DEVELOPING UPPER BODY STRENGTH FOR WOMEN IN THE CANADIAN FORCES

Final Report

Submitted by

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Executive Summary

This report has focused on the issue of upper body strength in women in the CF. It has included:

- A preface that discusses the issue of upper body strength of women in the CF as reported in the 2006-2007 Annual Report on EXPRES testing in the Canadian Forces.

- The benefits of improved upper body strength for women in the CF in addition to job performance including:

  - Increased muscle mass that increases energy expenditure for achieving and maintaining an optimal body composition.
  - Improved physical performance in recreational and daily living activities.
  - Enhanced bone strength and reducing the risk of osteoporosis.
  - Stronger ligaments and tendons to reduce the risk of injury.
  - Decreased risk of cardio-vascular disease.
  - Improved self-esteem and confidence.

- A discussion on the different types of strength and their relevance to upper body strength requirements of females in the CF; particularly:
  - *Absolute strength*: this is important for tasks that require moving or lifting heavy fixed loads.
  - *Relative strength*: this is important when moving or lifting your own body weight such as in the push-up test. Having a higher than optimal fat mass can reduce relative strength and hinder performance in tasks that are dependent on this type of strength.
  - *Strength endurance*: this is important for many types of repetitive tasks including the push-up test. It is influence by both absolute and relative strength of the muscles that are doing the work.

- The physical factors that affect upper body strength and development in women such as:
  - The amount and type of muscle available. The more muscle mass and the more high force generating type of muscle [fast twitch], the greater is the ability to produce force. These are both lower in the upper body musculature than in males.

- The ability to increase the muscle mass and strength in the upper body of women. The muscle mass, the amount of fast twitch muscle and the strength of the muscles are all increased in females who undertake that use variation, high resistances, multiple sets, and frequencies of 2-3 times per week.
- The importance of body composition in strength type tasks particularly those that require good relative strength and strength endurance.
- The center of mass in females is different than in males and differs between females depending on differences in skeletal anatomy and the distribution of fat mass in the chest, abdominal, and hip regions. Those with higher hip to waist ratios and who are heavy-breasted will need to emphasize the development of the core musculature of the trunk and lower back in order facilitate the lowering and raising of their center of mass in the plank position during the push-up test.
- The best nutritional strategy for women in the CF who want to improve upper body strength and meet or exceed the MPFS is to follow the Top Fuel for Top Performance manual for a balanced diet and energy balance.
- Training at different times in the menstrual cycle is not a factor in strength development for women.

- The psycho-social factors that affect upper body strength and development in women such as:
    - Reluctance to initiate and adhere to a resistance training program. This has been shown to be influenced by: history of success and self-efficacy; observing successful models or self-modeling; by reasoned action and planned behavior; and by the training environment.

      Strategies should include helping members to: form the intention to do resistance training; develop a positive attitude toward resistance training; to know the expectations of others; acquire some control over the training schedule and environment; acquire knowledge about training principles, equipment, and culture; to be involved in creating an environment that is welcoming, supportive, and comfortable.

    - Reluctance to train at the intensity and volume necessary to improve upper body strength. This can be due to; misconceptions about the effects of resistance training; the perception that resistance training is a masculine endeavor; the perception that the resistance training environment is hostile or uncomfortable.

A focus group suggested a number of strategies such as: privacy in the testing area; learning about training, the equipment, and the weight room culture in a non-threatening environment; making time in the facility available to train with other women; providing time during the work day to train; changing parts of the training facility to make it more gender neutral; scheduling classes for novices, women only, and/or families.

- Strength and occupational performance of female military personnel were shown to be related. Effective programs should embrace variation, be at least 3-6 months in duration and can include task specific training along with body weight and free weight exercises.

- General training principles were discussed and related to programs to improve upper body strength in female personnel in the CF. These principles included: training by objectives; safety; adaptation; progression; specificity; individualization; maintenance; recovery/rest/regeneration; skill; periodization.

- Specific training principles for improving strength developed through research and professional practice were discussed. The principles focused on the manipulation of 6 acute training variables and the relationship to developing upper body strength in female CF personnel. These variables were: the muscle actions including concentric and eccentric phases of an exercise; loading and volume including the magnitude of the resistance, the number of repetitions, number of sets, and number of exercises; exercise selection and order of execution with special reference to single and multi-joint exercises; rest periods between sets; the tempo or rate of eccentric and concentric phases of a contraction including the pause between these 2 phases; weekly frequency of training.

- In conclusion, this report includes information from a review of the existing scientific and professional practice literature and addresses information garnered through the Annual Report on EXPRES testing, the CFHLIS survey, and a focus group convened from amongst military and PSP staff.

It documents that a vast majority of CF personnel [97.7%] can and do pass the MPFS and, in particular, 96.6% of female personnel pass the upper body strength component including push-ups. The literature supports this and shows that the current strength standards are well within reach of all non-obese healthy females.

This report, the literature, and the focus group conclude that there are a number of psycho-social variables that should be addressed to insure that females are provided with the best possible environment to improve their upper body strength [and other fitness components] to and beyond the MPFS.

This report also addresses the physical variables that can impact on strength development in women and presents principles and direction for insuring that time invested in training results in optimal improvements in the physical capability to perform the EXPRES test, successfully complete the 5 common tasks, and reach even higher levels to enhance their occupational performance, lifestyle, and health. It recommends that the prescriptions offered in the newly developed WebEXPRES should act as the foundation for programs to enhance the upper body strength of females in the CF and, in particular, those who fail to meet the strength component of the MPFS. These recommendations have been incorporated into the WebEXPRES program for women in the CF who have failed the muscular strength and endurance portion of the EXPRES test.

Preface

The information in this preface is meant to address the issue of the upper body strength of women in the CF as reported in the 2006-2007 Annual Report on EXPRES testing in the Canadian Forces.

This information was based on the CF EXPRES test results submitted to Human Resources during the reporting period. It also includes selected information from the 2004 Canadian Force Health and Lifestyle Information Survey [CFHLIS] to augment selected data in the Annual Report. The information in the CFHLIS was obtained from a random sample of both regular and reserve personnel. These data are from 2999 regular personnel of the 4842 who received the survey and returned it [61.9% returns]. When data are reported from the CFHLIS it is indicated with italics, otherwise the data are from the Annual Report

In 2006/2007 [Annual Report], the total strength of the force was 63,783 [55,307 males and 8,476 females]. Of these, 70.1% [44,704] were tested on the MPFS, the LFCPFS [28,736] or were exempt [15,968] because they met incentive levels in the previous year. The other data for the other 19,079 [29.9%] were *unavailable*. The reasons for the unavailability included those who were tested but data had not yet been received or entered by Human Resources, and those were not tested which would include those who were deployed or in the process of deployment. This could account for some of the discrepancy between the annual report and the CFHLIS

The CFHLIS reported only 12% of the force as untested on CF EXPRES and did not include members of LFC who normally do the LFCPFS .

Of the 44,704 tested or exempt, 13.2% [5,881] were women and 86.8% [38,823] were men. Of the 19,079 not tested, 13.6% [2,595] were female and 86.4% [16,484] were males.

Of the 44,704 tested or exempt, 97.7% [43,665] either met or exceeded the MPFS/LFCPFS and 2.3% [1,039] failed to meet the standard.

The CFHLIS reported the overall pass rate to be 95.6 %.

The pass rate for women according to the annual report was 96.6% [5,682] and the pass rate for men was 97.8% [37,983]. The percentage failure for women was 3.4%

[199] and for men it was 2.2% [840]. This is strong evidence that the vast majority of women in the CF can and do pass the MPFS.

Records of which items were failed are not recorded with the Human Resource Management System.

The CFHLIS reported a pass rate of 96.3% for males and 90.1% of females who returned the survey. 69.9% of males who failed one or more components of the EXPRES test reported failing the aerobic test while 30.1% failed the strength component. Conversely, 43.3% of females failures were on the aerobic test and 70% reported failing the strength component.

These data from the Annual Report are summarized in the table below. [For the data from the CFHLIS see table 6.9 p. 67 in that report].

	Total #	% Male	# Male	% Female	# Female
National Force	63,783	86.7	55,307	13.3	8,476
Untested	19,079	86.4	16,484	13.6	2,595
Tested & Exempt	44,704	86.8	38,823	13.2	5,881
Met MPFS or LFCPFS	43,665	97.8	37,983	96.6	5,682
Failed MPFS or LFCPFS	1,039	2.2	840	3.4	199

If a member fails either the strength or aerobic component of the MPFS, they are given 3 months to offset the weakness and be tested again. The member is allowed 3 further EXPRES test failures each followed by up to 12 weeks of remedial training [DAOD 5023]. If the member fails the 4th consecutive test, the member is granted the opportunity to pass the standard on the 5 Common Tasks, if medically cleared, before being released from the force [although only 2 such tests have been administered in the past 2 years].

These data raise a number of issues:

- The percentage of males and females in the *data unavailable* group is the same as in the regular force and in the group that was tested. Therefore there is no gender issue regarding this population. However, this group makes up 30% of the force. There is no information on why the data for these personnel are unavailable but includes those that did complete the test but the results did not get to Human Resource Management for inclusion in the data base or were deployed or in the process of deployment. Therefore, non-compliance would be much lower than the 30% reported in the Annual Report.

[*This is supported by the CFHLIS where only 12% reported not completing the test*].

Other reasons that completed test data did not get included in the data base could be:

- missing the sampling time and therefore the test will be completed within the next year;
- a chain of command problem in not insuring the member is tested or failing to submit the results. This could be both for MPFS and the LFCPFS;
- loss or misplacement of data between the testing site and records at Human Resource Management;
- logistical reasons for delays in testing or submission of data such as changing base location.

  When the data for 30% of the force is unavailable it should be a serious concern for the chain of command. It would be helpful to know why this group is so large and if there is a relationship with other categories such as rank, trade, or base. However, there does not seem to be an age or gender link to the untested category. This type of analysis would help in both understanding the nature of the problem and developing solutions.

- The high pass rate across the force [97.7%] could suggest a number of things:

  - The force is very fit and the fitness programs within the CF are very effective. This does not seem to be the case in anecdotal reports from the chain of command.

    - The standard is too low and although the pass rate is high, the fitness of the force is being over estimated.

      This suggests that the standards should be re-evaluated on the MPFS and linked to the standards on the 5 Common Tasks. A good place to start would be to determine the false negatives and false positives when predicting success on the 5CT with the MPFS.

It is interesting that the only two tests used in the LFCPFS [weightload march and casualty evacuation] are not heavily loaded on upper body strength. Therefore there could be an upper body strength issue in LFC but it is not being evaluated. The recent inclusion of the trench dig in the LFCPFS at many bases should change that.

  - If the standards in the MPFS [and LFCPFS] are reasonable, then the high pass rate could reflect that the standards are not being adhered to in the testing or reporting. If fitness is important in the CF, then there should be oversight in the testing and reporting of results and rigorous adherence to protocols and standards.

- The pass/fail rate on the MPFS/LFCPFS for males [97.8%] and females [96.6%] is high and virtually the same. This should indicate that there is no need for a special program for women to enhance their upper body strength. There is no data in the Annual Report as to the reasons why personnel fail the MPFS.

  The CFHLIS data showed the failure rate for females to be much higher [9.9%] than the 3.4% in the Annual Report. Why self-reporting would result in this discrepancy is not known but if the higher failure rate is real and in combination with the 70% reported failures on upper body strength, the rationale for a special upper body strength program for female personnel is more compelling.

  The similar pass rate for males and females could also be due to different standards for males and females on the MPFS. The same pass rate does not mean that upper body strength is the same in both groups or even that it would be sufficient to meet the strength components in the 5 Common Tasks or that upper body strength in female personnel [and some males] doesn't need improving to effectively carry out their jobs.

- The failure of 3.4% of females [and 2.2% of males] on the MPFS may or may not be due to failing the upper body strength items on the test but, if it is, the problem may not be upper body strength but rather too much body fat. This will decrease the relative strength and decrease the ability to perform push-ups. The CF does not record data on body composition so if high body fat is the cause of the poor performance, it cannot be determined and the proper program initiated. High body fat could also be a significant reason for failures of both men and women on the aerobic component of the MPFS.

Body composition data should be acquired when a person does not pass the MPFS to determine the extent to which body composition contributes to the failure and to design the appropriate program.

The negative effect of increased body fat on performance of the EXPRES test was underscored in the CFHLIS that showed 74% of CF males and 41% of CF females were either overweight [52% M; 28% F] or obese [22% M; 13% F]. This was based on BMI calculated from reported heights and weights. The report highlighted that as BMI increases, exemption rate falls, excusals for medical reasons increase, and failures of one or more components of the EXPRES test increase.

- The 3.4% of women who were tested and failed the MPFS is 199 women out of a total of 8,476 in the CF [5,881 tested or exempt]. This seems to be a very small number for whom to establish a special program when we do not know how effective the current remedial programs are. There is no current way to record this information so the data does not exist. This small number of failures in the female population is underscored by only administering (2) 5 Common Task tests over the past 2 years. This suggests that current remedial programs are very effective in correcting fitness deficiencies. However, we do not know how many members who fail to meet the MPFS repeatedly fail and then undergo remedial training each time. This data would be helpful in assessing the effectiveness of the remedial programs.

  The very high pass rate and negligible failure rate, especially after remedial training, further emphasizes that the passing standard is very achievable by virtually all healthy female personnel in the CF.

  The test results filtered for age categories shows that of the 1039 failures, 44.5% [462] were in the under 35 years of age category and 54.3% [564] were in the 35-55 age group. The remaining 1.2% [13] was 55+ years of age. Data on the different age groups within both gender categories would be very helpful in localizing problems within both age and gender groups. The 44.5/54.3 % split for the under and over 35 age groups would suggest that age isn't a significant factor but it is possible that the age effect could be more predominant in the male or female groups.

- The lack of data available to PSP to assess the fitness of the force and to evaluate the effectiveness of remedial programs is a problem that should be resolved since this is a mandate of the PSP.

Therefore, although by the numbers it seems that the issue of upper body strength in female personnel in the CF may be perceived rather than real, the issues of low [and different] standards, use of a predictive test, a large number of untested personnel, and the lack of recorded information to evaluate the issue can mask an underlying problem.

The rest of this report will address the strategies and rationale for a program to enhance the upper body strength of female personnel in the CF because such a program can be a benefit to both those preparing for a test or re-test, as a resource for PSP staff, or for those who desire to improve their upper body strength to improve their job performance, health, and/or recreational enjoyment.

1. Introduction

1.1. The CF Universality of Service Principle

This principle dictates that all CF members must maintain a minimum physical fitness standard [MPFS] to remain in the CF.

There are many physically demanding tasks that challenge CF personnel in either their day to day job performance or in emergency situations that require pushing, pulling, lifting from above, hoisting from below, supporting, carrying over various distances, digging, traveling by foot for various distances carrying loads and recovering for repeat efforts etc. These have been documented and investigated to determine the nature of the physical demands they impose on personnel and the ability of the members to meet these demands is evaluated by the CF Five Common Tasks [DAOD 5023]

- Land evacuation;
- Sea evacuation;
- Low/high crawl;
- Entrenchment dig;
- Sandbag carry.

The requirement to perform these tasks is independent of gender, occupational classification, and rank.

Due to time, expense, and logistics, these tasks are not routinely assessed on CF personnel. The MPFS was established as a relatively cost effective, easily administered, predictive battery of standard fitness tests that were highly correlated to the Five Common Tasks. All of the Five Common Tasks have a significant requirement for upper body strength and strength endurance and thus there are two and possibly three elements in the MPFS that assess this type of fitness – push-ups, hand-grip strength, and sit-ups. The prediction of success on the Five Common Tasks was found to differ between the two gender [female and male] and two age categories [<35 years and 35+ years] on the different elements in the MPFS. Therefore, the MPFS are both age and gender specific.

1.2. Benefits of resistance training for women in the CF in addition to job performance.

There are many health and performance benefits of resistance training for women in the CF that have been reported in addition to that of meeting the MPFS:

- Increased muscle mass that elevates metabolic rate and contributes to achieving or maintaining an optimal body composition. Since increasing or decreasing the fat stores in the body is a direct consequence of energy balance, increasing the mass of a high metabolic tissue like muscle will increase the energy expenditure side of the equation and assist in maintaining or reducing fat mass.

- Improved physical performance in recreational and daily living activities. Many recreational pursuits require upper body strength to perform skills, resist injury and permit the desired intensity and frequency of participation. Similarly, there are many activities in daily living that involve lifting, supporting, pushing, pulling etc. that would be more readily accomplished with improved upper body strength.

- Enhanced bone modeling to increase bone strength and reduce the risk of osteoporosis. Resistance training has been shown to be one of the means for enhancing bone strength and reducing the risk of osteoporosis. This is not only important in peri and post- menopausal women but resistance training in pre-menopausal years has been shown to accrue benefits to bone health throughout the life span.

- Stronger connective tissue around joints to improve joint stability and prevent injury. Resistance training elicits changes in connective tissues such as ligaments and tendons that give them increased tensile strength which provides both joint stability and a resistance to injury during physically demanding tasks, sport, and recreation.

- Decrease in many risk factors for cardiovascular disease. Periodized resistance training programs bestow protection from cardiovascular disease by reducing risk factors such as total cholesterol, reduced low density lipoprotein and increased high density lipoprotein, lower triglycerides and the lowering of marginally high or high blood pressure.

There is also evidence of improved insulin sensitivity and reduction of risk factors for Type II diabetes. When these are combined with reduction in body fat, the health benefits from resistance training are further magnified.

- Improved self-esteem and confidence. This has been reported both as a result of the changes in body composition that occur as result of resistance training but also in association with the successful performance of resistance training exercises and completion of the program. The changes in body image seem to be the primary reason for the improved self-esteem but improved confidence as a result of mastering this type of training and of performing effectively in this training environment have also been reported.

2. What is Strength?

Strength is the ability for muscle to generate force in a specific movement. It is usually expressed in three different ways:

2.1. Absolute strength:

This is the *maximal* force that can be generated by the muscles that are recruited in a particular movement. This type of strength is important when heavy, fixed loads must be moved. Whole body absolute strength in women has been shown to be lower than men [approx 60-65%] as well as their upper [approx 45-55%] and lower body absolute strength [approx 70-75%]. There is a large variation in the reported values due, in part, to measurement techniques using different movements, at different speeds, and with different instruments but the differences do exist and are more pronounced in the upper compared to the lower body. These differences between men and women can persist, even after similar resistance training programs.

2.2. Relative strength:

This the maximal force that can be generated by the muscles that are recruited in a particular movement expressed relative to a person’s body weight. This type of strength is important when tasks require lifting, lowering or moving your body. There is still a substantial difference between women and men in strength relative to body weight in the upper body but the relative strength difference is reduced in lower body movements when compared to differences in absolute strength.

The push-up test in the MPFS is a measure of the ability to raise and lower your own body weight and therefore is a measure of ***relative*** strength/endurance rather than ***absolute*** strength. Since it is primarily the upper body musculature that generates the force in the push-up, the reduced relative strength in the upper body of females can make it more difficult to perform this task than for males.

Note that increases in absolute strength will increase relative strength as long as body weight does not increase or does not increase to a point where the increase offsets the gain in strength. Note also that decreases in body weight can increase relative strength without a change in absolute strength.

Relative strength is also expressed relative to fat free body mass to factor out differences in body composition between men and women. In this case, most studies report differences in upper body strength between the genders as somewhat reduced but still substantial [approx 65-75%] while lower body strength becomes similar [90-100%]. However, some have reported that when lower body strength is expressed as relative to lean body mass, the difference between genders, although reduced, still exists [85-95%]. This reduction in the relative strength difference compared to absolute strength is attributable to the higher fat mass in women than in men.

Relative strength has also been expressed relative to the cross-sectional area of the muscle which allows a comparison of muscle tissue alone without the confounding effects of other tissues such as bone and fat, etc. These studies show that differences in lower body strength are no longer evident and the relative strength in the upper body is almost the same [95%] and any differences are likely due to differences in the proportion of high force generating muscle cells [fast twitch] to low force generating muscle cells [slow twitch].

2.3.Strength Endurance

This is the ability to perform repeated repetitions of a particular movement with a submaximal load. This is related to both absolute strength [the stronger a muscle, the lower a fixed submaximal load will be when expressed as a % of maximum – therefore more repetitions of that load can be accomplished] and relative strength [as relative strength increases, the more repetitions of exercises that involve moving the body can be accomplished.

Since targets for push-ups involve doing repeated repetitions of raising and lowering body weight, improvements in absolute strength, relative strength, and strength endurance of the upper body musculature in women will enhance their performance of this test.

3. What factors can affect upper body strength and development in women?

3.1. Physical Factors

3.1.1. The amount of muscle available to develop force in upper body movements.

Since force generation [strength] is proportional to the cross-sectional area of muscle, the amount of muscle mass is directly related to the strength of those muscles. Women have less muscle mass than men and this difference is more pronounced in the upper body. It is unclear at this time whether women possess fewer muscle cells per muscle in the upper body but each cell is smaller than for a male in the same state of training. This is probably due to lower levels of the anabolic hormone, testosterone, but is also due to less regular involvement in moving high resistance type loads.

3.1.2. The type of muscle available to develop force in upper body movements.

Force production is also highly related to the type of muscle cells that are activated. The proportion of slow [low force generators] and fast [high force generators] muscle are directly related to the strength of those muscles. The proportion of fast to slow type muscle cells is lower in females than in males and this further reduces the strength and power capability in women. Also, the size of the slow twitch cells in the motor units of female muscle is often larger than the fast twitch cells whereas in men, the cross-sectional area of the fast-twitch is larger than the slow. This has been attributed to the lower loads that women, in general, move on a daily basis which results in less hypertrophy of the fast muscle cells. Since it is the fast motor units that generate the highest forces, the lower number and cross-sectional area of the cells in these motor units magnifies the difference in strength between the genders, particularly in the upper body.

The lower upper body muscle mass in women and the higher slow twitch/fast twitch cross-sectional area ratio suggests that in order to maximize strength gains, higher resistances should be incorporated into women's resistance training programs to recruit the fast motor units and stimulate increases in size of these high force generating units.

3.1.3. The ability to increase the muscle mass in the upper body.

Research in this area is somewhat equivocal but many studies have reported similar increases in muscle cross-sectional area and in all muscle fiber types in 8 to 12 to 20 weeks of resistance training in both genders.

In women, however, increases in the cross-sectional area of muscle do not seem to result in large increases in circumference of limbs or other regions of the body.

Some have also shown that with a periodized resistance program [see p. section 5.10 below] in combination with endurance training, fat mass was decreased, with small or no change in lean body mass but an increase in strength. This is attractive for those women who want improved strength without changes in body segment size. Those women who do show substantial increases in muscle mass and body size likely have higher than normal levels of anabolic hormones, lower estrogen to testosterone ratios, larger increases in anabolic hormones in response to training, or an ability to complete higher intensity and volumes of resistance training.

Women who follow a periodized, multi-set resistance program [3-6 months] show some increase in testosterone levels that were correlated to increases in muscle size and strength. Similarly, the same program produced a rise in the testosterone/cortisol ratio which would enhance the anabolic [growth] environment for muscle. This stimulus for increased muscle size is further enhanced by increases in growth hormone that are higher in response to multi-set vs. single-set programs.

The growth hormone increase is further augmented when rest periods between successive sets are short [1 minute].

Therefore, a resistance training program designed to increase size of the muscles [and therefore the strength] in the upper body of women should include programs that are periodized [see section 5.10 below], have high resistances, and include multiple sets.

3.1.4. The ability to increase the size of the fast twitch muscle cells.

The smaller size of the fast twitch muscle cells in untrained women in relation to both their slow twitch muscle and to the size of fast twitch in males suggests that there is a greater potential to increase the size of these high force generators in the upper body of women. The cross-sectional area of both fast and slow twitch muscle cells have been shown to increase in the lower body of women following resistance training but the evidence that the increases occur to the same extent in the upper body of women is less compelling but does indicate that the size of the fast twitch will be enhanced especially with programs that feature heavier loads and a variety of joint actions that utilize the same muscle groups in different movement patterns.

It has been reported that, following up to 6 months of non-periodized low-volume [single set] resistance training, the increases in women's strength levels off, whereas periodized, higher volume [multiple-set] programs show continued improvements in strength. This underscores the importance of *heavy loads* [to recruit and load the fast twitch motor units], *periodized* and *multi-set* programs to elicit progressive strength improvements in upper body strength in women.

3.1.5. The ability to increase strength in the upper body.

The *rate* of strength gain has been shown to be similar in women and men when following the same training program. However, men generally demonstrate greater *absolute* strength gains while women show similar or greater gains in *relative* strength. This is particularly important when a goal of the resistance training program is an increase in the ability to do push-ups – a task that relies on relative strength.

Since the push-ups are a *relative strength*-type task, as the mass of an individual is increased, fewer push-ups can be performed unless the forces generated by the muscle are also increased. If upper body strength is increased through an increase in the size of the muscular, the increased ability to generate forces by the larger muscle more than off-sets the increase in mass. However, if the body mass is increased by increasing the fat mass, then the ability to perform this *relative strength*-type task is decreased. Conversely, a decrease in fat mass alone can increase relative strength without a change in the force generating capability of muscle.

This highlights how important body composition is to the ability to perform tasks that are dependent on relative strength. When a goal of a resistance training program is to improve performance on a task [push-ups] that requires a specific amount of relative strength, then the objectives should be both an increase in strength and the achievement of an optimal body composition.

For those individuals who are carrying a significantly high amount of fat mass and cannot meet the MPFS push-up standard, their remedial program should offer strategies to reduce fat mass through diet and exercise as well as a program to improve absolute and relative strength.

Although women do show significant strength gains after up to 6 months of resistance training, absolute strength has been shown to still be lower than for untrained males. Continuing to elicit gains in both relative and absolute strength beyond a few months requires adherence to a periodized, multi-set resistance exercise program.

3.1.6.Distribution of the center of mass.

The center of mass in females is different than for males because of differences in skeletal anatomy and in fat distribution in the hip, abdominal, and chest regions.

This can result in the need to give a greater emphasis to developing core strength in women to enhance their ability to meet the MPFS push-up standard. Core strength is the strength of the trunk musculature and is particularly important in providing a bridge between the upper and lower body while holding the plank position, offering stability to the lumbar spine, and transferring momentum from the upper body "push" to the center of mass during the push-up.

The altered center of mass for heavy-breasted women and those with large hip to waist ratios will require that core strength and the strength of the triceps and pectoralis muscles will need to be stronger to meet the MPFS standard for push-ups than those who are not.
Therefore, to make women stronger in the upper body and core to handle differences in center of mass, a program needs to:

- include heavy loads [<10RM], high volumes [3^+ sets], and a frequency of 3 times per week;
- include exercises that challenge the core and upper body strength;
- include variety:
  - in the selection of exercises [single and multi-joint, concentric-eccentric-isometric];
  - in how the load is applied [free weights, machines, body weight, partner resistance];
  - in joint actions [flexion-extension, abduction-adduction, rotation, unilateral-bilateral];
  - planes of movement [frontal, lateral, sagittal];
  - body positions [sitting, standing, kneeling, stable, unstable]

Therefore, the scientific literature, the literature on best professional practices, and the data from the Annual Report on CF Expres testing strongly suggest that women in the CF can and do meet the standards for upper body strength. Following the physiological principles for training and strength development will insure that the target is reached and exceeded in the most effective way.

3.1.7. Nutrition

There are some nutrition issues that are common between genders and some that are unique to women that should be considered when prescribing nutritional strategies for females involved in strength training.

- The balanced diet is the foundation for health, fitness, and performance in both sport and physically demanding occupations. This insures all the cells and tissues are bathed in the required nutrients, fuels, water and energy supply. This is well articulated in the CF manual Top Fuel for Top Performance.

- Women have been shown to use less glycogen during resistance exercise and use more fat both during and following a resistance training session than do their male counterparts. They are less responsive to carbohydrate supplementation for replacing glycogen following exercise.
- Like men, strength training females require more protein than sedentary or endurance training females to build muscle.
- Hypohydration has been shown to reduce strength, strength endurance, and power in both men and women.

Therefore, women who are using resistance training to build strength should be encouraged to:

- follow the principles of the balanced diet as outlined in the Top Fuel for Top Performance manual and workshops;
- match increased energy expenditure with a greater emphasis on proteins and healthy fats [rather than high carbohydrate] before, during and especially after training;
- always be well-hydrated for both training sessions [to maximize the loads and volumes] and testing sessions [to maximize performance];
- be cautious about the use of supplements including creatine monohydrate. Although a number of studies have recommended creatine supplements for women to enhance recovery from resistance training sessions in the short term and to promote muscle building in the longer term, this practice should not be encouraged until long term deleterious effects have been ruled out.

The fundamental nutritional strategy for women in the CF who are pursuing improved upper body strength is to follow the directions in the Top Fuel for Top Performance manual for a *balanced diet* to provide sufficient fuel, building blocks and fluid and *energy balance* to achieve an optimal body composition.

3.1.8. The menstrual cycle

Although elevated estradiol level in the follicular phase has been linked to greater muscle building and higher levels of cortisol and, elevated progesterone in the luteal phase has been associated with increased breakdown of muscle, the use of a *menstrual cycle triggered training plan* has not received much support. This type of plan features high frequency, high volume, high resistance in the follicular phase and reduced loads and frequency in the luteal phase. Although this has theoretical attraction, most of the research suggests there is no difference in strength and/or power outputs in females over the different phases of the menstrual cycle.

However, changes in mood, water retention, and energy level occur in some females in the pre-menstrual period [and other phases as well] which can reduce their ability to perform optimally. Therefore, it may be helpful to some to offer flexibility around testing and re-testing times.

3.2. Psycho-social Factors

3.2.1. Reluctance to initiate and adhere to a resistance training program.

This is often due to *low confidence* in their ability to successfully initiate and/or complete a resistance training program. An individual's belief in their capability to plan and initiate a resistance training program to improve their strength is fundamental to its success. Social psychologists refer to this capability as "*self-efficacy*" and have shown it to be a cornerstone for converting a plan into action. This confidence is based on many different factors, some of which are:

3.2.1.1. History of Success and Self-efficacy

History of success in completing a task can affect self-efficacy. The *mastery* of the task and its lead-up activities is important in establishing the will to initiate and adhere to a program. Females, as a group, have not had the same exposure to performing resistance training exercises as males and that can affect their *self-efficacy*.

> Creating experiences in this environment that are positive, challenging, and rewarding should enhance the will to train and to continue the experience. The feelings of success or joy in training or testing environments are stored in memory along with the actual experience and will enhance confidence.

Helping females develop challenging yet achievable short-term goals, then positively reinforcing successes or rewarding small improvements in performance and technique will enhance self-efficacy and improve their motivation to initiate and adhere to the program.

3.2.1.2. Observing the success of others and self-modeling

Observing success of others who have been in a similar situation or who possess similar physical characteristics has been shown to be important not only for improving personal confidence but for offsetting any early lack of success.

Also, some have shown that *self-modeling* can also be effective in building confidence. This involves repeatedly visualizing the successful completion of the training experience as well as visualizing the successful completion of the task.

Therefore, to improve confidence in accomplishing the upper body strength training program, it is helpful to use identifiable *models* that have had success in both the process of undertaking a program and in the successful outcome of achieving the MPFS and/or to help participants develop the ability to visualize their own successful performance of the training or test.

3.2.1.3. Reasoned action and planned behavior

The willingness to initiate and adhere to an upper body strength training program can also be affected by "*reasoned action*". This assumes that people behave rationally by considering all available information and implications before making changes to their behavior.

The *theory of reasoned action* proposes that successful initiation and adherence to a behavior depends on;

- setting an intention to do it;

- the attitude one has towards the activity;
- the perceived expectations that other significant people have of the individual; and
- the degree of control that the individual perceives they have over the situation

Therefore, to facilitate the initiation and adherence to an upper body strength training program, the CF should develop strategies for:

- helping members to form *the intention* to do this type of training by getting them to record the intention and helping to reinforce it regularly;
- helping members establish a *positive attitude* both to training and improved strength by presenting the additional benefits such as health, self-esteem, and lifestyle;
- helping females become aware of *the expectation* of the chain of command and other members that they successfully complete the training and MPFS; and
- providing the female members with a degree of control over training times, locale, and the format of the training

The *theory of planned behavior*, however, suggests that the likelihood of forming a strong intention to undertake a strength training program is directly related to whether or not a particular member of the forces believes they have the *resources or opportunities to be successful*.

Therefore, to facilitate the successful initiation and adherence to an upper body strength training program the CF needs to provide and/or reinforce the resources and opportunities that are available to female members for improving their upper body strength.

These would include:

- how to set goals;
- how to set intentions and link these intentions to actions;
- examples of successful achievement in strength training by their peer group;
- visualizing good training techniques and the successful performance of tasks in the Expres test;

- the principles that guide exercise prescriptions for achieving different goals;
- different types of equipment and safe operation;
- the culture and practices in a resistance training environment;
- the benefits of resistance training for health;
- the benefits of resistance training for an active lifestyle; and
- the benefits of upper body strength for job performance in combat, rescue, and other physically demanding work tasks
- how to use the CF EXPRES and WebEXPRES programs to both reach and exceed the MPFS in upper body strength

It is also important to *provide this information and experiences* in as many formats as possible to insure that a lack of knowledge about resistance training, equipment and the benefits to health, lifestyle, and/or self image is not an obstacle to building confidence, participation and commitment.

These formats can include:

- workshops
- lectures
- posters
- brochures
- DVD's
- gender and skill specific classes
- informal instruction in the training room
- presentations by the chain of command
- models with whom they can identify
- web and e-mailed questions and answers
- self-directed programs

In addition to providing the appropriate information in different formats, it is also important to *create an environment* that is welcoming, supportive, and socially comfortable.

This can include physical changes to the training room and equipment including:

- color
- lighting
- wall décor
- flooring
- placement and type of equipment
  - rubberized rather than metal
  - fixed weight rather than adjustable
  - use of platemates for small increments in load
- music
- posted messages that are positive and supportive
- staff that are welcoming and build relationships with the personnel
- opportunities to train with other female personnel only
- opportunities for families to train together
- flexibility in work time to facilitate training, work, and family life;

It should be noted that a key to successfully creating a positive environment is getting input from the target clientele as to those things in the training environment that they currently find attractive, those to which they are neutral, and those they would change or add [with appropriate alternatives].

3.2.2.Reluctance to work at the load necessary to improve strength.

This can be due to:

- the *misconception* that training with relatively high loads, multiple sets, using free weights, and training 3 times per week will result in bigger muscles and a less feminine physique. This has been shown to not be the case;
- the *perception* that resistance training using free weights is primarily a masculine endeavor and not gender appropriate. Resistance training exercise has been shown to be perceived by many females as masculine. This can reduce confidence in females to a greater extent than if an activity is perceived as gender neutral;

Therefore it is important to:

- listen to the perceptions of females about resistance training and correct misconceptions about fears such as changing the feminine physique;
- respond to concerns and make efforts to structure the environment and program so that they are acceptable from a feminine perspective

- an environment that is perceived as hostile or uncomfortable and not conducive to pursuing the program. This has been shown to develop avoidance behaviors.

  The focus group presented a number of scenarios that suggested the strength training and the testing environment need to be improved or re-designed to enhance comfort and facilitate adherence. Suggestions included:

  - privacy in the testing area
  - opportunities to learn about equipment and the weight room culture with other novices before venturing in to train
  - making time available to train privately
  - scheduling classes for novices [female or male only] to decrease self-consciousness
  - creating a less masculine environment
  - allowing more flexibility in work time to allow for training
  - shifting the emphasis from games to fitness in training time

4. Strength and occupational performance of female military personnel

   There have been a limited number of well-controlled studies on the impact of resistance training on the performance of physically demanding tasks by female military personnel.

   One study reported significantly improved maximal box lift and repetitive box lift performances in female personnel following 14 weeks of progressive resistance training 1 hour per day, 3 days per week. Others have shown that 6 months of periodized resistance training diminished initial gender differences in total, lower, and upper body strength as well as in tasks that mirrored physically demanding military requirements such as repetitive box lifts and loaded run events. There is some suggestion that field task training can elicit moderate improvements in task performance but improvements level off when compared to periodized resistance training.

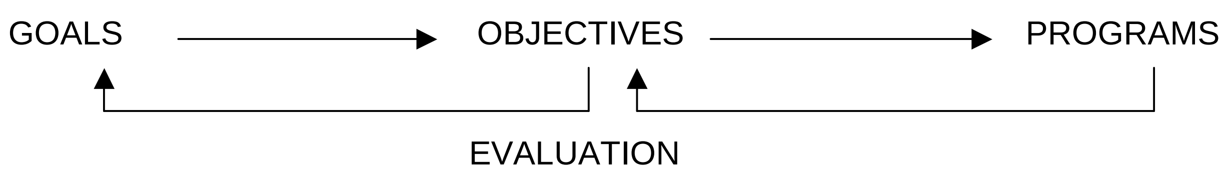
Therefore, evidence suggests that periodized resistance training is a very effective means to improving the performance of physically demanding military tasks for both females and males. The length of such programs should be at least 3 months and preferably 6 months followed by maintenance or further progressions in loading if more improvement is desired.

5. General training principles associated with strength development.

This section is intended to lay the foundation for understanding how we can change the capability of human muscle [and other tissues] to allow for successful completion of relevant tasks and functions. The 10 principles outlined below are not meant to be exclusive but rather were selected because they are highly related to this project of enhancing the upper body strength of women in the CF.

5.1.Training by objectives

This principle dictates that for a training program to be optimally effective, first establish the *general goals* you want to achieve, and then develop more *specific objectives* that will facilitate the achievement of these goals, and then create *programs* that will allow you to meet the objectives. It implies that regular *evaluation* occurs to determine if goals and objectives are being met and then altering programs accordingly. The figure below illustrates this link between goals, objectives, programs, and monitoring.



Therefore, the goals and objectives of a women's upper body strength program need to be clear and the programs designed to meet the goals and objectives.

There are 3 primary goals for the upper body strength program for women in the CF:

- to have sufficient upper body and core strength to meet the push-up standard for the MPFS;
- to have sufficient upper body strength to perform any duty that is required when on base or deployed. This is reflected in the ability to perform the 5 common tasks [see introduction];
- to have an appropriate level of upper body strength for their personal health, recreational, and family pursuits

The CF EXPRES as modified in the WebEXPRES programs has been developed to meet these goals. The program to develop upper body strength in female personnel should focus on these prescriptions with some modification to adjust for specific requirements of females who fail the push-ups test on the MPFS.

Proper evaluation of the program and the design of appropriate remedial or incentive programs will require specific information such as: gender; age; scores on each test item; height, weight, girths; and, performance following remedial programs. The WebEXPRES program instituted self-tests to permit individuals to assess their fitness on each component and then initiate appropriate programs to enhance or maintain these components. Implementation of this would help female personnel meet and achieve even higher levels of strength than those necessary to pass the MPFS.

5.2.Safety

This principle is fundamental to any program but should be stated.

Training prescriptions, facilities, equipment, clothing, and environment need to be of a standard that does not put the individual at unreasonable risk of injury.

This includes the intensity, frequency, duration, and type of exercise; the safe organization of the facility; equipment that is well maintained and readily operated; clothing that is appropriate for weather, work, and impact; and knowledge of exercise technique and the operation and storage of equipment.

Therefore, risk management should be a strategy before undertaking any training session.

5.3. Adaptation

This is the basic principle in training program design. The human body is very adaptable and, within our genetic limits, will change its structure [anatomy] and function [physiology] to meet regularly imposed challenges. To improve our anatomy and physiology, we must *overload* our body beyond what it is normally required to do. This forces the body to adapt to meet these new demands. This principle also implies that if the body is *under loaded* below what it normally does, then the adaptation will be to decrease its anatomical and physiological state to a lower level.

Therefore, a program to enhance and maintain the upper body strength of women in the CF must include exercises, loads, volumes, and frequencies of training that will stimulate development of upper body strength to a level that will allow the members to meet the goals of the CF and their own personal health and lifestyle goals.

The CFHLIS reported that only 37% of females in the CF were physically active while 28% were moderately active and 35% inactive [less than the equivalent of 30 minutes of walking per day] and the degree of activity decreased with increasing age. The report also highlighted that 81% of jobs in the CF require little or no physical activity. These data would suggest that there is a real need to encourage exercise of all forms to elicit positive adaptations rather than letting under loading take its course with the resultant decrease in health and performance on and off the job.

5.4. Progression

Once the body has adapted to a particular training load, the new load becomes the regular challenge and to get further adaptations, a further "overload" must be imposed. This *progression* of loading usually happens every 2 to 6 weeks and is in small increments of from 5 to 10%. Depending on the goals of the program, the progressions can happen by increasing the *absolute load*, for example increasing the weight on a barbell by 2 kg. They can also be progressed by increasing the *relative load*, for example increasing the load on a barbell from 60% of your max weight to 65%.

Progression also is recommended in a different context - skill acquisition and the mastering of complex movements and tasks. There should be a progression from simple to the complex movements. The focus should always be on safe and mechanically efficient movements as well as the preferred motor patterns.

Therefore, training programs to improve the upper body strength of women in CF should increase the loading over time to insure that strength gains do not level off until the targeted standards are achieved [at least].

Since skill is an important part of the performance of many multi-joint movements, exercise selection within a program should progress from simple component parts of a complex skill to the complex skill itself. For example, progress from upright row and shoulder press to the hang clean and push press or from the knee press-up to wall push-up to push-up.

Variants of the push-up can be used for progressions and for recruiting more muscle mass. The two prime movers for this exercise are the pectoralis major and the triceps brachii.It has been shown that the initial load in the normal hand position [the MPFS protocol] is about 65% of body weight while it is only about 50% from the knee variant. The load is somewhat greater during the lowering compared to the elevation phase and is increased as the speed of movement is slowed. As the hands are moved posteriorly, the contribution from pectoralis is increased in relation to triceps whereas as the hand position is moved forward, the emphasis shifts to greater recruitment from the triceps brachii. The highest level of activation of these muscles occurs when the hands are moved under the shoulders to a narrow base and the least activation occurs from the kneeling position.

Therefore, to get optimal improvements in push-up performance, a prescription should involve standard, narrow, and wide base hand positions and standard, posterior, and forward variants. The kneeling position and/or wall press-ups make good lead ups and a strategy to recruit all muscle to failure following failure on the standard pushup.

When the number of repetitions exceeds the desired range, the loading can be increased by slowing the tempo of the elevation and lowering phases.

5.5. Specificity

This principle is directly linked to the overload principle and states that the adaptation that occurs in response to an overload is specific to the type of overload and only occurs in those systems which are overloaded. For example, if the resistance training program is bicep curls, then those muscles that perform that action will adapt and will be specific to that movement.

In the learning and practice of skilled movements, it is important that the types of movements that are used to enhance our structure or our function will also enhance those skills that lead to the achievement of our goals and objectives. This does not mean that every activity in our training programs should simulate performance objectives. There are many instances when fundamental movement patterns need to be strengthened or reinforced before a more task-specific complex skill is trained.

Therefore an upper body strength training program for women in the CF should incorporate exercises that are lead-ups to or actually simulate actions that are directly related to the goals of the program.

The upper body strength components in the 5 common tasks involve such actions as lifting from above, supporting from below, pushing from below, pushing out, pulling in, pulling apart, pulling and/or pushing together, rotating at the core, stabilizing the core, transferring lower body momentum to the upper body via the core, pulling the body up and lowering down under control. Push-ups in the MPFS require holding the body in a “plank” position while moving under control from full extension of the arms at the elbow to 90 degrees of flexion and then back to full extension. Resistance exercises should include actions that mimic these movements under loaded conditions.

5.6. Individualization

This principle reinforces that different individuals will respond to a different extent to the same stimulus. The adaptation that will occur is dependent on each person’s unique genetic endowment; age, training state, health, and degree of fatigue.

Therefore, an upper body strength training program for women in the CF should provide sufficient flexibility in the scheduling to allow for longer or shorter periods before progressing the load, more frequent sessions to elicit the training effect, and changing the frequency of training for specific exercises to reflect individual strengths and weaknesses.

5.7.Maintenance

The training effect you build in response to an exercise overload is quite fragile. When you cease training, the benefits you acquired begin to decline. However, fitness can be maintained for more than a few months by:

- reducing the frequency of training to 1/3 of that which was used during training;
- decreasing the duration by 1/3;
- keeping the intensity at the same level as in the training period

This principle offers a strategy to maintain the acquired fitness when other demands are imposed that restrict the training time.

Therefore, an upper body strength training program for women in the CF should provide these strategies to maintain strength during periods of time when circumstances prevent training at the intensity, volume, and frequency necessary to improve upper body strength.

5.8.Recovery, Rest, and Regeneration

These terms are related but have different goals and therefore different strategies to achieve those goals.

- *Recovery* is the time(s) during a single training session when exercise is stopped to permit refueling of depleted energy stores, removal of fatiguing waste products [such as lactic acid], or to re-hydrate. This can occur on a scheduled basis such as between sets in resistance training or between high power work bouts in interval training, or it can happen by opportunity in short breaks during intermittent sports or in high power occupational work.

  The ½ time for restoring high-energy phosphates between short bouts of explosive or high resistance work lasting 1 to 30 seconds is approximately 30 seconds. The full-time for restoration is about 3 minutes.

The ½ time for removing lactic acid generated in moderate to high intensity efforts lasting up to 2 or 3 minutes is approximately 30 minutes with the complete removal lasting 1 to 2 hours.

Replenishment of glycogen stores and re-hydration can be accomplished in 30-120 minutes if high glycemic carbohydrates are ingested in this window of time. The replenishment can extend up to a day if this window is missed or multiple days in the absence of a sufficient carbohydrate load and fluid load.

These recovery times need to be addressed in the training prescriptions to insure that the optimal training intensity and volume can be achieved.

- *Rest* is the time between training sessions. In the hours and days following training, the body rebuilds broken down structures within cells to a level higher than pre-exercise. This rest period requires 48-72 hours following very high intensity exercise and from 12 to 24 hours for lower intensity work bouts. The consequence of exercising the same muscles and systems during the rest window is that the building of the training effect is restricted.

  The rebuilding following resistance training has been shown to be enhanced when, prior to and following training; protein or amino acids are added to the carbohydrate and fluid load in a ratio of 7g protein to 50g CHO.

  In practice, it is common to train the same systems and/or muscle groups on consecutive days if the intensity is low and the duration reasonable short [< 1 hour] and to train systems and/or muscle groups on alternate days if the intensity is high and/or the duration is long [> 1 hour].

- *Regeneration* is the time during a 4 to 6 week intense training cycle in which the loads over a 1 week period are dramatically reduced in intensity, duration, and frequency. This period is often called *unloading* and is used to regenerate neural and endocrine levels and to avoid overtraining symptoms. Common practice is to formally schedule these unloading weeks every 4 to six weeks depending on the training intensity and the training maturity of the individual.

Therefore an upper body strength training program for women in the CF should schedule appropriate recovery, rest, and regeneration period into the prescription to insure:

- replacement of fuels and fluids;
- removal of fatiguing waste products;
- sufficient time and the nutritional environment to build the training effect;
- the opportunity to regenerate the nervous and endocrine systems

5.9.Skill

Regardless of the nature of the load that is to be imposed and what the desired outcome is, there is a skill associated with that action or activity. Learning the skill should be one of the first steps in the training program to insure both safety and efficiency. When a skill is performed in a mechanically efficient way, more load can be moved per unit of force applied or more speed or acceleration can be achieved with the same metabolic cost.

Therefore, it is important to learn and master the skills involved in performance of the resistance exercises. This is especially important for more complex movements which require neural links in multi-joint actions such as bench press, shoulder press, dead lift, cleans, pull ups, or push ups.

5.10.Periodization

Planned variation in the training stimulus is important for optimal and continued gains in strength and power. This concept is often referred to as *periodization*. This variation can occur from set to set within a training session, between training sessions in the same week and/or between weeks in a 4-6 week training cycle.

The purpose of the variations is to maximize the muscle mass that is stimulated and to recruit different muscle groups as prime movers, stabilizers, and synergists. This variation should occur in:

- the load [e.g. from 5 RM to 10RM to 15 RM];
- the recovery time between loads [3 to 1 minute to 30s];

- the number of sets and exercises in a set;
- the different exercises that recruit the same muscle groups in different joint actions;
- equipment for loading [dumbbells, barbells, machines, body weight, partner resistance, stable and unstable platforms], in grip, stance, and body position

It has been shown that a periodized program using planned variation with a frequency of 3 times per week, loadings that vary from 6-20 RM, using 2-3 sets per session, featuring primarily multi-joint actions, and performed for from as few as 12 weeks to as many as 20 weeks will produce the most improvement in women's strength. Deviations from this will be less effective.

Therefore an upper body strength training program for women in the CF should provide prescriptions that are periodized over 12 to 20 weeks to insure that optimal gains in upper body strength are achieved and that improvement continues as the program progresses.

6. Specific principles which guide strength training prescriptions

This section will address the principles that govern the *prescription* of absolute strength, relative strength, strength endurance, and power.

- To increase *absolute strength*, resistance training has to increase the size of the muscle(s) [hypertrophy] and/or improve the ability of the nervous system to recruit the existing muscle more effectively.

- To increase *relative strength*, resistance training needs to improve recruitment of muscle but must guard against increasing size to any extent.

- To increase *strength endurance*, resistance training needs to increase absolute strength so that any submaximal load becomes a lower percentage of maximum, build tolerance to fatigue through repeated efforts against the submaximal load, or enhance efficiency so that the same work or power can be accomplished with less metabolic cost.

6.1.Acute training variables

The elements in a resistance training prescription that have been shown to effect strength changes are called the acute training variables and they are:

1. muscle action;
2. loading and volume;
3. exercise selection and order;
4. rest periods;
5. repetition velocity (tempo);
6. frequency

6.1.1.Muscle Action

The main *muscle actions* in resistance training programs are concentric and eccentric actions with isometric actions providing a secondary stabilizing role. To get the most effective hormonal response for increasing muscle size, training should include both concentric and eccentric actions. This is particularly true when the criterion task [push-ups] involves both actions.

The greatest difference in strength between males and females has been shown to be in concentric actions. Therefore, a program to enhance upper body strength in female personnel may need to initially focus on the eccentric actions of lowering body weight or external loads in order to complete sufficient volume to stimulate strength improvements. If programs include exercises with both concentric and eccentric actions, it would be prudent to continue with the eccentric phase when fatigue limits the concentric phase. Some examples of this would be with pull-ups and push-ups. When the number of full repetitions ceases, continue the pull-up by using a bench or partner assistance to get to the "up" position, then complete the lowering phase without assistance. Similarly with the push-up, use partner assistance or the kneeling position to get to the "up" position, then assume the plank and complete the lowering action unassisted.

6.1.2.Loading and Volume

- *Load* refers to the amount of weight or resistance in an exercise set and is generally agreed to be the most important variable in a resistance training program. It is usually determined by either a repetition maximum [RM] or by some percentage of 1RM. Prescribing the load by the RM method is the most practical because it eliminates doing repeated 1RM testing.

The RM continuum links training loads to different training effects keeping in mind that training effects are not exclusive to a particular RM load but rather are more predominant in a particular range of loads [see Table below].

DESIRED TRAINING EFFECT	**LOAD EXPRESSED AS RM RANGE**
RELATIVE STRENGTH	3-8 RM [QUITE HEAVY]
HYPERTROPHY [SIZE]	8-12 RM [MODERATE]
STRENGTH ENDURANCE	>20 RM [LIGHT]

With novices it is probably best to begin with loads that elicit >15 reps and not to failure until proper technique is established. This can be difficult if body weight is the load because they may be incapable of raising and lowering their body weight or only able to perform a few repetitions. Therefore, following proper technique would mean they could not meet these different targets to achieve the specific goals. This means an effective program should include progressions in both technique and load to allow for the specific objectives to be achieved. For example, incorporate either partner assistance or the kneeling position or wall press-ups to meet the proper loading target. Then, progress in technique until able to complete the prescribed number of repetitions. If personnel are able to exceed the number of repetitions of body weight exercises then the load can be increased either by partner resistance or slowing the tempo of each repetition.

- *Volume* describes the total amount of work performed in a single training session and is typically called the volume load and is commonly determined as the sum of the repetitions in each set x the load or resistance used in those repetitions. To prescribe *Training Volume* the prescription would include the # of sets; the #reps per set; the load [usually in RM]; and the number of sessions per week. For example:

3 SETS: 12 REPS [12RM]; 3 X WEEK

It has been shown that women are most successful at making strength gains in both the upper and lower body when:

- the volume load has 3 sets;
- the repetitions are in the 6-15 range to failure;
- the load [RM] is sufficient to produce failure in that range;
- the frequency is 3 times per week

Therefore, prescriptions to improve upper body strength in female personnel should set loads to meet objectives, and then optimize the volume by including 3 sets, 3 times per week.

6.1.3.Exercise Selection and Order

- *Exercise Selection* is choosing exercises for a resistance training program. The most commonly accepted classification is single-joint and multi-joint exercises.

  - *Single-joint exercises* [for example bicep curls] are often used to isolate specific muscle groups and have a lower risk of injury because of the lower level of skill and technique involved.

  - *Multi-joint exercises* [for example squats, bench press, push-up] are more demanding on the nervous system but are regarded as most effective for increasing overall strength because they allow a greater total weight to be lifted, force the nervous system to recruit muscles in sequence and, elicit greater increases in the acute levels of anabolic hormones.

  Depending on the goal of the program, both single and multi-joint exercises should be incorporated into resistance training programs since weakness in single joint actions can limit multi-joint strength.

  A typical number of exercises in a single workout would be in the range of 6-10 and would vary depending on:

    - the time available [fewer exercises with less time];

  - the number of sets desired [fewer exercises with increased sets];
  - the rest time between exercises and sets [fewer exercises with less rest time between exercises and sets];
  - whether the exercises will be completed successively or in an alternate fashion [fewer exercises when sets are completed successively rather than alternatively]

  Therefore, if the muscles involved in horizontal extension of the arms at the shoulder are weak, it would be wise to use a single joint exercise that isolates this muscle group so that multi-joint exercises that are dependent on that movement can be loaded to a greater extent.

  Multi-joint exercises have been shown to produce greater gains in muscle mass and gains in strength in the complex movement.

  Therefore, an effective program for enhancing the upper body strength of females in the CF should include a majority of multi-joint type exercises.

- *Exercise Order* refers to the sequence of exercises performed in one training session. The preferred sequence is performing multi-joint exercises before performing single-joint exercises. This has been shown to maximize the total resistance lifted during an exercise session and therefore results in a greater overall strength gain. This presents logistical problems when training large groups at the same time and individuals are assigned to “stations” and move in a circuit fashion. In this case, order is difficult to establish.

  Since multi-joint exercises elicit higher levels of the anabolic hormones, these exercises should be completed early in the program so that when single joint exercises are attempted, the hormonal environment will be conducive to increases in muscle mass. It has been shown that fewer repetitions of the multi-joint exercises can be accomplished if they are preceded by exercises involving single joint actions and the total resistance in the workout is maximized when multi-joint exercises are completed before single joint.

Therefore, a program to improve upper body strength in female members of the CF should be designed so that multi-joint exercises are completed before single joint in each exercise session. However, this may not be possible if workouts are scheduled in a group setting and exercises are completed as a circuit.

6.1.4.Rest Periods

Rest periods are the time given for *recovery* between sets and between exercises in the same set in which exercises are performed as “successive sets” [all sets of one exercise are completed before moving on to the next exercise]. In this case, rest periods are important because they contribute to the overall intensity of a session and can affect the training outcome. Some circuit training sessions are organized as “alternating sets” where one set of each exercise is completed before doing the next set of all exercises. In this case, adjacent exercises are organized to challenge different muscle groups so rest between sets and exercises are not necessary. This allows for economy of time but is not the preferred system to achieve gains in muscle size. The table below presents the standard prescription for rest periods in training sessions where exercises are completed in successive sets:

GOAL OF THE PROGRAM	REST PERIOD BETWEEN SETS
RELATIVE STRENGTH	3-5 minutes
ABSOLUTE STRENGTH [HYPERTROPHY]	1-2 minutes
STRENGTH ENDURANCE	30-60 seconds

Therefore, programs for improving upper body strength in women personnel need to match the load prescriptions [RM] to the recovery interval between sets to accomplish the desired effects. This is only required if the exercises are performed in successive fashion rather than in an alternate circuit format. The research on whether the successive or alternate format produces the most improvement in strength or hypertrophy is still equivocal but professional practice suggests that the successive format is best for hypertrophy but requires more time to complete the workout.

6.1.5.Repetition Velocity [Tempo]

This refers to the rate at which the load is raised [concentric] and lowered [eccentric]. Although this area has not been investigated to a sufficient extent, hypertrophy is related to amount of time the muscle is under tension. The recommended velocity standard for hypertrophy is a 2s concentric: 1s pause: 4s eccentric as this should maximize the time under tension although there is some support for a 2: 1: 2 tempo. For general strength programs a 1-2s concentric: 1-2s eccentric is recommended. Some practitioners refer to the pause phase as the isometric phase although not all of the time between the concentric and eccentric phases involves isometric contraction.

Therefore, when increases in muscle size in the upper body are a goal of the program, the prescribed tempo should be either 2: 1: 4 or 2: 1: 2. In light of the effectiveness of periodization in other factors, varying between these two should be the most effective. There is little to suggest that the slower eccentric phase in the 2: 1: 4 tempo would be beneficial for either relative strength or strength endurance.

6.1.6.Frequency

Training Frequency is the number of training sessions per week and is dependent on the type of training, the training status and recoverability of the individual. The rest interval between sessions must be sufficient to let the individual recover but not so long as to lose the training effect built after the last session. It is recommended that untrained individuals perform a whole body program *2-3 days per week*. As training status increases, the frequency can be increased to *3-4 days per week*. When programs are split [into upper and lower body or different body areas] then *4-6 days per week* is fine with no one area being loaded more than twice per week.

When training programs include combinations of aerobic, strength, power, and other fitness components, it can become logistically difficult to train all components at the ideal frequency and still have enough days to rest and insure recovery and the building of the training effect. This means that training needs to be prioritized so that appropriate time can be given to develop weak areas and stronger components can be maintained with lower intensity or volumes of exercise. When training for different fitness components on the same day [and in the same session], the component of major interest should be trained early to prevent fatigue from limiting the volume of training necessary to achieve improvements. Another common strategy is to use lighter loads or low volumes when training lower priority components in the same session as a high priority component.

Therefore, a program to enhance the upper body strength of women in the CF should give resistance training a high priority and insure that the frequency is 3 times per week and that training for other components in those sessions is completed following the strength workout and that the volume of work in the other component(s) is reduced.

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