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Correlation Between Functional Movement Screen Scores, Lower Limb Strength, Y-Balance Test, Grip Strength, and Vertical Jump and Incidence of Injury Due to Musculoskeletal Injury Among Abu Dhabi Police Recruits

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Objective: Training-related injuries and attrition put an additional burden on police and military institutions. Preventing and minimizing musculoskeletal injuries is the primary concern of the Abu Dhabi Police. Therefore, this study aimed to evaluate the correlation between functional movement screen, lower-limb strength, Y-balance test, grip strength and vertical jump and the incidence of musculoskeletal injuries among Abu Dhabi police recruits.

Design: Observational analytical study.

Methods: An observational study was conducted on 400 male police recruits of Abu Dhabi Police Academy. Physical performance was assessed before the 16-weeks basic police training. Spearman's correlation evaluated the correlation between the performance parameters and the outcome measures and logistic regression predicted the risk factors associated with musculoskeletal injuries.

Results: 149 (34.4%) participants reported at least one injury during the basic police training. Comparison between injured and non-injured participants showed significant difference in mean right Y-balance, back-leg-chest dynamometer, and vertical jump (p=0.02, p=0.02, and p=0.04, respectively). Spearman's correlation showed a significant negative correlation between risk of injury and back-leg-chest dynamometer and right Y balance (ρ = -0.11, p=0.03). Logistic regression showed that back-leg-chest dynamometer and right Y balance were significant predictors of injury (p =.036 and p=0.037; Odds ratio=0.96; 95% CI (0.92, 0.99) and Odds ratio=0.99; 95% CI (0.98,0.99).

Conclusions: Our findings suggest functional movement screen and grip strength may not independently predict injury rates, balance and lower-limb strength needs to be considered in injury prevention strategies to reduce musculoskeletal injuries.

Key Words: Police recruits, lower limb strength, musculoskeletal injury, Y balance test, Military training, Basic military training

Introduction

Tactical athletes (TAs) include individuals who possess specific physical abilities and work in combat scenarios, such as military personnel, law enforcement officers, firefighters, and emergency responders [1]. Excellent physical fitness is required to handle the physically demanding tasks associated with their occupations [2]. As a result, new recruits to these professions must complete rigorous basic military training (BMT) to prepare them for the physical demands of their careers before they start their service. The intense nature of BMT increases the risk of musculoskeletal injuries (MSIs) among the recruits. Prior studies suggest that 80% of military training-related injuries are musculoskeletal in nature

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[3], accounting for approximately 60% more days lost from training [4].

Various screening tools and measures are being used to predict the risk of MSIs among TAs. For instance, lower scores on the Functional Movement Screen (FMS) [5] and Y-Balance Test (YBT) [5, 6] for movement patterns and dynamic balance, vertical jump height for leg power [7, 8], lower limb strength using the Back-Leg-Chest dynamometer (BLCD) [9], and hand grip strength [10] independently associate with a higher risk of MSIs. These measures are widely used to assess injury risk among the tactical population during training and service deployment. Additionally, low baseline physical fitness has also been suggested to increase the risk of MSIs among tactical trainees [11]. Consequently, improving the physical fitness of the recruits becomes essential to mitigate individual, familial, and governmental repercussions. The cost of MSIs among the tactical population is significantly high; the US army spent 14.89 million dollars on injuries sustained by trainees [12]. Furthermore, MSIs have also been reported as the leading cause of attrition from BMT, which puts an additional burden on the training institutions.

The relationship between physical fitness, MSIs, and attrition rates among the recruits has been reported for US army recruits [13, 14], the Netherlands Armed Forces special infantry unit [15], and Australia [16]. Attrition rates due to MSIs during training were reported to be about 5% in the US army [14] and 10% in the Australian Armed Forces [16]. However, there is a lack of similar data regarding the tactical population of the Arabian Peninsula, such as the United Arab Emirates and Saudi Arabia, where a sedentary lifestyle is common due to the hot and humid climate [17]. The training-related injuries and attrition put an additional burden on the Abu Dhabi police and military institutions. Preventing and minimizing MSIs is the primary concern of the Abu Dhabi police due to 1) the short-term and long-term impact of MSIs on physical readiness and 2) the high financial cost associated with medical care, rehabilitation, and days lost from training. Therefore, this study aimed to evaluate the correlation between FMS scores, lower limb strength, YBT, grip strength, vertical jump, and the incidence of MSIs among Abu Dhabi police recruits.

Materials and Methods

Study Design

A cohort study was conducted at the Abu Dhabi Police Training Academy in the United Arab Emirates (UAE) between October 2021 and June 2022.

Participants

A total of four hundred forty-one (441) subjects were selected from the Abu Dhabi police recruitment department after passing the recruitment medical screening (RMS). The Abu Dhabi RMS includes a physical examination, blood work, mental health assessment, vision examination, and chest X-ray. Following the RMS, subjects attended an orientation session regarding the study and were invited to volunteer if interested. All subjects read and signed a written informed consent form approved by the Institutional Review Board of the Abu Dhabi Department of Health (ADDH), UAE [IRB# DOH/CVDC/2021/736] and Loma Linda University Health (LLUH), USA [IRB#5210303] prior to participation. Eligible subjects met the following inclusion criteria: 1) Age: 18-40 years and 2) passing the RMS. Subjects were excluded if they reported any MSIs, neurological or vestibular symptoms, or surgeries since passing the RMS.

Procedures

Four hundred forty-one subjects who fulfilled the inclusion criteria were recruited. Four physical therapists with an average of 10 years of tactical clinical experience collected demographic data and conducted baseline measurements. Demographic data included age, height, weight, body mass index (BMI), and body fat percentage (using GAIA 359 plus professional, South Korea). The baseline measurements were taken only once before entering Basic Military Training (BMT). These measurements included the following: 1) FMS to assess movement patterns and identify areas of dysfunction or limitations in movement. Specifically, the FMS consists of seven tests that

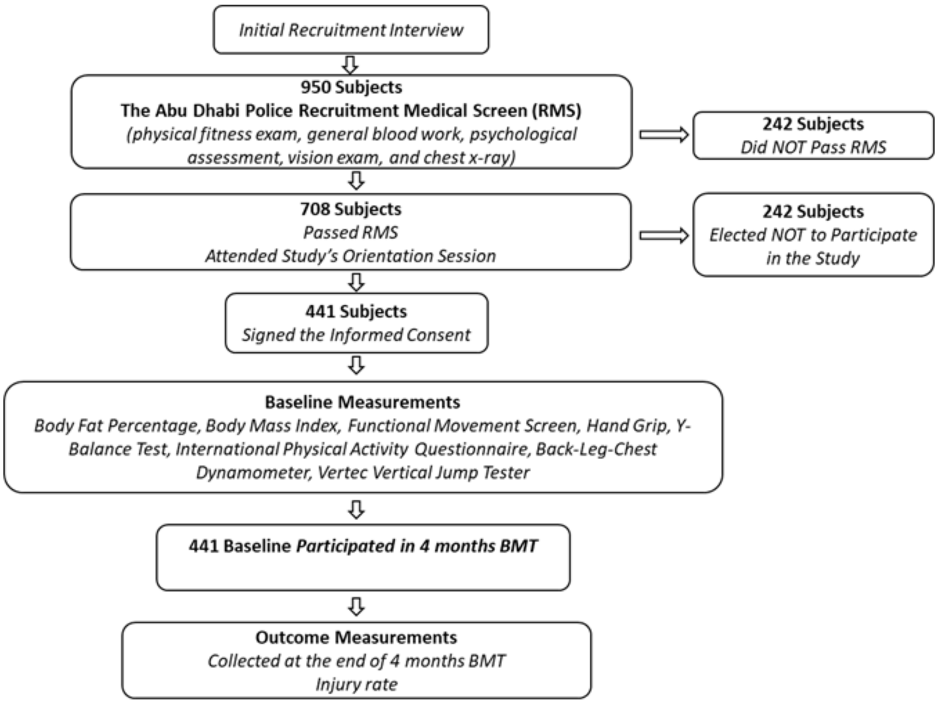

Figure 1. Study procedure flowchart.

assess mobility, stability, and neuromuscular control, namely the deep squat, hurdle step, in-line lunge, active straight-leg raise, trunk stability push-up, rotary stability, and shoulder mobility [18]. 2) Hand Grip using the Jamar Dynamometer to assess grip strength [19, 20]. 3) YBT to evaluate dynamic balance [21, 22]. 4) Self-report International Physical Activity Questionnaire (IPAQ) to assess physical activity levels [23]. 5) BLCD to measure lower extremity strength [24]. 6) Vertical Jump was assessed using the Vertec Jump system to assess lower body power and explosiveness [25]. Following the collection of baseline data, all participants entered a four-month BMT program at the Abu Dhabi Police Training Academy (Figure 1).

Outcome Measures

The outcome variables were collected from the police academy's medical clinic following the completion of the BMT. These included and MSI or pain.

Data Analyses

Data was analysed using SPSS version 28.0. Considering a moderate effect size of 0.5, a power of 0.80, an alpha of 0.05 and 20% dropout rate, the estimated sample size was 400 subjects. The data was summarized using frequency and relative frequency (%) for qualitative variables and mean (standard deviation [SD]) for continuous variables. The normality of the outcome variables was examined using the Shapiro-Wilk test. Mean (SD) of subjects' characteristics and baseline measures by injury status (yes/no) was compared using independent t-test. The relationship between status of injury (yes/no) and baseline measures was assessed using Spearman's correlation. A stepwise logistic regression was used to determine predictors of injury. The level of significance was set at $p \leq 0.05$.

Results

Four hundred forty-three males signed the informed consent. Subjects with a mean ± SD age of 21.7±2.5 years, BMI of 24.3±4.5 kg/m2 and body fat % of 21.8±8.0 participated in the study. One hundred forty-nine (34.4%) subjects reported at least one injury. There was no significant difference between those who reported at least one injury and those who did not in terms of mean age, height (cm), weight (kg), BMI

Table 1. Mean (SD) of characteristics of participants by injury status (N = 433)

	Yes (n_1 = 149)	No (n_2 = 284)	p-value
Age (years)	22.0 (2.5)	21.5 (2.4)	0.06
Height (cm)	172.7 (5.8)	172.2 (5.5)	0.35
Weight (kg)	72.6 (14.4)	72.2 (15.4)	0.80
BMI (kg/m^2)	24.2 (4.4)	24.3 (4.7)	0.89
Body Fat %	21.1 (7.5)	22.2 (8.3)	0.20

Abbreviation: SD: standard deviation, BMI: body mass index

Table 2. Mean (SD) of baseline measurements by injury status (N = 433)

	Yes (n_1 = 149)	**No (n_2 = 284)**	**p-value (Cohen's d)**
Functional Movement Screen	14.2 (1.3)	14.3 (1.3)	0.20 (0.13)
Hand Grip	40.4 (7.9)	40.2 (7.1)	0.16 (0.03)
Right Y Balance	94.3 (5.6)	95.6 (4.9)	**0.02 (0.24)**
Left Y Balance	95.3 (8.1)	95.8 (4.8)	0.37 (0.09)
Back-Leg-Chest	123.2 (30.4)	130.5 (30.9)	**0.02 (0.24)**
Vertical Jump	17.2 (4.7)	18.0 (3.3)	**0.04 (0.20)**

(kg/m^2) and body fat % (Table 1). Furthermore, the were no significant difference in baseline functional movement screen score, hand grip, and left Y balance measurements between the two groups ($p > 0.05$). However, there was a significant difference in mean right Y balance, BLC, and vertical jump ($p = 0.02$, $p = 0.02$, and $p = 0.04$, respectively, Table 2.)

The results of the Spearman's correlation showed there was a significant negative correlation between risk of injury and BLC and right Y balance ($\rho = -0.11$, $p = 0.03$) (Table 3).

Findings of the logistic regression showed that both variables were significant predictors of injury ($p = .036$ and $p = 0.037$; Odds ratio (OR) = 0.96; 95% confidence interval (CI) (0.92, 0.99) and OR = 0.99; 95% CI (0.98, 0.99)] (Table 4).

Table 3. Correlations between frequency of injury among subjects who reported at least one injury and baseline measures (N = 149)

	Functional Movement Screen	**Hand Grip**	**Right Y Balance**	**Left Y Balance**	**Back-Leg-Chest**	**Vertical Jump**
Frequency of injury	−0.13 (0.11)	−0.06 (0.48)	−0.06 (0.47)	−0.04 (0.62)	−0.23 (0.005)	−0.09 (0.29)
Functional Movement Screen	1.0	0.12 (0.15)	0.17 (0.04)	0.09 (0.29)	0.17 (0.04)	0.23 (0.005)
Hand Grip		1.0	0.09 (0.26)	0.05 (0.54)	0.31 (<0.001)	0.10 (0.24)
Right Y Balance			1.0	0.53 (<0.001)	0.25 (0.002)	0.23 (0.005)
Left Y Balance				1.0	0.18 (0.03)	−0.02 (0.84)
Back-Leg-Chest					1.0	0.07 (0.43)
Vertical Jump						1.0

Table 4. Predictors of risk of injury (N=433)

Variable	Coefficient (B)	Std. Error	Wald-Statistic	p-value	Exp(B)	95% Confidence Interval
Constant	4.28	1.93	4.93	0.03		
Right Y Balance	−0.04	0.02	4.38	0.036	0.96	(0.917, 0.993)
Back Leg Chest	−0.007	0.003	4.35	0.037	0.99	(0.984, 0.999)

Discussion

This study examined the association between injury rates and various factors including FMS, hand grip, Y balance, BLC dynamometer, and vertical jump among Abu Dhabi police trainees. The results demonstrated an association between injury rates and balance as well as injury rates and BLC dynamometer. However, no associations were found between injury rates and FMS, hand grip, and vertical jump.

Regarding the FMS score, our study did not demonstrate any correlation with injury rates, which aligns with previous studies [26, 27]. While the FMS can effectively identify deficiencies in specific movements, it should not be solely relied upon for predicting overall injury risk [26]. Meta-analysis studies have also shown uncertainty regarding whether an FMS score ≤4 out of 21 points is associated with an increased risk of injury [27]. However, other studies suggest that an FMS score <14 is linked to a higher injury rate [6, 18].

In terms of the YBT for the right lower limb, our study showed a low but significant correlation with injury rates, consistent with prior research [21, 22]. Interestingly, Plisky et al. (2009) concluded from their meta-analysis that while the YBT is a valid and reliable tool, it may not accurately predict injury when general cut points (i.e., not population-specific) are used for the lower quarter [22]. The YBT lower quarter score alone is not sufficient to predict injury risk [28]. Additionally, Cosio et al. (2020) reported that among Coast Guard trainees, the lower reach of the upper quarter on the YBT significantly correlates with the injury rate, while lower quarter reaches do not show such a correlation [6]. Furthermore, other studies suggest that a higher FMS score is associated with longer composite reaches on the YBT ($r=0.60$, $p<0.001$), and an in-line score of FMS has been identified as the strongest predictor of torso-loaded balance using the YBT [29].

Interestingly, vertical jump height did not establish a significant correlation with injury rates in this study, which differs from previous findings [7, 8]. Lower vertical jump height among police recruits has been associated with a significantly higher risk of injury or illness during basic police recruit training [7]. Another study suggests that higher vertical jump height corresponds to better physical performance and lower injury risk during police training [8]. However, our study found that lower limb strength, as measured by the leg-back-chest dynamometer, correlated with the incidence of injury. Our findings indicate that higher lower limb strength is associated with a lower risk of injury, and vice versa. In contrast to our study, Oliveira et al. (2021) reported no correlation between lower limb strength and injury rates [9].

Regarding grip strength, it did not correlate with injury rates in this study, which contrasts with prior findings [8, 10]. Tomes et al. (2020) reported significant differences in performance between injured and uninjured groups, specifically in right-hand grip strength for all injuries [8], suggesting that higher grip strength results in a lower incidence of injuries. Police recruits with lower grip strength scores are more susceptible to failing the tactical occupational task assessment. It is important to note that left-hand grip strength is significantly negatively associated with injury risk, whereas right-hand grip strength did not show such a correlation [10].

A key limitation of our study was the exclusion of women from the study, which was due to logistical constraints (e.g., feasibility). However, it is essential to acknowledge that gender differences may play a role in injury rates and risk factors. Future studies should aim to include female recruits to investigate potential variations in injury risk and the effectiveness of injury prevention strategies between genders. This will allow for more tailored and targeted interventions that address the specific needs and physiological differences of both male and female recruits.

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Conflicts of Interest

The authors declare no conflict of interest.

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