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AN EVALUATION OF PHYSICAL TRAINING EFFECTS IN THE DEVELOPMENT OF OCCUPATIONAL PHYSICAL SELECTION STANDARDS

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ABSTRACT

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DCIEM has been tasked to develop Occupational Physical Selection Standards (OPSS) with the aim of preselecting recruits to physically compatible military trades. Selection will be based upon the predictions of future performance from the physiological parameters of anthropometry, endurance and strength as evaluated by a battery of tests and measures. Administration of the battery at the Recruiting Center (prior to Basic Training) has been proposed. The question at hand has involved the effects of the Basic Training Program upon the development of OPSS in the event that the Recruiting Center is eventually selected.

This paper has addressed the Basic Training issue through a review of the literature. The training effects upon the OPSS predictors of anthropometry, endurance and strength have been evaluated with the additional consideration of anaerobic capacity. The analyses have yielded very confusing data which have been attributed to variabilities in training, testing, subject pools and experimental designs across studies. Very limited data were available specific to the Canadian Forces (CF) Basic Training Program and the OPSS battery of tests and measures. It is, therefore, recommended that a longitudinal study be conducted on a group of male and female CF recruits in order to evaluate the effects of CF Basic Training upon the test battery parameters. Selection standards may then be adjusted, as required, to ensure the valid preselection of recruits to specific military occupations.

INTRODUCTION

DCIEM is currently conducting a study to establish Occupational Physical Selection Standards (OPSS) for each trade in the Canadian Forces (CF). Identification and quantification of the physical demands of the tasks within each military trade are being completed. Concurrently, a battery of candidate tests and measures is being developed with respect to the physical attributes of anthropometry, endurance and strength (1). Future work will involve the identification of the battery tests and measures that best demonstrate a practical, predictive relationship with task performance for each military trade (1). These selected tests and measures will be subsequently employed in the development of OPSS.

The administration of a physical test battery and the application of trade specific physical standards will provide the CF with a valuable screening device. It will allow for an economy of time and resources by training only those individuals with a high probability of success for any given trade and screen out those individuals who are likely candidates for injury or attrition due to physical inability. Ultimately, the preselection of recruits to physically compatible military occupations will be achieved.

Three of the possible locations for the administration of the test battery are: a) the Recruiting Center; b) Basic Training Camp; c) Trades Training School. In the event that the Recruiting Center is selected consideration must be made of the physiological effects, if any, of the Basic Training Program yet to be imposed. Adjustment of physical standards may be warranted to account for a training effect provided detraining is not a consequence of trades training and trade assignment.

This paper focuses on the physiological effects of various training programs through an examination of the literature. Of primary concern are military populations, specifically those which have undergone the Canadian Forces Basic Training Program or one of a similar nature. The physical attributes of anthropometry, endurance and strength are explored in keeping with the scope of the OPSS battery of candidate tests. In addition, anaerobic capacity is reviewed for purposes of possible future consideration.

REVIEW OF LITERATURE

A review of the literature pertaining to the physiological effects of training has yielded confusing results. The wide range of pre-post training changes may be largely accounted for by two factors. One is the variation in subject pools with respect to age, sex and initial fitness level. The other is the variation in training programs with respect to intensity, frequency, duration and mode of exercise. Other contributing factors to consider are inconsistencies in experimental design and statistical analyses. In light of the above restraints, general tendencies have been identified for each of the parameters under review. All data have been represented as percent changes for purposes of standardization.

Anthropometry

The significance of anthropometry in the development of OPSS lies in the role of body dimensions in muscle mechanics and movement requirements within workspace environments (1). Of the numerous measures employed across studies stature or height, body weight, lean body weight and body fat are those most consistently reported. Since adult height is usually reached by the age of 18 years for both sexes and that subsequent growth is very slight (2), it has been assumed that training of adult, CF recruits will not significantly affect this measure of anthropometry. Consequently, height has been excluded from the present investigation.

The greater part of the literature has indicated no significant change in body weight for either males (3-16) or females (6,7,9,14,16,18-20) in response to a training program. Select studies have indicated increases (20-24) in body weight for males up to 6% (23) and decreases (17,20,25,26) to 2.5% (25). Females have demonstrated a range of body weight increases (10,20,23,24,26,27) to 8% (23) and a decrease of 1% (5).

The limited data available on detraining have ranged from no effect (8,13,28,29) to a 3.5% increase (8) for males. Less consistency was found in the detraining effects for females with three studies revealing 1.9% decrease (27), no effect (19) and 2.7% increase (30).

The effects of training upon lean body weight are those of increases (4,6,10,12,13,16,21,23,24,26) up to 6% (23) for males and similar increases (6,10,16,23,24,26,27) up to 6% (10,23,24) for females. A limited number of studies have also indicated no effect of training upon lean body weight for both males (3,12,25) and females (7). Although both sexes show a majority of increases from 0-6%, as previously noted, female data tend to lie at the upper end of this range while male data tend to lie at the lower end. It, therefore, appears that females respond to training with slightly greater increases in lean body weight than males.

Detraining was found to reduce lean body weight for both males (13) and females (27). A detraining period of 20 days of complete bed rest following normal physical activity resulted in a 1.5% decrease in lean body weight for males in a study conducted by Saltin and Blomqvist et al (13). Smith and Stransky (27) found a similar decrease of 1.5% with their female subjects when subjected to a 7 week period of normal activity following an equal time period of training. Despite similarity of subject pools across these two studies the variability in experimental designs does not allow for valid comparison across the sexes.

When represented as a percent change or as a total of skinfold measures in millimeters, a differential response to training between males and females was revealed with respect to body fat. Males were seen to respond with greater decreases in body fat in the range of 10-22% (3,4,6,7,9,10,12,14, 16,20,23,24,31). A few studies (12,20,21,25,26) have indicated either no effect or percent decreases in the range of 0-10% . An extreme value of a 6% increase was found by Bertina (22) in studying the effects of Basic Training on the Netherlands Army. Although this finding seems to support the contention that body fat increases with training the results are most likely confounded by the cross-sectional nature of the study. Females were found to respond to training with either no effect (7,9,14,18,20,27) or reductions in body fat (6,7,10,16 18,23,24,26) up to 14% (23).

Of the few studies reviewed that have examined the effects of detraining upon body fat, males have shown a range of increases from 0-29% (28,31). Similarly, females have shown no effect (27) and increases (23) in body fat back to a pretraining level.

Overall, it appears that the anthropometric changes incurred from a period of training or detraining have manifested themselves as body fat changes and lean body weight changes. Males tended to show greater percent changes in measures of fat while females showed their greater percent changes in measures of lean body weight. Total body weight, on the other hand, appeared to remain relatively constant over time for both sexes.

Endurance

The evaluation of cardio-respiratory endurance provides a valuable index of one's ability to sustain submaximal work over a period of time. Since this type of aerobic demand may be a factor in the success of military trade task performance it has been included in the OPSS study.

A common measure of endurance is that of maximal oxygen uptake, ie. VO2max. An analysis of studies employing direct and indirect methods of assessment via the treadmill, cycle ergometer, step test and Cooper's run has yielded variable results for both sexes. Male populations have shown from no change (6,7,11,23) to increases up to (4,9-11,17,20,25,31-33) and including 14% (32) in response to training. Select studies have indicated increases in the range of 17-30% (3,5,8,14,20,21,34,35). Increases as high as 32% and 94% are reflected in the Saltin, Blomqvist et al (13) study on the effects of 8 weeks of training following 20 days of complete bedrest. When viewed in terms of percent increases from the control condition (pre-bedrest) these improvements are reasonably reduced to 5% and 33% respectively.

An analysis of the effects of training upon VO2max in females has revealed a range from no significant change (9,20,33) to increases (6,7,10,23,27,32,36) up to 14% (32). These findings support the contention by some authors (5,7,10,32,36) that females respond to training with similar relative improvements as males. Other studies have indicated a range of improvements from 24-46% (5,14,18,19). This evidence of a slightly greater training response in females is believed to result from their lower initial fitness levels (14).

Detraining has been shown to reduce VO2max up to 32% and 23%, respectively, for males (13,23,31,32,34) and females (19,20,23,30,32,36). A slight increase of 1.1% has been indicated for males in a study by Barlet (29) on the German Federal Armed Forces. The author has attributed the increase in VO2max to enhanced post-test efforts as a result of tester motivation. Allen (34) conducted a longitudinal study on the aerobic capacity of male Royal Military College cadets over a period of 3.5 years. The improvement of maximal oxygen uptake by 23% over the first academic year was attributed to the highly physical nature of their indoctrination. Summer training further increased VO2max to a fitness level 30% above that at entry to the college. The second year resulted in a marked decline in VO2max back to a pre-training level. With further training VO2max increased and stabilized at a level 12% above that at entry. Fringer and Stull (19) and Pedersen and Jorgensen (36) suggest that an equal time period of detraining following training is sufficient to negate any training effect incurred.

Run distance and run time are alternate measures of endurance that have been employed within the literature. Distances run by males during Cooper's 12 minute test, as investigated by Bertina (22) and Viitasalo and Vainikka (15), have indicated a 4.5% increase and a no effect respectively. Run time for distances of 1-3 miles has been used extensively in military fitness evaluations (4,6,7,10,18,20,21,25) and has revealed improvements in a range of 5-14% (4,6,7,10,20,21,25) for males and 7-15% (6,7,10,18,20) for females. These results appear to be in keeping with the slightly greater improvements by females with respect to maximal oxygen uptake.

Strength

The majority of military tasks that are classified as physically demanding are those involving one or a combination of manual materials handling activities (1,37). These activities are of six basic types: lifting; lowering; pushing; pulling; carrying; walking (1,38). Since a major component inherent in each of these activities is muscular strength (38), it is the third and, possibly, most important physical attribute under consideration in the OPSS study.

Muscular strength can be defined as the maximal force muscles can exert in a single voluntary effort (39). This effort may be of either static or dynamic nature. Whereas static strength denotes virtually no change in muscle length and limb angle, dynamic strength is characterized by movement throughout a total range of motion (2,40,41). Much confusion, however, has resulted from the adoption of different definitions, terminologies, procedures and interpretations with respect to strength and it's evaluation (39). It is well established that strength is a function of several factors: muscular capability; health; motivation; experience; training; testing device; body position; body support (39). Due to the highly specific nature of strength and the general lack of standardization across the literature the data provided within are greatly confounded. For purposes of this investigation the categorization of strength as either static or dynamic has been based upon the nature of the testing rather than the nature of the training, as often the two were not congruous. A prime example of this involves the analysis of static strength. Despite its popularity as a mode of testing (4,12,15,16,23,24,26,31,33,42) only one of the studies reviewed (44) indicated static strength exercises as part of the training program.

The effects of training upon static strength have been compiled from various studies assessing a diversity of muscle groups and employing the following test apparatus: spring dynamometers; strain gauge dynamometers; cable tensiometers; load cells. Several measures of static strength have indicated no effect of training in either males (12,15,23,26,31,33,42) or females (23,26,33) although increases also have been found in ranges of 4-26% (12,16,23,24,26,31) and 9-30% (16,24,26),respectively. Greater increases up to 44% (12) have been reported for males involved in isokinetic training, ie. muscular contraction at constant speed, while an extreme value of 70% has been reported for arm extensor strength (33).

Data on the effects of detraining upon static strength are limited to a cross-sectional study (31) on military personnel. A comparison of recruits who had completed Basic Training with those subsequently involved in job specialty training has revealed static strength differences up to 29%. Statistical significance was not indicated.

The effects of training upon dynamic strength have been examined separately for measurements of a calisthenic nature and those employing an external resistance. Analysis of the latter has involved a further distinction between strength testing procedures that are isokinetic and those that are isotonic, ie. muscular contraction with a constant load.

The modes of calisthenic exercise that have been adopted by different investigators in the evaluation of dynamic strength are situps, pushups, pullups, chinups, flexed arm hang, wall climbing and rope climbing. Performances on these tests have shown improvements ranging from 0-36% (14,21,22,26) for males and 0-23% (14,18,26) for females. Robertson (26) has reported a 205% increment in pushup performance of female recruits consequent to a 7 week military training program.

Detraining effects upon dynamic strength have been investigated by Stamford, Weltman et al (14) on a population of police recruits. Performance scores on the two arm pullup and the flexed arm hang, for males and females respectively, increased significantly over recruit training. However, a re-evaluation following one year of active police service revealed significant decrements in their dynamic strength performances.

The indicator of isotonic strength encountered most frequently within the literature is that of the maximum weight lifted in one or a small number of repetitions. Investigations involving this mode of testing have indicated increases as a result of training in a range of 5-30% (12,16,43,44) for males and 11-29% (16) for females. Rasch and Pierson (42) conducted a study on male college students in which isotonic strength was represented by the sum of weights used in four upper body exercises. The imposed weight training program resulted in a 40% increment over the 6 week duration. Lesser increments ranging from 0-7% (12,22) have been indicated for males when throwing performance scores have been used as an isotonic strength measure. Improvements in the isotonic strength of females have been indicated in a study by Bell, Gill et al (18) in which the percentage of passing scores for a fireman's carry increased from 44% to 78%. No data were found on the effects of detraining upon this parameter.

Despite its present exclusion from the OPSS candidate test battery, dynamic isokinetic strength and it's response to training have been included in this review. Data analysis has been limited to two studies (12,45) both of which employed isokinetic devices in the training program and in the testing procedures. Michael and Parrish (45) found 24% and 45% increases in the leg extensor strength of males and females, respectively, subsequent to a 4 week isokinetic training program. Significant increases were evident by the end of the second week of training for both sexes. The authors account the difference in improvement between the sexes to the lower initial strength of females and, possibly, to a lower white to red muscle fiber ratio. They, further, have questioned the contribution of learning in the isokinetic strength improvements. Pipes and Wilmore (12) found improvements in isokinetic strength ranging from 0-79% for subjects both trained and tested in that mode and up to 8% for those trained by isotonic methods.

Anaerobic Capacity

At the beginning of physical work and during work of moderate to heavy intensity the demands for energy can not be met sufficiently by aerobic metabolism. Under these conditions anaerobic processes are brought into play and are of increasing importance as the severity of the workload increases. At near maximal effort work time is limited to a few minutes as energy stores become depleted and lactic acid accummulation induces muscular fatigue. This type of effort, though not predominant in most ordinary daily occupations (46), may be of greater significance in a military situation. The value of considering anaerobic capacity as a fourth physiological parameter in the OPSS study, therefore, remains of question.

A review of the literature with respect to anaerobic capacity has yielded very little data particularly with regard to females. Only three studies set out to evaluate the effects of training and detraining upon this parameter and did so via hand ergometry (26), cycle ergometry (35) and blood analysis (29). Alternative indices such as broad jump, vertical jump and running dash performances have also been considered for purposes of this review. None of the mentioned studies employed training methods specific to the development of anaerobic capacity. Nonetheless, the collective data have revealed increases as a result of training, ranging from 0-7% (12,21,22,35) for males. Robertson (26) found a greater increase of 17% for males and a corresponding 13% increase for their female counterparts. It may be that the improvements noted in tests of anaerobic capacity were largely reflections of aerobic capacity and strength gains as a result of training. This suggestion is made in light of the predominant aerobic and strength demands of the training methods employed and the questionable validity of purely anaerobic tests.

The effects of detraining upon anaerobic capacity are limited to one study (29) on males of the German Federal Armed Forces. It was found that a detraining period of three months subsequent to 6 weeks of Basic Training did not significantly affect this physiological parameter.

CONCLUSIONS

The application of OPSS will involve the administration of a test battery to CF recruits in order to predict future physical performance of specific military trades. Because training subsequent to recruiting may affect performance it may be necessary to make adjustments in the initial selection standards to account for this effect.

This paper has addressed the issue of Basic Training through an examination of the literature with respect to the training effects upon anthropometry, endurance, strength and anaerobic capacity. The analyses have yielded highly variable results for each parameter. This variability has been attributed to inconsistencies in such factors as training, testing, subject pools and experimental design. Very limited data were available specific to the CF situation and the OPSS battery of tests and measures.

In light of the above, it is recommended that a longitudinal study of male and female CF recruits be completed in order to evaluate the effects of the CF Basic Training Program upon the test battery parameters. Selection standards may then be adjusted, as required, to ensure the valid preselection of CF recruits to specific military occupations.

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