Progress in Nutrition 2021; Vol. 23, N. 4: e2021304 DOI 10.23751/pn.v23i4.12082

Original article

Adding Shooting Intervals to the 20m Multistage Shuttle Run Test: A New Test "Shooting Shuttle Run Test"

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Abstract. This study aims to develop a new test by modifying the 20 m multi-stage shuttle run test, in which shooting intervals are added. 137 male police candidates (20.91±1.19 years, height 177.42±6.02 cm, body weight 72.26±8.51 kg, body mass index 22.92±2.15 kg/m^2) who were studying at Police Vocational School participated in the study voluntarily. The 20-meter multi-stage shuttle run test has been modified and a 3-second shooting interval has been added to each level. Police candidates were first subjected to the multistage shuttle run test. They participated in the shooting shuttle run test one week later and the retest one week later. In the measurements, the mean heart rate and the number of completed shuttles were recorded. In the reliability analysis, the Intraclass Correlation Coefficient (ICC) of the Test-Retest data was calculated. In the validity analysis, The Concurrent Validity test was applied to the results of the original shuttle run test and the shooting shuttle run test, and the Pearson Correlation coefficient was used. As a result of the reliability analysis, a significant correlation was found in the completed shuttle (ICC r=0.99, p<0.01) and heart rate data (ICC r=0.95, p<0.01) of the test-retest measurements. As a result of the validity analysis, a significant correlation was found in the completed Shuttle (r=0.93, p<0.01) and heart rate data (r=0.90, p<0.01) of the shuttle run test and shooting shuttle run test measurements. As a result, it has been determined that the shooting shuttle run test, in which 3 seconds of shooting intervals are added, has a high level of reliability and validity. It can be said that the shooting shuttle run test can be used to simultaneously measure the shooting performance and endurance of police and security forces. It is recommended to use the shooting shuttle run test in all sports involving shooting, where shooting performance is important, and in sports such as football, basketball, and handball.

Key words: Shooting, multistage shuttle run test, police, performance, fatigue

Introduction

It can be said that activities with high fatigue effects such as suspect pursuit, long chases, and additional tasks without rest weaken the police performance and ability to use force. Failure to properly perform risky tasks can result in harm to police, suspects and the public (1–3).

Decreased physical performance in the face of fatigue, the difficulty of task or exercise (4), in other words, it is defined as the inability of the muscles to maintain the required power level (5). One or all conditions such as muscle weakness and tremor, loss of reaction speed, loss of visual perception may occur as a result of fatigue. In general, it can be said that fatigue negatively affects physical mobility and performance. Police skills that require pursuit, such as the chase, may require high levels of cardiovascular endurance. One of the performances that fatigue directly affects is pistol shooting performance, which is critical for the police profession (6).

Pistol shooting is a delicate skill that requires fine and complex motor skills (7,8). Studies report

that high fatigue and physical stress cause lower shooting accuracy (8–10). Fatigue due to exercise that requires heavy effort negatively affects shooting accuracy (11). The literature reports that shooting scores decrease when heart rate (HR) increases, and increase in shooting scores when HR decreases (12–14). Based on the general results of the studies, it can be said that there is an inverse relationship between shooting scores and HR.

Pistol proficiency tests are applied in 2 different ways, statically and dynamically (15). While static tests are applied based on various distance rules in static environments, the basis of dynamic tests is the presence of movement. In the dynamic tests, a series of missions are completed on the shooting tracks, which are based on the conflict scenario. In a study, it was reported that while the gun shooting accuracy of police officers was more than 90% in a static environment, the average accuracy of shooting in incidents was between 15-50% (16).

Studies show that fatigue due to physical stress and effort negatively affects shooting performance (2,5,9,10,17). Today, several studies have been conducted to measure shooting performance under fatigue pressure and to analyze its effects (6,8,12,17). These studies generally aim to find the relationship between physical stress and physical fitness and shooting performance under the pressure of fatigue, and to determine the factors affecting it. However, a protocol in which both cardiovascular endurance and shooting performance can be measured simultaneously has not been found in its methods and findings. As a result of the literature review, no test was found to measure shooting skills with the uninterrupted fatigue protocol.

Multistage Shuttle Run Test (MSRT), in which uninterrupted fatigue systematically increases, was developed to measure cardiovascular endurance (18,19). Different modifications have been developed since the day MSRT was introduced to the literature (20–31). All of these developed tests are used to measure cardiovascular endurance. As far as we know, there is no research similar to the Shooting Shuttle Run Test (SSRT) protocol in the literature. Therefore, the aim of the study is to analyze the effects of 3-second shooting intervals added to the levels of MSRT.

Materials and Methods

In this study, which is derived by the modification of the shuttle run test and allows shooting at every level with 3 second intervals, HR and Completed Shuttle (CS) data were examined. Participants (n=137) attended first MSRT and one week later SSRT. The test-retest group (n=76) selected by random sampling method among the participants also participated in SSRT one week later. The validity and reliability of the newly developed test were examined.

Subjects

137 male police candidates (20.91±1.19 years, height 177.42±6.02 cm, body weight 72.26±8.51 kg and body mass index 22.92±2.15 kg/m^2) voluntarily participated in the study. The research was approved by the Ethics Committee of Kırıkkale University with the protocol code of 29.06.2015-18/09. All participants were informed of the potential risks and benefits of the study before giving written informed consent following the Declaration of Helsinki. Participants were encouraged to avoid high-intensity physical activity and not consume caffeine/alcohol for 24 hours before the tests.

Procedures

The Multistage 20-meter Shuttle Run Test (MSRT). MSRT is an uninterrupted-maximal, reliable and valid aerobic capacity measurement method with burnout level, which includes going back and forth according to the signal tones between two lines formed in a 20-meter area (Figure 1) (18). The audio recording (32) and protocol (33) produced by the Australian Sports Commission were used in the MSRT application. All tests were carried out at approximately the same time of day (± 2 hours) and under similar environmental conditions (18-22 °C) in an indoor gym.

According to the Australian Sports Commission's protocol, the test starts at 8 km/h and continues at 0.5 km/h every minute. The beeps between the shuttles consist of a single tone, and 3 consecutive beeps at the levels where there are speed changes. Before starting

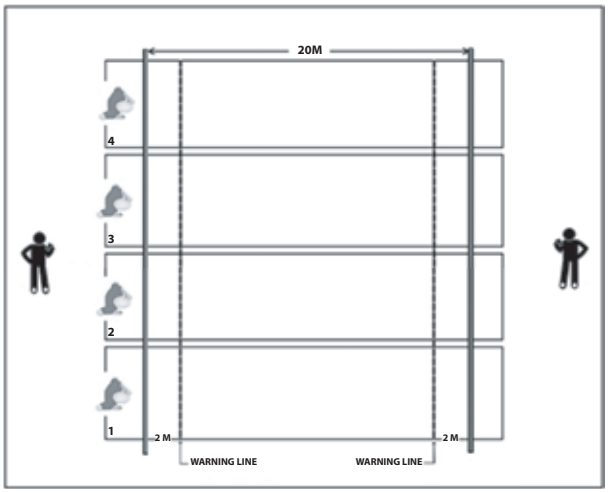

Figure 1. The multistage 20-meter shuttle run test

the test, participants were reminded that they should perform at the maximum level to provide motivation. During the test, the progress of the shuttle levels was reported by voice, providing continuous motivation and feedback. The test of the participant who received a red warning twice in a row was terminated and the last completed level and shuttle were recorded.

Shooting Shuttle Run Test (SSRT). The original MSRT application protocol is the same, with the only significant difference being the addition of 3-second shooting intervals at each level. Completed levels and the number of shuttles are recorded**.**

Shuttles with shooting interval are designed to be on one side. MSRT includes a speed increase of 0.5 km/h every 1 minute. It has been added to the 4th or 5th shuttles so that the shooting intervals do not coincide with the speed changes (Figure 2).

The mp3 file (32) containing the MSRT signals was rearranged with the MP3 Deluxe (34) computer program and 3 seconds were added for the shooting intervals. Different signal tones are used for shooting

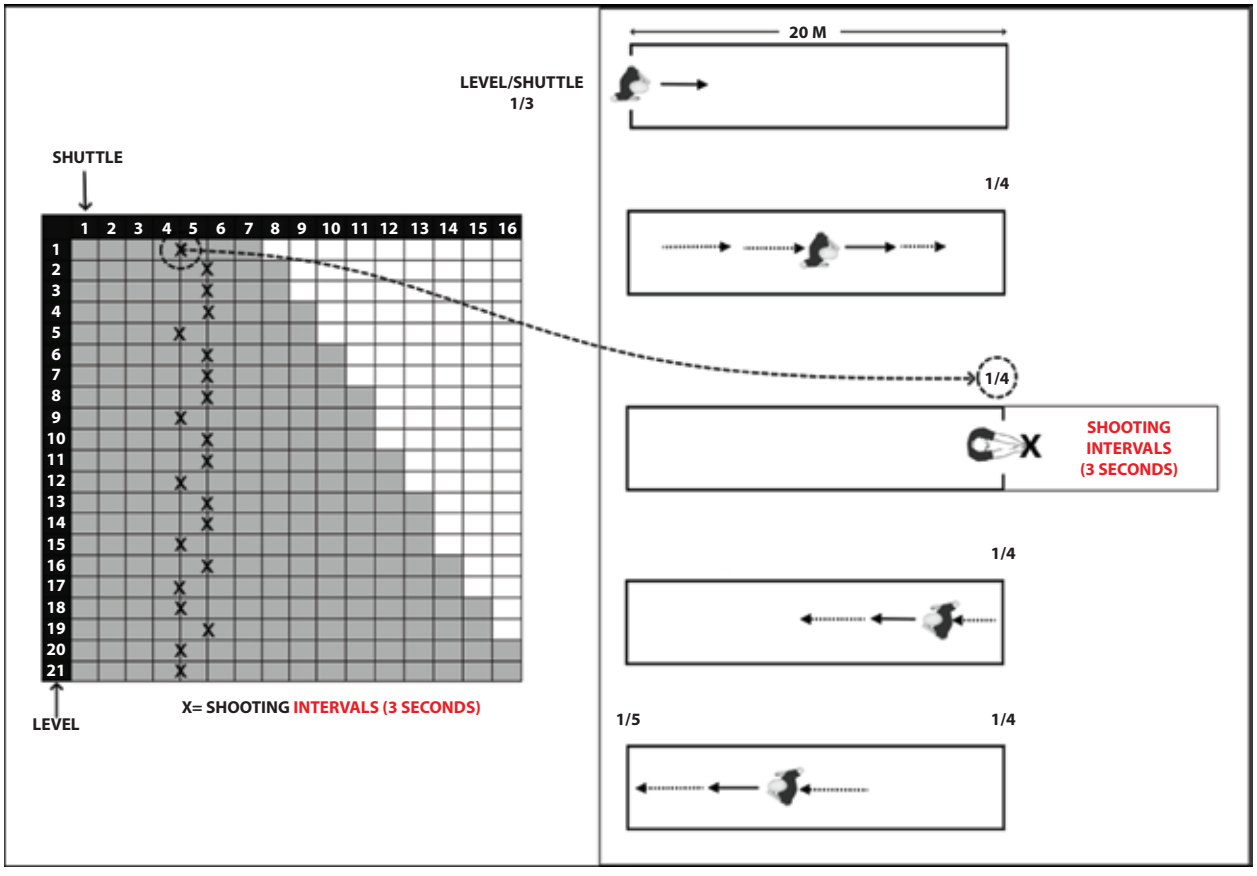

Figure 2. Shooting Shuttle Run Test Procedure

warnings. Participants waited 3 seconds in shooting intervals and continued the test according to the beeps.

Heart Rate Measurements. HR values are important as an indicator of strain. During the measurements, the HR changes of the participants were followed by telemetric watches. Changes in HR values in MSRT and SSRT measurements were recorded with Polar S810 (Polar Electro, Oy). The transmitter, which was fixed to the chest areas of the participants with an elastic belt, and the monitors (receiver) to be attached to the wrist were attached before the test. The Conductive gel was used to increase the conductivity of the surface of the transmitter in contact with the chest area. Electronic devices (mobile phones, etc.) with magnetic fields, which are thought to prevent data flow, were not taken into the test area. To ensure calibration, the test was started, and participants were asked to operate the heart rate monitor when they heard the beep. The minimum, average and maximum HR obtained during the measurements were recorded on the data forms. Only HR averages were considered as an indicator of physical strain between tests.

Statistical Analyses

SPSS 22.0 (Chicago, IL, USA) statistical package program was used in Windows environment for statistical analysis. Reliability is calculated with Intraclass Correlation Coefficient (ICC) value for test-retest results (35). Concurrent Validity analysis between the previously validated MSRT and SSRT data was applied and the Pearson Correlation Coefficient was used. Kolmogorov-Smirnov analysis was used for the normality tests of the data. All data showed normal distribution and calculated values were considered significant at $p<0.05$.

Results

Reliability

Descriptive statistics of SSRT Test-Retest data are presented in Table 1. According to the Kolmogorov-Smirnov normality test results ($p>0.05$), the data for all variables are normally distributed with 95% confidence.

As a result of the analysis performed to determine the Intraclass Correlation Coefficient (ICC) between the SSRT test-retest data, it was found that there was a positive (very strong) significant relationship (Table 2, Figure 3). High reproducibility was found between SSRT test-retest HR data (ICC=0.956: $p<0.01$) and TM data (ICC=0.997: $p<0.01$). The data obtained from the test-retest measurements are similar and the newly developed SSRT has high reliability.

Validity

Descriptive statistics of MSRT and SSRT data are given in Table 3. According to the Kolmogorov-Smirnov normality test results ($p>0.05$), the data for all variables are normally distributed with 95% confidence.

Table 1. Descriptive Statistics for SSRT Test-Retest Data

n=72	min	max	Mean	SD
Test HR_{mean} (bpm)	149	192	173.67	8.06
Retest HR_{mean} (bpm)	154	191	173.29	7.01
Test Shuttle	58	122	89.47	13.24
Retest Shuttle	58	123	89.79	13.19

Table 2. Intraclass Correlation Coefficient analysis for Test-Retest Results

HR_{mean}	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	,915[a]	,867	,946	22,503	71	71	,000
Average Measures	**,956**	,929	,972	22,503	71	71	,000
Shuttle							
Single Measures	,994a	,990	,996	325,816	71	71	,000
Average Measures	**,997**	,995	,998	325,816	71	71	,000

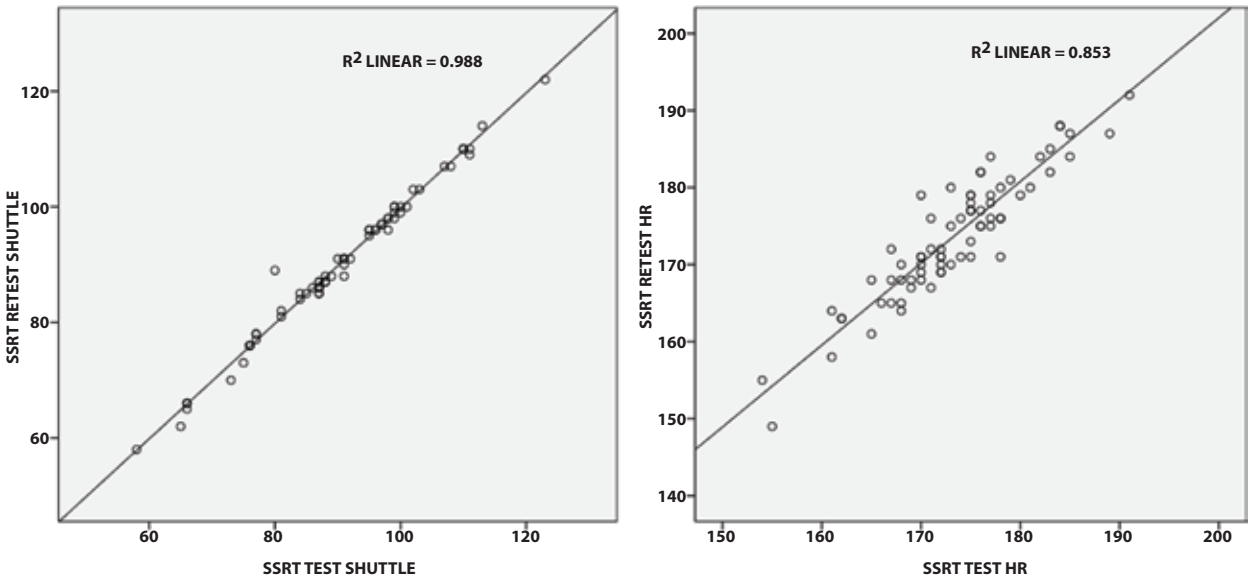

Figure 3. Test-Retest Scatter Plots

Table 3. Descriptive Statistics for Heart Rate and Shuttle at MSRT and SSRT

n=137	min	max	mean	SD
MSRT Shuttle	54	122	86.18	14.61
SSRT Shuttle	56	122	87.64	14.60
MSRT HR_{mean} (bpm)	150	188	169.76	7.28
SSRT HR_{mean} (bpm)	149	192	171.09	8.22

As a result of the Pearson correlation analysis performed to determine concurrent validity between MSRT and SSRT data, it was found that there was a positive (very strong) significant relationship (Table 4, Figure 4). There was a positive significant correlation between HR data (r=0.90: p<0.01) and CS data (r=0.93: p<0.01). Concurrent validity measures have high validity values and the newly developed SSRT is a valid test.

Discussion

As far as we know, no test has been developed in pistol proficiency test protocols that evaluates shooting performance in uninterrupted fatigue. Therefore, the

Table 4. Concurrent Validity Correlation Analysis Results at MSRT and SSRT

		MSRT HR_{mean}	**SSRT HR_{mean}**
MSRT HR_{mean}	Pearson Correlation	1	0.90**
	Sig. (2-tailed)		0.00
SSRT HR_{mean}	Pearson Correlation	**0.90****	1
	Sig. (2-tailed)	0.00	
		MSRT Shuttle	**SSRT Shuttle**
MSRT Shuttle	Pearson Correlation	1	0.93**
	Sig. (2-tailed)		0.00
SSRT Shuttle	Pearson Correlation	**0.93****	1
	Sig. (2-tailed)	0.00	

*n=137, **. Correlation is significant at the 0.01 level (2-tailed).*

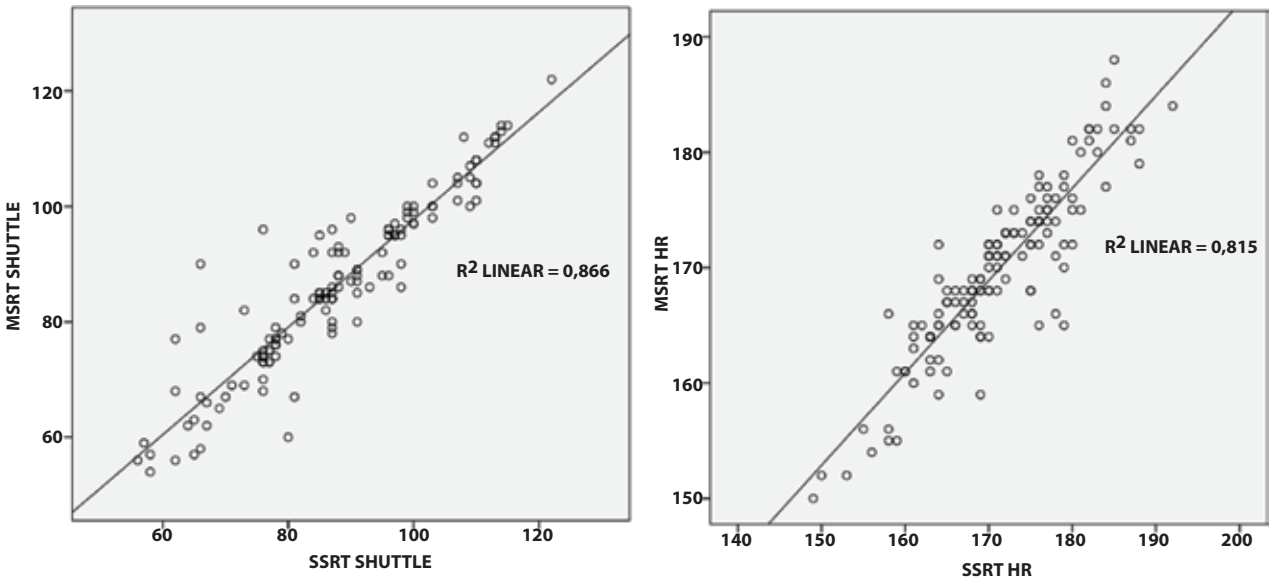

Figure 4. MSRT and SSRT Scatter Plots

SSRT is the first test developed specifically to evaluate the shooting performance of security guards under cardiovascular strain, allowing to measure shooting performance under uninterrupted fatigue. According to the main findings of the study, the 3-second firing intervals added to the MSRT levels did not affect the overall characteristics of the test. As a result of the MSRT and SSRT HR ($r=90$, $p<0.01$) and CS ($r=93$, $p<0.01$) analysis of the participants, it can be said that they have excellent concurrent valid correlations (Table 4, Figure 4). According to SSRT test-retest findings, it is a reliable test with HR (ICC=0.95, $p<0.01$) and CS (ICC=0.99, $p<0.01$) data (Table 2, Figure 3). A high ICC value is an important indicator that the SSRT test offers reproducible properties.

Evaluating shooting under the pressure of fatigue can be a crucial performance component. Shooting performance can be evaluated with 3-second intervals, which allows shooting at all levels of the MSRT test. In addition to shooting performance, it can also make predictions about aerobic capacity.

Various evaluations of performance can be made after fatigue is induced by experimental methods (36,37). There is a limited number of studies investigating shooting performance under fatigue pressure using the MSRT test (38,39). In these studies, cardiovascular endurance values were generally taken as an indicator of fatigue. Basketball shooting performance (39) and football kick performance (38) were evaluated in certain parts of the test with interruptions and breaks. Interrupted shooting protocol can allow rest, making results controversial. Because, when evaluated in terms of competition or dynamic environments, more than one shooting continues uninterruptedly until the activity/conflict is over. It can be said that shooting performance at all levels of uninterrupted fatigue is important in evaluating the athlete/police. Our study could be a pioneer in analyzing shooting performance at all levels of uninterrupted fatigue.

Mulazimoglu, who investigated the effects of fatigue on shooting performance in basketball players, determining fatigue levels by using the MSRT in his study (39). In his study, according to the MSRT results, he measured the shooting performance of the participants by giving intervals at moderate (50%) and high (90%) levels of fatigue. Participants were asked to continue the MSRT by measuring the 1st shooting performance at moderate fatigue and 2nd shooting performance at high fatigue. He reported that fatigue had negative effects on basketball shooting performance. Similarly, Radman et al. investigated the acute effects of kicking performance under gradually increasing physiological loads in football players (38). They used MSRT for physiological effects in their studies.

They cut certain levels of MSRT at 3-minute intervals and measured kick performance, lactate analysis, and HR at these intervals. They found that high-intensity physical exertion impairs kicking performance. In these studies, where fatigue was induced using MSRT, intervals are given for performance measurement. In these studies, giving intervals at a level that allows for rest may make the results controversial. The most important difference of our study is that the 3-second intervals given for shooting do not affect the general characteristics of MSRT.

There are studies evaluating pistol shooting under fatigue (6,12,17). In these studies, fatigue was provided with different protocols and its effect on shooting performance was investigated. In these studies, pistol shooting performance was measured under the pressure of fatigue induced by the bicycle ergometer (17), the upper body ergometer, and obstacle running (6) and intense exercise (12). In these studies, shooting performance was measured by giving intervals at certain levels of fatigue. The shooting was performed at levels that reached the estimated anaerobic threshold in certain areas of the exercise. Although our study, which measures shooting performance with fatigue due to aerobic capacity, maybe the first test in which shooting performance can be evaluated at every stage where fatigue pressure is applied continuously and uninterruptedly.

In future similar studies, carrying out the test by carrying police equipment (firearms and clothing, etc.) may contribute more to simulate fatigue. Knowing the effects of police equipment on fatigue can be important for shooting. In addition, since the study was conducted on male police candidates, its effects on women remained unanswered.

MSRT includes an increasingly difficult shuttle run with burnout (40). Test participation may require motivation. Although it was not included in the aims of our study, it is thought that the SSRT's inclusion of shooting may arouse the curiosity of the participants and may increase their interest in the test.

The results of this study show that SSRT, which measures shooting performance in uninterrupted fatigue, can be used as a reliable and valid test. SSRT can make significant contributions to the evaluation of police shooting performance under fatigue pressure. It can be used as part of the recruitment and selection procedure for specific missions such as special forces. In addition, in sports branches such as football, basketball and handball where shooting performance is important, test modifications can be made by considering the characteristics of the branch.

As a result, it is seen that SSRT is a reliable and valid measurement tool that can simultaneously measure aerobic capacity and shooting performance. With the protocol used, it can be said that shooting performance can be measured at any severity of gradual fatigue SSRT is the first test developed differently from the MSRT test in terms of measuring shooting performance under fatigue pressure.

Authors' contribution: MK is responsible for research concept and study design, literature review, data collection, data analysis and interpretation, statistical analyses, writing of the manuscript, or reviewing/editing a draft of the manuscript. AAD is responsible for data analysis and interpretation, writing of the manuscript, reviewing/editing a draft of the manuscript.

Conflicts of Interest and Source of Funding: There is no conflict of interest and financial interest in this study. This study was not supported financially.

Acknowledgements: We would like to thank all the participants and relevant institutions who participated in the study. This paper will be part of Mustafa Karatas's doctoral thesis, being completed as part of the "Institute of Health Sciences, Physical Education and Sports doctorate program" at the Kırıkkale University. Turkey

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