Waist Circumference and Waist-to-Hip Ratio in Law Enforcement Agency Recruits: Relationship to Performance in Physical Fitness Tests

Lockie, Robert G; Ruvalcaba, Tomas R; Stierli, Michael; Dulla, Joseph M; Dawes, J Jay; Orr, Robin M

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ABSTRACT

Law enforcement agencies (LEAs) employ tests to assess recruit physical fitness. Body fat can influence test performance but is difficult to measure during academy due to time, equipment constraints, and instructor knowledge. This study examined relationships between waist circumference (WC) and waist-to-hip ratio (WHR), practical measures of fat distribution, and fitness test performance. Retrospective analysis of 267 LEA recruits (age: ~28 years; height: ~1.73 m; body mass: ~80 kg; 219 males, 48 females), was conducted. The tests included: WC and WHR; grip strength; push-ups, sit-ups, and arm ergometer revolutions in 60 s; vertical jump (VJ); medicine ball throw; 75-yard pursuit run (75PR); and multi-stage fitness test (MSFT) shuttles. Partial correlations, controlling for sex, calculated relationships between WC, WHR, and the fitness tests. Recruits were split into quartile groups (based on the sample size) for WC and WHR (Group 1 had the lowest WC and WHR; Group 4 the highest). A one-way MANOVA, with sex as a covariate and Bonferroni post hoc, compared between-group test performance. A greater WC related to lesser push-up, sit-up, VJ, 75PR, and MSFT performance ($p \leq 0.024$). When recruits were split into WC groups, Group 4 had lesser performance in push-ups, sit-ups, VJ, and the 75PR compared to all groups ($p \leq 0.038$). When split into WHR groups, Group 4 performed less push-ups than Group 1, less MSFT shuttles than Group 3, and had a lower VJ compared to all groups ($p \leq 0.042$). Recruits with a greater WC tended to have poorer fitness test performance.

Key words: body composition; fat distribution; fitness testing; police; tactical

INTRODUCTION

Law enforcement is generally seen as a spasmodic profession where sedentary work can be dispersed with a physically demanding occupational tasks (e.g. civilian rescue, suspect pursuit and restraint), and places great physiological stress on those in this occupation (11, 25, 28, 44). As a result, it is important for LEOs to maintain an appropriate level of physical fitness (33, 44). Most LEAs conduct physical fitness testing as part of the hiring process, so that candidates that have the requisite physical abilities to complete academy training and the specific tasks required by the occupational demands of law enforcement can be appointed. Academy training is where LEA instructors and tactical strength and conditioning facilitators (TSAC-F) will train recruits to tolerate the physical rigors of the profession, while also teaching the necessary procedures required for the job (5, 7, 34). Body composition and fat distribution may influence the performance of a LEA recruit or incumbent when performing fitness tests and physical tasks (11).

Anthropometric and body composition measures can be used in the general population to provide a measure of relative risk of developing cardiovascular diseases (4, 13, 20, 41). This has application to LEA recruits and incumbents, due to the high incidence of cardiovascular disease in this population (45). There has been some analysis of the effects that body composition can have on the fitness of LEOs. Dawes et al. (8) investigated relationships between body fat as measured by the sum of three skinfolds (chest, abdomen, and thigh), with muscular endurance (number of push-ups and sit-ups in 120 s, maximum number of pull-ups, and time to complete an obstacle course) in part-time male Special Weapons and Tactics (SWAT) officers. Greater body fat related to less repetitions in the push-up (r = -0.461), sit-up (r = -0.525), and pull-up (r = -0.769) tests, and a slower obstacle course time (r = 0.563). Dawes et al. (11) also used the sum of three skinfolds to measure body fat in male LEOs. A greater estimated percentage of body fat correlated with a lower number of push-ups completed in 60 s (r = -0.413), vertical jump (VJ) height (r = -0.566), and relative one-repetition maximum bench press (r = -0.448). Although the collective variance (17-59%) for these relationships does show that variables other than body fat could influence performance in these tests, they still indicate the negative impact body fat can have. Violanti et al. (44) documented that higher levels of body fat, as measured via sum of three skinfolds (chest, abdomen, and thigh for males; triceps, suprailium, and thigh for females), was associated with less push-ups and sit-ups completed in 60 s, and a slower 2.4-km run time in incumbent LEOs. However, the accurate measurement of body fat via skinfolds requires specific training (32, 35). If a tester is not sufficiently trained in the technique required to take accurate skinfolds, the resulting measurements can have an unacceptable level of error (35).

Further issues for LEA instructors and TSAC-F who wish to measure body composition is the time taken to do this, and the potential costs of equipment. While dual-energy x-ray absorptiometry and air displacement plethysmography are highly valid methods (30, 39), the required equipment is not readily available to many LEAs. Waist circumference (WC) and waist-to-hip ratio (WHR) are both practical methods through which to estimate body composition and body fat distribution. WC is a simple and effective measure of fat mass in the abdominal region (38, 42), and a strong predictor of cardiovascular disease risk (19, 20, 42). WHR also provides a measure of body fat distribution, and a greater WHR has been linked to an increased risk of cardiovascular disease (13). Interestingly, Seidell et al. (41) intimated that WC and WHR measured different aspects of body composition and fat distribution, so they may not be interchangeable. Nonetheless, there is currently no known research that has measured the WC and WHR in male or female LEA recruits in relation to physical fitness performance. Given that fitness testing is utilized to determine readiness to commence academy training and job task performance, and that body fat can negatively impact fitness in male LEOs (8, 11), it would be useful to identify whether WC and WHR relate to fitness test performance in LEA recruits.

This study investigated the relationships between body fat as measured by WC and WHR and physical fitness test performance in male and female LEA recruits prior to academy training. The fitness tests included: grip strength; maximal push-ups and sit-ups completed in 60 s; VJ; medicine ball throw (MBT); 75-yard pursuit run (75PR); maximal revolutions completed on an arm ergometer in 60 s; and the multi-stage fitness test (MSFT) (1, 5, 18, 25, 29). It was hypothesized that (a) greater WC and WHR would correlate with lesser performance in the fitness tests; and (b) recruits who had a lower WC and WHR would perform better in the fitness tests.

METHODS

Experimental Approach to the Problem

A retrospective analysis of existing data was performed to investigate the potential influence that WC and WHR may have upon physical fitness test performance in LEA recruits prior to academy training. Partial correlations controlling for sex were used to investigate relationships between WC and WHR on performance in fitness tests typically used in law enforcement populations. Furthermore, recruits were stratified into quartiles to create low-to-high WC and WHR groups. A one-way multivariate analysis of variance (MANOVA), with sex as a covariate, was used to compare the different WC and WHR groups for males and females. Sex was controlled for in both the correlation and MANOVA as females tend to carry more body fat than males (14), and have lesser performance in typical LEA fitness tests (2, 12, 28).

Subjects

Data were collected by the staff from one US-based LEA in the week preceding academy training, and was released with consent from that organization. This sample was comprised of 267 recruits (age: 27.66 ± 6.65 years; height: 1.73 ± 0.09 m; body mass: 79.77 ± 14.17 kg), which included 219 males (age: 27.28 ± 5.91 years; height: 1.76 ± 0.07 m; body mass: 83.45 ± 12.70 kg) and 48 females (age: 28.92 ± 8.88 years; height: 1.62 ± 0.06 m; body mass: 63.76 ± 7.82 kg). The sample incorporated three LEA training cohorts that started their academy in the Fall and Winter in southern California. Any strength and conditioning programs prior to academy were generally completed voluntarily at the individual-level only by recruits. Based on the archival nature of this analysis (8-12, 25, 27, 28), the institutional ethics committee approved the use of pre-existing data.

Procedures

The data in this study were collected by staff working for one LEA. The staff were all trained by a certified TSAC-F who verified the proficiency of the staff members. Prior to testing, each recruit's age, height, and body mass were recorded. Height was measured barefoot using a portable stadiometer (seca, Hamburg, Germany), while body mass was recorded by electronic digital scales (Health o Meter, Neosho, Missouri). All tests were conducted outdoors on concrete or asphalt surfaces at the LEA's training facility on a day scheduled by the staff for the LEA. Testing typically occurred between the hours of 0900-1400 depending on recruit availability, and recruits typically did not eat in the 2-3 hours prior to their testing session as they were completing employee-specific documentation for the LEA. The weather conditions for testing were typical of the climate of southern California during the Fall and Winter months (24). Although conducting testing is outdoors is not ideal (even in southern California), there was no available indoor testing facility available for this LEA and these procedures were adopted by staff from the LEA at all levels (i.e. during the hiring process, for recruits during academy, and for incumbents during skills refresher programs). Recruits rotated through the tests in small groups of 3-4 and were permitted to consume water as required during testing.

Waist Circumference (WC) and Waist-to-Hip Ratio (WHR)

A thin-line metric tape measure (Lufkin, Apex Tool Group, Maryland) was used to measure WC and WHR for all recruits. The protocols used in this study followed that of Reinert et al. (39). WC was measured in cm at the narrowest part of the waist just superior to the naval. Hip circumference was measured at the greatest posterior extension of the hip. WHR was calculated by dividing WC by hip circumference.

Grip Strength

Grip strength for each hand was measured by a hand grip dynamometer (Takei Scientific Instruments, Japan) with procedures adapted from law enforcement research (6, 12, 18, 28). Recruits kept their testing arm by their side throughout the assessment (6), and squeezed the handle as hard as possible for approximately 2 s (31). One attempt was completed for each hand (12), the left hand was tested first for all recruits, and the score was recorded to the nearest kilogram (kg).

Push-up Test

Upper-body muscular endurance was assessed via a maximal push-up test where recruits completed as many repetitions as possible in 60 s. The protocol for this assessment followed that of established law enforcement research, where a tester placed a fist on the floor directly under the recruit's chest to ensure they descended to an appropriate depth (5, 8, 10-12, 27, 28, 33). All female recruits were partnered with a female tester.

Sit-up Test

Abdominal muscular endurance was assessed via the sit-up test, where the recruits completed as many repetitions as possible in 60 s. As for the push-up test, the sit-up test was conducted according to procedures established in law enforcement research (1, 5, 7, 11, 12, 27, 28, 33).

Vertical Jump (VJ)

A Vertec apparatus (Perform Better, Rhode Island, USA) was used to measure the VJ, and followed established assessment protocols (1, 5, 22, 23, 25, 33). VJ height was calculated in inches by subtracting the standing reach height from the jump height, before being converted to cm (25, 33). Each recruit completed two trials, with a recovery time between trials of approximately 60 s, and the best trial used for analysis.

Medicine Ball Throw (MBT)

The MBT was used to indirectly measure upper-body power, and the protocols were adapted from previous research (25). Recruits sat on the ground with their head, shoulders, and lower back against a concrete wall, and projected a 2-kg medicine ball (Champion Barbell, Texas, USA) which was lightly dusted with chalk as far as possible using a two-handed chest pass. The measurement taken, using a standard tape measure, was the perpendicular distance from the wall to the chalk-marking closest to the wall made by the ball (21, 25). Two trials were completed, with a recovery time between trials of approximately 60 s, and the best trial was used for analysis.

75-Yard Pursuit Run (75PR)

The 75PR was designed to simulate a foot pursuit for a law enforcement officer (26, 29), and is shown in Figure 1. The recruit completed five linear sprints about a square grid (each side was 12.1 meters [m]), while completing four, 45° direction changes zig-zagging across the grid. Recruits were also required to step over three barriers that were 2.44 m long and 0.15 m high that simulated road-side curbs during three of the five sprints. Time was recorded via a stopwatch, from the initiation of movement at the start, until the recruit crossed the finish line. Timing via stopwatches is standard practice in LEA testing (1, 5, 11, 26-28, 40). Furthermore, testers trained in the use of stopwatch timing procedures for running tests can record reliable data (15).

INSERT FIGURE 1 ABOUT HERE

Arm Ergometry

The arm ergometer test was used an assessment of upper-body endurance (26, 29), and was performed on a standard arm ergometer (Monark 881E, Vansbro, Sweden) positioned on a table. The procedures for this test have been detailed by Lockie et al. (26), and the recruit completed 10 revolutions of the arm ergometer prior to the test to set the resistance at 50 watts. After the tester initiated the test, recruits completed as many revolutions as possible in 60 s.

Multi-Stage Fitness Test (MSFT)

The MSFT was used to measure maximal aerobic capacity in the male and female recruits and was conducted on an asphalt surface. This test has also been used in previously in tactical populations, including military (37), correctional (17), and police (18) populations. Recruits were required to run back and forth between two lines spaced exactly 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 in the center of the running area, and positioned in such 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 stage the recruit was able to achieve, and the stage was used to calculate the total number of completed shuttles.

Statistical Analysis

Statistical analyses were processed using the Statistics Package for Social Sciences (Version 24; IBM Corporation, New York, USA). The first part of the analysis involved the calculation of partial correlations controlling for sex to investigate relationships between WC and WHR with the physical fitness tests. Statistical significance was set at $p < 0.05$. As categorized by Hopkins (16), 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.

For the second part of the analysis for this study, the recruits (males and females combined) were stratified into quartiles to create low-to-high WC and WHR groups. The quartiles were based on the sample size of 267, and cut points were calculated according to the formula: 25 or 50 or 75/100 x (267 + 1). This resulted in four groups: Group 1 (lowest 25% of the sample for WC or WHC); Group 2 (second lowest 25% of the sample for WC or WHC); Group 3 (third lowest, or second highest, 25% of the sample for WC or WHC); and Group 4 (fourth lowest, or highest, 25% of the sample for WC or WHC). When WC or WHR scores overlapped between quartiles, recruits that had the same score were placed in the higher quartile. This meant that each group did not have the same number of subjects, but also ensured a clear delineation between the groups. A one-way MANOVA, with sex as a covariate and Bonferroni post hoc adjustment for multiple pairwise comparisons, was used to calculate any differences between the groups. Statistical significance was again set at $p < 0.05$. The sex-adjusted descriptive data was presented as mean ± standard error (SE), and 95% confidence intervals (CI) were calculated.

RESULTS

The partial correlation data between WC and WHR with the physical fitness tests are shown in Table 1. The mean WC and WHR for the recruits in this sample was 88.78 ± 9.76 cm and 0.90 ± 0.09, respectively. The males in this sample had a WC of 90.91 ± 9.14 cm and WHR of 0.91 ± 0.08, while for the females these values were 80.65 ± 8.16 cm and 0.85 ± 0.12, respectively. There were significant positive relationships between WC and WHR with the number of push-ups completed, which were moderate and small, respectively. WC also had significant negative correlations with number of sit-ups completed, VJ height, and the number of MSFT shuttles completed, and significant positive correlations with MBT distance and 75PR time. The strength of each of these relationships was small.

INSERT TABLE 1 ABOUT HERE

The sex-adjusted descriptive data for the recruits stratified by WC are shown in Table 2. With regards to height, Groups 3 ($p = 0.037$) and 4 ($p < 0.001$) were significantly taller than Group 1. Body mass, WC, and WHR were significantly different between all groups ($p \leq 0.001$). Group 4 completed significantly less push-ups ($p \leq 0.009$) and sit-ups ($p \leq 0.038$), and had a slower 75PR time ($p \leq 0.018$) compared to all other groups. Group 4 had a lower VJ when compared to Groups 1 and 2 ($p \leq 0.017$), and Groups 3 and 4 had a greater MBT compared to Group 1 ($p \leq 0.004$). There were no significant between-group differences in grip strength for either hand, the number of arm ergometer revolutions, or shuttles in the MSFT.

INSERT TABLE 2 ABOUT HERE

The sex-adjusted descriptive data for the recruits stratified by WHR are shown in Table 3. Group 4 was significantly older than Group 3 ($p = 0.019$). There were no significant between-group differences in height, and Groups 3 and 4 were significantly heavier than groups 1 and 2 ($p \leq 0.001$). There were significant differences between all groups for WC and WHR ($p \leq 0.001$). Group 4 completed significantly less push-ups than Group 2 ($p = 0.023$), had a lower VJ compared to all other groups ($p \leq 0.042$), and completed less shuttles in the MSFT compared to Group 3 ($p = 0.004$). Group 3 had a greater MBT compared to Group 1 ($p = 0.010$). There were no significant between group differences for grip strength for either hand, number of sit-ups, number of arm ergometer revolutions, or 75PR time.

INSERT TABLE 3 ABOUT HERE

DISCUSSION

This study investigated the relationships between WC and WHR in LEA recruits with physical fitness tests typical to this population. The male recruits in this study had a slightly lower WC (90.91 ± 9.14 cm vs. 93.4 ± 16.3 cm) and WHR (0.91 ± 0.08 vs. 0.92 ± 0.08) compared to a sample of adult male North Americans (41). When compared to the general population females analyzed by Seidell et al. (41), the female recruits had a lower WC (80.65 ± 8.16 cm vs. 83.1 ± 17.9 cm) and WHR (0.85 ± 0.12 vs. 104.2 ± 15.9). Granted, the age range (18-94 years) from the adults analyzed by Seidell et al. (41) was much wider, but this data still provides a context for the recruits.

With regards to the partial correlation data controlled for sex, a greater WC related with fewer push-ups and sit-ups in 60 s, a lower VJ, greater MBT, slower 75PR time, and less shuttles completed in the MSFT. Only the correlation with MBT distance indicated a beneficial relationship with a greater WC. Although the strength of the significant correlations ranged from small-to-moderate which suggests other factors may influence fitness test performance (e.g. lean body mass, technical skill), the results still provide support to research that has shown a greater percentage of body fat as measured via skinfolds related to poorer fitness test performance (8, 11, 44). To highlight the potential impact of these relationships, poorer push-up performance has been linked to academy attrition in law enforcement recruits (43). Slower performance in the 75PR is also not desirable, as it was designed as a foot pursuit simulation (26). Regarding WHR, there was only one significant relationship, with a greater WHR relating to a lower number of push-ups. Seidell et al. (41) stated that WHR does not reflect variations in visceral fat only, given that hip circumference also incorporates bone structures (i.e. pelvic width), gluteal muscle, and subcutaneous gluteal fat. These initial findings drawn from the correlation data suggest that when compared to WHR, WC may be a more useful measure of body fat in LEA recruits when considering potential effects on physical fitness. Although there are limitations as to actual visceral fat levels can be interpreted from WC measurements, it is a practical measure and provides some indication abdominal fat and cardiovascular disease risk (3, 13, 20, 38, 41, 42).

When the sample was divided into quartiles on the basis of WC, Group 4 tended to have lesser performance in push-ups, sit-ups, the VJ, and 75PR. There were also no significant differences in the fitness tests between Groups 1, 2, and 3. This suggests that body fat as measured by WC only became an issue for fitness in the bottom quartile of this sample (WC = 101.32 ± 0.42 cm). As stated, these findings provide support to research that has documented the negative influence body fat can have on fitness test performance (8, 11, 44). Additionally, there is a practical impact that body fat could have during academy. Academy training for LEA recruits often features body weight strength training (5, 7, 34). A recruit that carries more body fat may complete less repetitions in exercises such as push-ups and sit-ups, and would be slower in running tasks. This could result in the reduction of work completed during training, which could accumulate and result in lower fitness outcomes. This additive effect of poorer fitness performance across a training program has been analyzed in army recruits (36), but requires further investigation in LEA recruits.

Another outcome that can be drawn from the results of this study is that given the mean WC for Group 4 (101.32 ± 0.42 cm), some of the recruits could be approaching what would be considered a high health risk WC (males = 110+ cm; females = 95+ cm) (3). Given the prevalence of cardiovascular disease in LEOs (45), and the health risks associated with a greater WC in the general population (3, 38), WC could also be used as part of general health screening for recruit and incumbent LEOs. This could serve as a means meeting duty-of-care obligations, noting that Orr et al. (33) has acknowledged the nature of law enforcement duties that may lead to this increased in body fat and poorer performance.

Even though there are limitations in how WHR can be used to estimate body fat (41), the between-group comparisons when WHR was used to split the sample into quartiles indicated some significant results. Group 4 had a lower VJ compared to all other groups, and completed less MSFT shuttles compared to Group 3. These results again support research into the negative effects of body fat on fitness in law enforcement populations (8, 11, 44). Furthermore, except for Group 3 having a greater MBT distance compared to Group 1, there were no other differences between Groups 1, 2, and 3. The difference in MBT distances between Groups 1 and 3 could be related to sex differences (i.e. males tend to have superior MBT performance compared to females) (25), or greater lean body mass in Group 3 recruits (this group was also significantly heavier than Group 1). However, any lean body mass differences cannot be confirmed from the data collected in this study. Nonetheless, taking the partial correlation and MANOVA data together, WC may be a more utile measure regarding body fat and its influence on physical fitness in LEA recruits than WHR.

What these results also emphasize is that LEA training instructors and TSAC-F should attempt to accurately measure body composition in their recruits and incumbents where possible. Although WC and WHR are simple and practical ways to measure fat mass in the abdominal region (38, 42), they do not provide information about lean body mass. This is notable, as greater lean body mass in male LEOs has been correlated with superior push-up, VJ, and bench press performance (11). Greater lean body mass could have influenced performance in the MBT, as the recruits from Group 3 with greater WC or WHR, and greater body size and potentially more lean body mass (41), had a greater throw distance compared to Group 1. Given the physical nature of the law enforcement profession (11, 44), it could be expected that lean body mass should help LEOs in job-specific tasks (11). Dual-energy x-ray absorptiometry and air displacement plethysmography are generally considered the gold standards for measuring body composition (30, 39). However, given the high cost, LEA staff could investigate more cost-effective ways in which to measure lean body mass, such as bioelectrical impedance devices (30).

There are certain study limitations that should be acknowledged. WC and WHR only provide indirect measures of body composition or fat distribution, although these tests were investigated as they are practical (38, 39, 42). Future research into the body composition of LEA recruits and incumbent should utilize methods such as dual-energy x-ray absorptiometry and bioelectrical impedance, which could also allow for the measurement of lean body mass. The number of female recruits analyzed in this study compared to the males was much lower, and comprised approximately 18% of the sample. However, this is typical of LEAs (5, 7, 27, 33, 40, 44), and thus representative of many agencies. Furthermore, the partial correlation and MANOVA controlled for sex in an attempt to focus on the influence of body fat measured by WC and WHR. Within the context of these limitations, the results from this study suggest that a greater WC, which can be indicative of greater intra-abdominal or visceral fat (38, 41, 42), can negatively influence physical fitness test performance in LEA recruits.

PRACTICAL APPLICATIONS

There are several practical applications that can be drawn from this research. As there were individual male and female recruits that had a WC that could be considered high risk for cardiovascular disease (3), and a greater WC has been linked to cardiovascular disease risk (19, 20, 42), WC could also be used as part of health screening process for recruits. For recruits wishing to join a LEA and needing to improve performance for required physical fitness testing, they should incorporate measures to reduce WC as opposed to being limited to simply performing the given physical fitness testing exercises (e.g. reducing body fat may be able to positively influence push-up performance, as opposed to just training push-ups). There could also be value in exploring other methods to measure body composition in LEA recruits, in order to illustrate whether there are changes in fat distribution and lean body mass following academy training. Bioelectrical impedance devices could be an appropriate method, due to lower cost and relative ease of use, although this requires further investigation.

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Table 1: Partial correlations controlling for sex between waist circumference and waist-to-hip ratio with physical fitness tests (grip strength for the left and right hands, number of push-ups and sit-ups in 60 s, vertical jump height, medicine ball throw distance, 75-yard pursuit run time, number of revolutions on an arm ergometer in 60 s, and number of shuttles in the multi-stage fitness test [MSFT]) in male and female law enforcement agency recruits (n = 267).

		Waist Circumference	Waist-to-Hip Ratio
Grip Strength Left	*r*	0.069	0.004
	p	0.290	0.953
Grip Strength Right	*r*	0.103	-0.028
	p	0.112	0.669
Push-ups	*r*	-0.326*	-0.144*
	p	<0.001	0.026
Sit-ups	*r*	-0.289*	-0.120
	p	<0.001	0.064
Vertical Jump	*r*	-0.269*	-0.198
	p	<0.001	0.002
Medicine Ball Throw	*r*	0.218*	0.058
	p	0.001	0.375
75-yard Pursuit Run	*r*	0.231*	0.082
	p	0.001	0.204
Arm Ergometer	*r*	0.084	0.015
	p	0.198	0.822
MSFT Shuttles	*r*	-0.146*	-0.076
	p	0.024	0.242

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

Table 2: Sex-adjusted descriptive data (mean ± SE; 95% CI) for age, height, body mass, waist circumference (WC), waist-to-hip ratio (WHR), and physical fitness tests (grip strength [GS] for the left and right hands, number of push-ups and sit-ups in 60 s, vertical jump [VJ] height, medicine ball throw [MBT] distance, 75-yard pursuit run [75PR] time, number of revolutions on an arm ergometer in 60 s, and number of shuttles in the multi-stage fitness test [MSFT]) for male and female LEA recruits split into quartiles based on WC.

	Group 1 (n = 60) Lowest 25% WC = 68-81 cm	Group 2 (n = 67) 2nd 25% WC = 82-89 cm	Group 3 (n = 73) 3rd 25% WC = 89-95 cm	Group 4 (n = 67) Highest 25% WC = 96-118 cm
Age (years)	26.64 ± 0.90 (24.87-28.42)	27.89 ± 0.80 (26.29-29.42)	26.78 ± 0.77 (25.26-28.30)	29.01 ± 0.81 (27.42-30.60)
Height (m)	1.70 ± 0.01 (1.68-1.72)	1.74 ± 0.01 (1.72-1.75)	1.74 ± 0.01* (1.72-1.76)	1.76 ± 0.01* (1.74-1.78)
Body Mass (kg)	67.62 ± 1.23 (65.20-70.03)	76.01 ± 1.08* (73.94-78.20)	82.54 ± 1.05*§ (80.47-84.60)	91.91 ± 1.10*§ϕ (89.75-94.07)
WC (cm)	76.47 ± 0.47 (75.55-77.39)	85.09 ± 0.41* (84.28-85.90)	91.81 ± 0.40*§ (80.47-84.60)	101.32 ± 0.42*§ϕ (100.34-102.74)
WHR	0.82 ± 0.01 (0.80-0.84)	0.87 ± 0.01* (0.86-0.89)	0.92 ± 0.01*§ (0.91-0.94)	0.97 ± 0.01*§ϕ (0.96-0.99)
GS Left (kg)	35.62 ± 1.42 (32.83-38.41)	40.02 ± 1.28 (37.49-42.54)	38.95 ± 1.25 (36.48-41.42)	38.15 ± 1.28 (35.62-40.68)
GS Right (kg)	38.81 ± 1.69 (35.49-42.14)	42.57 ± 1.53 (39.56-45.57)	42.51 ± 1.49 (39.57-45.44)	42.15 ± 1.53 (39.14-45.16)
Push-ups (repetitions)	46.16 ± 1.73 (42.76-49.57)	47.59 ± 1.53 (44.55-50.57)	42.26 ± 1.48 (39.34-45.18)	35.45 ± 1.55*§ϕ (32.40-38.50)
Sit-ups (repetitions)	38.56 ± 1.20 (36.20-40.92)	38.01 ± 1.06 (35.93-40.09)	35.22 ± 1.03 (33.20-37.24)	31.19 ± 1.07*§ϕ (29.08-33.30)
VJ (cm)	55.56 ± 1.52 (52.56-58.56)	53.82 ± 1.34 (51.18-56.47)	52.06 ± 1.31 (49.49-54.63)	48.04 ± 1.36*§ (45.36-50.74)
MBT (m)	5.49 ± 0.12 (5.25-5.73)	5.83 ± 0.11 (5.62-6.04)	6.20 ± 0.10* (5.99-6.40)	6.07 ± 0.11* (5.85-6.28)
75PR (s)	16.83 ± 0.16 (16.52-17.15)	16.96 ± 0.14 (16.69-17.24)	16.98 ± 0.14 (16.71-17.25)	17.56 ± 0.14*§ϕ (17.28-17.85)
Arm Erg (revolutions)	125.01 ± 2.73 (119.63-130.38)	128.88 ± 2.42 (124.10-133.65)	125.65 ± 2.38 (120.96-130.34)	128.65 ± 2.49 (123.74-133.56)
MSFT Shuttles	55.36 ± 3.05 (49.36-61.36)	56.43 ± 2.69 (51.13-61.74)	54.27 ± 2.59 (49.16-59.37)	46.54 ± 2.71 (41.20-51.87)

* Significantly ($p < 0.05$) different from Group 1.

§ Significantly ($p < 0.05$) different from Group 2.

ϕ Significantly ($p < 0.05$) different from Group 3.

Table 3: Sex-adjusted descriptive data (mean ± SE; 95% CI) for age, height, body mass, waist circumference (WC), waist-to-hip ratio (WHR), and physical fitness tests (grip strength [GS] for the left and right hands, number of push-ups and sit-ups in 60 s, vertical jump [VJ] height, medicine ball throw [MBT] distance, 75-yard pursuit run [75PR] time, number of revolutions on an arm ergometer in 60 s, and number of shuttles in the multi-stage fitness test [MSFT]) for female LEA recruits split into quartiles based on WHR.

	Group 1 (n = 60) Lowest 25% WHR = 0.65-0.84	Group 2 (n = 53) 2nd 25% WHR = 0.85-0.88	Group 3 (n = 77) 3rd 25% WHR = 0.89-0.92	Group 4 (n = 77) Highest 25% WHR = 0.93-1.29
Age (years)	27.00 ± 0.92 (25.19-28.82)	28.13 ± 0.89 (26.39-29.88)	26.06 ± 0.75 (24.57-27.54)	29.16 ± 0.75ϕ (27.69-30.64)
Height (m)	1.72 ± 0.01 (1.70-1.74)	1.74 ± 0.01 (1.72-1.76)	1.73 ± 0.01 (1.72-1.75)	1.74 ± 0.01 (1.73-1.76)
Body Mass (kg)	71.50 ± 1.56 (68.43-74.58)	75.95 ± 1.50 (72.99-78.90)	83.88 ± 1.28*§ (81.37-86.39)	85.23 ± 1.27*§ (82.74-87.72)
WC (cm)	78.87 ± 0.93 (77.05-80.70)	85.14 ± 0.89* (83.39-86.89)	91.50 ± 0.76*§ (90.01-92.99)	97.26 ± 0.75*§ϕ (95.79-98.74)
WHR	0.80 ± 0.01 (0.78-0.81)	0.87 ± 0.01* (0.85-0.88)	0.91 ± 0.01*§ (0.89-0.92)	1.00 ± 0.01*§ϕ (0.99-1.01)
GS Left (kg)	36.65 ± 1.48 (33.75-39.56)	39.45 ± 1.42 (36.65-42.25)	38.43 ± 1.28 (35.91-40.95)	38.47 ± 1.20 (36.11-40.82)
GS Right (kg)	40.09 ± 1.75 (36.63-43.53)	42.33 ± 1.69 (39.00-45.65)	41.81 ± 1.52 (38.82-44.80)	42.00 ± 1.42 (39.20-44.80)
Push-ups (repetitions)	45.08 ± 1.87 (41.41-48.76)	45.65 ± 1.79 (42.12-49.18)	42.88 ± 1.52 (39.88-45.88)	38.83 ± 1.51§ (35.85-41.81)
Sit-ups (repetitions)	37.80 ± 1.28 (35.29-40.31)	38.00 ± 1.23 (35.59-40.41)	34.16 ± 1.04 (32.10-36.21)	33.89 ± 1.03 (31.85-35.92)
VJ (cm)	55.96 ± 1.56 (52.89-59.02)	54.69 ± 1.50 (51.74-57.63)	52.41 ± 1.27 (49.90-54.91)	47.64 ± 1.26*§ϕ (45.16-50.13)
MBT (m)	5.61 ± 0.13 (5.36-5.86)	5.85 ± 0.12 (5.60-6.09)	6.16 ± 0.11* (5.95-6.37)	5.95 ± 0.10 (5.74-6.15)
75PR (s)	16.86 ± 0.17 (16.53-17.19)	16.95 ± 0.16 (16.64-17.27)	17.09 ± 0.14 (16.82-17.36)	17.36 ± 0.14 (17.09-17.63)
Arm Erg (revolutions)	128.90 ± 2.82 (123.34-134.45)	125.56 ± 2.70 (120.24-130.88)	125.28 ± 2.36 (120.64-129.92)	128.40 ± 2.31 (123.85-132.94)
MSFT Shuttles	54.11 ± 3.11 (47.97-60.23)	55.33 ± 2.98 (49.46-61.19)	57.98 ± 2.55 (52.97-63.00)	45.96 ± 2.51ϕ (41.01-50.90)

* Significantly ($p < 0.05$) different from Group 1.

§ Significantly ($p < 0.05$) different from Group 2.

ϕ Significantly ($p < 0.05$) different from Group 3.

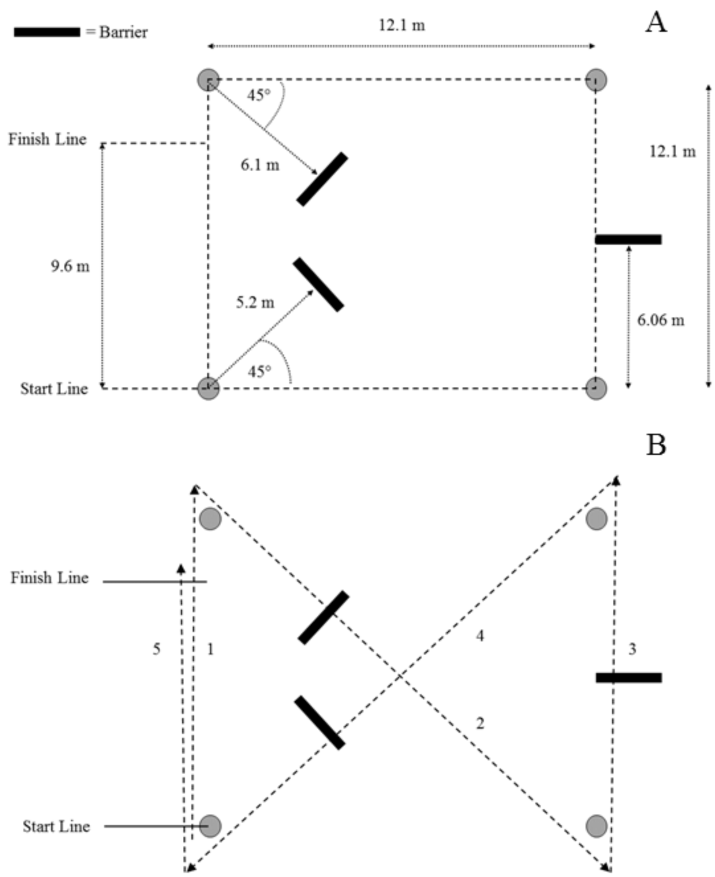

Figure 1: The dimensions for the 75-yard pursuit run in meters (m; A) and the running direction (numbered in order; B). The barriers were 2.44 m long and 0.15 m high.