law. Secondly, reaction time affects the resulting response (movement) time as it is part of it. That is why we analysed the reactivity of police officers from diverse point of view. I order to do that, we used four different tests measuring SRT and CRT. Besides the descriptive part, several correlations between tests were calculated to analyse possible connection between tests and their

potential for personnel evaluation. Several issues should be taken into account when comparing result on SRT and CRT from diverse tests.

At the beginning of the research we hypothesised that tested persons with a shorter SRT in the non-specific Reaction Test will achieve shorter SRT in specific shooting tests. But we have not found a relationship between the SRT in the non-specific Reaction test and performance in the specific shooting tests. There are two explanations of this finding. Firstly, in the specific shooting tests, the SRT is just part of the performance together with the MT (task accomplishment). That means, SRT has lower influence on the whole response time, which include also the correct gun manipulation. Also aiming weapons at target is part of the performance, but in the distance of 10 meters has not high influence on the total response time, as in the short range is the shooting task more instinctive. This fact was confirmed in our study, where the speed of task accomplishment was not correlated with inaccuracy. This means that by training, it is possible to achieve a high level of shooting skills in which speed is combined with accuracy. Secondly, as we didn't observe correlation between non-specific and specific SRT tests. We interpret this finding in that way – the specific response on the specific stimuli is critical, that is why specific tasks need specific tests. Finaly, we didn't observe correlation between SRT and CRT tests. It should be considered that genetic determination of SRT is approximately 80% [10]. Also, according to the Hicks law, the CRT is prolonging in the complex situation where number of stimuli is increasing. That is why SRT is not a predictor for better performance in the CRT tests. Our results are in the line with previous findings [17,18], that SRT is not a predictor of success in the complex decision making process.

CONCLUSIONS

In our study, we discovered new finding concerning the reaction time and stress tolerance among Czech police officers. The single reaction time among police training instructors was M=261.56±33.60 ms, which corresponds to the 66.28 percentile of age norm. Performance in the stress tolerance test also matches the average performance in population (M=45.56 percentile of correct reactions, M=61.67 percentile of incorrect reactions, M=51.44 percentile of skipped signals). That means that police officers do not differ from the average population in the SRT and CRT in non-specific tests. Tested persons with better reaction time were also better in the speed of task accomplishment in non-specific reaction test. On the other hand, police officers with faster reaction were not more inaccurate in the specific shooting tests. In conclusion, we can state that there is no relation between results in specific and non-specific reaction tests. Nonspecific test of SRT and CRT are suitable for a general assessment of motor abilities. Specific tasks need specific training and specific evaluation methods. Reactivity evaluation in law enforcement training should not focus on the reaction to the general stimulus but instead should encourage the use of specific stimulus analogous to those experienced in self-defence conditions.

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