ANTHROPOMETRY AND PHYSICAL FITNESS IN MALE AND FEMALE SOLDIERS AND THEIR CAPABILITY TO CARRY LITTERS

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INTRODUCTION

For a variety of occupations, such as field medical specialists who have to transport stretcher patients without ergonomic aids in rough terrain, an evaluation of physical fitness prior to specialist training appears to be necessary. This may protect the employee from overburdening by and from excess demands by the employer.

Although there is some information available on the ability to carry loads (1,2) especially with respect to possible spine injuries (3), so far the data has not been correlated to more easily measurable predictors such as weight or stature (representing overall muscular strength) or isometric or isokinetic strength. Findings that hand grip endurance amounts, at best, to 15% of the maximum strength (1,4) have shed doubts on female capabilities of carrying litter patients (5). Comprehensive studies of female military fitness have been published (6,7). The data, however, cannot be applied to the Bundeswehr Medical Service, since selection and recruiting procedures might vary in addition to possible methodological or ethnic differences.

METHODS

All 75 female and 60 self-selectedmale recruits of 4 different training cycles volunteered for the study. The measurements at the beginning and at the end of 10 weeks of basic military training (BMT) included weight, stature, sitting height, reaching height and body fat (skinfolds) (8,9). Isometric force was measured (baseline leg-chest–back dynamometer; Bücker, Sinzheim GE) in 4 positions: lifting from the squatting position; lifting from a height of 38 cm; lifting from the hip position; pressing upward from the shoulder position, together with right hand and left hand isometric grip force (Sadly Hand Dynamometer; Steeling Corp., Wood Dale, IL, USA). Carrying the patients was simulated either by sand bags weighing 60 to 90 kg on a stretcher (weighing 14 kg) or 2 water cans with equivalent weights for each hand. Successively increasing stretcher or water can loads had to be carried around an indoor volleyball court (55 m). Heart rate (Polar Elektro, Finland) was measured together with the time needed for the individual rounds. In some soldiers, 02 consumption was monitored using a telemetry system (AERO-Sport, USA). All data was entered into data sheets and further processed using the MS Excel and SPSS PC+ statistics program. Statistically significant differences are seen at $P < 0.05$.

RESULTS AND DISCUSSION

The study was designed as a "before and after test." Therefore, dropouts due to injury or other causes (e.g., other duty, retirement) could not be compensated. Thus, only data of recruits who participated in both measurements (55 females and 36 males) will be presented.

The anthropometric results are comparable to other published data (6,7). The changes of body weight, body fat amount and lean body mass of men and women during BMT were below 5% and statistically insignificant. This difference to previous studies (6) may be attributed to both the design of BMT and the short time period between the measurements.

The maximal isometric forces measured in the 4 different lift positions, both at the beginning and the end of BMT, are shown in Table 1, together with the

Table 1. Maxim isometric forces[1] at the start (S) and end (E) of BMT

Men	Right hand	Left hand	Squat position	38-cm position	Standing position	Shoulder level
Start of BMT[2]	549.9	513.4	1,447.0	1,608.3	944.5	1,547.8
	± 11.4	±13.3	±41.9	±42.8	±32.9	±69.2
End of BMT[2]	581.0	534.4	1,544.5	1,587.0	1,046.1	1,612.9
	± 12.4	± 12.3	± 46.8	±46.6	±37.6	±45.9
t-test, $P <$	0.066	0.245	0.120	0.735	0.044	0.429
S/E (%)	105.05	103.80	106.07	98.39	109.84	105.21
Women						
Start of BMT[2]	351.0	322.3	898.1	968.5	486.4	922.5
	± 6.5	±6.7	±20.7	± 25.3	± 10.3	±33.7
End of BMT[2]	368.4	337.8	1,025.8	1,004.7	586.6	1,081.4
	±6.6	±7.1	±22.6	±25.7	± 16.3	±37.0
t-test, $P <$	0.061	0.112	0.000	0.313	0.000	0.002
S/E (%)	105.0	104.8	114.2	103.7	120.6	117.2

[1]Force in Newtons. N = 36 male and 55 female recruits
[2]Values shown are means ± SEM.

maximal isometric handgrip strength values for men and women. The differences between men and women are statistically highly significant, which is not true, however, for all of the differences between beginning and end of BMT.

After BMT, women showed marked (> 10%) and statistically significant increases in strength during lift from the squatting, the standing positions and while pressing from the shoulder level position. These increases were less pronounced in men. In either group the slight differences of the handgrip strength readings did not reach the statistical significance level.

While all males were able to carry the simulated 90-kg patient at an average speed of 0.38 m/s, only 33 out of 75 female recruits were able to do so at the start of BMT (average speed 0.31 m/s). At the end of BMT, the number had improved to 29 out of 55 women. This improvement from 35% to 53% can be attributed to

the general conditioning during BMT. Heart rates rose during the carrying test to 168 ± 15 or 181 ± 11 bpm (males, females, respectively; means SEM). After BMT, the heart rates in both groups were lower; in males, however, the difference did not reach statistical significance. In females, the time needed to complete the carrying task was significantly reduced. During stretcher carrying, the O_2 consumption approached > 25 $ml \cdot min^{-1} \cdot kg^{-1}$ equivalent to 83% of maximal VO_2 in the females and documents the high workload posed on the young women.

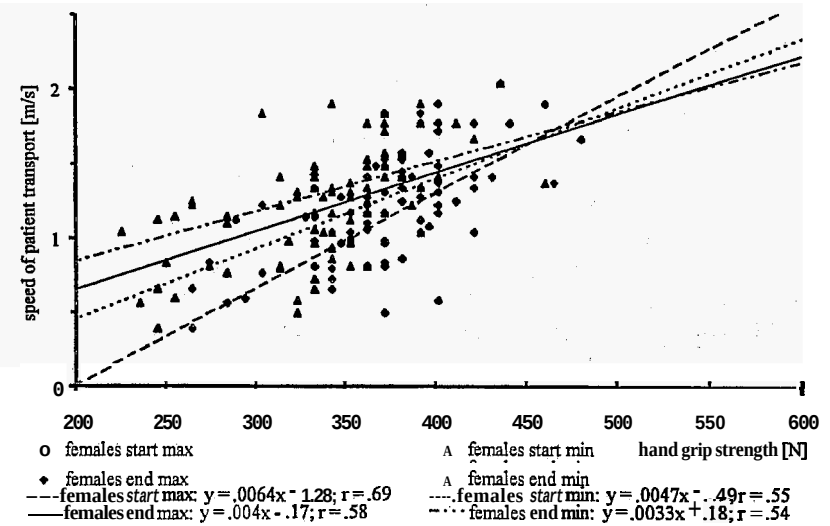

Figure 1. Correlation analysis of speed while carrying a simulated 80-kg patient as determined by isometric grip strength of the stronger (max) or weaker (min) hands in 55 female recruits prior to and after BMT (start, end, respectively).

Out of a correlation matrix prepared to evaluate various possible predictors, the handgrip strength showed the strongest correlation with load carrying and transport speeds. The correlations turned out to be much stronger in females than in males, while there was no difference between the values of the respective stronger or weaker hand (max, min in Figure 1) or of the time of measurement.

CONCLUSIONS

Measurements of various isometric force values revealed that the handgrip strength was the best predictor for the capacity to carry a simulated 90-kg patient. It is, therefore, suggested to administer a hand strength test prior to field medical specialist training in order to channel unsuited candidates to other career fields. Alternatively, special carrying training may be administered in order to prevent overburdening the young women.

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