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Lockie, Robert G.; Dulla, Joseph; Orr, Rob Marc; Dawes, Jay

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**The 20-m Multistage Fitness Test and 2.4-km Run: Applications to Law Enforcement
Fitness Assessment**

Key words: 1.5-mile run; aerobic capacity; beep test; police; tactical; progressive shuttle run test

SUMMARY

Aerobic fitness tests are common in testing protocols for law enforcement candidates, recruits, and officers due to the importance of aerobic fitness for academy survivability and job task performance. Two popular tests are the 2.4-km run and 20-m multistage fitness test (20MSFT). The differences, strengths and limitations for both tests are discussed in this paper, with a focus on the pacing required in each test. The 2.4-km run typically uses an internal pacing strategy, while the 20MSFT features an external pacing strategy due to the audible beeps that increase the running speed in the test. For the 2.4-km run, self-motivation is required to complete the event, whereas for the 20MSFT the external pacing requirement is more typical of a police foot pursuit where the offender dictates the pace. This may have greater application to job tasks, where pacing is often determined by external sources (e.g. pursuing and apprehending an offender). Additionally, for the 20MSFT the limited space required and ability to test indoors may make it more applicable for testing law enforcement personnel. Where possible, staff should explore the use of the most appropriate aerobic fitness test for use in their personnel, be it the 20MSFT or the 2.4-km run.

INTRODUCTION

Law enforcement places demands on several different physiological characteristics. For example, when on-duty law enforcement officers may be required to push, pull, lift, carry, drag, jump, and run at any moment (18). As a result of these wide-ranging physical demands, law enforcement agencies (LEAs) often have applicants complete a fitness testing battery that assesses certain qualities that are needed to safely and efficiently complete the required tasks of the job (3,28,29,53). These fitness testing batteries may include tests of muscular strength or endurance (e.g. push-ups and sit-ups), power (e.g. vertical jump, standing broad jump), change-of-direction

speed (e.g. 75-yard pursuit run), and aerobic fitness (e.g. maximal running tests) (8,11,16,35,45,47,61).

Superior aerobic fitness has been linked to academy survivability (16,35,61), and faster performance of occupational physical ability tasks incorporating tasks such as obstacle clearance, dragging, lifting, carrying, and running (6,15,37). Furthermore, the armor and tactical gear that needs to be worn by personnel can increase the metabolic demands of these activities (59), further stressing an individual's aerobic capacity. Davis et al. (14) discussed that enhancements in aerobic capacity can also contribute to an improved ability to complete load bearing tasks. In addition to this, higher aerobic fitness levels have been associated with lower risks of injury in tactical personnel (16,31,32), and better aerobic endurance and general fitness could help alleviate the risk of cardiovascular disease (30). This is extremely pertinent, as cardiovascular disease is prevalent among law enforcement officers (56,68).

Collectively, these studies highlight the importance of aerobic fitness for law enforcement personnel. This forms part of the reason why aerobic fitness tends to be a focus of law enforcement training programs (14). Accordingly, it is important for LEA staff to be able to effectively assess aerobic fitness in their candidates, recruits, and incumbent officers, either during the hiring process or as a fitness assessment. This paper will discuss several maximal aerobic tests commonly used to assess law enforcement personnel. This will provide context as to what has been historically used with this novel population. The 2.4-kilometer (km; 1.5-mile) run and 20-meter (m) multistage fitness test (20MSFT) will be specifically discussed, including the typical test structure and

strengths and limitations for each test. There will be a focus on demonstrating the potential value of the 20MSFT specific to law enforcement.

MAXIMAL AEROBIC CAPACITY ASSESSMENTS

Within the scientific literature, several different running tests that have been utilized across a range of tactical populations, including field- and laboratory-based assessments. An example of a laboratory-based assessment is the Bruce protocol on a treadmill which has been used to directly measure maximal aerobic capacity ($\dot{V}O_{2max}$) in Special Weapons and Tactics officers (55). However, laboratory assessments of aerobic capacity are not typically feasible in many occupational environments (58), which increases the value and use of field-based assessments. Field-based tests generally involve running over a set distance, with time used as the primary measure of performance. For example, a 3-km run has been used to assess Norwegian police officers (33). Michigan police academy cadets were assessed by a half-mile (approximately 805-m) shuttle run, which was a timed test involving 15 round trips between 2 cones placed 88 feet (26.82 m) apart (13). Two of the more common tests of aerobic fitness for law enforcement personnel are the 2.4-km run and the 20MSFT (39,41). The 2.4-km run has been more widely used, although the 20MSFT may have greater application to law enforcement. These two tests will be discussed in the following sections.

2.4-KM (1.5-MILE) RUN

One of the more popular running assessments in law enforcement personnel is the 2.4-km run, which has been used to assess aerobic fitness in candidates (8,11,45), recruits during academy (12,40,61), and incumbent officers (18,38,49,66). This test is typically performed outdoors,

however the running surface can vary depending on where the agency is located. As long as an accurate distance can be measured, staff could use an athletics or packed dirt track, grass field, or an urban course (assuming the course is relatively flat) to perform the 2.4-km run. Time is typically recorded via a stopwatch, although electronic timing methods (e.g. timing gates) could be used if they are available. Lockie et al. (40) has presented percentile ranking data for 2.4-km run times in law enforcement recruits, with times ranging from 7:50 minutes:seconds to 20:10 minutes:seconds.

The typical instructions for this test involve the individual being told to complete the course as quickly as possible. In addition to run time as a metric for aerobic fitness, $\dot{V}O_{2\max}$ can be estimated from the time attained (25,43). If agencies have been using the 2.4-km run as part of their hiring process, it is likely there is a bank of historical data to provide context for individuals they have hired. Furthermore, for many candidates and recruits, it could be a test that is easier to train for. An individual training to meet standards for entry into a law enforcement agency can more readily go for a run without the need for extra equipment.

However, the 2.4-km run is entirely self-paced which is a potential negative for the use of this assessment. The individual needs to be motivated to maintain a higher running pace when performing the 2.4-km, and can walk sections of the run or stop if they choose (8,11,43,45). While this would be less likely to occur during academy as training staff will be present to provide external motivation to recruits (36,42), the internal pacing is atypical of many job tasks (9). Another major consideration with the 2.4-km run is that due to the distance, most LEAs have to perform the test outdoors. Weather conditions can have a clear impact in performance. For example, warmer ambient temperatures can increase heat stress within the body, which decreases

time to muscular fatigue (67). This would likely lead to slower 2.4-km run times when performed in hotter conditions compared to cooler ambient temperatures (26,52). Finally, given that the 2.4-km run is a set distance run for time, those with lower levels of fitness would be required to run for longer given that they take longer to complete the distance. This may place the less fit at a higher cardiovascular strain during the event. Strengths and limitations for the use of the 2.4-km run to measure the aerobic fitness of law enforcement personnel are noted in Table 1.

INSERT TABLE 1 ABOUT HERE

20-M MULTSTAGE FITNESS TEST (20MSFT)

The 20MSFT (or beep test) has been extensively utilized to assess aerobic fitness in athletic populations (4,21,22,34). In recent years, shuttle run tests have had increasing use in law enforcement populations, including in Australia (50,51,60) and the United Kingdom (9). The 20MSFT is less prominent in law enforcement testing in the USA, although select agencies have used this test to measure aerobic fitness in recruits (16,39,41,42,44) and incumbents (17,48). Interestingly, the Los Angeles County Sheriff's Department transitioned from using the 2.4-km run to the 20MSFT as part of their Validated Physical Ability Testing during the hiring process for candidates (46). Dawes et al. (17) has presented percentile rank data for the number of shuttles completed in the 20MSFT by male and female patrol officers organized by sex and age.

The traditional set-up for the test is shown in Figure 1. Markers are positioned 20 m apart (15 m distances have also been used), and are spaced according to how many individuals are completing the test (and how many staff are available to monitor the test). When the test starts, individuals run

back and forth between the markers (i.e. they perform shuttle runs) in time with audible beeps. The 20MSFT used in previous law enforcement personnel starts at a running speed of 2.22 meters per second ($\text{m}\cdot\text{s}^{-1}$), and the running speed increases by $0.14 \text{ m}\cdot\text{s}^{-1}$ every minute, which signifies a change in level (39). The number of shuttles per level gradually increase as the pace gets faster and more shuttles can be completed every minute. Historically, the test's audible beeps have been played through a cassette or compact disc on a portable stereo (23). However, nowadays there are numerous smartphone- or tablet-based applications that incorporate a recording of the 20MSFT. The use of an application and a portable Bluetooth speaker allows more flexibility with the location for the test, as external power is not required. During this test, individuals run until they cannot maintain pace with the external beeps. Individuals are given one warning if they fail to place one foot on, or over, the 20-m mark by the beep of a shuttle. They are eliminated by either volitional exhaustion or failing to reach either side of the 20-m distance by the beep for two consecutive shuttles.

INSERT FIGURE 1 ABOUT HERE

Additionally, if LEA staff have large numbers of candidates or recruits to test and enough space, more novel set-ups for the 20MSFT can be used. One example is displayed in Figure 2. In this example, 40 m is required to provide the capacity to test two groups. One group will begin the 20MSFT from the left-hand side of the grid, while the second group will start in the middle. Once the 20MSFT begins, both groups run back-and-forth from the left to the right and back again as demanded by the audio track. As a result, neither group should interfere with the other, providing

the opportunity for larger scale testing, with the assumption that there is an appropriate number of staff to monitor the test.

INSERT FIGURE 2 ABOUT HERE*

Within law enforcement personnel, the most common metric is the cumulative number of completed shuttles (16,39,41). This measure is used because completed shuttles provides an absolute measure (i.e. more shuttles = better aerobic fitness), which is important in the assessment of law enforcement personnel. This is because for many law enforcement positions, job tasks do not differ relative to the age and sex of the individual. Accordingly, the interpretation of fitness tests is often considered within this light. The number of shuttles per level within the 20MSFT has been presented in the literature (39), and the table displayed by Lockie et al. (39) can be used to assist with scoring the test. $\dot{V}O_{2max}$ can still be estimated from the shuttle stage attained. This was originally detailed by Léger et al. (34), and further adapted by Ramsbottom et al. (57). Due to using a 20-m distance for the shuttles, the 20MSFT can be more readily performed indoors (39), limiting the impact weather conditions could have on the test. The direction changes required in the 20MSFT are more reminiscent of maneuvers required during tasks such as a foot pursuit (54), although it could be more stressful for older officers or those who experience knee pain (48). However, it should be noted that given the increasing speed of each shuttle, individual's generally run less distance during the 20MSFT. As an example, to reach the equivalent distance of 2.4 km, an officer would have to reach Level 13, Stage 2 in the 20MSFT, or a total of 120 shuttles (39). This would represent a $\dot{V}O_{2max}$ of approximately 57.6 milliliters of oxygen consumed per kilogram body mass per minute ($ml \cdot kg^{-1} \cdot min^{-1}$) (57), or a 2.4-km run time of approximately 8:55

minutes:seconds. Table 2 presents strengths and limitations for the 20MSFT. Some of these strengths and limitations relate to the external pacing strategy required in the 20MSFT.

INSERT TABLE 2 ABOUT HERE

INTERNAL VS. EXTERNAL PACING

Internal and external pacing are concepts that have been introduced in previous sections. The pacing strategy adopted, which refers to the manner in which a runner distributes their running speed and energy expenditure during a given event (2,64), can influence performance in an aerobic fitness test. A negative pacing strategy features an increase in speed as a run progresses, while a positive pacing strategy features a speed decrease (i.e. the runner is slowing down towards the end of the run) (2,62). Distance feedback, which indicates to the individual how far they may have left to run in an event, can encourage an increase in running speed towards the end of a run (20).

There is currently no available information on the pacing strategies adopted by law enforcement personnel. It could be expected that an individual completing the 2.4-km run would be aware of the distance completed, so the individual can use this feedback to dictate running speed. However, beyond distance information, it would be expected that the pacing strategy adopted is internal. As previously stated, this is atypical of common actions required by an officer during a work shift, where many of the tasks are paced by an external source (9). For example, the pursuit of a suspect is governed by the running speed of the suspect. Actions such as subduing a suspect and close-quarter combat are also governed by external factors, such as the officer physically responding to

the physical actions of the suspect. As a result, the 2.4-km run may not best represent the tasks required by a law enforcement officer.

In contrast, the 20MSFT is externally paced by the audible beeps present within the test. The progressive increase in running intensity can be more closely linked to the changes in intensity required in job tasks when an officer is on-duty (9). For example, an officer may need to quickly transition from checking an offender's bona fides to pursuing them if they decide to resist arrest (19). Law enforcement recruits and officers need to know whether they have the physical capacity to tolerate this type of change in intensity and physical demand. Not only does the final shuttle score provide feedback about this ability, but the individual's performance within the test can also highlight this. During the 20MSFT, the individual should keep running until failure; however, they can also voluntarily retire from the test. Although subjective, this can provide useful information. For example, if the 20MSFT is used to measure recruit fitness at the start of academy, training staff may perceive that an individual withdraws from the 20MSFT before they had actually reached the limit of their physical capacity. This could be linked to the mental resilience of the recruit, which is a quality that is also developed during the academy training process (7,36). Resilience is an important characteristic for tactical personnel (63), and this is because law enforcement can be a mentally stressful occupation (24). Poor performance in the 20MSFT may not only just inform staff as to limits to aerobic fitness, but mental resilience as well. It should be noted, however, that this may also be true of the 2.4-km run whereby a recruit does not have sufficient mental fortitude to maintain an internally driven pace.

This 20MSFT strength can also be a limitation as well. With reductions in physical activity across almost all age groups in the USA (10,65), many individuals may not be exposed to situations where they are required to exert themselves at close to maximal capacity. Thus, learning effects can influence 20MSFT performance (1,39,41), which LEA staff should be conscious of when using this test. This was highlighted in data recorded by Lockie et al. (39), who analyzed the relationships between the 2.4-km run and 20MSFT in 550 law enforcement recruits (463 males, 87 females) prior to academy. Lockie et al. (39) found that while there was a significant relationship between the two tests ($r = -0.57$), the predictive relationship was weak ($r^2 = 0.32$). Furthermore, the estimated 2.4-km run $\dot{V}O_{2\max}$ was significantly greater than that from the 20MSFT ($p < 0.01$; $45.07 \pm 4.82 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ vs. $34.34 \pm 5.53 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$). Lockie et al. (39) attributed this in part to the recruits being more familiar with the demands of the 2.4-km run than the 20MSFT. This was especially in relation to the higher intensity running demands for the 20MSFT, and the greater demands on movement technique due to the direction changes following each shuttle.

What also needs to be noted is that the higher intensity running features within the 20MSFT needs to be specifically trained. In a follow-up to their first study (39), Lockie et al. (41) investigated the relationships between the 2.4-km run and 20MSFT post-academy training in 326 recruits (276 males, 50 females). The staff from the LEA in these studies have historically focused on long, slow distance running during academy training (37,41). Lockie et al. (41) found that post-academy, the relationship between the 2.4-km run and 20MSFT was still significant but less than that found in the first study ($r = -0.49$). The predictive relationship between the two tests was also weaker ($r^2 = 0.24$). Lockie et al. (41) that these results may have indicated limitations in the high-intensity running and change-of-direction training during academy for these recruits. As a result, if LEA

staff were to use the 20MSFT to monitor fitness, improvements in this test could also provide an indication for not just aerobic conditioning, but also the ability to complete high-intensity actions and direction changes. These fitness and technical qualities have application to important job tasks for law enforcement officers (6,15,37).

It should also be acknowledged that there are other field-based maximal running tests that use an external stimulus to measure aerobic fitness. The Yo-Yo Intermittent Recovery Test has two versions (Level 1 and 2), and has been used to measure aerobic and high-intensity running performance for athletes from a range of different sports (5). The 30-15 Intermittent Fitness Test has also been commonly used in athletic populations (27), and has been adopted by some law enforcement agencies in Australia (51). However, any issues encountered with high-intensity running from the 20MSFT would likely be exacerbated in the tests such as Yo-Yo Intermittent Recovery Test and 30-15 Intermittent Fitness Test. It is likely that these tests would be more appropriate for more highly trained, specialist law enforcement operatives (e.g. Special Weapons and Tactics officers) than candidates, recruits, or general duty officers.

PRACTICAL APPLICATIONS AND CONCLUSIONS

This paper discussed the use of the 2.4-km run and 20MSFT in law enforcement personnel. Strengths and limitations were discussed for each test, with the potential value of the 20MSFT highlighted given its current lack of use in US LEAs. Though not without limitations, the external pacing strategy required in the 20MSFT may be more reflective of typical law enforcement job tasks. The need for aerobic capacity, high-intensity running, and the ability to change direction (i.e. repeatedly accelerate and decelerate) effectively have application to a great many policing

tasks. Furthermore, the limited space required for testing and ability to perform indoors provides great practical use for LEA staff, and potentially greater mobility for testing as well. In addition to aerobic fitness and conditioning, resilience could be anecdotally inferred from both tests. This has great value at the recruit level, where the development of mental resilience is an important outcome from academy training (7,36). The authors suggest that where appropriate, LEA staff explore the use of an assessment such as the 20MSFT to measure the aerobic performance of their personnel rather than employ the 2.4-km run just because this has been the traditional assessment. This is not to say that the 2.4-km run should not be used; rather, there are additional benefits present for the 20MSFT that have great application for law enforcement candidates, recruits, and incumbent officers.

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FIGURE LEGEND

Figure 1: The 20-m multistage fitness test (20MSFT) dimensions and example location of portable speaker.

Figure 1: Example 20-m multistage fitness test (20MSFT) set-up for testing two groups.

Table 1: Select strengths and limitations of using the 2.4-km run to assess aerobic fitness in law enforcement personnel.

Positives	Negatives
The test is easy to conduct with minimal equipment.	Internally-paced; individuals can stop and/or walk if they want to.
2.4-km run times provides a valid measure of aerobic fitness.	Requires the finding a location for the 2.4-km run (appropriate surface and gradient), and accurate measurement of this distance.
Most law enforcement agencies should have historical data, which could allow for comparisons within and between agencies.	The quality of the track used for this test may vary across different locations; could make setting up multiple testing sites challenging.
The test is completed in less than 20 minutes for most individuals.	Test performance can be heavily influenced by weather conditions.
Due to internal pacing strategies, individuals can have greater control of their physical exertion.	Limited direction changes required during the run; less indicative of running performed on-duty (e.g. changes of direction/ acceleration/deceleration during a foot pursuit).
Easier to train at home or in local area in own time.	Less fit individuals run for longer periods.

Table 2: Select strengths and limitations of using the 20MSFT to assess aerobic fitness in law enforcement personnel.

Positives	Negatives
Externally paced, and this is more similar to work-related tasks (e.g. foot pursuits are externally paced by the offender).	Learning effects could influence test performance (i.e. individuals not used to running at higher intensities).
Can be easily completed indoors in a climate controlled gymnasium. This potentially allows for more consistent conditions if the LEA uses multiple testing locations (which could also increase recruitment opportunities).	Some law enforcement agencies may not have historical data for the 20MSFT as it has not been regularly used, making within- and between-agency comparisons challenging.
Multiple people can be tested at once; could be very beneficial for testing large numbers of candidates or academy recruit classes.	Depending on the number of individuals being tested, multiple staff members may be required to supervise test.
Only requires a 20-m distance, with the width dependent on how many people will be tested at one time.	The direction changes required in the test are more technically demanding, and could be more stressful for older officers or those with history of lower-body injuries.
Less fit individuals will stop sooner, potentially reducing injury risk.	More equipment (cones, phone/tablet/portable speaker) are required.