

The Effect of Neuromuscular Training on Functional Movement Screen Scores in Injury-Prone Military Athletes

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Research

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Abstract

Background

Pre-participation examinations are the standard approach for assessing poor movement quality that would increase musculoskeletal injury risk. On the other hand, the neuromuscular control plays a significant role in the prevention of injury and rehabilitation. The main purpose of this study was to determine the effect of an 8-week neuromuscular training on functional movement screen (FMS) in injury-prone military athletes.

Methods

In the present quasi-experimental study, forty injury-prone male military athlete were identified by functional movement Screen. Functional Movement screen were assessed before and after the 8-week program. Participants were placed into 1 of the 2 groups: intervention (n = 20) and control (n = 20). The intervention group was required to complete a neuromuscular training program that met 3 times per week for 8-week. Data analysis was done using the independent t-test and analysis of covariance at the significant level of $p < 0.05$.

Results

The comparison of total FMS score indicated a significant difference ($P < 0.05$ and effect size = 0.83) between intervention (17.75 ± 1.55) and control (11 ± 1.55) groups. A significant improvement in mobility ($p < 0.05$ and effect size = 0.39), stability ($p < 0.05$ and effect size = 0.77) and advanced movement ($p < 0.05$ and effect size = 0.75) were also found.

Conclusion

An 8-week neuromuscular training program enhances functional movement screen in military athletes. It seems that this training program can minimize injury risk in injury-prone individuals.

Background

Individuals in the armed forces of all countries and military personnel are largely different from the ordinary individuals due to some physical fitness and characteristics [1]. There are jobs with high levels of stress, including military jobs. Numerous studies on the high vulnerability of military forces in various groups confirm this issue [2, 3]. This is especially important in military organizations that have trained personnel in specialized fields and spend a great deal of time and money on their training as their damage can lead to economic losses to the organization, affect their function and ultimately reduce military strength and readiness [3].

Due to the risk of injury after participation in sports activities and the importance of identifying injured military athletes, screening is significantly important before participation in sports activities. Risk factors and their association with injury also need further evaluation. A number of these evaluation methods have primarily focused on distinct factors such as power or range of motion. Since a combination of different factors is effective in causing injury, researchers have thus focused on evaluating comprehensive movement patterns for injury prevention [4]. Functional Movement Screen (FMS) is a method that can detect motor dysfunctions using translational motion that can identify high-risk individuals in addition to evaluating quality of implementation of functional movement patterns [4].

Cook et al. introduced Functional Motion Screen by considering pre-season screening and performance-related factors. The Functional Movement Screen was developed to evaluate movement performance during 7 movement patterns [4]. Scores from each movement are summed for a maximal composite score of 21 and a composite score of ≤ 14 is suggestive of increased injury risk in male football players [5], female collegiate athletes [6], and male military candidates [7].

The applied tests in the FMS such as the deep squat, the hurdle step and lunge challenge factors such as coordination, limb mobility, postural control, balance, pelvic and core stability [4]. These tests are designed to interact between motor chain mobility and the necessary stability to implement functional movement patterns and simply measure the state of neuromuscular coordination, especially core stability and balance [4]. The reduced individual stability and mobility decreases the FMS score and puts the individuals at a greater risk of injury. A great number of studies indicate that people with lower scores in the FMS test are forced to use compensatory movement patterns for optimal performance while exercising and this can also exert extra force on some body structures, thereby increasing the likelihood of injury [7].

Risk factors, which are common in most injuries among athletes include agonist and antagonist muscle involvement in strength, endurance and abnormal skeletal muscle structure, neuromuscular control, core muscle weakness, and bilateral imbalance or lack of muscle symmetry [8]. Given the above risk factors, various exercise activities are performed to reduce the likelihood of injury, including neuromuscular exercises that are performed to increase joint stability, improve proprioception, and develop protective reflexes to prevent injury because neuromuscular control dysfunctions play important roles in the likelihood of injury [9]. There is some evidence that proprioception is involved in maintaining the balance and proper functions of lower extremities and reducing the likelihood of injury; and it has been found that neuromuscular training programs are more effective than strength training in improving the muscle reaction [10]. Therefore, neuromuscular exercises aim to develop neuromuscular control, thereby increasing the joint stability that may reduce the likelihood of injury. These types of programs include strength, stretching, plyometric, balance and stability exercises [11]. The balance and core stability exercises can prevent or reduce the severity of lower extremity injury in male and female athletes [12]. They also cause better interaction of neuromuscular system and can improve functions of feet and lower extremities [13]. Military research has found that preventive injury training programs, which focus on

strengthening muscles of core stability (trunk control), agility and balance and do not use any additional equipment such as balance balls or wobble board, decrease the incidence of injury by 20–30% [14, 15].

As the prevalence of injury increases, it is important to prevent them and identify factors that make people prone to injuries. Given the high prevalence and cost of treatment as well as long duration of musculoskeletal injuries, the sensitivity and importance of preventing these injuries seem essential among military personnel. Therefore, the purpose of this study was to determine the effect of an 8-week neuromuscular training on functional movement screen in injury-prone military athletes.

Materials And Methods

Participants

This quasi-experimental study consisted of forty physically active male military athletes prone to injury (with a score of ≤ 14 in the FMS) between the ages of 24 and 33 that volunteered for this study. Military athletes (martial arts = 10, wrestling = 8, futsal = 12, volleyball = 10) were defined as militaries who participated in military sport teams, were currently in their off-season, and that were training at least 3 times per week (> 1.5 h/week). All participants were currently free from any kind of musculoskeletal injury, had not sustained any kind of musculoskeletal injury within the past 6 weeks, and had never undergone surgery for a musculoskeletal condition. For this purpose, the individuals were entered into the study with the approval of a physician and reviewing medical records.

Participants were selected by availability and purposive sampling that were assigned to either the training group (20 male: age = 27.45 ± 2.3 years, height = 176.72 ± 5.1 cm, weight = 75.02 ± 3.5 kg) or the control group (20 male: age = 27.20 ± 2.4 years, height = 176.42 ± 5.5 cm, weight = 74.05 ± 3.6 kg) based on their availability to participate in training. All participants completed all phases of the investigation and gave written informed consent before any data collection.

Procedures

All testing and training was done in the School of Sports Sciences health Center. This study was comprised of three phases: 1) pre-testing, 2) a supervised neuromuscular training three times per week for 8 weeks, and 3) post-testing. Prior to pre-testing, participants were familiarized to all aspects of the study protocol and performed practice trials of all assessments. During pre- and post-testing, all testers utilized the same verbal instructions. Once assigned, the intervention group was required to complete neuromuscular training 3 times per week in addition to their usual training routine. The Control group received no intervention. They were instructed to maintain usual daily activities for the duration of the 8-week intervention. All participants were in the off season of their respective sports and none of the athlete's off season training programs included neuromuscular training. Post-testing was conducted in a manner identical to pre-testing. All sessions were supervised by the one of researchers, who has qualifications as a personal trainer. The neuromuscular training program was designed to enhance

movement control and, as well as to increase the stability of the trunk, knee and ankle. The focus of all of the exercises was on the use of proper technique, such as good posture, maintenance of core stability or positioning of the hips, knees and ankles, especially “knee over toe” position. The neuromuscular training program included 9 exercises: 1) One-leg standing with a stick, 2) Squat exercises with a stick using, respectively, two legs or one leg, 3) Horizontal side support, 4) Jumping from side to side, 5) Modified pushups, 6) Stretching exercise for hip flexor muscles, 7) Hamstring exercise on the knees, 8) Stretching exercise with a stick for hamstring muscles and 9) Upper-body rotation while lying on one’s side; a “yoga stretch”. Participants were instructed to maintain a neutral position of the spine while holding the correct exercise position. The intensity and volume of each neuromuscular exercise were progressed gradually at a standard rate as previously described and shown in the Supplemental file [16].

Measures

The Functional Movement Screen (FMS) is composed of the following seven tasks: 1) Deep squat (DS); 2) Hurdle step (HS); 3) In-line lunge (ILL); 4) Shoulder mobility (SM); 5) Active straight leg raise (SLR); 6) Trunk stability push-up (PU); 7) Rotary stability (RS) (Fig. 1). “Clearing” tests (impingement, press up, and posterior rocking) are also included with the SM, PU and RS to expose other painful movements that may be overlooked while performing the primary FMS tasks. Additional details of each task have been published previously [4, 17, 18]. Each task is scored, and a 4-point scale (0–3) and on tests where left and right sides are measured, the lowest score is used, giving a total score out of 21 [4, 17, 18]. A score of 3 was assigned if the participant performed a functional movement pattern with no movement compensation. A score of 2 was assigned if the participant performed a functional movement pattern, with some degree of compensation. A score of 1 was assigned if the participant was unable to perform or complete a functional movement pattern according to published guidelines, and a score of 0 was reserved for participants who had pain with the movement or presented with pain while performing a clearing test [4]. Screens were performed in a convenience order, and participants were given adequate rest to account for fatigue. FMS has internal reliability and high rater (ICC = .98) between experienced and novice experimenters [19, 20]. Before starting the study, the examiners conducted a preliminary study of 14 participants to obtain the reliability of the interrater in proportion to the previously published values.

Scores were reported and analyzed in several ways to determine the efficacy of the neuromuscular training program. First, a composite score was calculated for the 7 tests by summing the final score for each assessment. Second, individual FMS tests were subcategorized into one of the following 3 categories: 1) Mobility, 2) Stability, and 3) Advanced movements. Mobility tests included the active straight leg raise and shoulder mobility assessment. Stability tests included the trunk stability push-up and the rotary stability assessment. Advanced movements included the deep squat, hurdle step, and inline lunge. Final scores for each category were summed to determine a composite score for that category [21].

Analyses

Data were analyzed using SPSS statistical software 22 (IBM, Armonk, NY, USA).). Independent t-test was used to compare the mean of Participants' descriptive characteristics between intervention and control groups. Analysis of covariance test was performed to determine statistically significant differences between- FMS scores between the two groups. Significance level was set a priori at $p < 0.05$.

Results

Table 1 presents participants' personal characteristics. Based on results of the independent t-test, there was no significant difference between personal characteristics of the two groups.

Descriptive statistics are presented in Tables 2, 3. A significant improvement in total FMS score was found following the 8-week neuromuscular program ($p = 0.001$, effect size = 0.83). A significant difference was found between all three stability (effect size = 0.77, $F = 115.33$, $P < 0.05$), and advanced movements (effect size = 0.75, $F = 100.34$, $P < 0.05$) and mobility (effect size = 0.39, $F = 23.12$, $P < 0.05$).

Table 1
Participants' descriptive characteristics and results of independent t-test

Variables	Intervention group	Control group	p
	Mean \pm SD	Mean \pm SD	
Weight (kg)	75.02 \pm 3.5	74.06 \pm 3.4	0.39
Height (cm)	176.72 \pm 5.1	176.42 \pm 5.5	0.34
Age	27.45 \pm 2.3	27.2 \pm 2.4	0.81

Table 2
Means ± Standard Deviations for pre- and post- single and composite scores

	Variable	Experimental group		Composite		Control group		Composite	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Advanced Movements	DP	1/85 ± 0/67	2/6 ± 0/5	82/0 ± 50/4	7/65 ± 1/09	6/0 ± 5/1	6/0 ± 6/1	84/0 ± 20/4	83/0 ± 30/4
	HS	1/6 ± 0/5	2/8 ± 0/5			65/0 ± 55/1	51/0 ± 5/1		
	ILL	1/05 ± 0/22	2/25 ± 0/22			36/0 ± 15/1	41/0 ± 2/1		
Mobility	SM	1/10 ± 0/30	2 ± 0/79	87/0 ± 75/2	04/1 ± 70/4	44/0 ± 25/1	48/0 ± 35/1	58/0 ± 35/3	63/0 ± 25/3
	ASLR	1/65 ± 0/57	2/7 ± 0/55			44/0 ± 1/2	55/0 ± 9/1		
Stability	TSP	1/65 ± 0/48	2/8 ± 0/41	81/0 ± 15/4	57/0 ± 70/5	47/0 ± 7/1	41/0 ± 8/1	71/0 ± 90/3	68/0 ± 55/3
	RS	2/5 ± 0/60	2/9 ± 0/30			61/0 ± 20/2	44/0 ± 75/1		

DP = deep squat; HS = hurdle step; ILL = inline lunge; SM = shoulder mobility; ASLR = active straight leg-raise; TSP = Trunk Stability Pushup; RS = Rotary stability

Table 3
Results of analysis of covariance related to total FMS score (n = 40)

Variable	Group	Steps		P	Effect Size
		Pre	Post		
		Mean ± SD	Mean ± SD		
Total FMS	Control	09/1 ± 4/11	55/1 ± 11	0/33	
	Experimental	11/6 ± 1/09	17/75 ± 1/55	0/001	0/83

Discussion

The main purpose of this study was to determine the effect of an 8-week neuromuscular training on functional movement Screen (FMS) in injury-prone military athletes. The research results indicated an

increase in scores of functional movement Screen after neuromuscular exercises. There was a significant difference between scores of functional movement Screen in the intervention group compared to the control group. A great number of studies have investigated the relationship between the FMS and occurrence of injury and they introduced FMS scores as a predictor of injury. These studies have found that people who scores less than 14 in this test are at injury risk, especially lower extremity injuries [4, 6, 22]. For instance, O'Connor et al. [7] indicated that scores below 14 were associated with an increased likelihood of injury in military personnel. Results of the present study on the impact of neuromuscular exercises indicated that FMS scores increased under the influence of these exercises. These findings were consistent with studies by Stanek et al. [21], Bagherian et al. [23], Finch et al. [24], Bodden et al. [25] and Kiesel et al. [26]. In a study on the effectiveness of a personalized corrective training program on the active firefighters' scores of functional movement screening test, Stanek et al. [21] classified tests into three categories: mobility, stability, and advanced movement tests. They reported that total FMS scores and the stability and advanced movement tests significantly improved due to the corrective training program, but mobility scores were not statistically significant despite their increase. In the present study, scores of all three categories of mobility, stability and advanced movement tests were also significantly improved, while effect sizes of three categories showed lower improved scores of mobility test than other two categories. Bagherian et al. [23] examined the impact of core stability training on the functional movement pattern in college athletes and indicated that eight weeks of core stability training resulted in improved functional movement and dynamic postural control in athletes. Finch et al. [24] also examined the effect of neuromuscular training program on injury prevention in football players. They suggested that neuromuscular exercises might help reduce the likelihood of injury in football players. Bodden et al. [25] and Kiesel et al. [26] also used a training algorithm by designed Cook in their separate training programs. This algorithm uses specific corrective exercises that are performed for four sessions per week and target movement pattern restrictions associated with seven tests of FMS [25, 26]. A program by Bodden et al. [25] focused on weak or asymmetric scores for 8 weeks with an initial emphasis on mobility patterns and then stability patterns. Kiesel et al. [26] first performed movement fitness exercises including massage of trigger points in core muscle groups and then stretching by oneself or an assistant in a 7-week program. Corrective movements of their program included the straight-leg bridge, single-leg stance by engaging the center of body, lowering leg by engaging the center of body, and single-leg toe touch. These exercises were also used in the program of the present study. Bodden et al. [25] evaluated FMS scores at the beginning of the first week and the end of the fourth and eighth weeks. Their findings indicated a significant difference in scores of FMS at the first and fourth weeks, but no significant difference was observed between the fourth and eighth weeks. In a research by Kiesel et al. [26] 41 players showed the symmetry in FMS tests at the end of study, but 31 players had symmetry in the tests at the beginning of study. In a research by Frost et al. [27] on 60 male firefighters with the mean age of 37 years, the first intervention program focused on improving overall body coordination and control by prioritizing strength, power, aerobic capacity and injury prevention training; and the second intervention program focused on maximizing performance and fitness rather than limitations of a particular movement pattern. Both interventions were performed for 12 weeks including three 90-minute sessions. Despite the fact that there was no detail about the interventions, none of them affected FMS scores [27].

Wright et al. [28] also stated that four weeks of exercise using body weight or elastic bands, which emphasizes performance quality, would have little effect on the functional movement screening scores of physically active students. They mentioned the short duration of study as its reason and stated that exercises might only affect components in isolation and not affect movement patterns over a short period. Based on the results of above-mentioned studies, intervention programs, which directly involve specific movement patterns in adult athletes, may affect FMS scores [25, 26]. On the contrary, intervention programs, which focus on the coordination and control of the whole body or maximization of performance and fitness, may not be successful in improving movement patterns [27]. Results of a research by Siamaki et al. [29] were in contrast to this issue. They found that basic movement patterns were improved using the FMS after 10 weeks of functional training in young male soccer players. Principles of training, especially the principle of specificity and selection of appropriate training variables were provided in their program. Siamaki et al. [29] believed that despite non-direct focus of their exercises on limitations of specific movement patterns similar to training interventions by Bodden et al. and Kiesel et al., the age of participants (which were adolescents) and comprehensive functional training program resulted in an impact on FMS scores according to findings of study and reported moderate effect size. In their view, adaptations and proper neuromuscular control and mechanical improvements resulting from strength, balance (a kind of proprioception), body center, speed and agility, power, and plyometric exercises, and specific exercise skills combined with self-myofascial release exercises, which are mostly used in participants with limited mobility, could improve basic motility patterns in soccer teenagers as an effective set [29]. It seems that above-mentioned theories about positive effects of exercise on FMS scores in similar studies can be considered for this study because the nature of applied intervention program in the present study included neuromuscular exercises by focusing on appropriate techniques including good posture, strengthening core stability, correcting movement pattern during exercise and maintaining hip, knee and ankle position, especially position of knee over toe. Given the relationships of FMS tests and factors such as core stability and balance according to the previous studies and the use of stability and balance exercises, which are important components of neuromuscular training in the present training program, it is likely that this training program could improve FMS scores by improving core stability and providing a proper posture control.

Limitations of the present study included the lack of control over the participants' nutritional status that might affect the participants' performance. The lack of evaluation of muscle length was another limitation of study. Muscle length can affect the individual function in most tests. Other limitations included the lack of precise control of mental and psychological conditions such as participants' types of attitude, motivation and anxiety levels during training and tests.

Conclusion

An 8-week neuromuscular training program enhances functional movement screen in military athletes. It seems that this training program can minimize injury risk in injury-prone individuals.

Abbreviations

FMS: functional movement screening- DS: Deep squat- HS: Hurdle step- ILL: In-line lunge- SM: Shoulder mobility- SLR: Active straight leg raise- PU: Trunk stability push-up- RS: Rotary stability

Declarations

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Not applicable.

Authors' contributions

SMS and MHA and ASH were responsible for the study design. ASH and SMS were responsible for collecting the consent forms from the study participants, collecting study data during the study, and writing the first draft of the manuscript. ASH was the primary author of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The present study was approved by the committee of ethics at Exercise Physiology Research Center of Baqiyatallah University of Medical Sciences (Ethical number: IR.BMSU.REC.1396.525).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

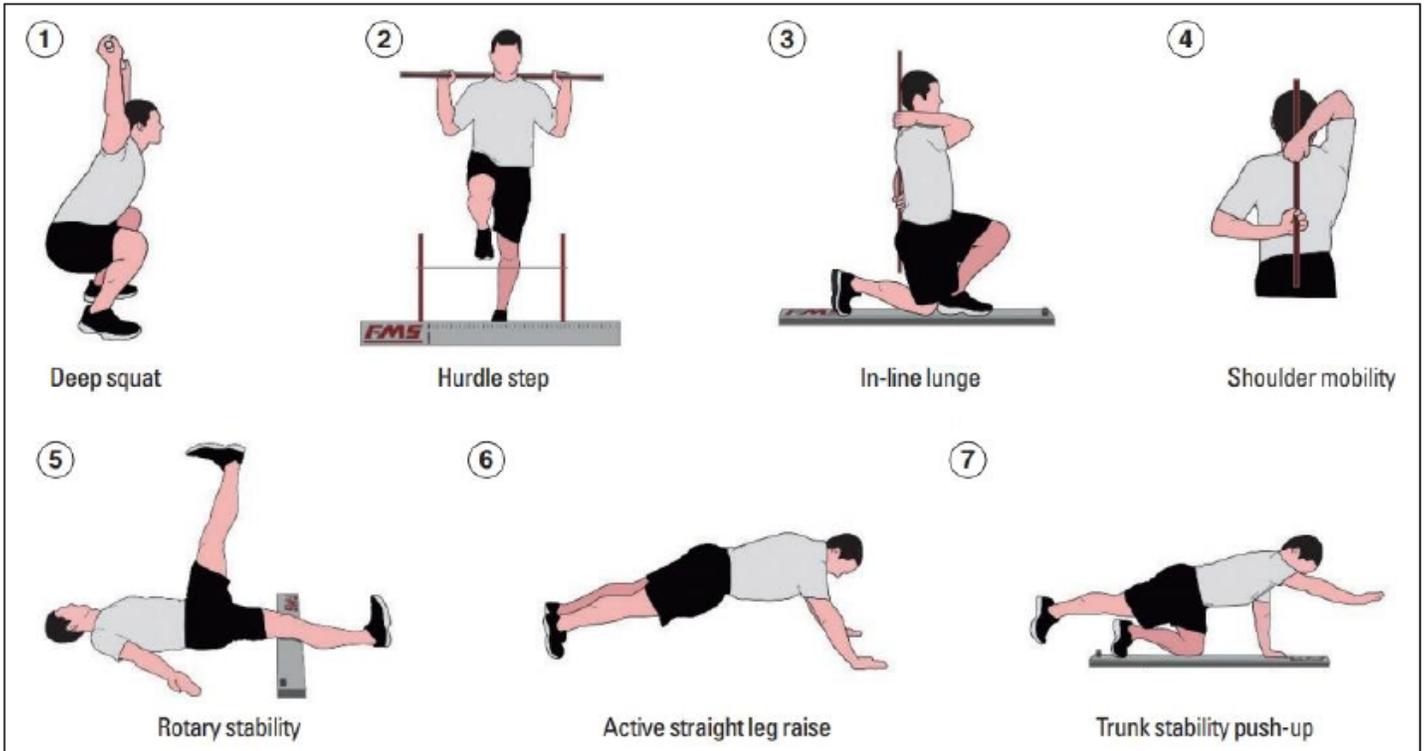


Figure 1

Functional Movement Screening Tests. 1) Deep squat, 2) Hurdle step, 3) Inline lunge, 4) Shoulder mobility, 5) Active straight leg-raise, 6) Trunk stability pushup, 7) Rotary stability