

Functional movement screen evaluation system for the prevention of military training injuries: a prospective study in China

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Abstract

Background: Military training injury is a difficult problem in the field of military training. This study aimed to evaluate the effectiveness and feasibility of functional movement screen (FMS) evaluation system and individualized intervention measures in preventing military training injuries.

Methods: A total of 420 recruits from a unit of the People's Liberation Army of China (PLA) were included as the research object. According to random grouping method, they were divided into observation group (Group A) and control group (Group B), with 210 patients in each group. Before recruit training, individual FMS were performed, and functional correction training was performed in the observation group according to the test scores, while no intervention measures were applied in the control group. After three months of training, the tests were repeated. Age, body mass index (BMI) and incidence of military training injuries were recorded during the training period.

Results: There was no statistical difference between the two groups in age, BMI, FMS score before the training ($P > 0.05$). After receiving functional correction training, the FMS score of the Group A was higher than that of the Group B, and the difference was statistically significant ($P < 0.05$). The incidence of military training injury in Group A and Group B was 20.95% and 44.02%, respectively ($P < 0.05$), and the difference was statistically significant.

Conclusion: The evaluation system of FMS and individualized intervention measures are feasible and effective in predicting and reducing the occurrence of military training injuries.

Background

Military training is the fundamental way to improve the combat effectiveness of troops. Due to various reasons, the current military training injuries increase year by year and remain high [1]. According to literature, the incidence of training injuries in the UK is 48.6% [2], 23.2% in Norway [3], 21.0% in the PLA [1], and 45.0% in the U.S. Marines [4]. Therefore, countries around the world attach great importance to how to reduce military training injuries and carry out a series of studies [5-8], however, most have proved ineffective. The main reasons are the generality of the intervention measures and the lack of pertinence. Second, some risk factors for training injuries (smoking, age, BMI, etc.) are mostly individual characteristics, which are difficult to change.

Studies have pointed out that part of the reasons for military training injuries are the reduced flexibility of the trainees' joints and the asymmetry of muscle strength [9]. FMS was designed by Garry Cook to evaluate the quality and asymmetry of movement. It can effectively screen out the dysfunction and asymmetry of subjects during movement and has the ability to identify injury risk [10, 11]. FMS has been widely used in rehabilitation training and physical training in competitive sports [12-14], nevertheless, studies on its application in the military field are relatively few. In this study, FMS test was conducted on recruits before military training, and personalized intervention and correction training was conducted

according to the scoring results, so as to explore the effectiveness and feasibility of FMS evaluation system in predicting and reducing the occurrence of military training injuries.

Methods

Study population

This study is a prospective study design, including 420 recruits of PLA as the research object. According to the random grouping method, they were divided into the observation group (Group A) and the control group (Group B), with 210 members in each group. All the recruits were male. The mean age of the Group A was 19.8 ± 1.5 years and BMI was 22.3 ± 2.9 years. The mean age of the Group B was 19.7 ± 1.4 years and BMI was 22.3 ± 2.8 years. All subjects were strictly screened according to inclusion criteria and exclusion criteria, and obtained informed consent.

Inclusion criteria and exclusion criteria

Inclusion criteria: 1. The research subjects have good compliance and can actively cooperate to complete various tests; 2. The subject has not received formal military training or other competitive training before. **exclusion criteria:** 1. Subjects have medical history of neck, shoulder, waist, knee and other diseases; 2. Those who cannot complete the FMS test due to various reasons is excluded.

Study methods

Standard FMS suites are applied. The test method follows the international standard working procedure of FMS. Orthopaedic surgeons, sports researchers and rehabilitation therapists were involved and all underwent a one-week training in FMS testing to ensure accuracy and reliability. The FMS test was performed in a relaxed state to eliminate the effects of fatigue. All subjects were tested twice by a professional and the average value is obtained. Seven tests (deep squats, hurdle step, inline lunge, shoulder flexibility, active straight- leg raise, trunk stability pushup, rotary stability) and three clearing exams were included in the FMS. We use a clearing exam at the first of the FMS. Each test is scored between 0 and 3, with an overall score of 0 to 21. According to the test results, the Group A was given corrective training, while the Group B was not given any intervention factors. After that, both groups received a 90-day military training according to the PLA military training program. The types of military training injuries that occurred to all subjects were recorded during this period. The FMS scores of all subjects were measured again after the training. Military training injury is defined as the injury of bone, soft tissue or organ in the process of military training, resulting in dysfunction affecting the normal military training for more than 1 day.

Statistical analysis

All data analysis was performed using SPSS version 25 (SPSS, Inc., Chicago, IL, USA) software. Data are expressed as the means \pm standard deviation for parametric samples, paired sample t test was used for intra-group comparison, and independent sample t test was used for inter-group comparison. Chi-square

test and Fisher's exact probability method were used for counting data of disordered classification. Univariate analysis was used to determine the correlation between the occurrence of training injury and BMI and FMS scores. $P < 0.05$ was considered statistically significant for all comparisons.

Results

Recruits' demographics

During the study period, FMS was performed on 420 recruits, of whom 17 were excluded. The remaining 403 recruits were included in the final analysis (Fig.1). These two groups had similar baseline demographic data (Table 1).

Table 1 Demographic data of the recruits

Variable	Group A	Group B	P value
Age(year)	19.8±1.5	19.7±1.4	0.15
BMI	22.3±2.9	22.3±2.8	0.23
FMS score	14.3±3.1	14.2±3.0	0.56

Training injuries and FMS scores

Military training injury occurred in 44 recruits in the Group A and 92 recruits in the Group B (21.89% and 45.54%, respectively). The incidence of training injury in Group A was lower than that in Group B, and the difference was statistically significant ($P < 0.05$) (Table 2).

Table 2 Occurrence of training injury in two groups of recruits

Item	Injuries (n,%)	No injuries (n,%)	χ^2 value	P value
Group A	44(21.89)	157 (78.11)	9.28	0.02
Group B	92(45.54)	110(54.46)		

At the end of the training, the FMS score of the Group A increased from 14.61 ± 2.11 to 16.23 ± 2.09 after the intervention of FMS correction strategy. The FMS score of the Group B increased from 14.59 ± 2.09 to 15.03 ± 2.09 . The difference was statistically significant (Table 3).

The final FMS score of the Group A was higher than that of the Group B, and the difference was statistically significant (Table 3).

Table 3 FMS score results for all recruits

Variables	Group A			Group B			#P
	Pre-training	Post-training	*P	Pre-training	Post-training	*P	
Deep squat	2.31±0.61	2.48±0.52	0.03	2.29±0.56	2.47±0.47	0.12	0.49
Hurdle step	1.99±0.57	2.19±0.56	0.01	2.00±0.53	2.02±0.49	0.09	0.13
In-line lunge	1.92±0.75	2.23±0.45	0.01	1.91±0.78	2.02±0.39	0.03	0.01
Shoulder mobility	1.96±0.53	2.31±0.49	0.01	1.95±0.54	2.00±0.49	0.07	0.01
Active straight- leg raise	2.52±0.34	2.61±0.36	0.05	2.53±0.43	2.61±0.39	0.21	0.46
Trunk stability push-up	2.02±0.92	2.23±0.62	0.03	2.01±0.89	2.12±0.59	0.02	0.03
Rotatory stability	1.92±0.61	2.12±0.23	0.02	1.90±0.59	1.95±0.23	0.11	0.04
FMS scores	14.61±2.11	16.23±2.09	0.01	14.59±2.09	15.03±2.09	0.02	0.04

*P, Compared within groups ; #P, compared among groups

Correlation analysis of training injury and FMS score

We further analyzed the correlation between different FMS scores and BMI values and the occurrence of training injuries, suggested that FMS score and BMI were correlated with the occurrence of training injury ($P < 0.05$) (Table 4). The results showed that FMS score and BMI were the risk factors of training injury.

Table 4 Univariate analysis of training injury and BMI and FMS scores

Variables	Injuries		No injuries		χ^2	P
	$n=136$	$n=267$	$n=136$	$n=267$		
	≤ 12	32	41		8.96	0.01
FMS score	12–14	56	80			
	≥ 14	48	146			
	≤ 18.5	4	8		13.12	0.04
BMI	18.5–25	89	210			
	≥ 25	43	49			

Discussion

Military training injuries restrict the improvement of military combat effectiveness and increase a large number of unnecessary expenses [15]. At present, the armies of all countries in the world attach great importance to the occurrence of training injuries, and have carried out a series of related studies [5–8]. However, most studies were limited to training history, injury history, smoking, age, gender, and BMI, These risk factors for injury are mostly individual characteristics that are often difficult to change. FMS can effectively screen out the dysfunction and asymmetry of subjects during movement [10, 11], therefore, targeted intervention can theoretically reduce the occurrence of training injury.

The incidence of military training injuries is a key indicator to evaluate the effectiveness of intervention measures, Coppack [16] and Sharma [17] pointed out that effective intervention measures for training injuries should be targeted at specific injury mechanisms. In the study, there was no statistical difference in the FMS score between the two groups before training. After training, the FMS score of the Group A was 16.23 ± 2.09 , which was higher than that of the Group B 15.03 ± 2.09 ($P < 0.05$). The incidence of military training injury in the Group A was 20.95% lower than that of the Group B (44.02%, $P < 0.05$). It indicated that FMS intervention is effective to improve the FMS score and reduce the incidence of training injury. Bushman et al. [11] pointed out that FMS score could be a risk factor for the occurrence of military training injuries, and the establishment of FMS archives for recruits preparing for military training could provide information for the future risk management strategies of this population.

It has been reported in previous literature [18–20] that when FMS score is lower than 14 points, the potential probability of training injury will increase. O'Connor [18] found that when the FMS score of trainees was lower than 14, the probability of training injury increased by 1.91 times. Brushoj et al. [21] also pointed out that when the flexibility of the body is reduced and the muscle strength is asymmetrical, rough military training is difficult to change the mobility and stability of the body without increasing the

compensation of the body and the probability of injury. In this study, by comparing and analyzing the occurrence of training injuries with different FMS scores, the correlation between FMS scores and the occurrence of military training injuries was further confirmed (Table 4), which is consistent with the views of the above-mentioned scholars. Therefore, it is feasible to predict the occurrence of military training injury based on FMS evaluation system.

Another finding of the study was that 209 recruits (51.86%) (Table 5) had FMS scores below the 14 cutoff point, which is worrisome and implies that these recruits have a potentially higher incidence of military training injuries. Bock et al. [22] pointed out in their study that FMS scores are related to the performance of tactical crowd on tasks, and police officers with lower FMS scores perform worse in defensive tactical tasks. Stanek[23] pointed out that firefighters require to practice a variety of functional movements, which can lead to a safer and more effective performance. Therefore, based on the current research results, it is necessary to actively carry out FMS testing and timely targeted intervention in the process of military training.

Although our study has reached some conclusions, there are the following limitations. Firstly, restricted by the training conditions, it is difficult for the subjects to ensure the homogeneity in training intensity and training time. Secondly, a prospective study design might have recorded a higher incidence of training injuries due to increased awareness of injury in the control subjects. At last, The individual intervention measures of FMS and the effectiveness of the system in preventing military training injuries still need to be demonstrated with large sample.

Conclusions

Based on the findings, the evaluation system based on FMS is feasible in predicting the occurrence of military training injuries, and targeted intervention measures can significantly reduce the occurrence of military training injuries.

Declarations

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Authors' contributions

JX and JZ conducted the experiments and wrote the manuscript, RBZ, JJK, XW, WW and LHC collected and analyzed the data. RBZ supervised the project. All authors read and approved the final manuscript.

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Availability of data and materials

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

Ethics approval and consent to participate

This trial was approved by the Guangzhou Special Service Recuperation Center of PLA Rocket Force Biomedical Research Ethics Committee. Informed consent was obtained from all participants.

Consent for publication

Informed consent for publication was obtained from all participants.

Competing interests

All authors declare no conflicts of interest.

Authors' information

Full list of author information is available at the first of the article

Abbreviations

BMI: Body mass index; FMS: Functional movement screen; PLA: People's liberation army

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Table 5

Table 5 was not provided with this version of the manuscript.

Figures

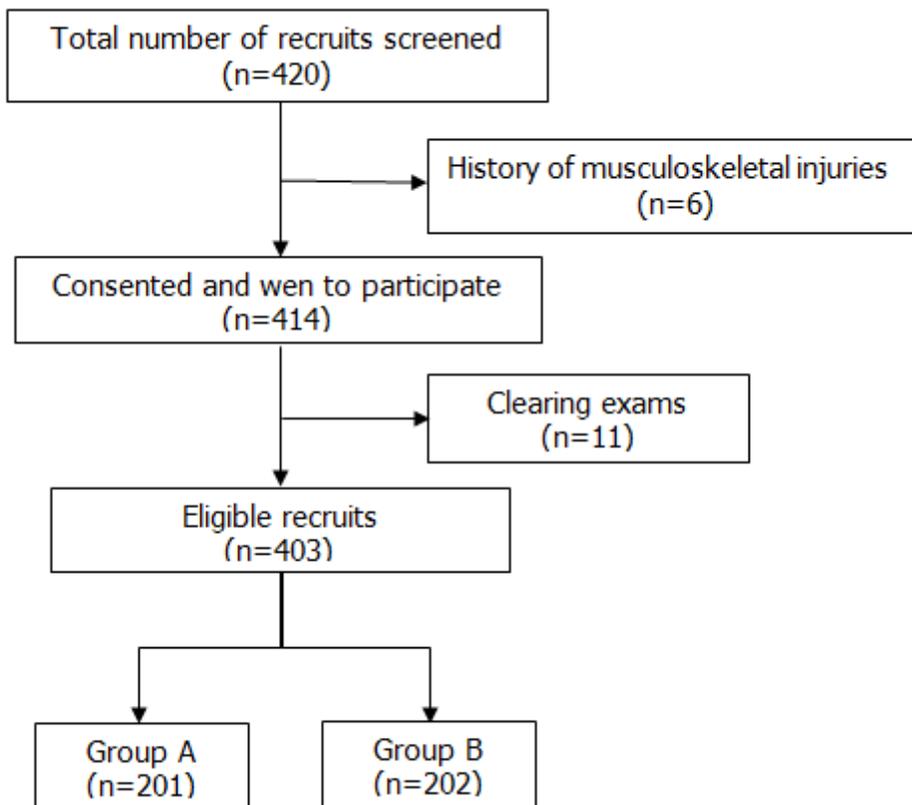


Figure 1

Flow diagram of the recruits showing the study design