Original Research

Relationships between Assessments in a Physical Ability Test for Law Enforcement: Is There Redundancy in Certain Assessments?

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ABSTRACT

International Journal of Exercise Science 11(4): 1063-1073, 2018. The purpose of this study was to investigate the relationships between tests incorporated into a physical assessment battery (PAT) for a law enforcement (LEA) to determine if there were redundancies (i.e. tests measuring the same qualities). A retrospective analysis of 226 recruits (196 males, 30 females) was conducted. The PAT consisted of: maximal push-ups and sit-ups completed in 60 s; a 75-yard pursuit run (75PR); maximal revolutions completed on an arm ergometer in 60 s; and a 2.4 km run. A one-way ANOVA ($p<0.05$) determined if there were significant differences in the PAT data between the sexes. Pearson's correlations ($p<0.05$) calculated relationships between each of the tests within the PAT, and males and females were analyzed separately. Further, tests that could potentially measure similar qualities, including upper-body endurance (push-ups/arm ergometer), abdominal endurance (push-ups/sit-ups), and aerobic fitness (arm ergometer/2.4 km run) were investigated further with one-sample t-tests to determine agreement. Males performed better than the females in all tests ($p \le 0.017$). There were significant correlations between assessments for both males and females (e.g. push-ups, sit-ups and arm ergometer, 75PR and sit-ups, arm ergometer and 2.4 km run), but the strength of these relationships was small-to-moderate. The one-sample t-tests for the selected comparisons (push-ups/arm ergometer; push-ups/sit-ups; arm ergometer/2.4 km run), for males and females were all significant ($p<0.001$), which meant the test pairs did not agree. The results indicate that if a LEA uses these tests in a PAT, they can do so knowing they are measuring five relatively distinct physical qualities.

KEY WORDS: Police, tactical, upper-body strength, upper-body endurance, abdominal endurance

INTRODUCTION

The use of physical ability and physical fitness testing as an employment qualification is very common among occupations that are physically demanding (18, 30). Most law enforcement agencies (LEAs) require officer candidates to meet a certain physical fitness level, or standard, as part of their selection process (21, 25). According to Hoover (16), these standards generally

include job simulation exercises, physical agility or stamina tests, and normative-referenced fitness or wellness tests. If the candidate is unable to successfully pass this portion of the selection process they are typically no longer considered as a viable officer candidate (32).

Generally speaking, these physical ability tests (PAT) consist of assessments designed to distinguish between those that have the physical ability to safely and effectively perform critical job-related tasks and those that do not (6). The diversity in these populations (i.e. age, ethnicity, and sex) (11, 20) must also be considered when selecting which assessment be used. These assessments can include but are not limited to: maximal push-ups and sit-ups that can be completed in 60 seconds (s) (5, 8, 11, 12, 22); agility courses and simulated pursuit runs such as the 75-yard pursuit run (75PR) (22); maximal revolutions that could be completed on an arm ergometer in 60 s (22); and a 2.4 kilometer (km), or 1.5 mile, run (5, 8, 11, 12, 22). Currently, there are no national standards related to physical requirements for law enforcement officers in the USA. As such, individual agencies are largely responsible for the development, implementation, and validation of the fitness testing battery they utilize. Many agencies use simulated job tasks and physical ability assessments as a method of determining the physical preparedness of law enforcement academy cadets (5). However, most LEAs have significant time and resource constraints which often makes the implementation of physical testing batteries challenging.

As a result of the size of the candidate classes (7, 24), and the time limitations placed on instructors, PATs selected should assess specific qualities (e.g. strength endurance, aerobic capacity, change of direction ability) and avoid redundancy. If multiple assessments are measuring the same quality, or if assessments are highly associated with each other, it may be more efficient for an agency to remove or replace that assessment with one that measures a different physical quality. There is currently no research that has investigated the relationships between assessments in a PAT for a law enforcement agency, with a view to determining the efficiency of physical fitness testing.

Therefore, this study investigated the relationships between assessments that were incorporated into a PAT battery for a LEA in the USA. The assessments included: maximal push-ups that could be completed in 60 s; 75PR; maximal revolutions that could be completed on an arm ergometer in 60 s; maximal sit-ups that could be completed in 60 s; and a 2.4 km run. In addition to this, tests that could potentially measure similar qualities, including upper-body endurance (push-ups and arm ergometer), abdominal endurance (push-ups and sit-ups), and aerobic fitness (arm ergometer and 2.4 km run) were investigated further. Males and females were analyzed separately (11). It was hypothesized that for both sexes, performance in the assessments within the PAT battery would correlate as fitter recruits will perform better across all tests. However, there would not be good agreement between the pairs of tests, which would indicate that they measured different physical abilities.

METHODS

Participants
Data was collected by the training staff of the LEA being investigated during the initial recruitment process and was released with consent from that organization (9, 10, 20). A sample of convenience comprised of 226 recruits (age: 27.29±6.12 years; height: 1.76±0.09 meters [m]; body mass: 80.36±12.07 kilograms [kg]) across three training classes. The sample included 196 males (age: 27.59±6.29 years; height: 1.78±0.07 m; body mass: 82.61±10.95 kg) and 30 females (age: 25.37±4.50 years; height: 1.62±0.09 m; body mass: 65.90±8.54 kg). Based on the archival nature of this analysis (8-10, 12, 20), the institutional ethics committee approved the use of pre-existing data. Nonetheless, the study still conformed to the recommendations of the Declaration of Helsinki.

Protocol
As stated, the data in this study was collected by the staff of one LEA using procedures that will be detailed. The staff were all trained by the LEA and were proficient in conducting the required assessments. Height and body mass were recorded in a classroom at the training facility for the agency. The tests were performed in the order detailed in this section. The push-up and sit-up tests, 75PR, and arm ergometer test were conducted outdoors on a concrete surface at the LEA's training facility. The 2.4 km run was performed with participants running around a predetermined running track as fast as possible.

Upper-body strength endurance was assessed via a maximal push-up test (7, 8, 20), where participants completed as many push-ups as they could in 60 s. The protocol for this assessment followed that of established research (1, 5, 7, 8, 11, 12, 20). Participants started in the standard 'up' position, with the body taut and straight, the hands positioned shoulder-width apart, and the fingers pointed forwards. The law enforcement agency utilized a standard water bottle to determine the bottom position of the push-up, which was positioned underneath the participant's chest (22). On the start command, the tester began the stopwatch, and participants flexed their elbows, lowered themselves until their chests contacted the water bottle, and extended their elbows until returning to the start position. The participants performed as many push-ups as possible using this technique in the allotted 60 s time period. Participants could rest in the up position with elbows locked, but only full repetitions were recorded (7, 20).

Abdominal muscle endurance was assessed via the sit-up test, where participants had to complete as many repetitions as possible in 60 s (1, 5, 7, 11, 12, 20). Participants laid on their backs on padded mats with their knees flexed to 90°, heels flat on the ground, and arms crossed across the chest and hands positioned on the shoulders. The feet were held to the ground by a test administrator or another candidate. On the start command, participants raised their shoulders from the ground while keeping their arms crossed, and touched the elbows to the knees (22). The participant then descended back down until the shoulder blades contacted the ground and completed as many repetitions as possible in the allocated 60 s time period. Participants could rest in the down position, and only full repetitions were counted (7, 20).

The 75PR was designed to simulate a foot pursuit for a law enforcement officer (22), and is shown in Figure 1. The participant in this test completed five linear sprints about a square grid (each side was 13 yards, or 11.89 meters [m]), while completing four, 45° direction changes zig-zagging across the grid. Participants were also required to step over three barriers that were 8 feet (2.44 m) long and 6 inches (0.15 m) high that simulated curbs during three of the five linear sprints. Time was recorded via a stopwatch, from the initiation of movement at the start of the sprint, until they crossed the finish line. Timing via stopwatches is standard across law enforcement officer running tests (1, 5, 12, 20, 26). Furthermore, test administrators trained in the use of stopwatch timing procedures for running tests (which the testers were in this study) can record reliable and consistent data (15).
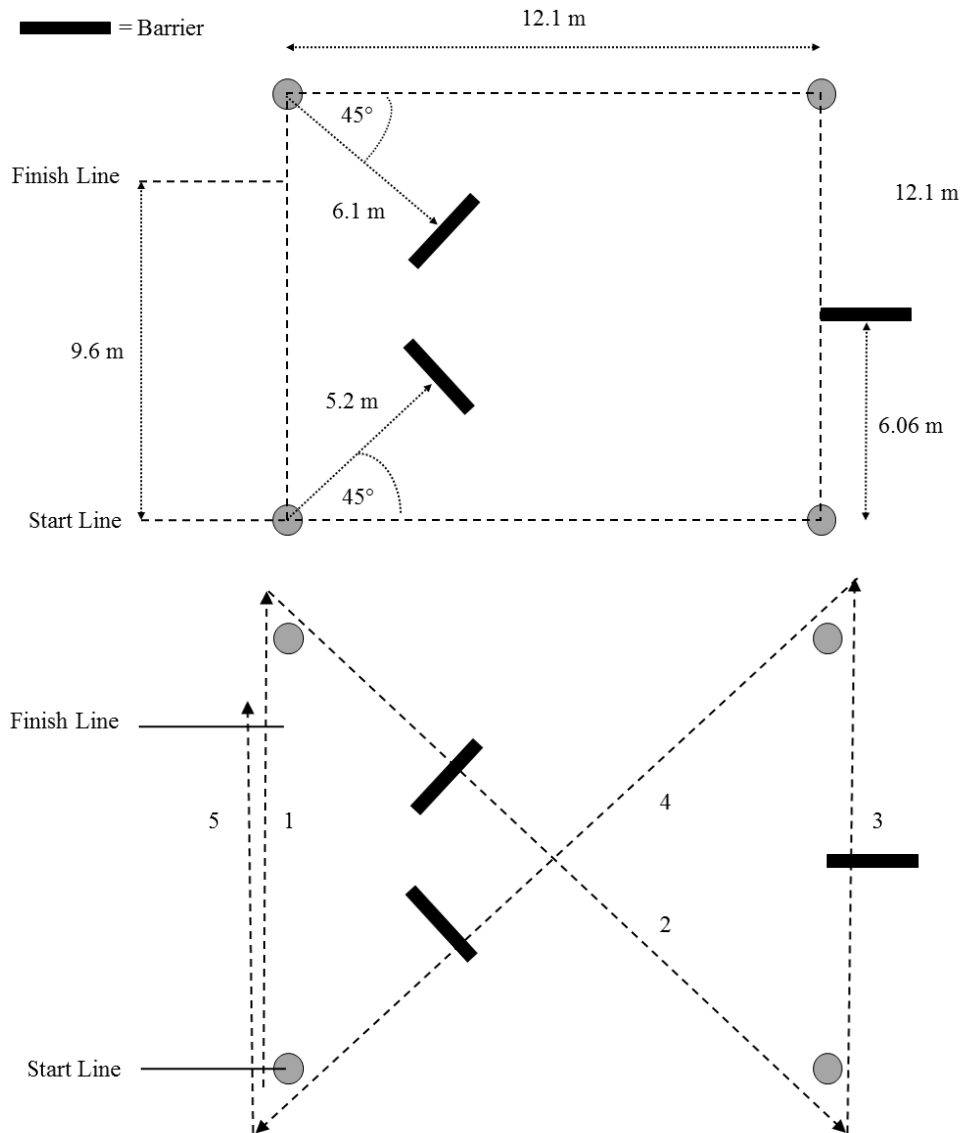

Figure 1. (A) The dimensions for the 75-yard pursuit run in meters (m) and (B) the running direction (numbered in order) for the 75-yard pursuit run. The barriers were 2.44 m long and 0.15 m high.

The arm ergometer test was used as an assessment of upper-body endurance. This test was performed on a standard arm ergometer (Monark 881E, Vansbro, Sweden) positioned on a table, and standard procedures were followed for all participants (22). The participant knelt on a padded mat as such that the crankshaft handle was level with the participant's shoulder. The test began from a position where the left arm of the participant was fully extended and parallel to the ground. The participant complete 10 revolutions of the arm ergometer prior to the test to set the resistance at 50 watts. The counter was set to zero before the test commenced. After the administrator initiated the test, participants attempted to complete as many revolutions as possible in 60 s.

The 2.4 km, or 1.5-mile, run was used to assess aerobic capacity, and performed using on a 440 yard (402-m) running track at the agencies' training academy. Participants completed six laps around this track, and were instructed to perform this run as quickly as possible (22). Similar to the instructions of other LEAs, participants in this study were also instructed to slow their pace if they experienced any pain, severe shortness of breath, or other abnormal signs (3). The 2.4 km mile run time was recorded for each participant on a handheld stopwatch to the nearest 0.10 s (5, 11).

Statistical Analysis
Statistical analyses were processed using the Statistics Package for Social Sciences (Version 24; IBM Corporation, New York, USA), and Microsoft Excel (Microsoft Corporation™, Redmond, Washington, USA). Descriptive statistics (mean± standard deviation [SD]; 95% confidence intervals [CI]) were calculated for each measured parameter for the males and females. A one-way analysis of variance (ANOVA) was used to determine if there were significant differences in the PAT data between the sexes, as this would also confirm the appropriateness of analyzing the sexes separately. The one-way ANOVA was used due to the robustness of this procedure (14, 20), with significance set as $p<0.05$. With regards to the correlation data, males and females were analyzed separately (11). Pearson's correlations calculated relationships between each of the assessments within the PAT. Significance for the correlations was set as $p<0.05$. The correlation (r) strength was designated as: an r between 0 to 0.3, or 0 to -0.3, was considered small; 0.31 to 0.49, or -0.31 to -0.49, moderate; 0.5 to 0.69, or -0.5 to -0.69, large; 0.7 to 0.89, or -0.7 to -0.89, very large; and 0.9 to 1, or -0.9 to -1, near perfect for relationship prediction (17). In addition to the correlation analysis, one-sample t-tests ($p<0.05$) were conducted on the calculated difference between certain tests that may measure similar qualities either due to the correlation data or face validity (i.e. the tests appeared to measure similar qualities), with comparisons made to zero. If there were no significant differences between any of the test pairs for the male or female recruits (i.e. the tests were comparable), then Bland-Altman plots would be constructed for these comparisons to detail the limits of agreement.

RESULTS

The mean PAT data for males and females can be viewed in Table 1. The males performed significantly more push-up and sit-up repetitions, more revolutions in the arm ergometer test, and were faster in the 75PR and 2.4 km run. Thus, it was deemed appropriate to analyze the

sexes separately. The correlation data for the males is shown in Table 2, while the correlations for the females is displayed in Table 3. In males, there were small-to-moderate relationships with the sit-up test, 75PR, arm ergometer, and 2.4 km run. The sit-up test correlated with the 75PR, arm ergometer (both small), and 2.4 km run (moderate). The 2.4 km run also had small relationships with the 75PR and arm ergometer. In females, there were significant relationships between the push-up and sit-up test, sit-up test and 75PR, and arm ergometer and 2.4 km run (all moderate).

Table 1. Descriptive data (mean±SD; 95% CI) for age, and performance of three different classes of candidates in the pre-screening PAT (number of push-ups and sit-ups completed in 60 s, time to complete the 75PR, number of revolutions completed in a 60-s arm ergometer test, and 2.4 km run time).

	Males (n=196)	Females (n=30)	p
No. of Push-ups	42.24±11.56 (40.62-43.87)	25.20±8.90* (21.88-28.52)	<0.001
No. of Sit-ups	40.10±8.67 (38.88-41.32)	36.00±9.07* (32.61-39.39)	0.017
75PR Time (sec)	17.24±1.11 (17.08-17.39)	18.64±1.30* (18.17-19.13)	<0.001
Arm Ergometer No. of Revolutions	131.41±14.51 (129.08-133.73)	109.43±12.10* (107.92-113.95)	<0.001
2.4 km Run Time (min:sec)	12:47-1:09 (12:31-13:03)	14:02±0:59* (13:40-14:24)	<0.001

* Significantly ($p<0.05$) different from the male recruits.

Table 2. Correlations between age, number of push-ups and sit-ups completed in 60 s, time to complete the 75PR, number of revolutions completed in a 60-s arm ergometer test, and 2.4 km run time in male recruits (n=196).

		Sit-ups	75PR	Arm Ergometer	2.4 km run
Push-ups	r	0.440	-0.276	0.282	-0.401
	p	<0.001*	<0.001*	<0.001*	<0.001*
Sit-ups	r		-0.276	0.282	-0.401
	p		<0.001*	<0.001*	<0.001*
75PR	r			0.004	0.234
	p			0.961	0.001*
Arm Ergometer	r				-0.149
	p				0.038*

* Significant ($p<0.05$) relationship between the two variables.

Table 3. Correlations between age, number of push-ups and sit-ups completed in 60 s, time to complete the 75PR, number of revolutions completed in a 60-s arm ergometer test, and 2.4 km run time in female recruits (n=30).

		Sit-ups	75PR	Arm Ergometer	2.4 km run
Push-ups	r	0.510	0.023	0.067	0.167
	p	0.004*	0.902	0.723	0.379
Sit-ups	r		-0.369	0.152	-0.314
	p		0.045*	0.422	0.091
75PR	r			-0.098	0.204
	p			0.607	0.279
Arm Ergometer	r				-0.443
	p				0.014*

* Significant ($p<0.05$) relationship between the two variables.

One sample t-tests were conducted on the push-up and arm ergometer tests, push-up and sit-up tests, and arm ergometer and 2.4 km run. Despite the significant correlation between the push-up and arm ergometer test in males, the one-sample t-test conducted on the difference

between these tests was significant (*p*<0.001), suggesting there was not agreement between these tests. This calculation was also run for the females between the push-up and arm ergometer tests, and these were significantly different from each other (*p*<0.001). Further, even though there were significant relationships between the push-up and sit-up tests, and arm ergometer and 2.4 km run for both male and female recruits, the one-sample t-test data demonstrated that each test pair was significantly different (i.e. they did not agree). Given that no test pairs agreed with each other, no Bland-Altman plots were constructed.

DISCUSSION

Many LEAs typically use a variety of test to assess physical preparedness during the hiring process. This is because law enforcement officers need a number of different physiological qualities to perform their job safely and effectively (19). Previous research has not investigated the efficiency of PAT batteries for any LEAs by determining the relationships between tests (i.e. to ascertain whether multiple assessments are measuring the same physical qualities). The purpose of this study was to investigate the relationships between assessments that were incorporated into a PAT battery (push-ups and sit-ups, 75PR, arm ergometer test, and 2.4 km run) for a LEA in the USA. The results of this study showed that there were limited relationships between these five assessments, which suggests these measures assess different physical qualities. This means that if a LEA uses these assessments they can do so knowing they are measuring five relatively distinct physical qualities.

Physical qualities that officers may need to use on the job in a foot pursuit situation are change-of-direction ability, speed, and agility. In both men and women, strength, power, and coordination are important qualities for effective change-of-direction ability and agility (23, 27, 28). In addition to this, performance of the 75PR is in part dependent on the participant's ability to produce force rapidly. The moderate correlations between age and 75PR time for both males and females, which suggested that younger candidates ran faster, could be in part attributed to potential declines in strength and power that occur with increasing age. For example, Dawes, et al. (11) found that power production as measured by vertical jump height declined with age increases in incumbent law enforcement officers.

When assessing the relationship between push-up and arm ergometer, although a significant (albeit small) correlation was identified for males, there were no significant relationships found for females, and the tests did not agree with each other for both male and female recruits. These results could in part be attributed to the dispersion of scores within the sample population, as males performed significantly more push-up and more revolutions in the arm ergometer test, in addition to the inherent performance differences between males and females in strength tests (20). These results also support the previous work of Dawes et al. (11), who documented that male officers tended to perform significantly better than female officers in strength and strength endurance-based tests including push-ups, isometric leg/back strength, and isometric grip strength. Many of the female recruits may be relying more on muscular strength than muscular endurance to complete the push-up test. Therefore, this would be different to the arm ergometer test, which may place a greater emphasis on upper-body endurance in this instance. This also

corresponds with the findings of Vaara et al. (29), who discovered that muscular endurance test scores (push-ups, sit-ups and repeated squats) related better to maximal aerobic capacity measured with indirect graded cycle ergometer and body fat content, rather than maximal strength test scores in young men aged 25.5±5.0 years. Within this PAT battery, the arm ergometer test is potentially providing a measure of upper-body endurance different to that from the push-up test in both men and women. However, the validity of this test for the job requirements of law enforcement officers requires further investigation.

Abdominal strength and endurance should be stressed in both the push-up and sit-up tests, as the abdominal muscles (e.g. rectus abdominis, lumbar erector spinae, external oblique, and internal oblique) are active across both movements (4, 13). When assessing the relationship between the push-up and sit-up tests for both males and females, there were significant relationships which indicated some crossover in abdominal strength and endurance across both tests. However, there was limited agreement between the push-up and sit-up tests, which indicated they did indeed measure different qualities in the sample of LEA recruits (upper-body pushing vs. abdominal endurance). These are qualities that law enforcement officers may need to use on the job (i.e. pushing strength for self-defense, abdominal strength for stability during defensive action and preventing low back injuries) (6). Any LEA that utilizes a sit-up and push-up should be confident that each is measuring a different, and potentially useful, quality.

There was a small correlation between arm ergometer and 2.4 km run, which could partially be attributed to both tests providing a measure of aerobic fitness (2, 31). However, there was no agreement between these two assessments, indicating that they likely measure disparate qualities. This is most likely due to maximal aerobic capacity being dependent on how it is measured (e.g. running vs. cycling vs. rowing). The 2.4 km run is a commonly used assessment in tactical populations, and in the United Kingdom all branches of the armed forces use 2.4-km run time and/or the 20-m multistage shuttle run test to assess aerobic fitness (31). The arm ergometer test is a less commonly used indicator of aerobic fitness in both tactical and the general population. Indeed, Bulthuis et al. (2) demonstrated that an arm ergometer test is best served in evaluation of training programs in patients with impairment of their lower extremities. Further to this, the arm crank is not often used as a maximal aerobic capacity test as local fatigue in the arms is the main limiting factor, as opposed to oxygen intake (2). Although the arm ergometer provides a different fitness measurement, as previously acknowledged, more research is needed to determine its relationship to job-specific tasks for law enforcement officers.

There are certain study limitations that should be acknowledged. This study investigated only one PAT battery for one LEA which had an independent set of protocols. All agencies may not use these assessments, so LEAs with different tests should ensure they do not have redundancies. There is also a possible issue of human error during data collection as stopwatches were used for the agility tests, and push-up and sit-up numbers are subject to the test administrator's discretion. Nonetheless, in accordance with previous law enforcement research, strict procedures were used for these tests (6, 8, 10-12, 29). Finally, further research is needed to confirm if these tests are assessing qualities that are required for law enforcement, especially in regard to the novel assessments of the 75PR and arm ergometer test. Although

these assessments are measuring distinct physical abilities, it must be confirmed that these physical abilities relate to whether an officer can safely and effectively perform job-related tasks.

In conclusion, the PAT battery for the law enforcement agency that was analyzed, which included push-ups, sit-ups, the 75PR, an arm ergometer test, and 2.4 km run, potentially identified five distinct physical qualities. This was demonstrated via a low number of correlations between the tests, in addition to no agreement between tests. Nevertheless, even though these tests appear to measure distinct physical abilities, further research is needed to establish whether these abilities are critical for law enforcement officers to safely and effectively perform job-related tasks.

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