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Reliability evaluation of functional movement screen for prevention of military training injury: A prospective study in China

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Abstract

Objectives: 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 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 was 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 3 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 ($P > .05$). 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 ($P < .05$). The incidence of military training injury in Group A and Group B was 20.95% and 44.02%, respectively ($P < .05$), 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.

KEYWORDS

FMS, military training injuries, prevention, reliability evaluation

Jing Zeng and Rong-Bing Zhang contributed equally as first authors.

1 | 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 People's Liberation Army of China (PLA),[1] and 45.0% in the US 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, body mass index [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] Functional movement screen (FMS) was designed by Gray Cook to evaluate the quality and asymmetry of movement. It can effectively screen for 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, it also plays an important role in the prevention and treatment of training injuries.[12-14] At present, FMS has been gradually applied in the field of military training. Due to the particularity of military profession, there is always controversy about whether it can predict training injury. Some studies[15,16] pointed out that there was no correlation between the test and the occurrence of military training injuries. On the contrary, Moran et al[17] found a certain correlation between the occurrence of military training injuries and FMS scores. However, most of the above studies exploring FMS and injury risk were based on a cut of 14, and the sample size of the studies was small. Based on a large sample of prospective controlled study, this study conducted individualized corrective training on the experimental group of recruits and divided the FMS scores into multiple nodes, so as to explore the effectiveness and feasibility of FMS evaluation system in predicting and reducing the occurrence of military training injuries.

2 | METHODS

2.1 | 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. All subjects were strictly screened according to inclusion criteria and exclusion criteria, and obtained informed consent.

2.2 | Inclusion criteria and exclusion criteria

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

2.3 | Study methods

Standard FMS suites are applied. The test method follows the international standard working procedure of FMS. Orthopedic surgeons, sports researchers, and rehabilitation therapists were involved and all underwent 1-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. All recruits complete FMS tests before the military training. The recruits in Group A were given corrective training for 2 weeks for individual items scoring <2 points. After the individualized corrective training, the two groups of recruits were randomly assigned to each training unit for 12 weeks of military training in order to ensure that the training time and training intensity of the two groups were as consistent as possible. 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. The final determination of military training injury was made by the research team's orthopedic surgeon with reference to the recruits' medical records.

2.4 | FMS interventions

Most of the intervention methods of corrective training were formulated by sports researchers and rehabilitation therapists according to the National Academy of Sport Medicine Guidelines. Due to the consideration of not affecting the military training plan, we have made appropriate modifications. Corrective exercises for deep squats include quad stretch and squat jumps; The corrective training content of the hurdle step was stride self-stretch; Sit-ups with knee flexed and lunge squat were used to correct inline lunge deficiencies of recruits; Regular exercises for shoulder flexibility include joint mobilization. Weakness in active straight-leg raise was corrected by proprioceptive neuromuscular facilitation stretch. Trunk stability push-ups were corrected by bench press, push up, and elbow plank. Side-to-side turn, quadruped diagonals, and core strength training were used to train the rotation stability of recruits. All corrective training sessions were performed twice a day for 15 minutes. The duration of corrective training sessions was 2 weeks.

2.5 | Statistical analysis

All data analysis was performed using SPSS version 25 (SPSS, Inc, Chicago, IL, USA) software. Data are expressed as the means ± 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. $P < .05$ was considered statistically significant for all comparisons.

3 | RESULTS

3.1 | 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. There were no significant differences in age, BMI, and FMS scores between the two groups before training (Table 1).

TABLE 1 Demographic data of the recruits

Variable	Group A	Group B	*P* value
Age (y)	19.8 ± 1.5	19.7 ± 1.4	.15
BMI	22.3 ± 2.9	22.3 ± 2.8	.23
FMS score	14.3 ± 3.1	14.2 ± 3.0	.56

Abbreviations: BMI, body mass index; FSM, functional movement screen.

3.2 | Training injuries

Military training injury occurred in 44 recruits in Group A and 92 recruits in 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 ($P < .05$) (Table 2).

3.3 | FMS scores

After the military training, the scores of deep squat in the two groups were significantly improved compared with those before the training, and the difference was statistically significant. There was no statistically significant difference between the two groups after the training (Table 3), suggested that the balance and functional flexibility of hip joint, knee joint, and ankle joint of lower limbs were improved to a certain extent after military training. However, after the training, the scores of hurdle step, shoulder flexibility, trunk stability push-up, and rotatory stability of Group A were significantly improved, and the differences were statistically significant. On the contrary, the scores of Group B showed no significant change in the above test items ($P > .05$) (Table 3).

At the end of the training, the FMS score of Group A increased from 14.61 ± 2.11 to 16.23 ± 2.09 after the intervention of FMS correction strategy. The FMS score of Group B increased from 14.59 ± 2.09 to 15.03 ± 2.09. The difference was statistically significant ($P < .05$) (Table 3). The final FMS score of Group A was higher than that of Group B, and the difference was statistically significant ($P < .05$) (Table 3).

3.4 | 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 ($P < .05$) (Table 4). The results showed that FMS score and BMI were the risk factors of training injury.

4 | DISCUSSION

Military training injuries restrict the improvement of military combat effectiveness and increase a large number of

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	.02
Group B	92 (45.54)	110 (54.46)		

TABLE 3 FMS score results for all recruits

Variables	Group A Pre-training	Group A Post-training	P^a	Group B Pre-training	Group B Post-training	P^a	P^b
Deep squat	2.31 ± 0.61	2.48 ± 0.52	.03	2.29 ± 0.56	2.47 ± 0.47	.12	.49
Hurdle step	1.99 ± 0.57	2.19 ± 0.56	.01	2.00 ± 0.53	2.02 ± 0.49	.09	.13
In-line lunge	1.92 ± 0.75	2.23 ± 0.45	.01	1.91 ± 0.78	2.02 ± 0.39	.03	.01
Shoulder mobility	1.96 ± 0.53	2.31 ± 0.49	.01	1.95 ± 0.54	2.00 ± 0.49	.07	.01
Active straight-leg raise	2.52 ± 0.34	2.61 ± 0.36	.17	2.53 ± 0.43	2.61 ± 0.39	.21	.46
Trunk stability push-up	2.02 ± 0.92	2.23 ± 0.62	.03	2.01 ± 0.89	2.04 ± 0.59	.16	.05
Rotatory stability	1.92 ± 0.61	2.12 ± 0.23	.02	1.90 ± 0.59	1.95 ± 0.23	.11	.04
FMS scores	14.61 ± 2.11	16.23 ± 2.09	.01	14.59 ± 2.09	15.03 ± 2.09	.02	.04

Abbreviation: FSM, functional movement screen.

[a]*P*, compared within groups.

[b]*P*, compared among groups.

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

Variables	Injuries (n = 136)	No injuries (n = 267)	χ^2	*P*
FMS score				
≤12	32	41	8.96	.01
12-14	56	80		
≥14	48	146		
BMI				
≤18.5	4	8	13.12	.04
18.5-23.9	89	210		
≥23.9	43	49		

Abbreviations: BMI, body mass index; FSM, functional movement screen.

unnecessary expenses.[18] 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 for 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[19] and Sharma[20] 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 Group A was 16.23 ± 2.09, which was higher than that of Group B 15.03 ± 2.09 ($P < .05$). The incidence of military training injury in Group A was 20.95% lower than that of Group B (44.02%, $P < .05$). 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[21-23] that when FMS score is lower than 14 points, the potential probability of training injury will increase. O'Connor et al[21] 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[24] 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, it was found that different FMS scoring points (≤12, 12-14, ≥14) had certain differences in the incidence of military training injuries. The lower the FMS score in a certain range, the higher the incidence of military training injuries (Table 4). This is basically consistent with the viewpoints of the above-mentioned scholars. Therefore, it is feasible to predict the occurrence of military training injury based on FMS evaluation system.

Previous studies[25,26] have pointed out that physical fitness data were also necessary to evaluate and monitor the effectiveness of existing military training programs and reduce the incidence of training injuries in the military population. In this study, it was found that after receiving the traditional military training program, the balance and flexibility of the lower limb joints of the two groups of recruits were improved. However, the stability, flexibility, symmetry, and shoulder flexibility of the recruits in Group B were not significantly improved compared with those before military training. ($P > .05$) (Table 3). However, the scores of the above items of recruits in Group A were significantly improved after receiving FMS corrective training ($P < .05$) (Table 3). Meanwhile, FMS scores were higher than those in Group B ($P < .05$) (Table 3). This indicates that the traditional military training is defective in improving the above indicators. Therefore, it is feasible to improve the physical fitness level of recruits through FMS corrective training combined with military training so as to reduce military training injuries.

Another finding of the study was that 209 recruits (51.86%) (Table 4) 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[27] 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 et al[28] 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. First, restricted by the training conditions, it is difficult for the subjects to ensure the homogeneity in training intensity and training time. Second, 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 a large sample.

5 | 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.

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DISCLOSURE

Approval of the research protocol: This trial was approved by the Guangzhou Special Service Recuperation Center of PLA Rocket Force Biomedical Research Ethics Committee. *Informed consent*: Informed consent was obtained from all participants. *Registry and the registration no. of the study/trial*: N/A. *Animal studies*: N/A. *Conflict of interest*: The authors have no conflicts of interest to declare.

AUTHOR CONTRIBUTION

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

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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