

Original article

20-m Multistage Fitness Test Normative Percentile Rank Data for Law Enforcement Recruits

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Abstract

The 20-m multistage fitness test (20MSFT) has been used to assess the aerobic fitness of law enforcement candidates prior to academy, and recruits during academy. There is limited research that has published normative data for the 20MSFT as performed by recruits. This study provided normative percentile rank data for 20MSFT shuttles and estimated maximal aerobic capacity ($\dot{V}O_{2max}$) for law enforcement recruits. Retrospective analysis on 1040 recruits (850 men, 190 women) from one law enforcement agency was conducted. Recruits completed the 20MSFT as part of a battery of fitness tests prior to their training academy. The number of completed shuttles was recorded and used to calculate 20MSFT percentile rankings for all recruits, men, and women, in the following bands: 90-100, 80-89, 70-79, 60-69, 50-59, 40-49, 30-39, 20-29, 10-19, and 0-9. Once the 20MSFT shuttle percentile ranks were developed, estimated $\dot{V}O_{2max}$ for these rankings was derived. All recruits combined, men, and women, had a 20MSFT mean of 52.38 ± 18.06 , 53.70 ± 18.23 , and 46.46 ± 16.05 shuttles, respectively. The data indicated the male recruits tended to perform better than female recruits, although 36% of the women were in the top half of all recruits in completed 20MSFT shuttles. Nevertheless, female recruits will likely need specific aerobic conditioning prior to and during academy. The $\dot{V}O_{2max}$ data suggested limitations in recruit aerobic fitness when compared to population norms. Familiarity with the 20MSFT and high-intensity running exposure could have influenced the $\dot{V}O_{2max}$ results. The provision of normative 20MSFT data provide recruit benchmarking and could inform fitness program design for staff.

Keywords: Aerobic Fitness, First Responder, Maximal Aerobic Capacity, Normative Data, Police, Tactical

Introduction

Law enforcement can incorporate physically demanding tasks that place great stress on officers. During the course of a shift, law enforcement officers may be required to drive at high speeds, push and pull heavy objects, lift, carry, and drag civilians from dangerous situations, jump obstacles, pursue and apprehend offenders, and use firearms (Decker et al., 2022; Schram et al., 2018). Numerous studies have shown that aerobic capacity underpins many law enforcement job tasks such as obstacle clearance, dragging, lifting, carrying, and running (Beck et al., 2015; Dawes et al., 2017a). In addition to job performance, superior aerobic fitness has been linked to the ability to tolerate the stress of academy training and successfully graduate to become sworn personnel (Dawes et al., 2019; Lockie et al., 2019; Lockie et al., 2022a; Lockie et al., 2020a; Shusko et al., 2017). Accordingly, aerobic fitness tests are often included in law enforcement-specific fitness testing.

For example, the 2.4-km (1.5-mile) run has been included within entry physical ability tests for law enforcement candidates (Bloodgood et al., 2021) and recruits during academy (Lockie et al., 2020b; Shusko et al., 2017). Normative data has been presented for the 2.4-km run when performed by law enforcement recruits (Lockie et al., 2020b) and first-year officers (Štefan et al., 2022). However, Lockie et al. (2021b) noted some limitations associated with the 2.4-km run as an assessment. One challenge is that the 2.4-km run is self-paced, whereby the participant needs to be motivated to maintain a faster pace. This self-pacing strategy is atypical of many law enforcement job tasks (Brewer et al., 2013). For most agencies using the 2.4-km run, they will have to perform this test outdoors, where weather conditions could impact performance. Another issue identified by Lockie et al. (2021b) that is especially notable for candidates and recruits is that because the 2.4-km run is a set distance timed run, low fitness participants will actually be required to run/walk for more time (i.e., it will take them longer to cover the 2.4-km distance). Lockie et al. (2021b) suggested that this could place low fitness participants at greater risk of cardiovascular strain.

In partial response to the issues identified by Lockie et al. (2021b), the 20-m multistage fitness test (20MSFT) has been used to assess aerobic fitness in law enforcement personnel (Dawes et al., 2019; Dawes et al., 2017b; Lockie et al., 2021a; Lockie et al., 2020c; Orr et al., 2016). Indeed, the Los Angeles County Sheriff's Department switched from using the 2.4-km run to the 20MSFT as part of their Validated Physical Ability Testing during the hiring process for candidates (Los Angeles County Sheriff's Department, 2019). The 20MSFT is externally paced, with participants running back-and-forth over 20 m and speed increasing each minute until the participant can no longer keep pace (Léger et al., 1988). Although the 20MSFT is not without its limitations (e.g., learning effects, stress induced by the direction changes), Lockie et al. (2021b) recognized several positives relative to its use in law enforcement fitness testing. External pacing, ability to conduct the test over a smaller area, opportunities for indoor testing, low fitness participants not lasting as long in the test were all documented as positive reasons behind the use of the 20MSFT.

A lack of historical data for the 20MSFT and law enforcement personnel was also identified as a limitation (Lockie et al., 2021b). Dawes et al. (2017b) has documented percentile rank data for the number of 20MSFT shuttles completed by male and female patrol officers. However, what is lacking is normative, percentile rank data for this test when it is performed by recruits. Hernandez et al. (2021) did present normative 20MSFT shuttle data for 200 female law enforcement recruits from 14 law enforcement academy classes across three different states in the USA, but there is currently no normative data available for male recruits. The generation of normative data for the 20MSFT is important for academy training staff, as it will allow for benchmarking of recruits, in addition to highlighting those recruits who are above or below average in their aerobic capacity as assessed by the 20MSFT. The presence of normative data could also assist staff with training program design for their recruits. Additionally, given that maximal aerobic capacity ($\dot{V}O_{2max}$) can be estimated from the 20MSFT (Ramsbottom et al., 1988), it would be also useful to present normative $\dot{V}O_{2max}$ data for law enforcement recruits.

Therefore, this descriptive study detailed percentile ranks of male and female law enforcement recruits' performance in the 20MSFT by shuttles completed and estimated $\dot{V}O_{2max}$. This was done to better distinguish fitness levels for law enforcement recruits. Retrospective analysis was conducted on pre-existing de-identified data provided by one law enforcement agency. The percentile rank data composed in this research could be used to drive training practices for candidates for a law enforcement agency, recruits in the lead-up to and during academy.

Methods

Design

The cross-sectional, descriptive analysis conducted in this study was similar to previous research that has documented normative data for first responder personnel (Hernandez et al., 2021; Lockie & Hernandez, 2020; Lockie & Moreno, 2020; Lockie et al., 2020b; Lockie et al., 2022b). Retrospective analysis on de-identified recruit data provided by one law enforcement agency from 12 academy classes was conducted. Percentile rankings were produced for all recruits combined, men, and women for the number of shuttles completed. Following this, estimated $\dot{V}O_{2max}$ from these rankings was derived using the table by Ramsbottom et al. (1988). The greater focus for the percentile rankings was on the number of shuttles completed, as law enforcement agencies generally do not use $\dot{V}O_{2max}$ as part of hiring standards (Lockie et al., 2021a).

Participants

As stated, retrospective analysis was conducted on de-identified data from 1040 recruits (age: 27.20 ± 6.14 years; height: 1.72 ± 0.10 m; body mass: 80.10 ± 14.05 kg), including 850 men (age: 27.19 ± 6.10 years; height: 1.75 ± 0.09 m; body mass: 83.38 ± 12.56 kg) and 190 women (age: 27.25 ± 6.31 years; height: 1.62 ± 0.07 m; body mass: 65.47 ± 10.55 kg). Based on the use of archival data in this study, the institutional ethics committee approved the use of pre-existing data (HSR-17-18-370). The study followed the recommendations of the Declaration of Helsinki (World Medical Association, 1997).

Measurements and Procedures

The 20MSFT was completed as part of a battery of fitness tests completed by recruits (Bloodgood et al., 2020; Collins et al., 2022; Lockie et al., 2019; Lockie et al., 2022a; Lockie et al., 2020a; Lockie et al., 2018; Lockie et al., 2021c). Data from the other fitness tests were not considered within the context of the current research. Prior to all testing, each recruit's age, height, and body mass were recorded. Height was measured using a portable stadiometer (Seca, Hamburg, Germany), while body mass was recorded by electronic digital scales (Omron Healthcare, Kyoto, Japan). Testing was conducted at the law enforcement agency's training facility on a day scheduled by the agency staff. Testing occurred between 9:00am-2:00pm for all classes, depending on recruit availability. Recruits generally did not eat in the 2-3 hours before their testing session as they were required to complete paperwork for the agency, but they were allowed to consume water as needed during testing. The weather conditions for testing were typical of the Southern California climate (Bloodgood et al., 2020).

The 20MSFT was used to measure maximal aerobic capacity in the recruits and was conducted outdoors on an asphalt surface according to procedures described in a multitude of law enforcement studies (Bloodgood et al., 2020; Collins et al., 2022; Lockie et al., 2019; Lockie et al., 2022a; Lockie et al., 2020a; Lockie et al., 2018; Lockie et al., 2021c). Although outdoor testing may not be ideal for the 20MSFT, this was the only available space at the agency's training facility. The 20MSFT has high reliability (intraclass correlation coefficient = 0.96) (Aandstad et al., 2011). Recruits typically completed the 20MSFT in groups of 14-16 and were supervised by staff working on behalf of the agency. The structure of the test is shown in Figure 1. Recruits ran back and forth between two lines spaced 20 m apart, which were indicated by markers. The speed of running for this test was standardized by pre-recorded auditory cues (i.e. beeps) played from an iPad handheld device (Apple Inc., Cupertino, California) connected via Bluetooth to a portable speaker (ION Block Rocker, Cumberland, Rhode Island). The speaker was located central to the running area, and positioned so

that it would not interfere with the recruits. The test was terminated when the recruit was unable to reach the lines twice in a row in accordance with the auditory cues. This test was scored according to the final level and stage the recruit was able to achieve, and the level and stage results was used to calculate the total number of shuttles completed.

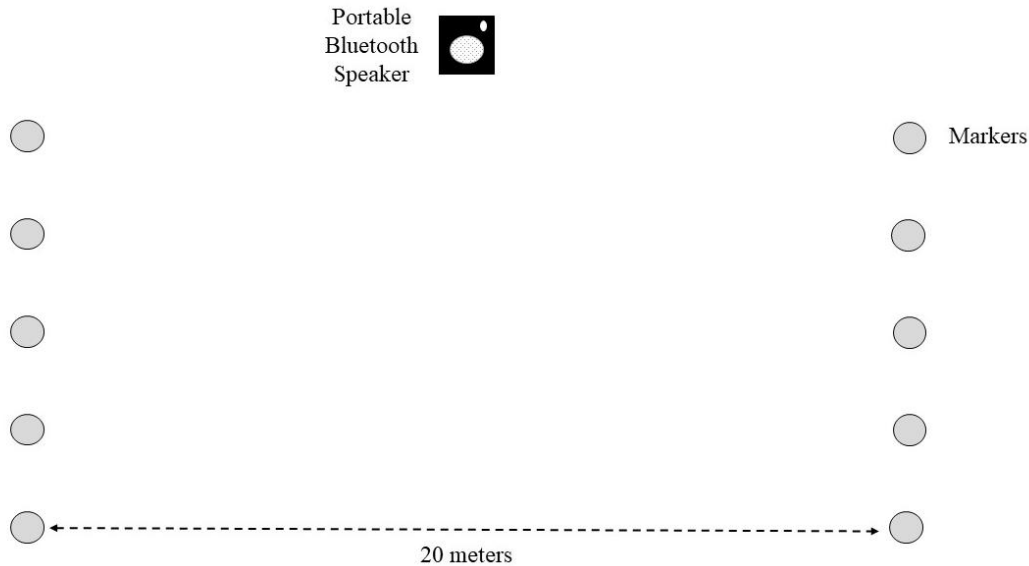


Figure 1. The 20-m multistage fitness test (20MSFT) dimensions and location of portable speaker.

Statistical analyses

Data were collated for all recruits for the different academy classes, with the descriptive (mean \pm standard deviation) data derived for completed 20MSFT shuttles for all recruits combined, male recruits, and female recruits. Microsoft Excel (Microsoft Corporation™, Redmond, Washington, USA) was used to calculate the percentile ranks for all recruits combined, and male and female recruits separately (Hernandez et al., 2021; Lockie & Hernandez, 2020; Lockie & Moreno, 2020; Lockie et al., 2020b; Lockie et al., 2022b). The “Rank and Percentile” tool within the Data Analysis ToolPak was used to calculate the percentile rankings for the 20MSFT in the following bands or ranks: 90-100, 80-89, 70-79, 60-69, 50-59, 40-49, 30-39, 20-29, 10-19, and 0-9. Once the percentile ranks were developed for the 20MSFT shuttles for all recruits combined, men, and women, the estimated $\dot{V}O_{2max}$ for these rankings was derived using the table by Ramsbottom et al. (1988). The same percentile ranks/bands were used for estimated $\dot{V}O_{2max}$.

Results

Figure 2 displays the descriptive data for all recruits combined, men, and women. The percentile rank data for all recruits combined, men, and women, and shown in Tables 1, 2, and 3, respectively. The number of men and women in each band are noted for all recruits combined. When the sexes were documented separately, the number of recruits in each band was noted. The equivalent estimated $\dot{V}O_{2max}$ for the percentile rank data for all recruits combined, men, and women, are shown in Tables 4, 5, and 6, respectively. For the estimated $\dot{V}O_{2max}$ rankings, that there is overlap between the different bands. This was due to the estimations provided by Ramsbottom et al. (1988), whereby there is not a $\dot{V}O_{2max}$ score for every shuttle level.

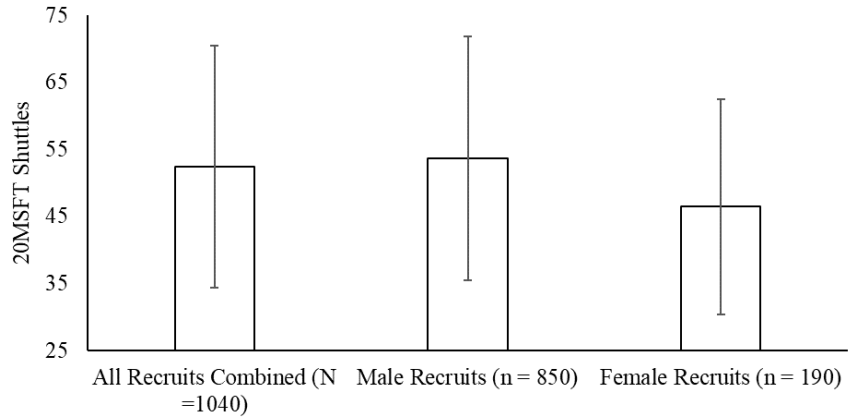


Figure 2. Descriptive (mean ± standard deviation) data for the number of completed 20-m multistage fitness test (20MSFT) shuttles for all recruits combined, male recruits, and female recruits.

Table 1. Percentile rankings for 20-m multistage fitness test (20MSFT) shuttles for male and female law enforcement recruits combined.

Percentile Rank	20MSFT Shuttles	Males (n = 850)	Females (n = 190)
90-100	77-118	97	11
80-89	67-76	90	11
70-79	61-66	82	15
60-69	55-60	94	15
50-59	50-54	92	17
40-49	46-49	74	13
30-39	42-45	91	19
20-29	38-41	74	24
10-19	33-37	70	37
<10	8-32	86	28

Table 2. Percentile rankings for 20-m multistage fitness test (20MSFT) shuttles for male law enforcement recruits.

Percentile Rank	20MSFT Shuttles	Number
90-100	78-118	89
80-89	69-77	81
70-79	62-68	87
60-69	57-61	71
50-59	52-56	97
40-49	47-51	89
30-39	44-46	58
20-29	39-43	95
10-19	33-38	97
<10	17-32	86

Table 3. Percentile rankings for 20-m multistage fitness test (20MSFT) shuttles for female law enforcement recruits.

Percentile Rank	20MSFT Shuttles	Number
90-100	68-100	20
80-89	60-67	19
70-79	54-59	17
60-69	48-53	17
50-59	44-47	21
40-49	40-43	17
30-39	38-39	14
20-29	35-37	23
10-19	28-34	23
<10	8-27	19

Table 4. Percentile rankings for maximal aerobic capacity ($\dot{V}O_{2max}$) estimated from the 20-m multistage fitness test for male and female law enforcement recruits combined.

Percentile Rank	$\dot{V}O_{2max}$ (ml/kg/min)	Males (n = 850)	Females (n = 190)
90-100	44.5-57.1	97	11
80-89	41.8-44.5	90	11
70-79	39.9-41.1	82	15
60-69	37.8-39.2	94	15
50-59	35.7-37.8	92	17
40-49	34.3-35.7	74	13
30-39	32.9-34.3	91	19
20-29	31.8-32.9	74	24
10-19	29.5-31.0	70	37
<10	<29.5	86	28

Table 5. Percentile rankings for maximal aerobic capacity ($\dot{V}O_{2max}$) estimated from the 20-m multistage fitness test for male law enforcement recruits combined.

Percentile Rank	$\dot{V}O_{2max}$ (ml/kg/min)	Number
90-100	45.2-57.1	89
80-89	42.4-44.5	81
70-79	39.9-42.4	87
60-69	38.5-39.9	71
50-59	36.4-38.5	97
40-49	35.0-36.4	89
30-39	33.6-35.0	58
20-29	31.8-33.6	95
10-19	29.5-31.8	97
<10	<29.5	86

Table 6. Percentile rankings for maximal aerobic capacity ($\dot{V}O_{2max}$) estimated from the 20-m multistage fitness test for female law enforcement recruits combined.

Percentile Rank	$\dot{V}O_{2max}$ (ml/kg/min)	Number
90-100	41.8-51.9	20
80-89	39.2-41.8	19
70-79	37.1-39.2	17
60-69	35.0-37.1	17
50-59	33.6-35.0	21
40-49	31.8-33.6	17
30-39	31.0-31.8	14
20-29	30.2-31.0	23
10-19	27.6-30.2	23
<10	<27.6	19

Discussion

The 20MSFT has featured as an entry-level fitness test for law enforcement candidates (Los Angeles County Sheriff's Department, 2019), and has incorporated into fitness testing of law enforcement recruits prior to academy training (Bloodgood et al., 2020; Collins et al., 2022; Lockie et al., 2019; Lockie et al., 2022a; Lockie et al., 2020a; Lockie et al., 2018; Lockie et al., 2021c). The law enforcement organization from which the current data was drawn do not have a hard minimum cut score for the 20MSFT that dictates recruitment decisions, but rather uses a score based upon performance in different tests (push-ups, sit-ups, 75-yard pursuit run, and 20MSFT) (Los Angeles County Sheriff's Department, 2019). The goal was to present normative percentile data for the 20MSFT in a large sample of law enforcement recruits. Additionally, normative data for estimated $\dot{V}O_{2max}$ derived from the number of completed shuttles in each percentile band was included to provide more practical information for training staff. As will be discussed, the data from the current descriptive study have useful implications for law enforcement academy training staff.

The first data presented was for all recruits combined in the 20MSFT. Some law enforcement organizations will not use sex-specific standards, so it is important to present data that represents all recruits. The recruits in the current sample were tested prior to their training academy, and it could be expected that their aerobic fitness would improve after training (Crawley et al., 2016; Lockie et al., 2020c). Nonetheless, staff could use the percentile ranks to identify where recruits currently reside, and how 20MSFT and aerobic performance changes over time. The application of percentile ranking data could be especially important for recruits with lower aerobic fitness such that specific training programs can be designed. For example, a recruit could be in the 30-40% rank after academy training, which on the surface could be considered less than ideal. However, if they started academy in the 10-19% rank, this could be evidence of an effective aerobic training program for this recruit.

To provide some context for the current data, when compared to the male 20-29 year old state patrol officer normative data, the 20MSFT mean from the current study was slightly below that from Dawes et al. (2017b) (53.70 ± 18.23 shuttles vs. 55.63 ± 20.90 shuttles). The equivalent percentile ranks in the current study tended to be a few shuttles lower than those documented by Dawes et al. (2017b). The female percentile rank data was very similar to that from Hernandez et al. (2021). Interestingly, specialist male police officers completed more than 70 shuttles in the 20MSFT (Maupin et al., 2018). Recruits from the current sample interested in pursuing specialist roles (e.g., Specialist Weapons and Tactics) would likely need to improve their aerobic fitness over the course of their careers.

Men tend to exhibit greater power and work efficiency in aerobic exercise tasks compared to women (Pate & Kriska, 1984), which can be related to differences in lean body mass which influence aerobic capacity (Janssen et al., 2000). When comparing the percentile ranks for the men versus the women, for each equivalent rank, the men tended to have a high number of completed shuttles compared to the women. Nonetheless, within the combined data, 69 female recruits (36% of the total sample of women) were in the top 50% of all recruits. This is indicative of other law enforcement normative data studies which has shown that there are women who outperform men in certain fitness tests (Lockie & Hernandez, 2020; Lockie & Moreno, 2020; Lockie et al., 2020b). Further, in an analysis of the 20MSFT in law enforcement recruits, Lockie et al. (2021a) found that although male recruits completed 15% more 20MSFT shuttles compared to female recruits, the difference only had a small effect of 0.44. Lockie et al. (2021a) suggested that the 20MSFT may have had less of a disparate impact on women and could be reflective of the preparation made by recruits prior to academy (i.e., completion of aerobic conditioning and high-intensity running prior academy by better performing recruits). These data do reinforce that women attempting a career in law enforcement likely need to target aerobic conditioning as men could have physiological advantages in aerobic activities. However, with effective training, women can develop their aerobic capacity to the extent where they are on par or better than their male colleagues.

As stated, law enforcement agencies generally do not use $\dot{V}O_{2max}$ as part of hiring standards (Lockie et al., 2021a). Although estimations will vary depending on the aerobic fitness test used to calculate $\dot{V}O_{2max}$ (e.g., 2.4-km run vs. the 20MSFT) (Lockie et al., 2021a; Lockie et al., 2021b), $\dot{V}O_{2max}$ data does provide some additional context for the recruits. When compared to general population norms (Riebe et al., 2018), the recruits from this organization exhibited relatively lesser aerobic fitness. For example, the 80-89% rank for the male recruits (42.4-44.5 ml.kg/min) would actually fall within a 'poor' classification for 20-29 year olds (Riebe et al., 2018). This was less extreme for the female recruits; those women in the 40-49% rank would be classified as poor according the 20-29 year age group standards. These results could be indicative of some of the challenges associated with law enforcement recruitment. Less people are applying to law enforcement positions (International Association of Chiefs of Police, 2019), and within the general population, there has been shifts towards greater obesity and physical inactivity (Centers for Disease Control and Prevention, 2020; Fryar et al., 2020). These actualities reinforce why it is important to produce law enforcement-specific recruit normative data, as it profiles what recruits look like at a certain point in time, and any shifts in recruit fitness can be documented. The downstream effect of this could be how fitness programs should be administered at training academies, especially if there is a greater volume of recruits reporting with lesser aerobic fitness. However, the results could have also been influenced by the learning effects associated with the 20MSFT (Aandstad et al., 2011; Lockie et al., 2021a). Recruits less familiar with the running demands of this test may not have performed as well, which led to a lower estimated $\dot{V}O_{2max}$. Nonetheless, given the external pacing of the 20MSFT (Léger et al., 1988), and typical law enforcement job tasks (Brewer et al., 2013), this test is still very applicable for law enforcement recruits.

There are study limitations that should be noted. Only data from one agency was analyzed in this study. Fitness test performance can vary across different agencies (Myers et al., 2019), so the current normative data may not be applicable to all departments. The current research only provided a descriptive analysis of recruit 20MSFT data; the effects of 20MSFT performance on academy survivability and future job performance cannot be determined. There was a large discrepancy of men and women in the sample (i.e., 850 men vs. 190 women), although this is typical of many law enforcement organizations. As stated, is plausible that learning effects influenced the 20MSFT performance in the recruits (Aandstad et al., 2011; Lockie et al., 2021a). Law enforcement training academies have historically featured high volumes of long, slow distance running (Lockie et al., 2021a; Lockie et al., 2020c). Recruits more experienced with this type of training may not have performed as well in the 20MSFT.

Conclusion

This study documented normative data for law enforcement recruits in the 20MSFT. With regards to between-sex comparisons, the data indicated the male recruits tended to perform better than female recruits, although 36% of the female recruits were in the top half of all recruits in completed 20MSFT shuttles. Nonetheless, female recruits will likely need specific aerobic conditioning prior to and during academy. The estimated $\dot{V}O_{2max}$ data suggested limitations in recruit aerobic fitness when compared to population norms. Familiarity with the 20MSFT and exposure to high-intensity running could have influenced these results. Nevertheless, the provision of normative 20MSFT data provide benchmarking of the aerobic fitness of recruits and could inform fitness training program design for academy staff.

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