Title:

Prevention of Musculoskeletal Injuries in Slovenian Armed Forces

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This was a two arm randomized control trial in which soldiers were randomized into control (N=41) and experimental (N=64) group. The sample size calculation was based on an expected difference of 25% in physical ability parameters (continous variables) between the intervention and control group. Assuming a Type I error (a) = 0.05 and Type II error (b) = 0.20, a minimum of 70 soldiers (35 per study group) was required to detect a significant increase of physcial abilities. Due to an expected "dropout/noncompliance rate" of 5% the total calculated number was 75 soldiers. Prior and following the intervention both groups underwent physical fitness testing. The effect of intervention was evaluated through the change in performance on those tests. Injury occurrence was followed for the period of one year from February 2017 to February 2018. Injuries were prospectively registered on a weekly basis.

Physical fitness testing

The PPT testing was performed in the gym of the SAF military post. All tests were conducted between 8 AM and 12 PM, and the actual arrival to the testing location was adjusted to daily routine and tasks of the soldiers according to a testing list provided by a commanding officer. Each testing group had 18 members, and they arrived at the gym 15 minutes before testing. The testing procedure was then explained and briefly demonstrated by an in- dependent military member that was not participating in the study. After the introduction all soldiers had 10 minutes to warm-up. The test battery started with either a jump test or pull-ups. The testing battery did not start with a single leg bridge test (SLBT) as this could potentially influence subjects' jumping or balance capacity. It was therefore performed as the third test together with a plank test (Figure 1). During the testing, all subjects were in combat SAF uniforms and were wearing standard SAF military boots. Where needed, body armors and helmets were used (total weight of 8.4 kgs). The testing battery is depicted in Figure 2.

Countermovement Jump (CMJ) Testing. To measure the magnitude and direction of forces during CMJ jumps, 2 Kistler force platforms (Kistler 9286AA; Kistler Instrument Corp, Winterthur, Switzerland) with custom-made ARS software (S2P, Science to Practice, Ltd., Ljubljana, Slovenia) were set up in parallel, so that the subjects could place each foot on 1 platform while performing a jump. The subjects started a test from an upright standing po- sition (Figure 2A) with hands held on hips, making a preliminary downward movement by flexing at the knees and hips, then im- mediately extending knees and hips again to jump vertically up off the ground. For the purposes of the current study, only CMJ height in centimeters (calculated from flight time) was used as an outcome measure. The CMJ test was performed in uniform and boots, and then, the same procedure was repeated with soldiers wearing body armor and a helmet (loaded CMJ; Figure 2B). Under each testing condition, a subject had 2 jump trials, and the repetition with the highest jump was used for further analysis.

Single Leg Bridge Test. The SLBT is a simple field test for ham- string function where soldiers initially lie down on the ground with 1 heel on a box 60 cm high (Figure 2E) as previously pro- posed (8). Subjects were instructed to push down through the heel to lift their bottom off the ground while holding their arms crossed over the chest. Consistent verbal coaching was provided throughout the procedure to ensure that the correct technique was maintained. Repetition was considered regular when the subject has touched the ground and has then extended his hip to 0° without resting on the ground. It was not allowed to use a non-testing leg to gain momentum by, e.g., by swinging that leg. The test was terminated when the technique became irregular or a subject could not proceed with the test due to fatigue. After a short break, the test was repeated for the opposite leg. The initial testing leg was randomly chosen for each subject. The number of successful repetitions for each leg was used as the outcome measure for further analysis. This testing protocol has been previously shown good to have excellent reproducibility with intra-rater intraclass correlation coefficient (ICC) values in the range of 0.77–0.89 and inter-rater ICC values in the range of 0.89–0.91 (8).

Loaded Prone Plank Test. For the prone plank test, subjects maintained a prone position in which the body mass was sup- ported by the toes and forearms (Figure 2F). The test was per- formed in a full army uniform while wearing body armor and a helmet. Subjects were instructed to maintain a neutral position of the spine and pelvis and to breathe normally during testing. Elbows were directly below the shoulders, and forearms and fingers were extending forward, while the feet were kept shoulder-width apart. To assist them in achieving a rigid neutral position, a wooden stick was used to help the align spine and

pelvis. Although we are aware that oscillation of the wooden stick may vary according to the anthropometry of the subject, we have successfully implemented the test as this was only an additional

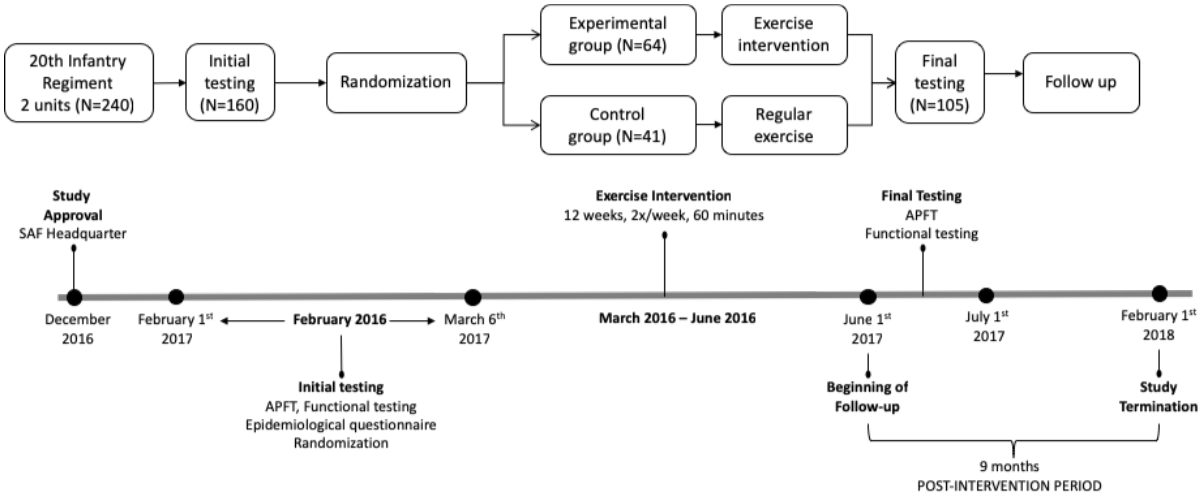
tool for subjects to better understand the required testing position. Each test was terminated when the subject was unable to maintain their posture or their pelvis moved up or down 5 or more centimeters. Each holding time was recorded using a stopwatch. The holding time (seconds) of the prone plank test was used for further analysis. The reproducibility of this test has been con- firmed in previous studies (30) with reported ICC values of 0.99 (95% confidence interval 0.98–0.99) and (coefficient of variation [CV]) 2.0 6 1.56%.

Pull-ups. The starting position for pull-ups was with arms fully extended and locked in elbows (Figure 2C), with an overhand grip, the body motionless, and feet off the floor. From this starting position, the subject was instructed to bend and cross- over the knees backward and then to pull-up over the bar until the chin has cleared the top of the bar without any excessive body motion. The body was then lowered until arms are again fully extended or locked out. One complete pull-up was counted when the subject's arms were locked out. This pro- cedure is repeated at the subject's own pace (rest between repetitions was allowed only in the full hang position) until the subject could no longer complete a full pull-up. The number of successful repetitions was used as the performance measure in this task.

Stork Balance Stand Test. The stork balance stand test is a single leg balance test with eyes closed. The testing position is single leg stance with hands on the hips, where the non-supporting foot is held against the inside knee of the supporting leg (Figure 2D). The subject is instructed to close their eyes, raise the heel off the floor, and balance on the support base of the anterior foot. The stopwatch was started as the heel was raised from the floor. The stopwatch was stopped if any of the following occurred: the hand(s) came off the hips, the supporting foot swiveled or moved (hops) in any direction, the non- supporting foot lost contact with the knee, or the heel of the supporting foot touched the floor. The total time in seconds for each leg was recorded.

Intervention

Experimental group was training according to specific 12 week functional training program (6 exercises, 2 times a week, progressive, functional), while control group trained according to standard SAF training routine. Standard SAF routine considers five 1-hour training sessions per week. In experimental group only 2/5 training sessions were modified.



Statistical Analyses

Mean values and SDs were calculated for all tests. The normality of data was checked using the Shapiro-Wilk test. For the MANUAL test, percentile ranks were reported. Multivariate analysis of covariance with post hoc Bonferroni correction for multiple comparisons was used to evaluate functional performance

differences in relation to APFT mark (range 2–5) while controlling for age and body mass. Levene's test of equality of error variances was used to check that the error variance is equal across groups. Chi square test was used to compare injury rates in experimental and control group. A significance level of 0.05 was used for each tes