AEROBIC AND NEUROMUSCULAR TESTS ARE REQUIRED IN EVALUATING THEIR PHYSICAL PERFORMANCE OF SOLDIERS IN OPERATIONS

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INTRODUCTION

Good levels of both aerobic and neuromuscular fitness are of great importance in order to ensure sufficient physical performance of soldiers. However, it is well-known that physical fitness, especially, cardiovascular fitness of adolescents has decreased by 8-12 % during the last 2-3 decades (e.g. Dyrstad et al. 2005; Santtila et al. 2006; Knapik et al. 2006). Leyk et al. (2006) have studied more than 58000 applicants for the German Bundeswehr. They have found that failure rates of the male volunteers had significantly increased since 2001 and more than 37 % of the participants failed to pass the physical fitness tests (PFT). Changes in neuromuscular fitness seem, however, to be controversy. Knapik et al. (2006) have reviewed that muscle strength has increased among US Army recruits between 1978 and 1998. However, in a population-based study, muscle fitness has decreased but later than aerobic fitness (Santtila et al. 2006).

The decreasing trend in physical fitness together with simultaneously increasing body fat is one of the greatest threats for public health as a whole. These developmental trends are particularly prominent among young people. Existing data shows that physical activity levels decrease during the teenage years and young adulthood, while the prevalence of inactivity increases (Leslie et al. 2001). Changes in social environments are often cited as explanatory factors for decreased physical activity among young people. For example, TV viewing has been shown to be significantly associated with obesity and decreased physical activity (Sidney et al. 1996). Furthermore, within the early years of adulthood, significant changes in life circumstances and social-economical background may strongly affect physical activity patterns (Leslie et al. 2001). On the other hand, work-related demands have changed dramatically, which definitely has an impact on physical fitness. A positive association has been found between heavy physical work and a high level of fitness in young workers. More specifically, better cardiorespiratory fitness, handgrip strength, and trunk muscle endurance have been observed among men doing heavy physical work compared to those doing lighter work (Tammelin et al. 2002).

As a consequence of a reduced amount of physical activity (occupational, household and leisure time activities) combined with a hypercaloric diet, increasing numbers of overweight and obese individuals, especially among children and teenagers, exist worldwide (Rocchini, 2002; Reilly et al. 2004). In the United States, the prevalence of obesity has nearly doubled in the 1990s (Weinstein et al. 2004), while at the same time the prevalence of type 2 diabetes and other obesity-related diseases has dramatically increased (Patrick et al. 2004).

The soldiers are recruiting from this same population of the youth. Therefore, the importance of physical fitness tests has increased while selecting capable soldiers, especially, for special forces. In the present study, we have compared laboratory and field tests performed in military environment.

METHODS

The conscripts (n=68) and reservists (n=783) volunteered to participate in the present study. Direct bicycle ergometer or treadmill running tests have been used as golden standard measurements of maximal aerobic capacity (peakVO_2 or VO_2max), while predicted VO_2max measurements are based on the assumption that there is a linear relationship between heart rate and VO_2 (Åstrand et al. 1954). In our VO_2max studies by a bicycle ergometer, the initial work load was 50 W. It was increased by 25 W every second minute until exhaustion (MILFIT/FitWare, AinoActive Oy, Helsinki, Finland). VO_2 was measured continuously using a gas analyzer (SensorMedics, Yorba Linda, California, USA) (Figure 1). Heart rate was recorded continuously by a heart rate monitor (Polar Electro, Kempele, Finland).

Furthermore, muscle strength and endurance are also important factors in many daily activities of soldiers. In the present neuromuscular tests, bilateral isometric maximal strength of the arm and leg extensors, grip strength, and muscle endurance (recording of the number of repetitions in one-minute push-up, sit-up and squat actions) were utilized (see Figure 1).

Figure 1. Maximal oxygen bicycle ergometer test (left), bilateral isometric strength test for the arm extensor muscles (middle), and push-up test (right).

RESULTS

Figure 2 demonstrates that in the first tests, the predicted mean (±SD) VO_2max value was 45.2±7.7 $ml \cdot kg^{-1} \cdot min^{-1}$, while the direct value was 44.8±8.5 $ml \cdot kg^{-1} \cdot min^{-1}$. The absolute and relative differences between the methods were -0.42 $ml \cdot kg^{-1} \cdot min^{-1}$ ($p=0.46$) and 0.9%, respectively. In the second test the predicted and direct VO_2max values were 47.4±6.7 $ml \cdot kg^{-1} \cdot min^{-1}$ and 48.7±7.3 $ml \cdot kg^{-1} \cdot min^{-1}$. The absolute and relative differences between the methods were 1.28 $ml \cdot kg^{-1} \cdot min^{-1}$ ($p<0.05$) and 2.7 %, respectively. VO_2max measured indirectly and directly correlated significantly ($r=0.80$-0.84, $p<0.001$) with each other (Figure 3).

The mean (±SD) maximal bilateral isometric strength for the leg extensors was 2917±878 N and for the arm extensors 898±201 N. Respectively, the mean (±SD) number of sit-ups was 38±10, push-ups 29±13, and repeated squats 44±9 repetitions per minute. Significant correlations were found between maximal strength of the arm extensors and repeated push-ups ($r = 0.58$, $p < 0.001$) as well as between repeated squats and VO_2max ($r = 0.55$, $p < 0.001$). No significant relationships were observed between maximal isometric strength of the arm or leg extensors and that of VO_2max.

Figure 2. Maximal oxygen uptake measured by direct bicycle ergometer (white bar) and predicted MILFIT protocol (black bar) during the first and ninth training weeks (* $p<0.05$) including changes in VO_2max with barrier line (**$p<0.01$).

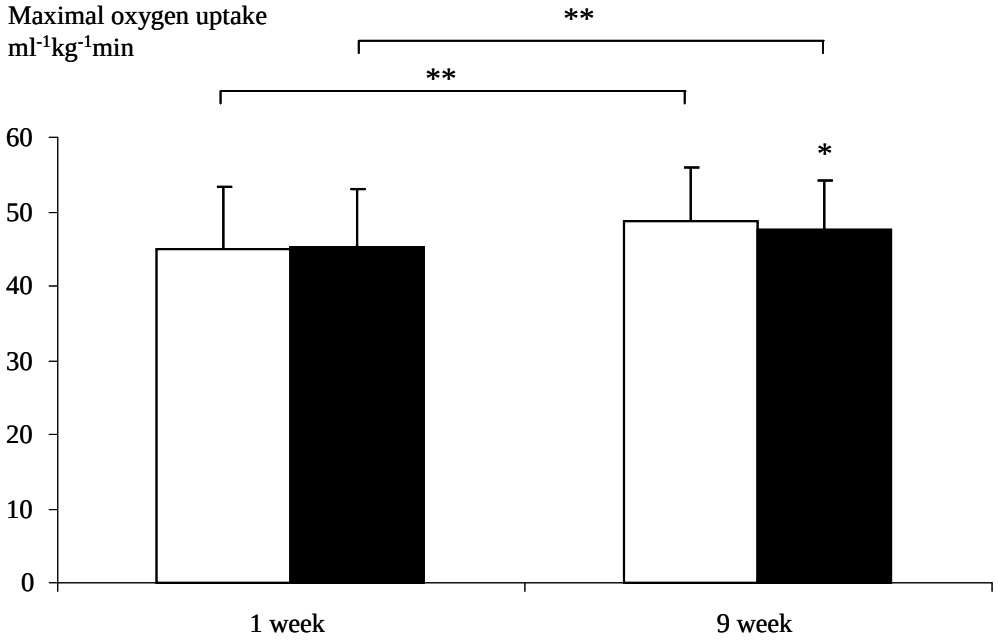
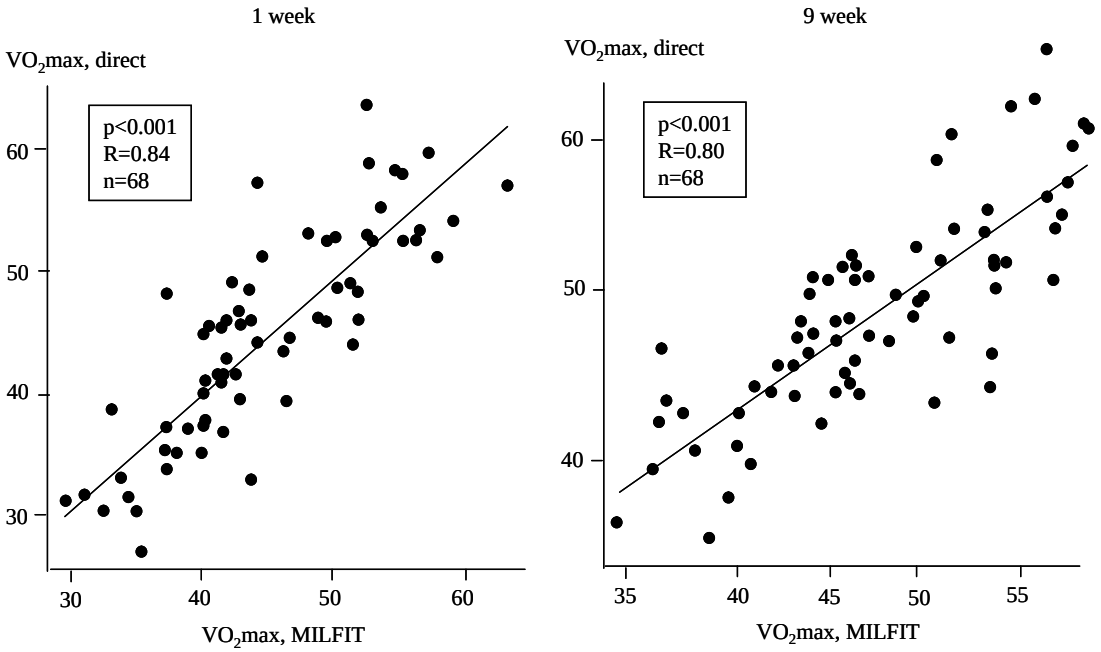


Figure 3. Relationship between the direct maximal oxygen uptake (VO_2max) and predicted maximal oxygen uptake (MILFIT, VO_2max) during the first and ninth week bicycle ergometer tests.



DISCUSSION

The present predicted VO_2max measurements only slightly over- or underestimated the VO_2max values of the direct measurements. Therefore, it can be concluded that our protocol is fairly accurate and valid to predict VO_2max values in male subjects. Nevertheless, in a large group of subjects with great interindividual variation in physical fitness, the muscle endurance tests such as push-ups, sit-ups and repeated squats seem to measure not only the level of muscle endurance, but also to some extent that of maximal strength. The relationship between maximal strength and muscle endurance was found in push-ups but not in repeated squats. However, the performance in repeated squats was related with VO_2max, whereas that of push-ups did not. In conclusion, the present muscle fitness tests seem to measure rather well the overall fitness profile of soldiers, and the contributive role of maximal strength could be indentified for the arm but not for leg extensor muscles.

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