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Original scientific paper

Sprint Running, Agility and Anaerobic Endurance: Standards for the Students at the University of Criminal Investigation and Police Studies

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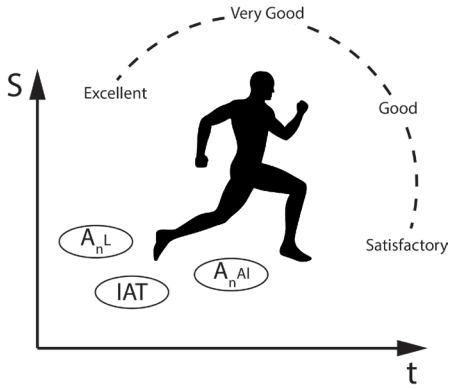
Abstract: Resolving critical incidents can be extremely physically demanding for police officers. Consequently, throughout the selection process, training, and working career, police officers' physical abilities are often assessed with a battery of tests. Research has been conducted with a total sample of 523 students (232 female and 291 male) at the University of Criminal Investigation and Police Studies (UCIPS), with the aim of defining the norms for Linear sprint performance at 20 m (LSP20m), Illinois agility test (IAT) and Shuttle run 300-yard (ShR300y). The homogeneity of the results has been established by the low skewness and kurtosis coefficient, as well as by the values obtained from the Kolmogorov-Smirnov test, meaning the data are not significantly statistically different from the normal distribution. Based on the percentile distribution, qualitative and quantitative normative values have been defined for LSP20m, IAT and ShR300y. The achievement levels have been ranked as follows: < P10 (insufficient), P10 to P25 (poor), P25 to P50 (fair), P50 to P75 (good), P75 to P90 (very good) and > P90 (excellent). LSP20m, IAT and ShR300y tests can be used for assessing acceleration, running speed and change-of-direction speed in the anaerobic work regime. Furthermore, they correspond to the first stage of critical incidents resolution – *getting to the problem* (hence can be viewed as job-related fitness tests). Since population norms have been established, their implementation in the battery of tests for the assessment of UCIPS students' physical abilities in the sense of running tests can be quantitatively applied at the situational system of testing of Specialized Physical Education.

Keywords: police students, Specialized Physical Education, physical abilities, testing procedure.

Graphical abstract



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INTRODUCTION

Due to the diversity of the tasks performed by police officers (POs), this profession is considered extremely demanding and stressful. Despite the fact that their work is greatly deskbound (Anderson et al., 2001; Lagestad & van den Tillaar, 2014), while on duty, POs may face unique physical challenges. For instance, POs are obliged to pursue and apprehend criminals, control masses, remove obstacles, and assist after traffic accidents, or during natural disasters (Strating et al., 2010; Lockie et al., 2020). In these critical incidents, the resolution of which is an integral part of the job, POs' physical ability could be singled out as one of the key requirements for successful work performance (Dawes et al., 2017; Lockie et al., 2018).

In order to meet the abovementioned professional demands, when selecting candidates who are to be educated to become POs, physical abilities (PAs) are often evaluated (Orr et al., 2018; Koropanovski et al., 2020). Once the selection process has been completed, one of the key education components pertains to physical training (PT), aiming to enhance cadets' PAs in comparison to the initial state, as well as to help them acquire adequate specific skills (Dimitrijević et al., 2014; Lagestad & van den Tillaar, 2014; Lockie et al., 2020). In other words, the goal of PT is to develop general physical abilities (GPA) and specific strength and motor abilities (SSMA) to the prescribed standard level, so as to enhance POs' work efficiency (Lockie et al., 2020; Janković et al., 2020; Mantilla-Rodriguez et al., 2021). However, not all cadets manage to graduate, and the reason might be the failure to meet the predefined GPA and SSMA standards (Lockie et al., 2019). Therefore, by regularly evaluating GPA and SSMA, it is possible to monitor the effects of PT, as well as the means of its realization, and utilize the obtained results in order to further improve the education process (Strating et al., 2010; Dopsaj et al., 2012; Orr et al., 2016).

In practice, various institutions dealing with PT of the future POs have been found to emphasize the significance of developing certain PAs. Accordingly, different programs and batteries of tests are conducted in order to improve and assess PAs (Lockie et al., 2019). At the University of Criminal Investigation and Police Studies (UCIPS), the development and evaluation of GPA and SSMA takes place within the scientific area of Specialized Physical Education (SPE). The initial testing that candidates face is organized at the entrance exam. At this stage, the following PAs are assessed: the level of muscle force development (hand grip for women and maximal isometric force of the back extensors for men), muscular power of lower limbs (standing long jump and Abalakov vertical jump test), upper-body muscular endurance and power (sit-up test within 30 seconds and push-ups performed within 10 seconds), aerobic endurance (12-minute Cooper running test), and motor educability (contraction and stretching test) (Dopsaj et al., 2007; Koropanovski et al., 2020). By means of this battery consisting of seven tests, candidates' general level of physical ability is evaluated – graded from 0 to 20 points, with a defined eliminatory threshold (Janković & Dimitrijević, 2012). This manner of selection, by means of which candidates with insufficient physical abilities are eliminated, enables the admitted students who embark on an educational process within SPE to achieve the projected goal and develop PAs to the level of 66.6% compared to the national population's average (Dopsaj et al., 2007).

Generally, the goal and tasks of the SPE are directly related to the development of the dominant abilities, skills and knowledge applied in POs' practice when using force. Edu-

cation is conducted via related segments at three levels: basic training, advanced training and situational training (Amanović et al., 2015). In order to monitor the effects of the SPE teaching program through the projected student progress compared to the initial level, after each completed level, GPA and SSMA are evaluated (Janković & Dimitrijević, 2012). Apart from the tests conducted at the entrance exam (Koropanovski et al., 2020), the battery of tests contains the assessment of the following: running speed (20m flying start), repetitive strength of arm flexors (time needed for 10 chin-ups), and isometric force of the leg extensors. The defined norms need to be met in order for a student to be eligible for the next segment of the SPE exam (Blagojević et al., 2019). At the basic and advanced level, SSMA is evaluated by expert grading of the techniques from SPE domain (Amanović et al., 2015). At the situational level, job-related fitness test is also used for the assessment of POs' specific ability (Janković et al., 2015).

Job requirements entailing physical competence, in the sense of successfully performing professional assignments, could be applied as the foundation for PA testing during the assessment of work abilities (Hogan, 1991). For this reason, one of the ways the efficiency of POs education can be improved is by permanent evaluation and re-validation of the existing tests, accompanied by an additional implementation of new appropriate measurement procedures and normative parameters (Anderson et al., 2001; Strating et al., 2010; Dopsaj et al., 2012). Analysing the structure of UCIPS students' PA assessment has led to the conclusion that including additional tests for evaluating agility and anaerobic lactic endurance could contribute to a more accurate estimation of GPA and SSMA, thereby encompassing these significant areas of motor and work space, from the aspect of POs' professional ability (Janković & Dimitrijević, 2012; Janković et al., 2015). Taking into account the structure of critical incidents resolution (Anderson et al., 2001), the assessment of linear running, as well as running with direction changes, in the anaerobic work regime, could be regarded as an important segment of the battery of tests for PA of POs evaluation. Therefore, not only does this paper aim at defining standards for the tests which assess short sprint performance, agility and anaerobic endurance of students of both sexes, but it also aims at determining their norms compared to performance success. The significance of the paper pertains to the possibility of improving PA evaluation, by complementing the current battery of tests for the UCIPS students at the situational level of the SPE.

METHODS

Sample of Respondents

The testing was conducted with six generations of third-year UCIPS students, within the scope of the SPE, in the period between 2014 and 2020. The total sample consisted of 523 students, out of which 232 were female (44.36 %) – average age of 21.6 ± 0.9, body height 169.7 ± 4.9 cm, body mass 62.3 ± 6.5 kg, BMI 21.6 ± 1.9 kg/m^2, and 291 male (55.64 %) – average age of 21.9 ± 1.1, body height 182.5 ± 6.2 cm, body weight 82.6 ± 9.4 kg, BMI 24.8 ± 2.2 kg/m^2. All tested respondents voluntarily participated in the research and gave their verbal consent to participate. As the first step they were familiarized with the goal of the study, as well as with the manner of gathering information. All measurements were

conducted in accordance with the ethical principles of research involving human subjects declared by The Helsinki Committee, as well as by The Ethics Committee of the University of Sport and Physical Education in Belgrade (ethical license number 484-2).

Procedures

Testing was conducted according to the same standard procedures for each generation. The cycle of testing lasted for three weeks; i.e., testing took place once a week, thus providing respondents with sufficient amount of time for a complete recovery. Linear sprint performance was assessed in the first week, change-of-direction speed in the second, and the level of anaerobic endurance in the third. At the start of each testing session, the test procedures were explained and demonstrated in detail. Subsequently, all respondents performed a low intensity mock test, so as to get acquainted with the direction of movement and the requirements of the test. Getting acquainted with the testing procedures, as well as with the manner of performance, enabled the participants to achieve representative results. Having familiarized themselves with the test, the respondents performed a standard warm-up (10-minute running warm-up and 10-minute dynamic stretching). After a 5-minute rest, the testing was conducted at the maximum intensity, and the results thereby obtained were noted for the purposes of the analysis in this research.

Performance Assessments

Linear sprint performance was evaluated over 20 m (LSP20m, expressed in seconds at the third decimal). Running sensors were set at the starting and finish line, at the distance of 20 m, height of 120 cm, and width of 150 cm between the timing gates. The respondents were waiting for a signal in a standing position, 1 m in front of the first pair of sensors and were instructed to run at maximal speed to the final pair of sensors. Going through the first pair of sensors activated the chronometer, whereas running through the last one shut it off. The total score for the test consisted of two components; acceleration was assessed as the time from 0 to 10 m, whereas running speed was evaluated as the time from 10 to 20 m (Mirkov et al., 2008; Younes et al., 2013). The time was measured with photocells connected to a computer system designed for physical ability testing (*Physical ability test 02*, UNO-LEX, NS, Serbia), with the precision of 0.001s.

Illinois agility test (IAT, expressed in seconds at the third decimal) was used to assess the change-of-direction speed (Figure 1) (Streetman et al., 2022; Koropanovski et al., 2022). At the starting line, the respondents were waiting in a standing position for a signal to start the test. On command, the respondents began running toward the first turning cone (TC1), and activated the chronometer by going through the first pair of sensors, set at the height of 120 cm, whereas the width between them was 150 cm. At TC1, they turned around and headed back toward the central cone (CC1), turned again toward the fourth central cone (CC4), and weaved through the central cones in both directions. The last segment of the test was running to the second turning cone (TC2), turning around it and running to the finish line where the chronometer was stopped by going through the

second pair of sensors (Lockie et al., 2013b; Kukić et al., 2020). The time for IAT test was measured by means of the same system as LSP20m (Physical ability test 02, UNO-LEX, NS, Serbia), with the precision of 0.001s.

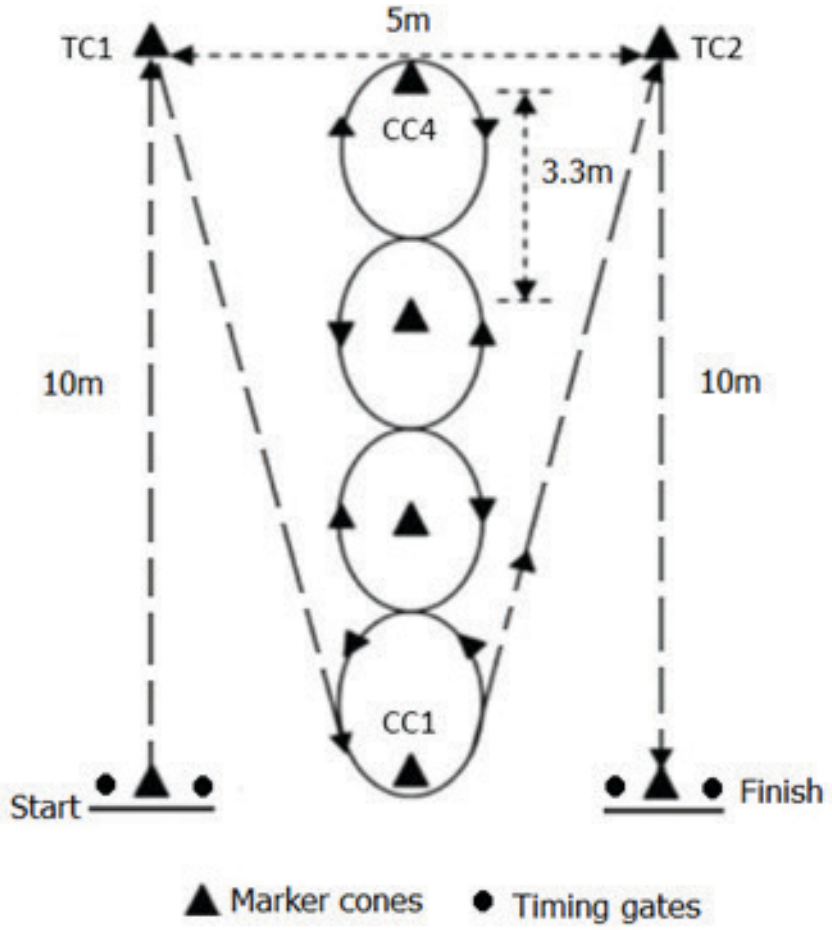

Figure 1. *Schematic of the IAT*

For the purposes of Anaerobic endurance assessment, Shuttle run 300 yard was used (ShR300y, expressed in seconds at the first decimal). The participants were informed about the adequate running intensity for this assessment, in order for them not to attempt to maximally sprint the entire distance. Testing protocol is such that there are two reference points, set 25 yards apart from one another. The respondents start at the signal, from a standing position, aiming to run to the 25-yard mark, touch it with their foot, turn and run back to the start. This procedure is repeated six times (a single run means going from the starting line to the mark and back) without stopping. Throughout the test, the respondents were notified about the completed sections, and the test was finished once the respondent crossed the finish line after the sixth cycle (Sporis et al., 2008). The time taken to complete ShR300i was measured with a stopwatch (Casio HS-70V, Tokyo, Japan), with the precision of 0.01s.

Statistical Analysis

All statistical analyses were conducted by means of Statistical Package SPSS Statistics for Windows, Version 20.0. The presented data were observed separately for males and females. Within the descriptive statistics, the mean value (Mean), standard deviation (SD), as well as minimal (Min) and maximal (Max) values of the results were calculated for each variable. With a view to define the homogeneity of the set, the values of skewness (Skew) and kurtosis (Kurt) were calculated. In the next procedure, the regularity of individual variable distribution was evaluated by means of Kolmogorov-Smirnov test (KS). The normality of data distribution was shown graphically using Q-Q plots. In order to define the criteria of tests performance success, the next step of statistical analysis focused on measuring the distinctive percentiles: 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles. These percentile ranks were chosen according to the physical performance and overall professional performance of police officers, using the following criteria: deficient < 10^{th}, poor: from 10^{th} to 25^{th}, fair: from 25^{th} to 50^{th}, good: from 50^{th} to 75^{th}, very good: from 75^{th} to 90^{th} and excellent: > 90^{th} percentile (Mantilla-Rodríguez et al., 2021).

RESULTS

The results have shown that the research was conducted on the exceptionally homogenous set, as confirmed by a low level of skewness and kurtosis coefficient compared to Gaussian curve (Table 1). Likewise, KS results show that the data are not statistically significantly different from the normal distribution (Table 1, Figure 2, Figure 3, Figure 4). This indicates that the observed data are approximately normally distributed, signifying that the tests are highly discriminatory. Based on the defined values of percentile distribution (Table 2), the norms have been set for LSP20m (Table 3), IAT (Table 3) and ShR300y (Table 4).

Table 1. *Descriptive Statistics for LSP20m, IAT, and ShR300y for Male and Female Students*

Variables	Sex	Mean	SD	Min	Max	Skew	Kurt	KS
LSP20m (s)	Female	3.815	0.220	3.249	4.468	0.098	-0.062	0.200*
	Male	3.309	0.167	2.830	3.801	0.341	0.457	0.200*
IAT (s)	Female	20.547	1.236	17.555	22.961	-0.138	-0.764	0.200*
	Male	18.063	0.841	15.820	19.912	0.158	-0.472	0.200*
ShR300y (s)	Female	74.9	3.8	65.4	81.9	-0.287	-0.545	0.200*
	Male	65.1	2.9	57.2	70.9	-0.274	-0.394	0.200*

*This is a lower bound of the true significance.

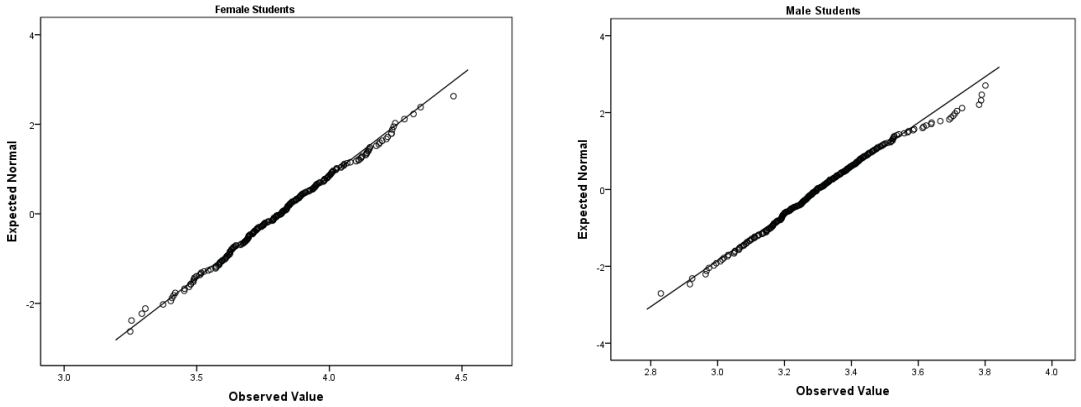

Figure 2. *Normal Q-Q Plot of LSP20m for Female and Male Students*

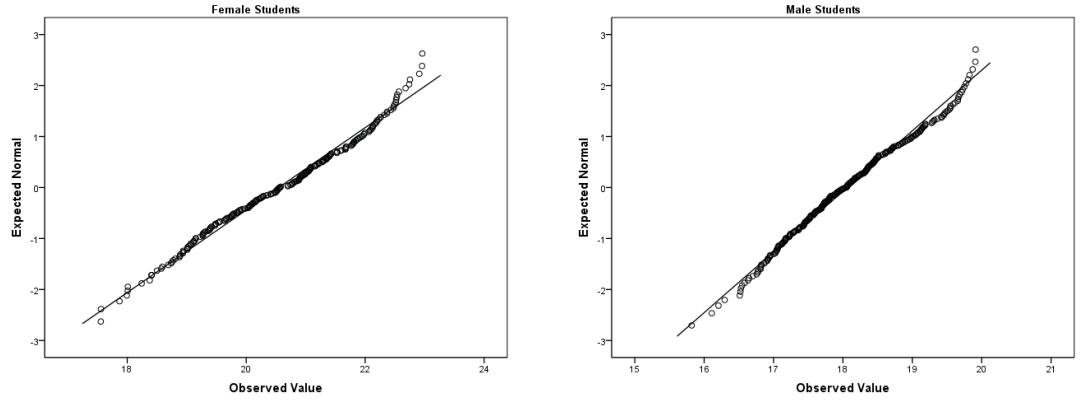

Figure 3. *Normal Q-Q Plot Of IAT for Female and Male Students*

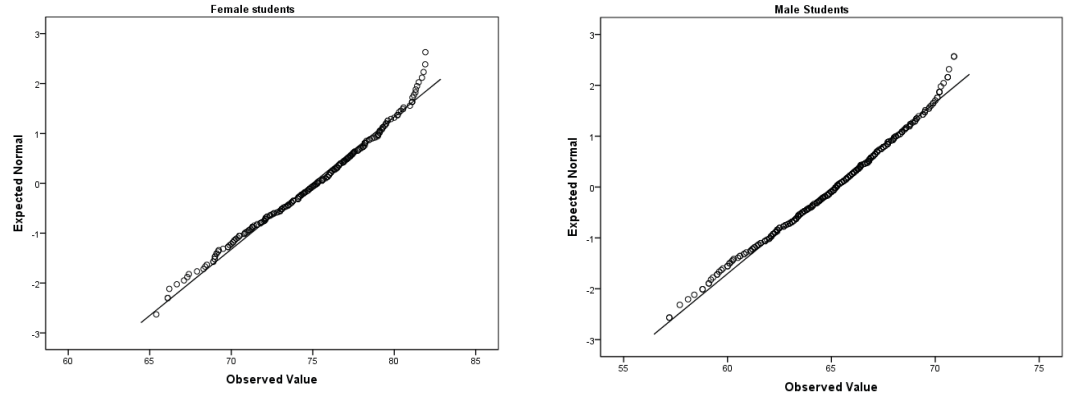

Figure 4. *Normal Q-Q Plot of ShR300y for Female and Male Students*

Table 2. *Percentile Distribution Results for Female and Male Students*

Percentiles range	Female students			Male students		
	LSP20m	IAT	ShR300y	LSP20m	IAT	ShR300y
90	3.531	18.937	69.8	3.103	17.027	60.9
75	3.668	19.551	72.2	3.195	17.457	63.1
50	3.818	20.564	75.3	3.296	18.050	65.2
25	3.956	21.498	77.8	3.413	18.614	67.2
10	4.123	22.187	79.7	3.523	19.288	68.9

Table 3. *Norms for LSP20m Evaluation Defined Compared to the Percentile Distribution*

Percentiles range	Success	Grade	Female students		Male students	
			Normative	Nº (%)[1]	Normative	Nº (%)[1]
90 – 100	Excellent	10	3.531 and faster	23 (9.91)	3.103 and faster	29 (9.97)
75 – 90	Very Good	9	3.532 – 3.668	35 (15.09)	3.104 – 3.195	46 (15.81)
50 – 75	Good	8	3.669 – 3.818	58 (25)	3.196 – 3.296	72 (24.74)
25 – 50	Satisfactory	7	3.819 -3.956	58 (25)	3.297 – 3.413	72 (24.74)
10 – 25	Sufficient	6	3.957 – 4.123	35 (15.09)	3.414 – 3.523	44 (15.12)
0 – 10	Insufficient	5	4.124 and slower	23 (9.91)	3.524 and slower	28 (9.62)

[1] Number and percentage of respondents compared to the observed population.

Table 4. *Norms for IAT Evaluation Defined Compared to the Percentile Distribution*

Percentiles range	Success	Grade	Female students		Male students	
			Normative	Nº (%)[1]	Normative	Nº (%)[1]
90 – 100	Excellent	10	18.937 and faster	23 (9.91)	17.027 and faster	29 (9.97)
75 – 90	Very Good	9	18.938 – 19.551	35 (15.09)	17.028 – 17.457	44 (15.12)
50 – 75	Good	8	19.552 – 20.564	57 (24.57)	17.458 – 18.050	73 (25.09)
25 – 50	Satisfactory	7	20.565 – 21.498	59 (25.43)	18.051 – 18.614	73 (25.09)
10 – 25	Sufficient	6	21.449 – 22.187	35 (15.09)	18.615 – 19.288	43 (14.78)
0 – 10	Insufficient	5	22.188 and lower	23 (9.91)	19.289 and lower	29 (9.97)

[1] Number and percentage of respondents compared to the observed population.

Table 5. *Norms for ShR300y Evaluation Defined Compared to the Percentile Distribution*

Percentiles range	Success	Grade	Female students		Male students	
			Normative	Nº (%)[1]	Normative	Nº (%)[1]
90 – 100	Excellent	10	69.8 and faster	24 (10.34)	60.9 and faster	28 (9.62)
75 – 90	Very Good	9	69.9 – 72.2	35 (15.09)	61.0 – 63.1	44 (15.12)
50 – 75	Good	8	72.3 – 75.3	58 (25)	63.2 – 65.2	74 (25.43)
25 – 50	Satisfactory	7	75.4 – 77.8	58 (25)	65.3 – 67.2	76 (26.12)
10 – 25	Sufficient	6	77.9 – 79.7	34 (14.66)	67.3 – 68.9	39 (13.40)
0 – 10	Insufficient	5	79.8 and slower	23 (9.91)	69.0 and slower	29 (9.97)

[1] Number and percentage of respondents compared to the observed population.

DISCUSSION

Based on the obtained results of the examined sample and the application of the method of distributive clustering of results, the norms for the UCIPS student for linear sprint running, agility and anaerobic endurance were determined. The implementation of the obtained study results in the function of applied tests could provide scientific standardization of the assessment of physical abilities of the UCIPS students in relation to specific tests for anaerobic running abilities. An intrinsic part of police work is resolving certain critical incidents where GPA and SSMA would need to be manifested (Dopsaj et al., 2012; Dawes et al., 2017). The structure of critical incidents resolution can be divided into three relatively separate stages: getting to the problem, solving the problem and removing the problem. The first stage (getting to the problem) refers to arriving to the scene as fast as possible and/or pursuing a suspect. In such occasions, POs are required to run 87 meters on average, in the range from 5 to 350 meters, whereby one needs to run at the maximum or almost maximum speed with potential sudden direction changes (Anderson et al., 2001). Distances run by POs in the *getting to the problem* stage are mostly performed at sub-maximum or maximum speed, occurring in anaerobic work regime (McArdle et al., 2007). LSP20m test consists of two components: acceleration and reaching maximum running speed (Mirkov et al., 2008), and considering that the time taken to perform the test is less than 5 seconds, it is in the zone of anaerobic alactic endurance (Sybil et al., 2018). On the other hand, IAT involves rapid acceleration, deceleration, as well as direction changes when sprinting in a linear fashion, i.e., it provides information of the possibility of running with direction changes at different angles (Kukić et al., 2020). As opposed to LSP20m, it lasts approximately 20s (female 20.547 ± 1.236; male 18.063 ± 0.841), and hence could result in metabolic limitations in the IAT performance (Lockie et al., 2013b). On average, the duration of ShR300y was 74.9 ± 3.8 seconds for females, and 65.1 ± 2.9 seconds for males. This test, containing a linear direction change, and thus both acceleration and deceleration, is performed at sub-maximum intensity with high heart-rate frequencies and lactate concentration (Sporis et al., 2008; Faude et al., 2009). By means of LSP20m, IAT and ShR300y tests, PAs can be evaluated from the aspect of acceleration, running speed and change-of-direction speed in the anaerobic work regime. Furthermore, the above-mentioned tests, with their structure and the manner of performance, can be defined as job-related fitness tests to a certain extent (pertaining to the first stage of critical incidents resolution – *getting to the problem*). Therefore, their implementation into the existing battery of PA assessment at the situational level of SPE can be considered justified.

The achievements at the tests assessing running speed at various distances are linked with the quality of occupational tests performance (Lockie et al., 2018). The aforementioned research has found that *99-yard obstacle course run* and *500-yard run* tests, conducted within job-specific testing battery, are statistically significantly related to the running results at 200 m run and 2.4 km run tests. In addition, there is a small to moderate correlation of GFA assessment test results (push-ups, sit-ups, pull-ups, mountain climbers) with job-specific task performance. To rephrase it, POs can be expected to achieve better results in job-specific tasks and at job-related fitness tests with a higher level of anaerobic capacity (Strating et al., 2010; Janković et al., 2015; Dawes et al., 2017). One of the reasons for this is in the fact that the intensity and realization time of job-related fitness tests correspond to the anaerobic lactate work regime (Janković et al., 2015). Additionally, the efficiency of

realizing certain segments of the tests, such as the ability to manoeuvre around obstacles, may also depend on linear sprinting performance and change-of-direction speed (Lockie et al., 2013a; Young et al., 2015; Lockie et al., 2020). For this reason, it is necessary to develop and control the aforementioned physical abilities, in the aim of POs' better professional competence. In Janković and Koropanovski (2017), a statistically significant correlation was found between POs' specific abilities assessment test results on the one hand, and linear sprint performance (30 m running test), IAT and ShR300y test on the other, in the respondents of both sexes. To put it differently, the success at LSP20m, IAT and ShR300y tests could be linked with job-related fitness test success. Aside from that, Lockie et al. (2019) suggest the importance of high-intensity running and change-of-direction speed (including strength, power and sprint ability), which could improve the odds for a successful university performance of police cadets. This may be an additional reason for the introduction of these tests in the battery for PA assessment in the UCIPS students.

In the further procedure, the tests being highly discriminatory, as defined by the normal distribution, determining qualitative and quantitative normative values of all observed variables has been made possible. Considering that the population in question consists of physically trained and selected police cadets, the levels of success were determined at 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles (Table 3, Table 4, Table 5). The exhibited percentile distribution can classify the observed physical abilities and rank them as follows: < P10 (insufficient), P10 to P25 (poor), P25 to P50 (fair), P50 to P75= (good), P75 to P90 (very good) and > P90 (excellent), all in accordance with the existing methodological standards (Dopsaj et al., 2012; Janković et al., 2015; Lockie et al., 2020; Mantilla-Rodríguez et al., 2021). UCIPS is a high education facility whose manner of evaluation is conducted by the application of the European Credit Transfer and Accumulation System (Koropanovski et al., 2020). Accordingly, test performance defined by percentile distribution is greatly adjusted to the passing standards of student achievement (Warfvinge, 2008). This system enables grading students' success as Excellent (~10%), Very Good (~15%), Good and Satisfactory (total approximately 50%), Sufficient (~15%) and Insufficient (~10%), for all observed tests.

One of the factors in defining the level of POs' work abilities pertains to the results of PA assessment tests (particularly if the tests evaluate SSMA), thus enabling the use of percentile distribution to classify individuals for different jobs within police organization. On the other hand, by determining the achievement of certain individuals to be below the standard level (< P10), the organization could assist by conducting additional adequate training programs with a view to enable each individual to achieve the desired norms that would make him or her professionally competent (Janković et al., 2020). As already shown, regardless of the selection and the SPE training programs realized in the first and second year, approximately 10% of both male and female students is below P10 in all observed tests. This can additionally lead to the fact that one-size-fits-all training should not be used. Instead, if possible, additional implementation of individual or ability-based trainings could enable students who fail to meet the desired normative to significantly improve their abilities (Orr et al., 2016; Lockie et al., 2020). In this manner, PA in students below

the standard level could presumably be enhanced to meet the desired level, thereby fulfilling one of the SPE objective – the development and maintenance of GPA and SSMA as one of the parameters of POs' work ability.

CONCLUSIONS

LSR20m, IAT and ShR300y tests contain motor patterns of acceleration and deceleration, linear sprint and change-of-direction speed, conducted at the maximum or sub-maximum intensity. The manner in which they are conducted corresponds to one of the segments in resolving critical incidents (the stage referred to as *getting to the problem*), which can classify them, to a certain extent, within job-related fitness tests in anaerobic work regime. The normal distribution of observed variables enabled defining of qualitative and quantitative values of the results, based on the percentile distribution. Thereby, establishing norms for grading the UCIPS students within the scientific area of the SPE at the situational level of training has been made possible.

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