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Relationships between Absolute and Relative Lower-Body Power and Foot Pursuit Ability in Law Enforcement Recruits

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ABSTRACT

International Journal of Exercise Science 14(3): 1078-1089, 2021. An essential job task for law enforcement officers is a foot pursuit. Lower-body power should aid foot pursuit ability; however, there has been minimal investigation of this relationship. This study investigated relationships between absolute and relative lower-body power measured by the vertical jump (VJ) with the 75-yard pursuit run (75PR), which is a change-of-direction (COD) speed test that simulates a foot pursuit in law enforcement recruits. Data from 487 male and 95 female recruits who completed the VJ and 75PR prior to academy training was analyzed. VJ variables included VJ height, relative VJ, and peak power and power-to-body mass ratio calculated from VJ height. The 75PR was timed and involved five sprints about a square grid with four direction changes across the grid. Independent samples t-tests confirmed between-sex differences in the VJ and 75PR. Pearson's correlations and stepwise regression calculated relationships between VJ height, body mass, and 75PR for males and females separately. Male recruits outperformed female recruits in the absolute and relative VJ and 75PR ($p \leq 0.002$). There were significant relationships between all VJ variables with the 75PR for both sexes (r = -0.304 to -0.463). VJ height and body mass predicted the 75PR for male recruits ($r^2 = 0.208$); VJ height predicted the 75PR for female recruits ($r^2 = 0.214$). Greater absolute and relative power derived from the VJ could contribute to faster 75PR performance in recruits. In addition to foot pursuit ability, absolute power could benefit other policing tasks such as load carriage and obstacle clearance.

KEY WORDS: 75-yard pursuit run, deputy sheriffs, occupational testing, police, tactical, vertical jump

INTRODUCTION

An important job task for a law enforcement officer is a foot pursuit, where an officer must chase and apprehend an offender (42). Due to the importance of this task, law enforcement agencies will often incorporate physiological tests that measure foot pursuit ability during different phases of hiring and training (5, 18, 19, 23, 30). These tests typically resemble change-of-direction

(COD) speed tests, where personnel need to run a set course while maneuvering through different direction changes and around obstacles. One law-enforcement specific COD test example is the 75-yard pursuit run (75PR). The 75PR was designed to simulate a foot pursuit and is used by a USA-based law enforcement agency during fitness testing in the initial hiring process (3, 5). In addition to being a surrogate for foot pursuit ability (3, 5, 18, 19, 29, 30, 42), the 75PR has practical application for law enforcement recruits. Previous research has indicated that recruits who had a slower 75PR performance are less likely to graduate from academy training (19, 21, 24).

It is important to note that the design of a COD speed test will influence the characteristics (e.g. movement technique, strength, power, linear speed) that are important for tactical performance (38). As a result, law enforcement-specific COD speed tests should be explicitly analyzed. Previous research has shown that there are relationships between lower-body strength and power and different measures of COD speed in athletic populations (1, 12, 31, 33). There has been previous analysis of the relationships between lower-body strength and power relative to the 75PR (42). In male and female civilians, Post et al. (42) detailed that there were significant ($p \leq 0.01$) relationships between the 75PR and relative strength measured by the isometric mid-thigh pull ($r = -0.41$), lower-body power measured by vertical jump (VJ) height, standing broad and lateral jump distance ($r = 0.56$-0.78) (42). While these results were encouraging, they were drawn from a civilian sample, which Post et al. (42) did note was a limitation in their study. It is important to investigate these relationships specific to law enforcement, as general population norms may not always represent law enforcement personnel (11). Distinct analysis of law enforcement populations can also better serve the development of training programs for these individuals (7). Indeed, even though law enforcement agencies will recruit from the general population, it is not known if recruits exhibit the same relationships between lower-body power and COD speed as measured by the 75PR.

There has been limited analyses of lower-body power and COD speed utilizing other tests in law enforcement. For example, Orr et al. (41) found that the standing broad jump distance related to a faster Illinois Agility Test in unloaded ($r = -0.649$) and loaded ($r = -0.686$) conditions in female police officers. In campus law enforcement officers, VJ performance did not relate ($p = 0.159$) to an occupational physical ability test incorporating tasks such as stair ascent, obstacle clearance, dragging, and sprinting (2). In contrast, Dawes et al. (8) found that faster performers in an occupational physical ability test involving running, dragging, crawling, pushing, and carrying, also had greater lower-body power measured by VJ height ($r = -0.54$, $p < 0.001$). These conflicting findings within the literature indicate a need for further investigation of lower-body power and COD speed in law enforcement personnel.

A further consideration is that some practitioners have noted the limitation of using VJ height as the metric for lower-body power, and have suggested more direct measures of power should be taken (36). Notwithstanding the costs associated with some types of equipment used to measure jump performance, the absolute measure of jump height has direct application to law enforcement personnel (28). Officers may need to climb fences and clear obstacles in their occupation, and these obstacles will not change their height relative to the power produced by

a recruit or officer (2, 8, 20, 29). Nonetheless, it is of value to analyze different measures of absolute and relative lower-body power that can be inferred from jump tests, and how they could influence COD speed in law enforcement personnel.

Therefore, the aim of this study was to investigate the relationships between absolute and relative lower-body power derived from the VJ and the 75PR tests in male and female law enforcement recruits. Similar to a range of other law enforcement studies, the current research involved the retrospective analysis of archival data (3-6, 8-11, 18-20, 23, 24, 27, 29, 30, 32, 45, 47). The VJ variables included: VJ height (cm); relative VJ height (cm·kg^{-1}); peak anaerobic power measured in watts (PAPw) derived from VJ height; and power-to-body mass ratio (PAPw divided by body mass; P:BM). Body mass was also included in the correlations as it was included in the relative VJ calculations. A further aim was to determine whether VJ height and body mass predicted 75PR time. Relative VJ, PAPw, and P:BM were not included in the regression analysis due to collinearity (i.e., VJ height was included within all these variables) (13). It was hypothesized that absolute and relative VJ variables would relate to 75PR time in the male and female recruits. It was further hypothesized that VJ height and body mass would predict 75PR time in the recruits.

METHODS

Participants

The deidentified archival data analyzed in this study were released with consent from one USA-based law enforcement agency. The sample of convenience comprised 582 recruits from eight academy classes (487 males, 95 females). Descriptive recruit data is shown in Table 1. Only those recruits with full datasets were considered in the analysis for this study. Out of the datasets made available to the researchers, datasets for 28 recruits were excluded. The characteristics of the participants featured in this investigation, as well as the between-sex ratio, was analogous to that from previous law enforcement research (3-5, 18-20, 22-24, 29, 30). As stated, the researchers were provided permission to analyze the data via gatekeeper approvals from the law enforcement agency involved in this study (6, 27, 32, 45, 47). Based on the archival nature of this analysis, the California State University, Fullerton Institutional Review Board approved the use of pre-existing data (HSR-17-18-370). This study was conducted in accordance to the ethical standards of the International Journal of Exercise Science (37), and the recommendations of the Declaration of Helsinki (48).

Protocol

Data were collected by staff working for the USA-based law enforcement agency in the week preceding academy training as part of a larger fitness testing battery conducted by the agency (23, 30). Before testing, age, height, and body mass of recruits from all classes were recorded. A portable stadiometer (seca 213, Hamburg, Germany) was used to measure the body height of recruits, while electronic digital scales (HBF-514C, Omron Healthcare, Kyoto, Japan) were used to measure body mass to the nearest 0.1 kg. Following this, recruits from all classes completed a series of dynamic movements (e.g., squats, lunges, push-ups, shoulder and hip mobility movements) that served as a warm-up (23). Within the fitness testing battery, recruits rotated

through the tests in groups of 3 - 4, and they were allocated to a testing station before rotating to the next station once all groups were completed (23, 30). However, only the VJ and 75PR tests outcome variables were considered for this study. A testing circuit was used due to participant numbers and associated time constraints and designed to minimize any effects of fatigue on the recruits. Physical training attire was worn by recruits, and testing occurred between 0900-1400 depending upon recruit availability at the agency's outdoor training facility. Recruits generally did not eat in the 2 - 3 hours prior to testing as they were completing employee-specific paperwork. The weather conditions during testing across the classes were typical of the southern California climate (4). Across a calendar year in southern California, Bloodgood et al. (4) noted that testing conditions could feature ambient temperatures of 21-29° C, and relative humidity of 8 - 71%, depending on the time of year. Although this may be a limitation, the law enforcement agency from this study needed to recruit year-round to maintain staff. Further, data recorded as part of this process has been analyzed in the scientific literature (4, 19, 22, 23, 25, 29, 30).

A Vertec apparatus (Vertec Scientific Ltd., Aldermaston, UK) was used to measure the VJ. Established procedures were adopted to measure VJ height (4, 19, 23, 25, 28-30, 35), and these procedures have been shown to have a high test-retest reliability ($r > 0.99$) (2). Clear instructions were provided to each recruit to minimize any testing errors (4, 19, 23, 25, 28-30, 35). The recruit stood side-on to the Vertec on their dominant side and reached upward to displace as many vanes as possible while keeping their feet flat on the ground to record standing reach height. The last vane moved became the zero reference. The recruit then performed a countermovement (with no preparatory step) and jumped as high as possible. Jump height was recorded from highest vane moved. VJ height was calculated in inches by subtracting standing reach height from jump height, and converted to cm. Each recruit completed two trials, with a between-trial recovery of approximately 60 s, with the best jump height analyzed. VJ height was recorded in absolute terms (cm) and also relative to body mass through the formula: relative VJ = jump height·body mass^{-1} (26). PAPw was calculated from the VJ via the formula: PAPw = (60.7·VJ height [cm]) + (45.3·body mass [kg]) – 2055 (43). P:BM was calculated by dividing PAPw by body mass: P:BM = PAPw·body mass^{-1} (10, 25, 33, 35).

The 75PR was used by the agency to simulate a foot pursuit and is shown in Figure 1. This test also provides an effective measure of COD speed, with Post et al. (42) detailing significant relationships between the 75PR and established tests of COD speed in the Illinois agility test ($p \leq 0.001$; $r = 0.67$-0.84) and 505 ($p < 0.001$; $r = 0.69$-0.84) in trained men and women. Accordingly, it was deemed appropriate to analyze the 75PR as an indicator for foot pursuit ability and COD speed for the recruits in this study. As recruits completed this test during the hiring process (3, 5), there was familiarity with the 75PR requirements. Nonetheless, directions for the 75PR were provided to ensure recruits correctly performed the requirements of the test (3, 5, 18, 19, 24, 29, 30). The recruit completed five sprints about a square grid while executing four direction changes across the grid. Recruits stepped over three 2.44-m long and 0.15-m high barriers that simulated curbs during three of the five sprints. Time was recorded via a hand-held stopwatch, from the initiation of movement, until the recruit crossed the finish line (3, 5, 18, 19, 24, 29, 30). A single staff member recorded 75PR time during a testing session. Previous research has shown

that these procedures had high trial-to-trial reliability (intra-class correlation coefficient = 0.85) (18). Two trials were completed with at least two minutes rest between trials; the fastest 75PR trial was analyzed in this study.

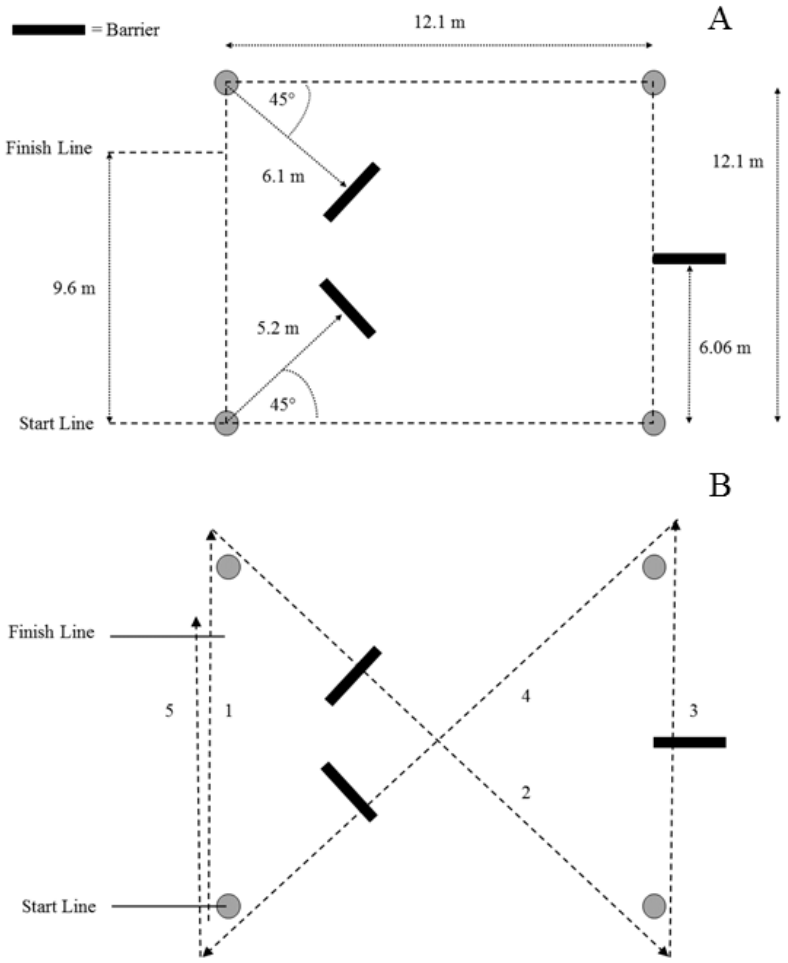

Figure 1. The dimensions for the 75-yard pursuit run in meters (A) and the running direction (numbered in order; B).

Statistical Analysis

Statistical analyses were calculated using the Statistics Package for Social Sciences (Version 27.0; IBM Corporation, New York, USA). Descriptive statistics (mean ± standard deviation [SD]) were derived for all variables. Normality of the data was confirmed by visual analysis of the stem-and-leaf plots (15, 39, 40), and linearity was also assessed. Independent samples t-tests compared the sexes to confirm the need to analyze each sex separately (42). Pearson's correlations determined relationships between the VJ variables and the 75PR for males and females, with significance set a priori at $p < 0.05$. Body mass was also included in the correlation analysis as it was involved in the relative VJ, PAPw, and P:BM variables. Correlation strength was designated as: an r between 0 to ±0.3 was small; ± 0.31 to ± 0.49, moderate; ± 0.5 to ± 0.69, large; ± 0.7 to ± 0.89, very large; and ± 0.9 to ± 1 near perfect for relationship prediction (14). Stepwise linear

regression analyses ($p < 0.05$) were conducted for the 75PR to ascertain whether VJ and body mass predicted this test for the male and female recruits. Relative VJ, PAPw, and P:BM were not included in the regression was each featured both VJ height and body mass in the calculations, so this removed any issues with collinearity (13).

RESULTS

There were no significant differences in age between the male and female recruits ($p = 0.331$). Male recruits were, on average, significantly taller, heavier, and superior in the VJ and 75PR compared to females ($p < 0.05$; Table 1). For the male and female data, the deviation from linearity for the relationship between the 75PR and the VJ variables was not significant ($p = 0.061$-0.504), confirming the use of Pearson's correlations.

Table 1. Descriptive data (mean ± standard deviation) for all (N = 582), male (n = 487), and female (n = 95) law enforcement recruits.

	All Recruits	Males	Females
Age (years)	27.32 ± 6.20	27.21 ± 5.93	27.88 ± 7.45
Height (m)	1.73 ± 0.09	1.76 ± 0.07	1.62 ± 0.06*
Body Mass (kg)	80.54 ± 13.61	83.65 ± 12.06	64.55 ± 9.16*
VJ Height (cm)	53.30 ± 12.80	55.91 ± 11.64	39.91 ± 9.76*
Relative VJ (cm·kg^{-1})	0.67 ± 0.17	0.68 ± 0.17	0.62 ± 0.17§
PAPw (watts)	4828.32 ± 1110.41	5128.06 ± 897.49	3291.79 ± 777.77*
P:BM (watts·kg^{-1})	59.86 ± 9.86	61.61 ± 9.05	50.93 ± 8.98*
75PR (s)	17.06 ± 1.13	16.82 ± 0.94	18.33 ± 1.15*

* Significantly ($p < 0.001$) different from the male recruits. § Significantly ($p = 0.002$) different from the male recruits. Vertical jump (VJ), peak anaerobic power measured in watts (PAPw), power-body mass ratio (P:BM), and 75-yard pursuit run (75PR).

The 75PR correlation data for the male and female recruits is shown in Table 2. Body mass did not significantly correlate with the 75PR for either male or female recruits. There were significant, moderate relationships between VJ height, relative VJ, and P:BM with the 75PR for male recruits, and a small relationship with PAPw. For the females, there were significant moderate relationships between VJ height, relative VJ, PAPw, and P:BM with the 75PR. The results from the stepwise regression analysis are displayed in Table 3. VJ height and body mass predicted the 75PR for male recruits, with 21% explained variance and a significance level of $p < 0.001$. Only VJ height predicted the 75PR for female recruits, with 21% explained variance and a significance level of $p < 0.001$ as well.

Table 2. Correlations between the 75-yard pursuit run (75PR) with vertical jump (VJ) variables (relative VJ; peak anaerobic power measured in watts [PAPw]; power-body mass ratio [P:BM]) for male (n = 487) and female (n = 95) law enforcement recruits.

	75PR – Males	75PR – Females
Body Mass	0.079	-0.109
VJ Height	-0.448*	-0.463*
Relative VJ	-0.406*	-0.362*
PAPw	-0.304*	-0.411*
P:BM	-0.447*	-0.456*

* Significant ($p < 0.001$) relationship with the 75PR.

Table 3. Stepwise linear regression analysis for the 75-yard pursuit run (75PR) performed by male and female recruits with the vertical jump (VJ) variables (peak anaerobic power measured in watts [PAPw]).

Variables	r	r^2
75PR – Males		
VJ Height	0.448	0.201
VJ Height, Body Mass	0.456	0.208
75PR – Females		
VJ Height	0.463	0.214

Significance was $p < 0.001$.

DISCUSSION

This study investigated relationships between the absolute and relative VJ measures (VJ height, relative VJ, PAPw, P:BM, and body mass) and the 75PR in male and female law enforcement recruits. The analysis detailed the potential impact that absolute and relative lower-body power could have on COD speed, and potentially foot pursuit ability in law enforcement personnel. There were significant relationships between all the VJ variables and the 75PR for both the male and female recruits. Body mass by itself did not significantly correlate with 75PR time; however, when combined within the relative VJ, PAPw, and P:BM variables, there were significant relationships. These results suggested law enforcement training staff could implement training protocols that develop absolute and relative lower-body power in their recruits to possibly enhance COD speed and foot pursuit ability as assessed by the 75PR. This could involve plyometrics to potentially enhance jump performance and movement speed (31), in addition to other modalities to enhance body composition (i.e., reduced non-functional mass) (17, 46). As law enforcement training academies can have a normal training duration of up to 27 weeks (27), with appropriate programming training staff should be able to improve COD speed in most of their recruits. Crawley et al. (7) found that police academy cadets were able to improve their change-of-direction speed, as shown by a decrease in time to complete the T-test, over a 16-week training academy. Physical training for the cadets in the Crawley et al. (7) study involved strength training, aerobic conditioning, and plyometrics. The combination of these training modalities, in addition to improvement of other fitness qualities (e.g. improved muscular endurance as shown by increased number of push-up and sit-up repetitions, enhanced aerobic fitness as shown by decreased ½-mile shuttle run time) contributed to a 5% decrease in T-test time (i.e. faster COD speed) (7). Future research should analyze whether specific training including plyometrics could enhance performance in a law enforcement-specific COD speed test

such as the 75PR in recruits, and how this type of training may affect their ability to complete foot pursuits.

It should be noted that the strength of the relationships between the VJ variables and the 75PR was small-to-moderate, suggesting other factors may contribute to a faster 75PR. Post et al. (42) intimated that power in the horizontal and lateral planes, isometric lower-body strength, and running speed all contributed to superior 75PR performance in male and female civilians. However, incorporating a range of fitness tests to investigate this in law enforcement recruits is difficult for a variety of reasons (19, 28). Some of the challenges when conducting fitness testing with law enforcement personnel include time constraints, equipment and staff limitations, and injury risk to recruits which could affect future or current employment. Nonetheless, further investigations are required to determine how best to enhance COD speed and foot pursuit ability in law enforcement personnel. For example, future research could incorporate a wider array of fitness tests, including assessments of movement quality, strength, and power, to detail relationships with COD speed. This has been recommended for Reserve Officers' Training Corps cadets (34), and could be adopted for law enforcement recruits.

Even though the explained variance was only 21% in the stepwise regression for both male and female recruits, VJ height and body mass predicted the 75PR for males, and VJ height predicted the 75PR for females. VJ height provides an indirect measure of lower-body power, with greater jump height implying greater lower-body power (31). Body mass is involved in deriving power generated from the VJ (43). Given that relative VJ height and P:BM were not contributors to the predictive relationships, these data would suggest that absolute power was potentially important for a faster 75PR. In support of this result, VJ height as an absolute power measure has been previously correlated with a faster 75PR in civilians (42). Although practitioners may critique the VJ height metric, there is application for law enforcement personnel (36). During a foot pursuit, officers may need to clear fences and other barriers and obstacles (2, 8, 20, 29). This requires absolute power as these obstacles will generally not change their height regardless of the relative power of the officer. Absolute power is also important to move quickly when wearing the occupational loads (i.e., tactical gear) required when on-duty, as greater inertia needs to be overcome (41). Accordingly, the ability to achieve a greater VJ height could benefit the officer's running speed during a foot pursuit, supplementary to other important law enforcement tasks.

There are study limitations that should be noted. Power was only extrapolated from the VJ, as this was the only data available to the researchers. Numerous other physical qualities contribute to COD speed, including technique, strength, and linear speed (1, 12, 31, 33, 42). However, as noted it can be difficult to conduct large-scale testing on law enforcement recruits (19, 28). All power variables were derived from the VJ, which may mean that to an extent they are interrelated. Nonetheless, the VJ is a common test in law enforcement where power capabilities can be inferred (2, 4, 8, 10, 19, 25, 35). Further to this, including different VJ calculations to derive additional power metrics has been adopted in both athletic (1, 26, 33) and law enforcement populations (10, 25, 35), and provides supplementary information to jump height. Only two trials for the VJ and 75PR were performed due to time constraints, with limited VJ

familiarization, and this could lead to some data errors. Nonetheless, these procedures have featured in other published research (4, 18, 19, 23, 25, 29, 30, 35), and the data were collected for record within the agency. There could be a degree of variability across recruit cohorts not tested at the same time. However, data analysis where data is collated across multiple recruit cohorts test at different times of year are commonplace, and often necessary, in law enforcement research (4, 5, 16, 19, 23-25, 29, 30, 44, 46).

In conclusion, there were significant relationships between VJ height, relative VJ, PAPw, and P:BM with the 75PR in male and female law enforcement recruits. VJ height and body mass predicted the 75PR in male recruits; VJ predicted the 75PR in females. These data suggest law enforcement recruits could develop both absolute and relative lower-body power to enhance their COD speed and foot pursuit ability. It should be acknowledged, however, that other characteristics, such as lower-body strength and movement technique, may contribute to faster COD speed in law enforcement recruits and officers. Nevertheless, the predictive relationships imply that absolute power could be important for COD speed in recruits, which is notable as this quality would be expressed in other job tasks such as movement under load and obstacle clearance. Future research should investigate whether improving lower-body power could enhance recruit performance in law enforcement-specific COD speed tests such as the 75PR, and whether this also contributes to better foot pursuit ability.

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REFERENCES

1. Banda DS, Beitzel MM, Kammerer JD, Salazar I, Lockie RG. Lower-body power relationships to linear speed, change-of-direction speed, and high-intensity running performance in DI collegiate women's basketball players. J Hum Kinet 68: 223-232, 2019.

2. Beck AQ, Clasey JL, Yates JW, Koebke NC, Palmer TG, Abel MG. Relationship of physical fitness measures vs. occupational physical ability in campus law enforcement officers. J Strength Cond Res 29(8): 2340-2350, 2015.

3. Bloodgood AM, Dawes JJ, Orr RM, Stierli M, Cesario KA, Moreno MR, Dulla JM, Lockie RG. Effects of sex and age on physical testing performance for law enforcement agency candidates: Implications for academy training. J Strength Cond Res Epub doi:10.1519/jsc.0000000000003207, 2019.

4. Bloodgood AM, Moreno MR, Cesario KA, McGuire MB, Lockie RG. An investigation of seasonal variations in the fitness test performance of law enforcement recruits. FU Phys Ed Sport 18(2): 271-282, 2020.

5. Cesario KA, Dulla JM, Moreno MR, Bloodgood AM, Dawes JJ, Lockie RG. Relationships between assessments in a physical ability test for law enforcement: Is there redundancy in certain assessments? Int J Exerc Sci 11(4): 1063-1073, 2018.

6. Conkin C, Hinton B, Ross K, Schram B, Pope R, Orr R. Inter-rater reliability and a training effect of the functional movement screen in police physical training instructors. Cogent Soc Sci 6(1): 1763769, 2020.

7. Crawley AA, Sherman RA, Crawley WR, Cosio-Lima LM. Physical fitness of police academy cadets: Baseline characteristics and changes during a 16-week academy. J Strength Cond Res 30(5): 1416-1424, 2016.

8. Dawes JJ, Lindsay K, Bero J, Elder C, Kornhauser C, Holmes R. Physical fitness characteristics of high vs. low performers on an occupationally specific physical agility test for patrol officers. J Strength Cond Res 31(10): 2808-2815, 2017.

9. Dawes JJ, Lockie RG, Orr RM, Kornhauser C, Holmes RJ. Initial fitness testing scores as a predictor of police academy graduation. J Aust Strength Cond 27(4): 30-37, 2019.

10. Dawes JJ, Orr RM, Elder CL, Krall K, Stierli M, Schilling B. Relationship between selected measures of power and strength and linear running speed amongst Special Weapons and Tactics police officers. J Aust Strength Cond 23(3): 23-28, 2015.

11. Dawes JJ, Orr RM, Flores RR, Lockie RG, Kornhauser C, Holmes R. A physical fitness profile of state highway patrol officers by gender and age. Ann Occup Environ Med 29(16): 16, 2017.

12. Delaney JA, Scott TJ, Ballard DA, Duthie GM, Hickmans JA, Lockie RG, Dascombe BJ. Contributing factors to change-of-direction ability in professional rugby league players. J Strength Cond Res 29(10): 2688-2696, 2015.

13. Enders FB. Collinearity. Retrieved from: https://www.britannica.com/topic/collinearity-statistics; 2013.

14. Hopkins WG. A scale of magnitude for effect statistics. Retrived from: www.sportsci.org/resource/stats/index.html; 2013.

15. Jeffriess MD, Schultz AB, McGann TS, Callaghan SJ, Lockie RG. Effects of preventative ankle taping on planned change-of-direction and reactive agility performance and ankle muscle activity in basketballers. J Sports Sci Med 14(4): 864-876, 2015.

16. Korre M, Loh K, Eshleman EJ, Lessa FS, Porto LG, Christophi CA, Kales SN. Recruit fitness and police academy performance: A prospective validation study. Occup Med 69(8-9): 541-548, 2019.

17. Kukić F, Koropanovski N, Jankovic R, Čvorović A, Dawes JJ, Lockie RG, Orr RM, Dopsaj M. Association of sex-related differences in body composition to change of direction speed in police officers while carrying load. Int J Morphol 38(3): 731-736, 2020.

18. Lockie R, Hernandez E. The 75-yard pursuit run performed by law enforcement recruits–Percentile rankings and implications for training. TSAC Report (57): 16-22, 2020.

19. Lockie RG, Balfany K, Bloodgood AM, Moreno MR, Cesario KA, Dulla JM, Dawes JJ, Orr RM. The influence of physical fitness on reasons for academy separation in law enforcement recruits. Int J Environ Res Public Health 16(3): 372, 2019.

20. Lockie RG, Dawes JJ, Balfany K, Gonzales CE, Beitzel MM, Dulla JM, Orr RM. Physical fitness characteristics that relate to Work Sample Test Battery performance in law enforcement recruits. Int J Environ Res Public Health 15(11): 2477, 2018.

21. Lockie RG, Dawes JJ, Dulla JM, Orr RM, Hernandez E. Physical fitness, sex considerations, and academy graduation for law enforcement recruits. J Strength Cond Res 34(12): 3356-3363, 2020.

22. Lockie RG, Dawes JJ, Moreno MR, Cesario KA, Balfany K, Stierli M, Dulla JM, Orr RM. Relationship between the 20-m multistage fitness test and 2.4-km run in law enforcement recruits. J Strength Cond Res Epub doi:10.1519/jsc.0000000000003217, 2019.

23. Lockie RG, Dawes JJ, Moreno MR, McGuire MB, Ruvalcaba TJ, Bloodgood AM, Dulla JM, Orr RM. We need you: Influence of hiring demand and modified applicant testing on the physical fitness of law enforcement recruits. Int J Environ Res Public Health 17(20): 7512, 2020.

24. Lockie RG, Dawes JJ, Orr RM, Dulla JM. Physical fitness: Differences between initial hiring to academy in law enforcement recruits who graduate or separate from academy. Work 68(4): 1081-1090, 2021.

25. Lockie RG, Dawes JJ, Orr RM, Stierli M, Dulla JM, Orjalo AJ. An analysis of the effects of sex and age on upper- and lower-body power for law enforcement agency recruits prior to academy training. J Strength Cond Res 32(7): 1968-1974, 2018.

26. Lockie RG, Jeffriess MD, Schultz AB, Callaghan SJ. Relationship between absolute and relative power with linear and change-of-direction speed in junior American football players from Australia. J Aust Strength Cond 20(4): 4-12, 2012.

27. Lockie RG, MacLean ND, Dawes JJ, Pope RP, Holmes RJ, Kornhauser CL, Orr RM. The impact of formal strength and conditioning on the fitness of police recruits: A retrospective cohort study. Int J Exerc Sci 13(4): 1615-1629, 2020.

28. Lockie RG, Moreno MR, Bloodgood AM, Cesario KA. Practical assessments of power for law enforcement populations. TSAC Report (49): 6-12, 2018.

29. Lockie RG, Moreno MR, Rodas KA, Dulla JM, Orr RM, Dawes JJ. With great power comes great ability: Extending research on fitness characteristics that influence Work Sample Test Battery performance in law enforcement recruits. Work 68(4): 1069-1080, 2021.

30. Lockie RG, Ruvalcaba TR, Stierli M, Dulla JM, Dawes JJ, Orr RM. Waist circumference and waist-to-hip ratio in law enforcement agency recruits: Relationship to performance in physical fitness tests. J Strength Cond Res 34(6): 1666-1675, 2020.

31. Lockie RG, Schultz AB, Callaghan SJ, Jeffriess MD. The effects of traditional and enforced stopping speed and agility training on multidirectional speed and athletic performance. J Strength Cond Res 28(6): 1538-1551, 2014.

32. Lyons K, Stierli M, Hinton B, Pope R, Orr R. Profiling lower extremity injuries sustained in a state police population: a retrospective cohort study. BMC Musculoskelet Disord 22(1): 115, 2021.

33. McFarland I, Dawes JJ, Elder CL, Lockie RG. Relationship of two vertical jumping tests to sprint and change of direction speed among male and female collegiate soccer players. Sports 4(1): 11, 2016.

34. McGuire MB, Lockie RG. Motor skill, movement competency, and physical fitness assessments for Reserve Officers' Training Corps cadets. Strength Cond J 43(2): 75-83, 2021.

35. Moreno MR, Dulla JM, Dawes JJ, Orr RM, Cesario KA, Lockie RG. Lower-body power and its relationship with body drag velocity in law enforcement recruits. Int J Exerc Sci 12(4): 847-858, 2019.

36. Morin JB, Jimenez-Reyes P, Brughelli M, Samozino P. When jump height is not a good indicator of lower limb maximal power output: Theoretical demonstration, experimental evidence, and practical solutions. Sports Med 49(7): 999-1006, 2019.

37. Navalta JW, Stone WJ, Lyons TS. Ethical issues relating to scientific discovery in exercise science. Int J Exerc Sci 12(1): 1-8, 2019.

38. Nimphius S, Callaghan SJ, Bezodis NE, Lockie RG. Change of direction and agility tests: Challenging our current measures of performance. Strength Cond J 40(1): 26-38, 2018.

39. Orjalo AJ, Callaghan SJ, Lockie RG. The effects of the barbell hip thrust on post-activation performance enhancement of change of direction speed in college-aged men and women. Sports 8(12): 151, 2020.

40. Orjalo AJ, Lockie RG, Balfany K, Callaghan SJ. The effects of lateral bounds on post-activation potentiation of change-of-direction speed measured by the 505 test in college-aged men and women Sports 8(5): 71, 2020.

41. Orr RM, Kukić F, Čvorović A, Koropanovski N, Janković R, Dawes J, Lockie R. Associations between fitness measures and change of direction speeds with and without occupational loads in female police officers. Int J Environ Res Public Health 16(11): 1947, 2019.

42. Post BK, Dawes JJ, Lockie RG. Relationships between tests of strength, power, and speed and the 75-yard pursuit run. J Strength Cond Res Epub doi:10.1519/jsc.0000000000003398, 2019.

43. Sayers SP, Harackiewicz DV, Harman EA, Frykman PN, Rosenstein MT. Cross-validation of three jump power equations. Med Sci Sports Exerc 31(4): 572-577, 1999.

44. Shusko M, Benedetti L, Korre M, Eshleman EJ, Farioli A, Christophi CA, Kales SN. Recruit fitness as a predictor of police academy graduation. Occup Med 67(7): 555-561, 2017.

45. Strader J, Schram B, Irving S, Robinson J, Orr R. Special Weapons and Tactics occupational-specific physical assessments and fitness measures. Int J Environ Res Public Health 17(21): 8070, 2020.

46. Violanti JM, Ma CC, Fekedulegn D, Andrew ME, Gu JK, Hartley TA, Charles LE, Burchfiel CM. Associations between body fat percentage and fitness among police officers: A statewide study. SH@W 8(1): 36-41, 2017.

47. Wiley A, Joseph A, Orr R, Schram B, Kornhauser CL, Holmes RJ, Dawes JJ. The impact of external loads carried by police officers on vertical jump performance. Int J Exerc Sci 13(6): 1179-1189, 2020.

48. World Medical Association. World Medical Association Declaration of Helsinki. Recommendations guiding physicians in biomedical research involving human subjects. JAMA 277(11): 925-926, 1997.