Effects of a periodized functional strength training program (FST) on Functional Movement Screen (FMS) in physical education students

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

**Purpose:** To examine the effects of periodized functional strength training (FST) on FMS scores of sport university students with higher risk of injury.

**Material:** Thirty three participants (age 21.6±1.3 years, height 177.8±6.9 m, mass 80.4±7.7 kg) with Functional Movement Screen (FMS), total score ≤ 14, were selected from eighty two volunteered students of University of Physical Education and Sport in Gdansk and randomly assigned to experimental (n=16) and control group (n=17). The FMS test was conducted one week before and one week after the 12 week training intervention. The experimental group participated in FST program through 12 weeks. The control group did not engage in any additional physical activity than planned in their course of study. The collected data were analysed using Statistica 13.3 pl (StatSoft Inc). Wilcoxon signed rank test was used to establish the statistical significance of the difference between FMS total scores within each group and Mann Whitney U test between groups before and after the 12 week training intervention.

**Results:** 45 % of volunteers in the first FMS testing showed total scores ≤14. The experimental group that participated in functional strength training (FST) program changed significantly FMS total scores after 12 weeks (p<0.05). There were also significant differences in FMS total score between groups after the experiment (p<0.05).

**Conclusions:** There is a need for injury prevention programs for students of University of Physical Education and Sport in Gdansk. It is clear from this study that FST is effective in improving FMS total score in students with cut off score ≤14.

**Keywords:** injury prevention, male students, functional strength training, functional movement screen.

Introduction

Injury risk can be a major concern while participating in any kinds of physical activities or sports. Especially musculoskeletal injuries are an inherent risk of athletic performance. Noncontact injuries represent approximately 20% of all injuries incurred during games and 40% of injuries incurred during practices among collegiate students [1]. To minimize the risk of injuries, an effective way to identify physical dysfunctions exposing to injury and injury prevention program are needed. In order to assess injury risk during various physical activities, several movement oriented tests have been established [2–5]. One of the most popular injury risk assessments is the Functional Movement Screen (FMS).

Over the past years, many studies have investigated the reliability and validity of the FMS [6–8]. The FMS consists of 7 tests: the deep squat, the in-line lunge, the hurdle step, shoulder mobility, active straight leg raises, trunk stability push-up, and the rotary trunk stability assessment [2, 9]. Each test is scored on a scale of 0–3 with a maximum value of 21 for the 7 tests. Bonazza et al. [6] in their meta-analysis stated that the FMS had the ability to predict injury risk and determined that athletes who scored ≤14 on the FMS were 2 times more likely to sustain an injury during training. Similar conclusions were stated by another meta-analysis by Bunn et al. [7]; individuals who scored ≤14 were 51% more likely to sustain a musculoskeletal injury. Furthermore, Kiesel et al. [10] reported that subjects who showed an asymmetry were 3 times more likely to become injured even with scores above the injury risk factor of 14.

A variety of intervention programs have been used to retrain dysfunctional movement patterns and increase FMS scores above 14 points [11-14]. Programs focused on coordination, neuromuscular control showed their effectiveness in increasing FMS scores. Bodden et al. [15] showed a sufficient increase in total FMS scores above 14 in experimental group that used the FMS protocol based on neuromuscular control after 4 weeks. Jafari et al. [16] reported a significant increase in total FMS score in firefighters after 8 weeks NASM (National Academy of Sport Medicine) training protocol based on flexibility and neuromuscular control.

Several studies have examined changes in FMS total score after different modes of resistance training [17-20]. Recently a new type of strength training modality known as functional strength training (FST) emerged among fitness as well as strength and conditioning professionals. FST employs multiple planes of motion, targets multiple muscles in a single exercise and mimics movement patterns seen in everyday life or sport [21, 22]. In contrast, traditional strength training programs incorporate more isolation/machine training and one plane of motion.
exercises. Liao et al. [19] reported significantly greater increases in FMS total scores after FST compared to traditional strength training among 12-13 years old girls. Similar observations were made by Yildiz et al. [18] that showed greater improvements in movement competency after functional strength training in comparison to traditional strength training in young tennis players. Nonetheless only one study analyzed the influence of periodized strength training on FMS total score. Cosio-Lima et al. [20] compared changes in FMS total scores between periodized traditional strength training group and typical military training group of army cadets after 12 weeks. The research showed no statistical meaningful changes in any of the groups.

However, up to date, no previous studies have sought to examine the effectiveness of periodized FST on FMS total score in adults. Therefore the aim of this study was to examine the effects of periodized FST using kettlebells and bodyweight exercises on FMS scores of sport university students with higher risk of injury (≤14 on the FMS).

Material and methods

Participants:

Eighty two students of physical education of Gdansk University of Physical Education and Sport (mean age: 21.6±1.3 years, mean height: 177.8±6.9 cm, mean body mass: 80.4±7.7 kg) volunteered for the first part of the study. The inclusion criteria allowing subjects to participate in the second part of the study consisted of: receiving no more than 14 points on FMS total score, not receiving 0 score on any of the FMS tests, being not involved in professional sport training in the previous 2 years, having no recent injury. The subjects that fulfilled the inclusion criteria (n=33), were randomly assigned into an experimental group (n=16) or a control group (n=17).

Procedure:

The study had two parts. In the first part, the FMS total score profile of 82 subjects that volunteered to participate in the study, was assessed. In the second part of the study, only participants that fulfilled the inclusion criteria took part. The experimental group participated in FST program through 12 weeks. The control group was not engaged in any additional physical activity than planned in their course of study. The FMS total scores were determined after 12 weeks of FST program in experimental as well as in control group. The anthropometric measures were performed only once, one week before the 12 week strength training program for creating the anthropometric profile of all participants.

The FMS is a screening tool comprised of 7 individual tests to assess an individual’s overall functional movement capacity. The FMS consists of 7 movement patterns that include an overhead deep squat (DS), a hurdle step (HS), an in-line lunge (ILL), shoulder mobility (SM), active straight leg raise (ASLR), trunk stability push-up (TSPU) and rotary stability (RS). Details of each movement task of the FMS test have been published previously [2]. The scoring system range for each of the 7 screen tests is from 0 to 3, where 3 indicates appropriate execution of the movement pattern, 2 indicates execution of the movement pattern with some compensatory adjustments, 1 indicates inability to perform the movement pattern and 0 indicates pain during the test. Each task was performed three times, and the best result was used for further analysis. Total score from all 7 tests range from 0 to 21. A total score of ≤14 was operationally defined as a cut-off score to determine poor movement capacity [6, 7]. The FMS test was conducted by 3 certified instructors. The FMS test was completed by using standard equipment (FMS Test Kit, Functional Movement Systems Inc., Chatham, Virginia, USA). All anthropometric data were collected by a physician specifically trained according to a standardized protocol. Height was recorded to the nearest 0.1 cm with a standing stadiometer (Seca 217) and body mass was measured to the nearest 0.1 kg with a high-precision mechanical scale (ADE M318800).

The strength training program was constructed on a traditional linear periodization model, based on developing high-volume and low-intensity training during the first mesocycles of the macrocycle, with progressive increases in training intensity and technical skills with simultaneous decreases in training volumes of the consecutive mesocycles (Table 1) [23]. The training program involved 8 multi joint exercises divided into two training days for 4 exercises per each training day. Each training day consisted of 2 lower body exercises, one upper body exercise and one global exercise. With each mesocycle the technical execution and intensity of each exercise increased by changing body position, increasing range of motion, changing tempo of exercise execution and adding external load. The intensity was monitored and expressed via perceived exertion (RPE) values measuring repetitions in reserve (RIR) [24]. Each workout was conducted under supervision of certified personal trainers.

Statistical analysis:

Statistical analyses were completed in Statistica 13.3 pl (StatSoft Inc). Descriptive statistics (mean and standard deviation) were calculated. Because the assumption of normality and homoscedasticity were violated on the Saphiro-Wilk test, Wilcoxon signed rank test was used to establish the statistical significance of the difference between FMS total scores within each group and Mann Whitney U test between groups before and after the 12 week training intervention. P<0.05 values were accepted statistically significant in all analyzes.

Results

Figure 1 presents FMS total score distribution among all volunteers before training intervention. Table 2 shows FMS total score distribution among experimental group and control group before and after 12 week training intervention. FMS total scores between pre-test results and post-test results are presented in Table 3. There was a significant difference between FMS total scores before and after the 12 week intervention in the experimental group, (p <0.05) and no significant changes in the control group (p>0.05) see Table 3. There was no difference in
### Table 1. 12 week strength training program*

| Exercise/movement pattern | Week 1-3 | Week 4-6 | Week 7-9 | Week 10-12 |
|----------------------------|----------|----------|----------|------------|
| Squat Body weight squat with valgus correction | Squat with kettlebell | Kettlebell goblet hold squat | 2 kettlebell front squat |
| Push up Push up walk out | Push up | Push up on suspension trainer | Push up on suspension trainer-feet elevated |
| Get up Get up to press with kettlebell | Get up high pelvis to bend with kettlebell | Get up post to high pelvis with kettlebell | Get up to half kneeling with kettlebell |
| Hip bridge 1 leg isometric hold hip bridge | 2 leg dynamic hip bridge | 2 leg dynamic hip bridge with shoulders on a bench | 1 leg dynamic hip bridge with shoulders on a bench |

### Day 2

| Exercise/movement pattern | Week 1-3 | Week 4-6 | Week 7-9 | Week 10-12 |
|----------------------------|----------|----------|----------|------------|
| Lunge Split squat with body weight | Split squat with kettlebell-goblet hold | Forward lunge with kettlebell-goblet hold | Forward lunge with 2xkettlebell in front of the chest |
| Hip hinge Hip hinge with elastic band | Romanian deadlift with kettlebell from a box | Romanian deadlift with kettlebell from the ground | Romanian deadlift with 2xkettlebell from the ground |
| Upper body pull Half kneeling row with resistance band | Suspension trainer row | Suspension trainer row with one hand | Suspension trainer row-feet elevated |
| Windmill Bodyweight windmill | Windmill with kettlebell | Windmill with kettlebell | Windmill with 2xkettlebell |

*Week 1–3: 16–20 rep., RIR 4, tempo 4-2-2 (ex.-iso-con.), 3 set, 60 seconds. rest, 4 session/week (2xday 1, 2xday 2), 10 minutes. Warm-up/40–50 minutes of training/10 minutes of cooling; Week 4–6: 12–15 rep., RIR 3, tempo 3-1-2 (ex.-iso-con.), 3 set, 90 seconds. Rest, 4 session/week (2xday 1, 2xday 2), 10 minutes. Warm-up/40–50 minutes of training/10 minutes of cooling; Week 7–9: 8–10 rep., RIR 2-3, tempo 2-1-2 (ex.-iso-con.), 4 set, 120 seconds. Rest, 2 session/week (day 1, day2), 10 minutes. Warm-up/40–50 minutes of training/10 minutes of cooling; Week 10–12: 5–7 rep., RIR 1-2, tempo 2-1-2 (ex.-iso-con.), 4 set, 180 seconds. Rest, 2 session/week (day 1, day 2), 10 minutes. Warm-up/40–50 minutes of training/10 minutes of cooling.
baseline values in the FMS total score between control and experimental group (MD=-0.159, p=0.518). However a significant difference was found after pre-test and post-test FMS total scores between groups (MD=-3.154, p<0.001).

**Discussion**

The main purpose of this study was to examine the effectiveness of 12 week, periodized FST program on FMS total scores in physical education students with baseline score ≤14. The FMS total score profile of volunteered students showed that 45% of them are at higher risk of sustaining an injury. Two meta-analysis confirm that FMS total scores ≤14 are associated with higher injury risk [6, 7]. It might indicate that participants with cut-off score ≤14 have poor movement competency due to limited joint range of motion, stability and movement control [2, 25–28].

The primary finding of this study was the significant time-by-intervention effects on FMS total score. There were significant differences within experimental group before and after training intervention (p<0.05) and between experimental and control group after the intervention (p<0.05). All participants in the experimental group increased their FMS total score above 14. This is the first study to examine the effectiveness of periodized FST on FMS total score in young active adults. The results were consistent with previous intervention studies that examined effectiveness of FST on movement competency in children [18, 19]. However previous studies did not used a periodized strength training program and participants were adolescents.

In this study a linear periodization was used. Periodized training programs were used firstly only in professional athletic populations, however today it is also widely used with untrained population and amateur athletes. Williams et al. [29] in their meta-analysis showed that periodized strength training programs are more effective in developing strength than non-periodized programs either in athletic and untrained population. Nonetheless, there is little evidence of periodized programs on FMS total score. Only one study by Cosio-Lima et al. [30] examined changes in FMS total score after periodized traditional strength training program. The researchers found no significant changes in FMS total score. Studies that also used traditional strength training demonstrated no meaningful FMS total score changes [18, 19]. Based on the results of the current research, periodized functional strength training (FST) is able to increase FMS total scores above cut off score ≤14.

**Table 2. FMS total score distribution in control and experimental groups pre testing and post testing conditions**

| Testing timeframe | TS | Control group (n) | Percent (%) | Experimental group (n) | Percent (%) |
|-------------------|----|-------------------|-------------|------------------------|-------------|
| Pre               | 12 | 2                 | 11.765      | 1                      | 6.25        |
|                   | 13 | 4                 | 23.529      | 3                      | 18.75       |
|                   | 14 | 11                | 64.706      | 12                     | 75          |
| Post              | 12 | 3                 | 17.647      | 0                      | 0           |
|                   | 13 | 5                 | 29.412      | 0                      | 0           |
|                   | 14 | 7                 | 4.176       | 0                      | 0           |
|                   | 15 | 2                 | 11.765      | 1                      | 6.25        |
|                   | 16 | 0                 | 0           | 6                      | 37.5        |
|                   | 17 | 0                 | 0           | 7                      | 43.75       |
|                   | 18 | 0                 | 0           | 2                      | 12.5        |

**Table 3. FMS total score changes within groups**

| Group             | n   | Pre (mean±SD)       | Post (mean±SD)      | MD (post-pre) | Difference ratio (%) | p      |
|-------------------|-----|---------------------|---------------------|---------------|----------------------|--------|
| Control group     | 17  | 13.529±0.717        | 13.471±0.943        | -0.058        | -0.03                | 0.777  |
| Experimental group| 16  | 13.688±0.602        | 16.625±0.806        | 2.937         | 1.56                 | <0.001*|

**NOTE:** Pre - tests before training intervention, Post - tests after training intervention, TS - FMS total score.
have indicated that FST can develop specific athletic performance variables such as counter movement jump, sprint time, agility or maximal strength as affectively as traditional strength training [18, 19, 21, 22].

One limitation to this study should be noted. There were no physiological fitness measures included in the study even though a periodized strength training was implemented. Changes in strength, power of lower and upper limbs as isometric strength and endurance of core muscles could have been included. It is highly recommended to do a follow up study to examine those physiological variables.

Conclusions
The study showed that there is a need for injury prevention program for students of University of Sport and Physical Education in Gdansk. Almost half of 82 volunteered students to the study were at higher risk to sustain a musculoskeletal injury due to cut off total score ≤14 on the FMS test.

According to the results of the research, FST is an effective method in improving low FMS total scores in young adults that are at higher risk to sustain a musculoskeletal injury. Future studies should examine the injury rate among students of physical education at sport universities and compare more modes of training in improving FMS scores.

Conflict of interest
The author declares that there is no conflict of interest.

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