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Influence of Body Composition on Functional Movement Among Police Officers

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ABSTRACT

International Journal of Exercise Science 17(4): 418-428, 2024. Research indicates that the Functional Movement Screen (FMS) can be used to measure functional movement quality and characterize musculoskeletal injury risk in tactical populations. Although body composition has been linked to chronic disease in police officers, the link between body composition and functional movement quality has not been explored in this population. As such, the purposes of the study were to examine: (a) the effect of body mass index (BMI) on functional movement, and (b) determine the significance of fat mass (FM) and fat free mass (FFM) in predicting functional movement among active-duty police officers. Thirty-five active- duty police officers (31 male, 4 female; mean ±SD, age: 33.4 ±9.4 years, height: 177.4 ± 8.0 cm, weight: 88.4 ± 15.3 kg) were recruited to participate in this study, as part of a larger study on police fitness. All demographic data, BMI, FM, FFM, and FMS composite score (FMS CS) were obtained over two data collection sessions. With age held as a significant covariate, the results of the one-way ANCOVA revealed no significant effect of BMI category on FMS CS ($p = 0.077$). The linear regression analysis results suggest that FM and FFM contributed 36.9% variance in FMS CS while controlling for age ($p < 0.001$). FM was a significant individual predictor of FMS CS ($p < 0.001$), while FFM was not a significant individual predictor of FMS CS ($p = 0.111$). The current results reinforce the importance of police officers body composition management for health and functional movement quality across a career.

KEY WORDS: Functional movement screen, body mass index, BMI

INTRODUCTION

Police officers are at a heightened risk of workplace injury due to the varied and physical nature of occupational duties (1, 5, 29). It has been reported that police officer duties often require submaximal to maximal effort during demanding tasks (e.g., jumping, balancing, climbing, pushing, pulling, fighting) while bearing load (e.g., protective equipment) in highly dynamic environments (29). This confluence of occupational factors results in increased injury risk to the shoulders, knees, and back in particular (37). A recent study conducted by Orr and colleagues revealed that the most common causes of injury for police are physical assault, slips, trips, and falls (36). Such heightened risk of workplace injury places burden on the worker and the employer by way of increased days on the force lost due to injury, occupational restrictions during rehabilitation, and/or worker's compensation claims (16, 22, 29, 46). A large body of occupational health research has been conducted which characterizes injury types and injury mechanisms, as well as implementing risk reduction measures in various populations, including police officers (18). A section of this literature focuses on injury screening strategies, with many of these studies examining the impact of predictor variables on the incidence of injury, such as body composition and fitness (26, 44).

One of the most popular tools to evaluate functional movement is the Functional Movement Screen (FMS), a seven-series movement screen created by clinicians Gray Cook and Lee Burton in 2006 (8). This screen addresses proprioception, neuromuscular control, and motor learning. In the years since the publication of the FMS as a screening tool, the FMS has demonstrated strong and established interrater and intra-rater reliability (19, 43, 48). Some studies have affirmed the low sensitivity (0.33-0.58) and high specificity (> 0.70) of the FMS in utilizing the FMS as a diagnostic tool for musculoskeletal injury (MSKI) risk, suggesting the FMS is relatively poor (33-58%) at identifying injury risk presence, but relatively good (> 70%) at identifying a lack of injury risk presence (3, 48).

The FMS has been utilized in research involving tactical populations for over a decade now. To date, this body of literature has been largely directed at characterizing participants at low or high risk of injury, typically using the normative cutoff score of ≤ 14 (19, 20, 35, 38). A collection of studies on military personnel have generated convincing evidence that military officers and candidates who score at or below an FMS composite score (CS) of 14 are at higher risk of injury than their counterparts scoring above a 14 (6, 13, 26, 35). Similarly, the body of scholarly work in firefighting suggests that the FMS holds value in assessing relative injury risk within this population (10, 11, 31, 42). While the FMS has been widely used to beneficial effect in studies on military and firefighter personnel, the screening tool has yet to be rigorously studied among police officers.

From the few studies conducted, preliminary findings indicate that in police recruits, there is a significant relationship between FMS CS and occupational performance (4). In a longitudinal study of active duty police officers, McGill and colleagues were unable to determine an association between FMS CS and the incidence of a diagnosed back injury, yet the authors' attribute the lack of findings, in part, to the complexity of back injury (30). Recently, researchers have turned their attention toward the potential predictors of functional movement quality among active duty officers, finding that age and dynamic balance may be contributing factors to FMS CS (39). Given the high risk of musculoskeletal injury in police officers, and the link between FMS CS scores and injury risk established in the broader tactical literature, more research is needed to understand the factors contributing to FMS CS scores in this unique population of workers**.**

Scholars have theorized a link between body composition and injury risk, yet these conjectures have yet to be fully substantiated with primary data (29). Within the extant literature, police officer body composition has been described using primarily body mass index (BMI) and body fat percentage (BF%). While there are known limitations to using BMI as a standalone indicator of body composition in medical practice, the consistent associations between BMI with chronic disease and occupational performance, BMI remains a useful variable in studies related to overall police officer health and injury risk (29, 41, 47). Using BF% and weight to delineate fat mass (FM) and fat free mass (FFM) may further offer insight into fat and muscle as indicators of injury risk (21). Thus, research aimed at examining the contributions of various body composition measures to performance on injury screening tools like the FMS are needed. Therefore, the purposes of the current study were to examine: (a) the effect of BMI on functional movement scores, and (b) the contribution of FM and FFM in predicting FMS CS.

METHODS

Participants

The first author's Institutional Review Board approved this study. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (33). All participants provided their written informed consent before participating in the study.

Thirty-five active-duty police officers (31 male, 4 female; mean ± SD, age: 33.4 ± 9.4 years, height: 177.4 ± 8.0 cm, weight: 88.4 ± 15.3 kg) volunteered to participate in this study. The proportion of females included in this study is consistent with the biological sex distribution (~12%) observed nationally (9). This convenience sample of officers was recruited through existing relationships between the first author and contacts from two separate agencies within the metro-area of a Midwest city. Recruitment took place via word-of-mouth and email flyer invitations to participate. Monetary honorariums were provided for study participation.

Females and males were not differentiated within the scope of this study as this study purposed to compare body mass with FMS CS rather than component FMS scores. Previous literature does not support significant differences between FMS CS for males and female (2, 28, 14, 25, 28, 40). Participants met inclusion criteria if they were: (a) over 18 years of age, (b) could speak and write English fluently, (c) had no recent illness or injury prohibiting participation in physical activity, and (d) had no musculoskeletal (MSK) limitations prohibiting participation in job-related training or duty. Participants were excluded if they used steroids or other medications which could alter test results (such as muscle relaxers, stimulants, or anti-depressants). Given that the current study reflects one component of a larger ongoing research project, post hoc calculations of power and effect sizes were reported (see Results).

Protocol

All data were collected between September 2019 and October 2020. As part of a larger study on police officer fitness, data were collected across two separate laboratory visits, with every effort being made to collect all data within a seven-day period. Mean time between sessions was 5.3 days (range = 2-8 days). Only one participant (outlier of 24 days) was not able to conform to the seven-day window due to unforeseen work conflicts and holiday breaks. The majority of participants (62.6%) completed their sessions at a similar time of day (e.g., mornings). To support participation and retention, every effort was made by the research team to accommodate officers' work and family schedules. Thus, 4 of the 70 total data collection sessions were conducted outside typical business hours (9-5pm). More specifically, demographic and body composition data were collected during the first visit, and functional movement screen data was collected during the second visit.

Prior to attending laboratory sessions, participants were instructed via the informed consent document to follow specific lifestyle guidelines. Participants were informed of the study protocol as well as the nutritional (i.e., consumption of < 200 mg caffeine within 3 hours of testing, no meals 2 hours prior to testing, no alcohol, anti-inflammatories, or supplements throughout the duration of the study) and recreational physical activity restrictions (i.e., no maximal effort exercise prior within 24 hours of testing) required during study participation. Given the varying work demands (e.g., overtime) and shifts covered by participants, and in the interest of minimizing barriers to participation, shift schedules were not controlled for in the current study.

Descriptive data obtained included: height, weight, BMI, BF%, FM and FFM. Height was measured to the nearest tenth of a centimeter (cm) (Seca 213 portable stadiometer) and body weight was measured to the nearest tenth of a kilogram (kg) (Seca 869 flat scale). From these measurements, BMI was calculated as kg/m^2.

Participants were grouped into categories based off their BMI. Twelve participants were categorized as normal (BMI = 18.5-24.9), 9 participants were categorized as overweight (BMI = 25.0-29.9), and 14 participants were categorized as obese (BMI ≥ 30.0) (34, 41). Estimated BF% data were obtained using a whole body Omron Body Composition Monitor and Scale (HBF-514C) (45). While the algorithm for computing BF% is proprietary, research has demonstrated the reliability and validity of the instrument for estimating BF% in college students (45) and the ecological validity (e.g., cost effectiveness, efficiency of measurement) of the instrument for use in police officer populations (27). Hydration status was not controlled for in the protocol. FM and FFM mass were computed manually using the previous weight measurement.

The Functional Movement Screen (FMS) was utilized to assess FMS CS in this sample. The FMS consists of seven movement patterns, scored from zero to three, with a maximum score of 21 (8). The seven movement patterns include the deep squat (with dorsiflexion modification as appropriate), hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability test (8). Test performances received a zero if pain is evoked, a one if the movement pattern cannot be performed or the positions required cannot be assumed, a two if the movement pattern is completed, but compensations were seen during the pattern, and a three if the pattern is completed correctly, without compensations (8). If the movement pattern was bilateral in nature (hurdle step, in-line lunge, shoulder mobility, active straight leg raise, and rotary stability test) the test was performed bilaterally, with the lower score between both sides being used for that sub- test (8). Following completion of the FMS, scores from each movement pattern were summed to generate a CS for each participant (maximum score = 21). The first author, rater for all participants, completed the FMS Level 1 Online Certification in 2012 and has significant experience with FMS screening in tactical populations. All co-authors completed the updated Functional Movement Screen Level 1 virtual training modules (September of 2019) with the first author. The inter-rater and intra-rater reliability of the FMS has been consistently demonstrated in previous literature (19, 48). The FMS was conducted with no prior warm-up and no prior intervention, so as to mimic conditions in which a police officer may have to go from static activity to dynamic movement with no preparation or warning.

Statistical analysis

Prior to all statistical procedures, the distributions of all continuous variables were visually examined to confirm no violations of normality. To examine the effect of BMI on functional movement, a one-way analysis of covariance (ANCOVA) was performed. Given the previously established relationship between age and functional movement (13, 37), age was held as a covariate in the model. Effect sizes were interpreted as small (η_p^2 = 0.01), medium (η_p^2 = 0.06), and large (η_p^2 = 0.14). To examine the contribution of FM and FFM in predicting functional movement, a linear regression analysis was performed. Collinearity statistics (tolerance and variance inflation factors) were reviewed to ensure the lack of multicollinearity. For all tests, an alpha level of 0.05 was utilized to determine statistical significance. All statistical analyses were performed using IBM SPSS Statistics 27.0 software.

RESULTS

The descriptive statistics of the study by BMI category are presented in Table 1. While age was determined to be a significant covariate ($F_{1,31}$ = 10.359, p < 0.001), the results of the one-way ANCOVA revealed no significant effect of BMI category on FMS CS ($F_{2,31}$ = 2.791, p = .077, η_p^2 = 0.153, 1 - β = 0.509).

Table 1. Participant descriptive statistics by Body Mass Index category.

	Mean ± standard deviation			
	All Participants (*N* = 35)	Normal (*n* = 12)	Overweight (*n* = 9)	Obese (*n* = 14)
Age (years)	33.39 ± 9.38	30.58 ± 10.31	34.30 ± 9.62	35.14 ± 8.46
Height (cm)	177.38 ± 8.04	177.11 ± 8.95	178.34 ± 8.35	176.91 ± 7.53
Weight (kg)	88.44 ± 15.25	73.05 ± 9.30	86.68 ± 8.15	102.89 ± 7.81
BMI (kg/m^2)	28.12 ± 4.72	23.23 ± 1.74	27.22 ± 1.16	32.96 ± 2.94
BF%	22.17% ± 7.51	16.22% ± 5.23	21.54% ± 5.69	27.72% ± 6.34
FFM (kg)	68.25 ± 9.99	61.34 ± 9.52	68.12 ± 8.81	74.27 ± 7.43
FMS CS	14.49 ± 2.11	15.25 ±1.91	15.00 ± 1.94	13.50 ± 2.10

Pearson correlation coefficients revealed a significant relationship between FMS CS and FM ($r = -0.597$, $p < 0.001$) but not between FMS CS and FFM ($r = 0.033$, $p = 0.424$). Results of the linear regression analysis revealed that FM and FFM contributed a significant amount of variance in FMS CS ($R^2 = 0.637$, $R^2_{adj} = 0.369$, SEE = 1.67, $F_{2,32} = 10.931$, $p < 0.001$). FM was a significant individual predictor of FMS CS, while FFM was not a significant individual predictor of FMS CS. The unstandardized and standardized coefficients for individual predictors are reported in Table 2.

Table 2. Regression model coefficients.

	β	Std. Error	B	*t*	Sig.
(Constant)	14.332	1.954		7.330	< 0.001
Fat free mass (kg)	0.049	0.030	0.234	1.639	0.111
Fat mass (kg)	-0.155	0.033	-0.667	-4.669	< 0.001

DISCUSSION

The purposes of the current study were to examine the effect of BMI on functional movement scores and examine the contribution of FM and FFM in predicting FMS CS. Results of this study indicate that BMI did not have an effect on functional movement while accounting for age. Additionally, FM and FFM collectively accounted for 36.9% of the variance observed in FMS CS. FM specifically was a significant predictor of FMS CS, whereby a single standard deviation increase in FM (~8.96 kg) may result in a –0.667 standard deviation reduction in FMS CS (~1.4 points). Although such a change may not exceed the minimal detectable change (MDC) of 2.07 (43), these potential increases in FM associated with age or inactivity are relevant to active-duty police officers. The significance of age as a covariate in the current study is consistent with findings from previous research in police officer populations (13, 37). In total, the data presented in this study constitute a unique contribution to the scant literature on police officer functional movement. Specifically, this is the first study to explicitly link measures of body composition to performance on the FMS.

The BMI-related findings of the current study are consistent with previous research, where differences in FMS were not observed between BMI categories (12). That said, the current findings are inconsistent with research in police officers, whereby participants categorized as severely obese by BMI were at greater risk of musculoskeletal injury than all other BMI categorized participants (32). Given the descriptive statistics shown in Table 1, along with the large effect size and power observed during the ANCOVA analysis, it is possible that the result is practically meaningful and larger sample size may yield a significant finding in future studies. In all, the current findings provide some evidence that BMI remains a useful variable in the conversation about police officer functional movement (41), yet more research is certainly needed to elucidate the specific effects of BMI on FMS scores and injury risk.

The significant relationship between increased FM and decreased FMS CS is consistent with previous literature (12, 15, 30, 49). The current results may suggest officers with decreased FM may perform better on the FMS, which may indirectly contribute to a decreased risk for MSKI. In understanding why FM was seen to influence FMS CS more than FFM, it is likely the physical restriction and limitation on range of motion created by carrying excess fat on the human frame makes the tests in the FMS more difficult to execute effectively. In that line of reasoning, it makes sense that high levels of FM could subsequently impact officers' movement efficiency in job tasks like jumping or fighting, leaving them at risk of increased risk of injury at or around the joints (37). Finally, it is important to recognize that future studies should incorporate careful monitoring of hydration status to further clarify the influence of FM on FMS CS.

By contrast, FFM may have less impact than FM on FMS CS, since the FMS does not necessarily require substantial strength-related performance to complete coordinated movements or controlled movement through range of motion. A systematic review recently revealed that increases in lower body power (e.g., vertical jump), pull ups, maximal oxygen consumption (VO2max), and grip strength were associated with reduced risk of injury (23, 24). Thus, and taken in combination with the significance of FM as a significant predictor of FMS, it is possible that police officers who train regularly and maintain their physical condition will have higher movement quality and efficiency than those who do not train regularly or maintain physical condition.

While the main focus of the current paper involves the impact of body composition on FMS CS, it is also worth noting the literature which suggests corrective exercise programming can improve FMS CS (17, 42). Thus, incorporating mobility and core training into daily routines may additionally support functional movement quality. Such corrective exercises may be more suitable for those who are not physically or mentally prepared to begin aerobic and/or anaerobic training programs aimed at improving body composition, while still contributing meaningfully to injury prevention on the job.

The current research is not without limitations. First and foremost, our sample size limits the power achieved of our study. That said, the large effect size observed in the ANCOVA and notable beta weights from the regression analysis suggest that the current findings likely hold clinical relevance, even despite the small sample size achieved. Second, this study involved both female and male police officers. While this choice was based on previously literature, which revealed no difference in FMS CS between males and females (2, 28, 40), it is possible that individual FMS component tests may differ between biological sexes (7, 14, 25). As such, and even though the proportion of females included in the current study approximates what is observed locally and nationally, future studies should seek to expand female participation and consider utilizing categorical data (i.e., individual FMS subtest scores, observed asymmetries) to characterize dependent variables. Future research should also strive to determine the prognostic capacity of the FMS for MSKI and compare it to the findings of the literature of other tactical and active populations. Data pertaining to shift schedules were not collected or controlled for in the current study design. Future research designs should include shift schedule as a variable of interest, thus enhancing the specificity of movement-related conclusions drawn in this population.

Lastly, the significant effect of age as a covariate in the current analysis warrants brief discussion. Previous research indicates that higher FMS CS scores were observed among recruits compared to attested officers (37). In examining differences in health and fitness across age groups, the occupational demands of policing likely contribute beyond the effects of age alone to the declines observed in fitness from academy to active duty (36, 37). Thus, and while changes to body composition would be expected across a career (e.g., volumes of patrol vs. administrative duties), the understanding of experience and age as distinct yet related contributors to health and fitness in police officers remains incomplete. Going forward, it is possible that the potential interaction effect of age and experience may be more meaningful than either variable in isolation.

Based on this study and previous research, professionals working with active-duty police officers should provide education surrounding the potential benefits of decreasing body fatness to enhance functional movement quality, at all ages. By managing body composition, officers can improve their functional movement quality, thereby potentially supporting a reduced risk of musculoskeletal injury. The collective results of the study regarding BMI, FM, and FFM reinforce the importance of considering them multi-faceted nature of body composition in studies of police officer health and fitness. Overall, this novel study adds to the emerging literature on FMS screening among police officers.

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