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ANALYZING PHYSICALLY DEMANDING JOBS: THE CANADIAN FORCES APPROACH

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ABSTRACT

The need for an objective system to match individuals to physically demanding occupations has become evident in the Canadian Forces (CF). A research program is underway to develop appropriate selection standards for incoming CF personnel. A task analysis methodology was employed to determine the physical requirements for individual occupations. It was shown that the useful quantitative data could be gathered and compared to recommended guidelines for manual work (in particular lifting tasks). Over 130 separate tasks were analyzed and recommendations were made regarding when and how ergonomic strategies could improve worker selection and performance.

INTRODUCTION

Despite increasing technological advances in the industrial workplace, there are still significant requirements for manual work in many areas. Thus, the need for an objective system to match the physical abilities of individuals to the physical requirements of occupations is required. Within the past few years high attrition and training costs, advances made by women in non-traditional occupations and the impact of recent human rights legislation on employers in Canada, have accounted for this issue becoming increasingly important.

The Canadian Forces (CF), one of the largest employers in Canada, is not exempt from these considerations. Over the past few years an intensive program has been underway to develop physical selection standards for individual military occupations or trades, with the objective of better utilization and increased productivity of its personnel.

The underlying research philosophy was to match the physical capabilities (strength, muscular endurance, anthropometry) of the potential user population with the actual job demands. This approach has been utilized in previous military and industrial research programs. The U.S. military services (USAF, Army, USN) have stated that their standards should be based on objectively determined physical demands of each occupational specialty (Ayoub et al., 1979, Vogel et al., 1980). Several industrial-based studies have concentrated on identifying the most limiting task(s) from the range of activities possible in the job context (Norman et al., 1983, Arnold et al., 1982). The intrinsic physical demands have been determined in these studies through questionnaire surveys and interviews with job supervisors, reviews of job specification literature, and on-site observation and evaluation.

This paper describes the methodology used to analyze specific military jobs for eventual development of appropriate trade related entry standards for the CF.

METHOD

Data Acquisition

Previous research has established that pre-employment selection criteria should be objectively based on actual job demands. Identification of physical demand was achieved in three phases:

1) an initial open-ended questionnaire completed by trade incumbents and supervisors;

2) follow-on interviews with 4-6 active trades personnel to verify the responses from the questionnaire; and

3) on-site evaluations of representative tasks for each trade.

i) Questionnaire. The questionnaire survey was designed to develop an inventory of those tasks which required significant physical effort or imposed significant anthropometric restrictions on the trade population (Saunders et al., 1982). It was administered to 20-30 personnel of each trade, representing a wide variety of experience, rank and geographic location and was organized into four sections:

1) personal data;

2) identification of physically demanding tasks performed as part of the daily duties (distinctions were made between trade-specific duties and general military duties). Equipment used, working conditions, and the specific restrictions involved were described, as well as subjective impressions of level of task difficulty;

3) subjective responses regarding trade physical requirements (standards) such as height, weight, arm and leg strength required; and

4) details of any specific anthropometric problems, imposed by the equipment or

workplace, which might necessitate operator size limitation.

ii) Interviews. There was an effort to interview individuals with different military backgrounds so that their collective experience would encompass the various trade posting locations and related equipment. The primary goals of these Subject-Matter-Expert (SME) interviews were to:

1) verify the trade task lists documented in the questionnaire survey;

2) obtain general information about the structure and duties of each trade; and most importantly

3) identify and quantify (subjectively) 3-5 tasks representative of the average physical demand of the trade (i.e., if recruits could cope with these demands, they could handle the majority of the physically demanding duties associated with the trade).

Examples of the type of data collected during the SME sessions are listed in Table 1.

TABLE 1

Data Collected During Interviews

A. SME Description

1) Rank
2) Years in Trade
3) Gender
4) Previous Postings

B. Task Description

1) Type of Activity
2) Object Description
3) Weights
4) Distances
5) Repetitions
6) Duration
7) Rate

C. Workspace Considerations

1) Distances (i.e., vertical, horizontal, area)
2) Body Position
3) Absolute angle of force

D. Conditions

1) Number of People Required
2) Environment
3) Clothing
4) Equipment Variability

In those trades with diverse physical demands, selection of representative tasks was accomplished by applying the following criteria:

1) select tasks representative of the physical demands imposed upon individuals during their training for entry level trades;

2) select tasks that involve a high percentage of personnel in the trade;

3) select tasks that are performed frequently;

4) select tasks where the workload requirement of a single person could be easily determined; and

5) select tasks that require a minimal use of mechanical aids.

iii) On-Site Task Evaluations. The objective was to obtain quantitative data, in situ, on the tasks identified as representative for each trade during the interviews. Extensive data were collected for each task to precisely define task conditions, and to identify limiting task characteristics. It had become evident from the questionnaire and interviews that the majority of the physically demanding tasks involved lifting and carrying of materials. This was also found in the U.S. military studies with lifting and carrying accounting for greater than 70% of all activities (McDaniel, 1978). Thus, in order to delimit the scope of the program, only those tasks involving lifting and carrying were analyzed (tasks involving pushing, pulling, torquing, climbing, digging and the like were not quantified).

Requirements for task quantification during this phase were as follows:

1. that each task be demonstrated by experienced personnel under controlled conditions;

2. appropriate measurements of object weights and dimensions, critical distances and workspace dimensions, and positions of load in reference to the operator; and

3. photographs and video tape recordings of task performance were taken.

Data Reduction

Lifting and biomechanical models were used to evaluate the physical demand of these jobs in relation to norms established for other (industrial) populations. They also represented an objective method of determining whether these tasks were actually physically demanding (i.e., outside recommended limits for a majority of the population).

NIOSH Lifting Model. This model is used to analyze the physical demands of lifting tasks (NIOSH, 1981). It presents recommendations to control the various types of hazards (fatigue, injury, etc.) associated with the unaided act of two-handed (symmetric) lifting of objects of definable weight and size. These recommendations are quantitative and are specific to safe load

weights, object size, location and frequency of handling for a given situation. It can also be used to indicate when selection and training are necessary, and when engineering controls to job design/redesign can be implemented.

To determine the hazards associated with a specific lifting situation, two limits [action limit (AL) and maximum permissible limit (MPL)] are provided based on epidemiological, biomechanical, physiological, and psychophysical criteria. Analyzed lifting tasks may thus be of three types:

1. those above the MPL should be viewed as unacceptable and require engineering controls (job design/redesign);
2. those between the AL and MPL are unacceptable without administrative (selection and training) or engineering controls; and
3. those below the AL are believed to represent nominal risk to most industrial workers.

Static Biomechanical Model. A computerized, static biomechanical model is also being utilized in specific instances to predict joint torques and spinal compressive forces for individuals in specific job postures (Norman, 1983). Outputs are expressed in Newton-meter torques (including direction) at each joint and lumbar spinal compressive and shear forces in Newtons. These lumbar spinal compressive forces can also be compared with maximum tolerance values for compression as outlined by NIOSH (1981).

In addition, this model can estimate stresses for actions other than lifting (i.e., push/pull, etc.). It is particularly useful in identifying the most limiting posture/action within a single task (i.e., beginning, middle, or end of lift sequence).

RESULTS AND DISCUSSION

From the questionnaire survey, 1163 tasks were identified as physically demanding, of which approximately 70% involved lifting and carrying activities (Saunders et al., 1982). Of those tasks, 848 were trade specific and the balance comprised 31 different tasks common to more than one trade (315 occurrences). Each task was listed by trade and subsequently catalogued in an inventory of tasks.

After validation interviews and on-site evaluations, the task list was reduced to 126 separate trade-specific tasks and five common tasks (with greater than 10 trades involved) (Celentano and Nottrodt, 1983). The analysis showed that 70 trade specialties (70%) had significant physical requirements, representing over 75% of the population.

As can be seen from Table 2, greater than 95% of the criterion tasks involved lifting and carrying (including lifting). This result was not totally unexpected, as the USAF found in a preliminary interview study of eleven specialties that 90% of the tasks described were manual materials handling activities (MMHA) (McDaniel, 1978). This confirms that a majority of the tasks with significant physical demands have a small set of common task elements, (lifting, lowering, carrying, push, pull) as defined from analyses of civilian jobs (McDaniel, 1978). It was also shown that of the quantified tasks, 65% were performed more frequently than once per week.

TABLE 2

Distribution of Tasks by Physical Activity

Activity	n
Lifting	102
Carrying (including lifting)	23
Push/Pull	3
Torque/Turn	1
Hold/Position	2

The NIOSH model data were used to compare the predicted output (AL and MPL based on CF task conditions) with the actual job demands (load weight). Of the 131 tasks analyzed (Table 2), 107 could be compared directly to this lifting model. From these tasks, 31 had actual load weights below the AL, 59 were between the AL and the MPL, and 17 were above the MPL. The predominance of tasks (greater than 85%) below the MPL suggest that selection and training strategies would be effective (NIOSH, 1981).

The lifting and static biomechanical models will assist in the job redesign process (where indicated) by identifying which job factors are most limiting. Particular job redesign strategies could include optimizing work-rest schedules, introduction of mechanical aids, use of more than one person for heavy work, adjustment of frequencies of activities, and improved design for containers and objects that must be manually handled.

CONCLUSIONS

The methodology proved effective in identifying and quantifying representative physically demanding tasks within jobs. Emphasis was placed on (triple) redundancy for accuracy of information, even though most stages were primarily subjective in nature. Our analysis has shown that lifting and carrying were predominant and as a result pre-employment selection tests and on-the-job training should concentrate on these activities. Muscular endurance was, perhaps surprisingly, not as great a factor in critical job demands (i.e., in terms of repetitive materials handling). The models demonstrated where selection, training, and job design techniques can be applied to improve the selection of personnel for trades.

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