ASPI | Afarand Scholarly Publishing Institute; Turkey
ISSN: 2008-2630 *Iranian Journal of War & Public Health* 2023;15(3):279-284 10.58209/ijwph.15.3.279

Role of Chronic Pain and Physical Fitness in Predicting Susceptibility to Musculoskeletal Injuries in Navy Personnel

ARTICLE INFO

Article Type
Descriptive Study

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How to cite this article
Shirvani H, Sobhani V, Kazemipour M, Mozafaripour E, Yaghoubitajani Z. Role of Chronic Pain and Physical Fitness in Predicting Susceptibility to Musculoskeletal Injuries in Navy Personnel. Iranian Journal of War & Public Health.2023;15(3):279-284.

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Article History
Received: May 4, 2023
Accepted: July 19, 2023
ePublished: July 29, 2023

ABSTRACT

Aims Musculoskeletal injuries (MSKI) are known as one of the most important leading causes of loss of duty time among military personnel. A practical approach to reducing the risk of MSKI and related consequences seems beneficial to identify at-risk personnel. Therefore, the present study aimed to determine whether chronic pain and physical fitness can predict scores of FMS tests in Navy personnel.

Instrument & Methods 125 active-duty Navy personnel aged 18-38 participated in this cross-sectional study at Bandar Abbas City, Iran, in 2021 winter. Susceptibility to MSKI was assessed using Functional Movement Screening, and Physical Fitness was measured using 60-second push-up and sit-up, deep squat jump, and Cooper's 12-minute run tests. Chronic pain intensity was evaluated using the Nordic Musculoskeletal Questionnaire-Extended and Visual Analog Scale, respectively. A multiple linear regression model was applied to predict FMS scores.

Findings The mean age, height, weight, and BMI of the subjects were 28.5±8.5 years, 178.9±10.2cm, 76.2±9.5kg, and 24.7±3.3kg/m2, respectively. The sit-up (p=0.002), Cooper's test distance (p=0.001), and chronic pain index (p=0.04) predicted 83% of the variance of the FMS score significantly.

Conclusion Sit-up number, Cooper test score, and chronic pain are the predictors of musculoskeletal injuries of Navy active personnel that predicate 83% of the variance of the functional movement screening test.

Keywords Military Personnel; Pain; Physical Fitness; Military Health

CITATION LINKS

[1] Exercise and mental ... [2] Physiological Employment Standards III ... [3] Operational physical performance ... [4] Stress fracture risk factors in basic ... [5] Musculoskeletal injuries and United States ... [6] Predicting upper quadrant musculoskeletal ... [7] Functional movement screen and aerobic ... [8] Use of the functional movement screen ... [9] FM 7-22 army physical readiness ... [10] The use of 2 conditioning ... [11] Optimizing the physical training of ... [12] Physical training, fitness, and injuries: ... [13] Assessing fitness for military ... [14] Ability of fitness testing to predict ... [15] Impact of physical fitness and body ... [16] Update on the relation between ... [17] The pathophysiology of the chronic ... [18] Neck–shoulder muscle activity in general ... [19] Differences in lumbar spine ... [20] Dynamic knee valgus kinematics and ... [21] Strengthening the reporting of ... [22] Association of depression ... [23] The effect of pulsed electromagnetic ... [24] Adaptations in single-leg ... [25] Musculoskeletal fitness and ... [26] Alteration in shoulder kinematics and ... [27] Functional and radiographic ... [28] Validity of Cooper's 12-minute ... [29] Behavior of fascicles and tendinous ... [30] Could the deep squat jump predict ... [31] Fitness tests and occupational ... [32] Relationship of push-ups ... [33] Pre-participation screening: The ... [34] Interrater reliability of the functional ... [35] Development and test-retest ... [36] The prevalence of musculoskeletal ... [37] Upper limb disorders ... [38] Neck/shoulder and low-back disorders ... [39] Repeatability and validity of ... [40] Applied analysis of recurrent ... [41] Lateral collinearity and misleading results ... [42] Injury rates and injury risk factors among ... [43] Risk factors of acute and ... [44] Influence of aerobic fitness level ... [45] Fatigue alters lower extremity ... [46] Clinical gait analysis: Theory ... [47] The influence of abnormal hip ... [48] Deficits in neuromuscular ... [49] The mechanistic connection between the ... [50] Gender differences in hip adduction ... [51] Trunk muscle activation in low-back pain ... [52] Effect of whole-body-vibration training ... [53] Relationship between functional movement ... [54] The effect of core stability training ... [55] Influence of remote pain on movement control ... [56] Experimental hand pain delays recognition ... [57] Effect of painful and non-painful sensorimotor ... [58] Disrupted working body schema of ... [59] Modulation of motor variability related ... [60] A novel experimental knee-pain model ... [61] Effect of tonic pain on motor acquisition and retention ... [62] The effect of acute back muscle fatigue ... [63] Individuals with non-specific low back pain use a trunk ...

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Introduction

The intense physical demands of military training and operational environments expose military personnel to an increased risk of Musculoskeletal injuries (MSKI) [2]. MSKI is considered one of the most significant leading reasons for duty time loss in military personnel resulting in millions of limited duty days and medical visits [3, 4]. Molloy *et al.* report that noncombat musculoskeletal injuries may account for nearly 60% of soldiers' limited duty days and 65% of soldiers who cannot deploy for medical reasons [5]. Therefore, at-risk military personnel should be identified through an effective approach to reducing MSKI risks and the related consequences [6]. In this regard, Functional Movement Screening (FMS) tests can be considered practical and valid for identifying and screening at-risk military personnel [7]. In addition, since many potential factors can affect the related scores to develop a susceptibility to MSKI, obtained scores can be used as a reliable indicator among this population [8].

Regardless of the specific duty within any organization, all Navy personnel require sufficient physical fitness to complete occupational combat-related specific tasks safely and effectively [9]. To prepare Navy personnel for the various demands of their career, they frequently experience intensive and regular physical training workouts to increase their fitness [10, 11]. Some studies reported that poor physical fitness in military personnel, such as low muscular strength and endurance and poor cardiorespiratory and flexibility, are leading risk factors for injuries [4, 12].

In active-duty personnel, the primary health-related components of physical fitness include cardiorespiratory endurance, muscle strength and endurance, body composition, and flexibility which can be related to the development of MSKI in this population [13]. Among these, cardiorespiratory endurance, which is typically measured by running time, has been confirmed to be associated with a higher risk of injuries among tactical personnel [14]. However, no consensus was presented for predicting the potential of other physical fitness components, such as muscle strength and endurance [14, 15]. Furthermore, it was discovered that no research has been conducted on the association between various components of physical fitness and FMS scores among active-duty military personnel. This gap in research is significant because understanding the relationship between physical fitness and FMS scores can help military leaders and healthcare professionals design targeted interventions to improve overall physical fitness and reduce the risk of injury among military personnel. Therefore, further research is needed to better inform military training and injury prevention strategies [7].

On the other hand, it is hypothesized that chronic pain and musculoskeletal injuries can lead to uncontrolled, compensatory movements and altered muscle recruitment strategies [16]. Subsequently, alterations in motor control and movement patterns increase an individual's susceptibility to upcoming injuries. These changes can lead to compensatory movements and musculoskeletal imbalances, further exacerbating the risk of MSKI. As a result, the body is forced to rely on suboptimal movement patterns that place additional stress on certain joints, muscles, and tissues [16]. Over time, these compensations can cause a pain cycle and lead to more chronic pain [17]. For example, Szeto *et al.* confirmed that chronic neck pain can lead to altered neck and shoulder muscle activation patterns, and in the long term, these alterations can cause MSKI in related segments [18]. Likewise, similar findings were reported for individuals with pain in the lower back, knee, and hip areas [19, 20].

As mentioned earlier, chronic pain and MSKI are commonly considered problematic issues in the military, which can probably affect their susceptibility to acute and chronic injuries in the future [3, 12]. However, no evidence has been found on how chronic pain and MSKI are related to the incidence of acute and chronic upcoming MSKI and influence FMS scores. The current study aimed to determine whether chronic pain and physical fitness can predict FMS test scores in Navy personnel.

Instrument and Methods

A cross-sectional study was conducted on the Iranian Navy personnel at Bandar Abbas City, Iran, in 2021 winter. The reporting of the current study follows the guideline of 'Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) [21]. The participants included young men on active duty aged 18-38 years. Sample size estimate was performed using G*Power software (Version 3.1.9.2; Kiel, Germany) and based on a previously published study [7]. Ninety-eight candidates were estimated to be sufficient with a Type I error rate of 5% and power of 80%. Assuming a dropout rate or missing data of approximately 20%, 125 participants were included. The subjects were recruited from the Iranian Navy personnel serving in Bandar Abbas military base through advertisements on bulletin boards. The criteria to be eligible to enter the study included being in the desired age range, serving in one of the operational units, having chronic pain in at least one segment of the musculoskeletal system permanently or intermittently over the past three months, and confirming musculoskeletal injuries as the cause of such chronic pain by a specialist physician [22, 23]. Individuals were excluded from the research if they had a history of lower extremity injury, making movement restrictions [24, 25], and the existence of any visible musculoskeletal deformities in the lower and upper extremities in normal standing posture [26, 27].

All participants signed an informed consent form before the study commencement.

FMS and physical fitness tests and NMQ-E questionnaire were used for data gathering. Furthermore, before data collecting, to determine the intra-tester and intersession reliability for FMS tests, data were obtained for ten subjects on two separate days with a one-week interval. Intra-class correlation coefficients (ICC3) were found to be high for all components of FMS tests (0.82<ICC<0.93).

Physical fitness test: Before conducting tests, all the stages were explained to the subjects, encouraging them to do their best and utilize all their ability to complete the test. To assess physical fitness, Cooper's 12-minute run test was used for evaluating cardiovascular function, in which the subjects started running on a track by the examiner's sign for 12 minutes. The location was marked, and the distance was measured with an accuracy of one meter for each subject [28]. The deep squat jump test was used to assess lower extremity muscle strength. The subjects were asked to stand behind the line and to obtain the total strength of the lower extremity muscles, to be in a full squat position for 2-3 seconds, and then to jump forward. The distance between the heel contact and the starting line was measured with one-centimeter accuracy and was recorded as the score of each subject [29, 30]. Push-up and sit-up tests were applied for strength and endurance of the upper extremity and core muscles in 60 seconds, respectively [31]. To perform the push-up test, the subject was asked to place his hands on the ground 10 to 20cm wider than shoulder width, keep the trunk straight, then lower the body until the elbow is 90 degrees of flexion and return to the initial position. The number of correct push-ups performed in 60 seconds is recorded as a score for the individual [32]. To implement sit-up, the subjects bent their knees and crossed their hands on the chest in a supine position. At that time, the subjects performed the test by the sign of the examiner by lifting the trunk from the ground, touching the knees with the elbows, and completely returning to the starting position. The number of repetitions performed in 60 seconds was recorded as the score of each subject [32]. The above-mentioned tests were approved for strong correlations with job performance in military personnel [31].

FMS test: applied as an injury prediction index, including a series of seven fundamental movement patterns (the deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raises, push-ups, and rotary stability), which are commonly associated with athletic movements [33]. Such a series of seven tests scored on an ordinal scale considering four categories, which is confidently applied by trained experts to assess the movement patterns of an active person [34]. Each test was performed three times, in which a score was assigned according to performance ranging from three to zero (three being the best and zero being the worst) [33]. Further, the primary examiner observed all the testing processes and recorded them with a digital camera for more investigation.

Chronic pain and chronic musculoskeletal injury assessments: were used to evaluate the prevalence and consequences of musculoskeletal symptoms in nine body regions created by Dawson *et al.* [35]. The NMQ-E has been recently applied to various occupational studies to assess musculoskeletal injuries [36-38]. Meanwhile, previous research using NMQ-E indicated appropriate repeatability and sensitivity for measuring the prevalence of musculoskeletal pain in occupational and general populations [35, 39].

Multiple linear regression was used to evaluate whether the study variables predict FMS scores. We performed a univariate analysis for each independent variable with an FMS score as the dependent variable. Variables were selected to be included in the multiple linear regression with significant associations of $p<0.02$ in the linear model analysis [40]. Variance inflation factor (VIF) was calculated to assess multicollinearity severity between independent variables. VIF<5 is assumed to be acceptable for interesting variables because VIF>5 indicates a multicollinearity issue [41]. All statistical analyses were obtained using SPSS 20 software, setting the significant difference at $p<0.05$.

Findings

The mean age, height, weight, and BMI of the subjects were 28.5±8.5 years, 178.9±10.2cm, 76.2±9.5kg, and 24.7±3.3kg/m^2, respectively.

Sit-up, Cooper test, and chronic pain results had significant univariate relations to musculoskeletal injuries (Table 1).

Table 1. The mean of evaluated parameters and the univariate linear regression analysis of FMS with potential predictors

Parameter	Means±SD	p-Value
FMS	14.81±1.65	-
Push-up (number)	27.35±8.19	0.18
Sit-up (number)	33.79±6.77	0.04
Squat jump (centimeter)	225.72±17.42	0.07
Coopers test (meter)	1763.54±247.94	0.01
Chronic pain (degree)	2.70±1.32	0.01

The sit-up (p=0.002), Cooper's test distance (p=0.001), and chronic pain index (p=0.04) predicted 83% of the variance of the FMS score significantly (Table 2).

Table 2. Multiple linear regression for FMS

Parameter	Unstandardized coefficient		t	sig
	B	SE		
Constant	4.47	2.43	-	-
Sit up (number)	0.08	0.02	3.39	0.002
Coopers test (meter)	0.003	0.001	3.76	0.001
Chronic pain (number)	-0.289	0.14	-2.035	0.04

Discussion

Specifying variables to predict military personnel susceptibility to MSKI may assist clinicians and researchers in designing injury prevention programs more effectively. Therefore, the study aimed primarily to determine if chronic pain and physical fitness could predict scores of FMS tests in Navy personnel. In the current study, among the investigated variables, three out of five were found as predictors of FMS test scores in Navy personnel. All these three variables revealed 83% of the variance in the FMS test in Navy personnel. The present findings demonstrated that some physical fitness variables predicted FMS test scores and susceptibility to MSKI in Navy personnel; individuals with higher physical fitness presented higher FMS test scores.

Previous studies indicated that some physical fitness tests, such as running time and sit-ups, are applied potentially to predict susceptibility to MSKI in military personnel [42, 43]. In addition, cardiorespiratory impairments and muscular fitness may indicate a poor ability to perform long-lasting weight-bearing activities requiring strength and aerobic capacity, such as loaded marching [43]. As a result, conscripts with lower cardiorespiratory fitness levels may perceive military training as complicated and get more fatigued rapidly. Movement patterns may be altered by such fatigue in the lower extremities [44, 45]. Since the FMS tests are a series of seven fundamental movement patterns, any related changes in these patterns can probably affect the obtained score. Hence, it is logical that good results in running tests predicted FMS scores in the present study. In addition, proper pelvis alignment in the frontal plane is essential for preventing abnormal movement of the lower extremity, so abnormal movements in the pelvis and trunk can influence movement patterns on the lower extremity [46, 47]. During dynamic tasks such as the FMS tests, excessive trunk motions, occurring due to insufficient core muscle performance in the frontal and sagittal planes, may produce compensatory adjustments and/or impaired movements to the distal joints to accommodate the lack of pelvic control [48]. Therefore, insufficient stability in controlling the core may contribute to the deviation of movement patterns from the correct form [49].

Previous studies reported that decreased trunk musculature performance caused poor control of hip adduction and internal rotation during weight-bearing functional activities and an increased tendency toward uncontrolled movement [48, 50, 51]. In this regard, Maeda *et al.* reported that a trunk-muscle-strengthening program might improve trunk-flexor isometric strength [52]. In addition, another study found a significant correlation between FMS scores and trunk stabilization [53]. It has been evidenced that eight weeks of core training exercises increased FMS scores, functional movement patterns, and dynamic postural control confirming that trunk stabilization is required to improve the quality of movement [54]. Based on the mentioned factors, the better performance of trunk musculature, which this study assessed through a sit-up test, the better control of distal joint movement patterns, and the increased obtained FMS score.

Regarding pain, it is evident that the sensations of pain play an important role in demanding cognitive resources and may thus disrupt neuromuscular control [55]. Therefore, people bias attention toward painful areas as pain can alter the perception of the body schema [56, 57]. Additionally, in many conditions, pain may affect performance on cognitive and motor tasks and deviate movement control strategies, muscle and joint coordination, and even motor learning. Further, it may alter movement control strategies, muscle and joint coordination, and even motor learning which can be observed by alterations in postural control [57-63].

In the current study, subjects experienced chronic pain at least in one body segment, which may interfere with movement control strategies and lead to a poor movement pattern for avoiding pain. Therefore, such pain causes a negative association between chronic pain and FMS score.

Despite our expectations, no predictions were observed in the push-up and squat jump for the magnitude of the FMS test score. Among seven FMS tests, only one test was approximately close to the nature of these two tests since we calculated the sum of the scores for all tests, which were considered as the total score for each subject. It seems that push-up and squat jump tests do not have a potential effect on FMS test score prediction.

The main limitation of the present study is male personnel inclusion; therefore, the findings may not be generalizable to both genders. In addition, the current study was conducted on Navy operational personnel; hence, the results should be applied with caution to other military branches. Based on the findings, chronic pain, and physical fitness can predict scores of FMS tests in Navy personnel. Therefore, due to the susceptibility of these populations to MSKI resulting from chronic pain, such variables are worth taking into account by clinicians when designing and suggesting injury prevention programs.

Conclusion

Sit-up number, Cooper test score, and chronic pain are the predictors of musculoskeletal injuries of Navy active personnel that predicate 83% of the variance of the functional movement screening test.

Acknowledgments: Authors appreciate Baqiyatallah University of Medical Sciences to make available the facilities of this study.

Ethical Permissions: Ethical approval was obtained from

the Ethics Committee on Research at Baqiyatallah Hospital, Iran, which approved the study (under No. IR.BMSU.BAQ.REC.1398.016, 2020-1-28). The protocol of current study approved at the Iranian Registry of Clinical Trials on 2020-6-13 (IRCT20180821040843N2).

Conflicts of Interests: None of the authors has competing interests declared.

Authors' Contribution: Shirvani H (First Author), Introduction Writer (20%); Sobhani V (Second Author), Discussion Writer (20%); Kazemipour M (Third Author), Methodologist (20%); Mozafaripour E (Fourth Author), Main Researcher/Statistical Analyst (25%); Yaghoubitajani Z (Fifth Author), Assistant Researcher/Introduction Writer/Discussion Writer (15%)

Funding/Support: This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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