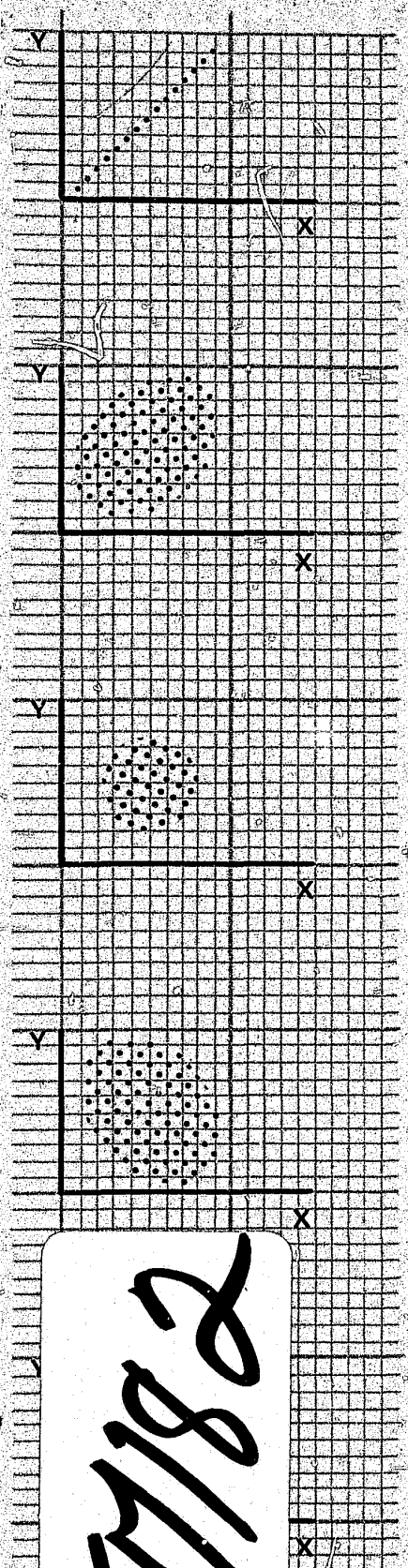

PHYSICAL PERFORMANCE CAPABILITIES OF WOMEN:

INCLUSION OF CHIN-UP AND PUSH-UP ITEMS IN THE MAINTENANCE EXAMINATION BATTERY FOR STATE POLICE TROOPER (MICHIGAN)

April, 1978

RESEARCH REPORT

Test Research Section

State of Michigan

DEPARTMENT OF CIVIL SERVICE

FINAL REPORT: Physical Performance Capabilities of Women: Inclusion of Chin-Up and Push-Up Items in the Maintenance Examination Battery for State Police Trooper (Michigan)

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FOR: Michigan Civil Service Commission
Bureau of Selection

DATE: April, 1978

I. INTRODUCTION

This report represents our efforts to meet five major objectives as defined by the Michigan Civil Service Commission, Bureau of Selection. They are as follows:

1. Determine the fairness and reasonableness to require the incumbent women State Police Troopers to perform a minimum of five chin-ups as part of the first annual Physical Performance Maintenance Examination.

2. Submit a written statement of opinion on or before February 10, 1978, making recommendations on the above chin-up requirement.

3. Test University of Michigan female Physical Education Majors to measure the ability of physically-fit women in performing five chin-up repetitions (the demographic characteristics of these women to be matched with those female State Troopers scheduled to participate in the above examination).

4. Conduct a thorough review of the scientific literature in regards to: a) the abilities of females to perform chin-ups; b) interrelationships between chin-up performance and various arm and shoulder strength measures; c) length of time to acquire chin-up ability through strength training; and, d) the impact of aging on chin-up performance and ability to acquire strength.

5. Suggest modifications and alternative test items for the present Physical Performance Maintenance Examination and outline a remedial physical training program for State Troopers against whom job-related physical performance standards have adverse impact on a basis of membership in a protected group.

These objectives are addressed in this same order in Sections II through VI of the report. Gratitude is expressed to Ms. Gretchel Parcells and Mr. Rick Sigsby, graduate students in Physical Education at the University of Michigan, who ably assisted in the testing and literature search aspects of the project. Ms. Peggy Foss, a graduate student in Physical Education and Michigan State University also assisted significantly during the literature review. Ms. Donna Gregory of the Michigan Department of Civil Service, Bureau of Selection, provided various demographic data, test results, test-site dimensions, etc., essential to selecting the subjects and carrying out the testing aspects of the project.

By way of introduction to this report, it seems appropriate to reference a portion of the introduction of an earlier report (December 1975) titled, Recommended Job Related Physical Performance Tests for the State Police Trooper Class (Michigan), wherein mention is made of the "interrelatedness" of physical performance screening tests, academy training and evaluation, and maintenance training and periodic evaluations. A subsequent statement indicated that while some of the suggestions related to these matters may be impractical or logistically impossible to immediately implement, they may provide ideas for future development within the State Police Trooper system. It appears that we are now involved in these "future" developments.

II. FAIRNESS AND REASONABLENESS OF CHIN-UP TESTS FOR WOMEN

The determination of the fairness and reasonableness of requiring incumbent women State Police Troopers to perform a minimum of five chin-ups as part of the first annual Physical Performance Maintenance Examination to be conducted on February 16, 1978, was considered of paramount importance. A major factor supporting the subsequent statement of opinion that a chin-up test item should be required was the results of pilot tests conducted on fourteen Physical Education Majors. These pilot tests were conducted at the completion of testing for a project on police applicant screening tests being conducted for another jurisdiction. The chin-up performances of the volunteer subjects and their ages, heights, and weights are given below:

Subject	Age (Years)	Height (Ft-In)	Weight (lbs)	Chin-Ups (reps)
1	24	5-4	132	8
2	30	5-0½	108	6
3	23	5-2½	107	2
4	22	5-0	110	2
5	23	5-4½	121	0
6	25	5-4	145	0
7	24	5-6	150	1
8	21	5-4	121	2
9	26	5-4½	131	3
10	21	5-5½	128	3
11	21	5-10	141	3
12	22	5-2	142	0
13	26	5-9	127	1
14	21	5-7	130	2

These initial results indicated that the majority of the women were capable of performing at least one chin-up and that two exceptionally fit subjects could perform as many as six and eight repetitions. It was noted that these two subjects were not the youngest of those tested (ages 30 and 24 years, respectively). One subject was currently a gymnastics instructor (8 repetitions) while others who performed 3 repetitions were in training for other types of athletics (field hockey, synchronized swimming, etc.) in addition to being Physical Education Majors.

Another factor in support of retaining the chin-up test as a measure of arm and shoulder girdle strength was that a preliminary review of the literature indicated that women can, because they apparently have the inherent capability, develop adequate strength to perform chin-ups. These studies and others are reviewed in Section IV.

An early indication of sensitivity to the appropriateness of including chin-ups and push-ups as part of the proposed maintenance evaluation is given in Section V (Difficult Test Items for Women) of the 1975 report. Quotes from Page 12 state: "The push-up and chin-up tests will prove to be more difficult for women than for men as part of the periodic performance evaluation. "The push-up and chin-up tests were purposely not included as screening test items since the arm-shoulder strength of women is known to be less than that of men and this would introduce considerable selection bias." "These same items were purposely included in the periodic appraisal tests since there is good evidence that women can develop these needed strengths if they practice proper strength training techniques."

III. WRITTEN STATEMENT OF OPINION

The following is the statement of opinion dated February 6, 1978, submitted to Ms. Donna Gregory, Social Research Analyst, Department of Civil Service, Lewis Cass Building, Lansing, Michigan.

This is intended as a preliminary statement on the advisability of requiring incumbent women State Police Troopers to perform a minimum of five chin-ups as part of a "maintenance" physical performance evaluation to be conducted during the early weeks of February 1978. My intention is for the statement to be helpful to those responsible for administering the tests both in terms of understanding the rationale for the stated opinion and in clarifying any interpretations they may feel compelled to make, relative to the individual performances of those being tested.

Statement of Opinion

It is my opinion that all incumbent State Police Troopers, both male and female, scheduled for maintenance physical performance evaluations during February 1978, should be tested utilizing all test items of the test battery described in an earlier report to the Department of Civil Service. This report is titled Recommended Job Related Physical Performance Tests for the State Police Trooper Class (Michigan)and is dated December 1975. Descriptions of each test item begin under the heading "periodic evaluation of troopers" on Page 4 and continue through Page 8 where minimal acceptable levels of performance are given in Table 3.

During the February 1978 testing, the results from the chin-up item should only be used to assess the current capability-status of selected incumbent State Police Troopers. To achieve this objective, examinees should be encouraged to perform as many chin-ups as possible even though it is likely that some may be aware of the minimum passing standard that has been previously suggested. Individual results of the chin-up tests should be recorded as the maximum number of repetitions that each examinee can perform. Minimal acceptable levels of performance should not be stated and

no attempts should be made to apply the previously recommended minimal standards of five chin-ups. Furthermore, it should be made clear to the examinees that their performances on the chin-up item is important to evaluating the appropriateness of including this test item in future tests, and that their individual performance on the chin-up item will not be included in a summary of their results for the other items of the test battery (i.e., their data will only be included in expressions of group results).

IV. TESTS ON UNIVERSITY OF MICHIGAN FEMALE PHYSICAL EDUCATION MAJORS

An important criteria to be met in selecting subjects from available University of Michigan female Physical Education Majors was that their average age and physical characteristics should closely match those of female State Police Troopers from the 90th Recruit School who were scheduled to take the maintenance exam on February 16, 1978. Descriptive data for 14 female troopers are given below along with their marital status and number of children they have borne. Averages for age, height and weight for the selected Physical Education Majors are shown in the final row of these demographic data.

90th Recruit School

I.D. No.	Age (Years)	Height (Ft-In)	Weight (lbs)	Marital Status	No. of Children
1	24	5-5	121	M	-
2	31	5-6	136	D	2
3	24	5-4	121	S	-
4	23	5-8	168	S	-
5	24	5-10	145	S	-
6	26	5-3½	127	M	1
7	24	5-2½	128	M	-
8	26	5-10	140	D	2
9	24	5-4	120	S	-
10	28	5-7½	133	M	1
11	24	5-3	132	S	-
12	32	5-9	145	S	2
13	24	5-5	132	S	-
14	29	5-6	126	M	2
Mean	25.9	5-6	134		
± SD	2.9	2.5 in.	12.8		
Mean	24.8	5-4½	123		
± SD	4.0	2.0 in.	11.4		

A review of these comparative means indicates that the 20 selected Physical Education Majors were quite closely matched to the 14 incumbent female Police Troopers scheduled for testing. The matching was viewed as being about as close as possible, given the constraints of limited numbers of available graduate students in the age range of 25-35 years.

In absolute mean difference units, the Physical Education Majors were 1.2 years younger, 11 pounds lighter, and 1.5 inches shorter than the incumbent Troopers. These differences were not viewed as great enough to preclude the drawing of any valid conclusions about the inherent strength and performance capabilities of women and the "fairness" of requiring female State Police Troopers to perform both chin-up and push-up tests.

Table 1 contains performance data for the 20 selected women Physical Education Majors on four of the five test items (chin-ups, sit-ups, push-ups and 1-mile run) included in the recommended maintenance test battery. Tests of right and left grip strength were made using a hand grip dynamometer since this strength testing equiment was readily available. The mile run was included since it was considered important to generate comparative times for female subjects performing this test on a flat gymnasium floor rather than on a banked running track. Tests of seated stretch ability were not administered since performance on this item has not and will likely not present any particular selectivity bias toward any group as defined by sex.

The reader should review the performance data of Table 1 with a specific definitional frame of reference since these are, in some ways, rather unique data. First of all, the subjects were all selected on the basis of being female, on being an undergraduate or graduate Physical Education Major student at the University of Michigan, and on being over 21 years of age. Selectivity bias entered the subject recruitment process at several levels; i.e., some subjects were contacted because of prior knowledge that they were strong or had demonstrated in previously mentioned pilot tests that they could perform at least one chin-up. Other subjects were included if they were judged to be fit even though their ability to perform chin-ups was unknown. Furthermore, it is important to recognize that while the selected Majors were generally quite physically fit, they do not represent levels of performance that could be demonstrated by an even more select group of females who train and participate in competitive athletics. The main point here is that the Majors work out frequently to maintain their general physical fitness in a manner more comparable to that which might be followed by incumbent female State Police Troopers. To this end, the performance results serve as a more reasonable standard than higher level performance records that could be generated by highly selected female athletes who train for many hours each week.

Given the above frame of reference, it is clear that while 13 of 20 subjects could perform at least one chin-up and some exceptionally strong subjects could complete 8 to 11 repetitions, seven subjects were unable to complete even one chin-up. This reinforces the earlier statements that females have the inherent capability to develop adequate arm and shoulder strength to elevate their body weight in a chin-up exercise. The fact that some females cannot perform this feat even though they have been involved in physical activity programs for some years likely reflects their individual attitudes toward the importance of developing the needed arm and shoulder strength. It was interesting to note the surprise on the parts of some when they "learned" that they could not perform any chin-ups; i.e., it appeared that they were unaware of their own weakness.

Table 1

PERFORMANCE BY SELECTED WOMEN PHYSICAL EDUCATION MAJORS

I.D. No.	Age (Years)	Height (Ft-In)	Weight (lbs)	Summed Grip Strength (KG)	Chin-Ups (Max Reps)	Sit-Ups (Reps/90 Sec)	Push-Ups (Reps/60Sec)	1-Mile Run (Min:Sec)
1	22	5-4	108	64	3	60	31	7:37
2	24	5-6½	143	51.5	0	55	23	8:32
3	26	5-9	125	66	0	38	0	8:45
4	22	5-7	130	84	1	52	15	7:45
5	25	5-5	130	79	5	62	23	7:37
6	23	5-5	135	63	0	48	13	9:17
7	26	5-4½	126	40	3	52	28	7:50
8	21	5-7	127	65	2	35	10	8:12
9	27	5-4½	105	50	0	42	14	8:27
10	28	5-4	130	68	0	38	15	8:55
11	36	5-5½	129	83	5	40	15	8:39
12	25	5-5½	123	78.5	2	53	16	8:49
13	22	5-4	136	67	0	41	5	8:17
14	24	5-4	129	76	9	72	42	8:05
15	30	5-0	109	45	8	31	15	7:57
16	21	5-5½	114	51	2	42	10	7:55
17	30	5-3	130	68	1	39	17	8:32
18	21	5-3	102	60	11	60	49	8:12
19	21	5-3	120	70	3	65	35	6:57
20	21	5-3	109	45	0	58	16	7:57
Mean	24.8	5-4½	123.0	63.7	2.8	49.2	19.6	8:12
± SD	4.0	2.0 in.	11.4	13.1	±3.3	±11.4	±12.14	± 33 sec.

The Physical Education Majors performed well in the sit-up test, doing an average of 49.2 sit-ups in the 90 second time limit. The range of performances was 31 to 72 repetitions. All of the subjects exceeded the performance minimum standard of 30 repetitions set for incumbent State Police Troopers.

The pattern of push-up performance by Physical Education Majors was highly variable and similar to that for chin-ups. Although their average performance of 19.6 repetitions per 60 seconds exceeds the standard of 15 set for Police Troopers, six Majors completed less than 15 repetitions and one could not successfully perform even a single push-up. Others performed exceedingly well with records of 42 and 49 repetitions. The reader should keep in mind that modified hand-knee push-ups (sometimes called female or executive) were not performed but the Majors were required to perform conventional push-ups using a standard hand-foot contact position. This makes the highest performances even more impressive and perhaps assists in understanding why some performances were so poor; i.e., even women Physical Education Majors are unaccustomed to performing "male-type" push-ups and are usually encouraged to practice a modified form.

It is of interest that four of six Majors who were unable to perform a minimum of 15 push-ups were also unable to complete any chin-ups, whereas three subjects who could do no chin-ups completed 15, 16 and 23 push-ups. Two other subjects who were capable of performing 2 chin-ups could do no more than 10 push-ups. This emphasizes the different muscle groups tested with each item and the independence of strengths of these muscle groups within the same individual; i.e., the extensors may be comparatively stronger than the flexors and the subject can perform push-ups but not chin-ups. The proportion of one's body weight that must be elevated in each case, of course, enters into these considerations of accounting for individual differences in that a person who carries a greater proportion of their body weight in their lower body will be handicapped in doing chin-ups but will be at an advantage for performing push-ups. In summary, it is apparent that women have the inherent capability to perform push-ups using a standard hand-foot contact position. It follows that it is both reasonable and fair to require incumbent female State Police Troopers to perform standard push-ups as part of a Maintenance Physical Performance Test battery.

The average time for women Physical Education Majors to complete a one-mile run was 8 minutes and 12 seconds. This is considerably faster than the minimum performance standard of 9 minutes. One subject exceeded the nine minute goal and one subject completed the event in 6 minutes and 57 seconds. One important technical aspect related to these one-mile run performance times is that the subjects ran on a gymnasium floor rather than on a track surface. It was recognized that run performance times would be slower for events run in a gymnasium, so a rectangular course (88 ft. x 44 ft) was established similar to that used during the first annual Physical Performance Maintenance Examination (84'5" x 45'3½"). Pylons were positioned in the corners of the rectangular course and subjects ran 20 laps around the course to total a one-mile distance.

Right and left grip strengths were determined for each subject and summed to yield the data shown in Table 1. These tests were conducted using a Stoelting hand grip dynamometer which was adjusted to yield maximum grip strength efforts. These tests were included to initiate the establishment of a data base for physically-fit females in anticipation of possibly including such evaluations for incumbent State Police Troopers. Values ranged between 40 and 84 kg. with a mean of 63.7 kg. This latter value is at about the 90th percentile for summed grip strengths of similar age non-athletic females as measured in an epidemiological health study of a total community in Tecumseh, Michigan (1).

Further evidence in support of the fairness and reasonableness of requiring incumbent female State Police Troopers to perform chin-ups and push-ups as part of the maintenance exam is gleaned from the results of the first annual test administered on February 16, 1978 (see Table 2). Although 3 or 5 women failed the chin-up test, 2 others passed with performances of 7 repetitions each. Two of the five women tested also failed the push-up test since they could not complete 15 push-ups within 60 seconds. These two women had also failed the chin-up test. These results indicate that some incumbent women State Police Troopers could pass all items of the maintenance exam including traditionally difficult chin-up and push-up items performed in a conventional manner; i.e., no modified form of these tests was necessary for female as opposed to male examinees.

V. REVIEW OF THE SCIENTIFIC LITERATURE

A review of the scientific literature was carried out using a computerized information retrieval system (MEDLARS) as well as the time-honored technique of reverse-historical searching of more recent papers and their lists of references or bibliographies. This search was conducted to gain insight into four areas of concern outlined in the project contract: 1) What evidence is there that females possess the inherent capability to develop the needed arm and shoulder-girdle strength to perform standard chin-up and push-up exercise tests?; 2) What interrelationships exist between one's ability to perform chin-up exercises and various measures of arm and shoulder-girdle strength?; 3) What length of time would be needed to acquire the needed strength to perform chin-up exercises if none could be performed initially?; and finally, 4) What impact does aging have on chin-up performance ability and the ability to acquire the needed strength?

These questions will be directly addressed whenever possible. However, in other cases the literature may speak "around" the question and an effort has been made to draw reasonable and defensible inferences from the published data. This is necessary because the amount of data directly related to the chin-up and push-up performances of women is known to be extremely limited since these tests have not been included in test batteries. In fact, some investigators have suggested that it is well known that women lack the strength to do chin-up and push-up exercises and consequently it makes little sense to attempt to test them using these items.

Table 2

Michigan Department of State Police
STATE POLICE ANNUAL MAINTENANCE TEST
Date Administered: February 16, 1978

Annually after hire, troopers must pass an evaluation of physical fitness consisting of:

NAME	PUSH-UP	BENT-KNEE SIT UP	SEATED STRETCH TEST	MILE RUN	CHIN-UP
STANDARD	15 push-ups in 60 sec.	30 bent-knee sit-ups in 90 sec.	Within 6 in. of the heel	less 9 min.	5 continuous
Sex					
M	20/26 sec.	50/80 sec.	+2	7:00	No. 8
F	32/60 sec.	69/90 sec.	-1	8:21	No. 7
M	20/22 sec.	35/67 sec.	+3.5	7:49	No. 10
M	35/33 sec.	30/38 sec.	+5	8:30	No. 6
M	31/38 sec.	47/83 sec.	+1	7:30	No. 6
*F	11/60 sec.	NA	NA	9:20	No. 1
M	26/60 sec.	40/70 sec.	+5	8:25	No. 9
M	65/60 sec.	30/44 sec.	+6	7:15	No. 9
M	24/24 sec.	52/90 sec.	+4	8:02	No. 10
M	30/30 sec.	64/90 sec.	+4	6:53	No. 5
M	30/25 sec.	30/44 sec.	+2	7:30	No. 16
M	25/28 sec.	30/48 sec.	+8	6:45	No. 14
*F	14/60 sec.	43/90 sec.	+4	9:07	No. 0
M	35/33 sec.	36/66 sec.	+2	8:15	No. 8
M	20/30 sec.	59/90 sec.	+6	7:15	No. 5
M	32/60 sec.	51/90 sec.	+3	8:03	No. 6
M	15/16 sec.	51/90 sec.	+3	7:40	No. 5
M	20/26 sec.	35/65 sec.	+4	7:30	No. 9
M	25/38 sec.	30/32 sec.	+5	7:33	No. 9
M	20/22 sec.	30/43 sec.	-1	7:00	No. 7
F	26/60 sec.	52/90 sec.	+5	8:30	No. 7
*F	26/60 sec.	56/90 sec.	+2	8:04	No. 2
M	45/60 sec.	50/80 sec.	+6	7:10	No. 10
M	31/60 sec.	57/90 sec.	+3	7:16	No. 5
M	29/38 sec.	30/40 sec.	+1.5	8:17	No. 7
M	25/38 sec.	40/90 sec.	+1	8:00	No. 6
M	33/60 sec.	59/90 sec.	+5	7:39	No. 6
M	32/50 sec.	70/90 sec.	+4.5	7:30	No. 8
Averages:	28.4/40.5 sec.	44.6/71.6 sec.	+3.6	7:36	No. 7.4
Troopers (Males)	29/36.9 sec.	42.8/68.4 sec.	+3.6	7:32	No. 8
Troopers (Females)	24.5/60 sec.	55/90 sec.	+3	8:33	No. 4

*Individual failed some portion of the maintenance test.

NA - Test results were lost. The 3 scored items included above are those that were remembered by the staff administering the test.

A sequel to these statements are the suggestions that alternative or modified test items be given to determine the relative strengths of females. While this approach may be appropriate for research studies wherein female subjects are used and the effects of treatments evaluated, it is far less effective in the initial screening and periodic evaluations of the physical performance abilities of males and females. This is especially true when both sexes work at identical jobs and must face the same job tasks requiring fixed demands in terms of physical work performance. Caution must therefore be used in evaluating and comparing the results of studies of male and female subjects where different forms of the "same" test have been used; eg., modified vs. standard push-ups, bent arm support vs. pull-ups, etc. Similar caution must be used in the areas of muscle strength-performance relationships, improvement over time while training, and aging effects. The major reason for precaution in these latter areas is that a majority of the scientific literature reflects evaluations of male rather than female subjects since an increased interest in the exercise physiology of females has only occurred in recent years.

Inherent Capability of Females to do Chin-Ups

A recent publication by Montoye and Lamphiear (1) includes hand grip and arm strength percentile scores for males and females over a wide age range (10 to 69 years). Measurements were made of right and left grip strengths using an adjustable hand grip dynamometer (Stoelting) while arm strength was measured using a dynamometer-pulley apparatus so that the individual pulled downward on a bar with both arms while in a standing position. The individual's feet were held by toe straps and the arms were raised and bent at the elbows to grasp a bar (palms toward grip) at about forehead level. Pulling downward from this initial position primarily involves use of the arm flexors and other muscles to a lesser degree. Since data were collected on 82% of an entire community, the authors felt that the scores more nearly represent the arm and grip strengths of healthy males and females than other studies of more selective sub-populations.

A critical finding relevant to this report is that for every age group among females, the mean arm strength to body weight ratio was less than one. The authors conclude therefore that it is not surprising that pull-ups is not a good test for girls and women since more than half of them cannot exert a force equal to their body weight. This serves to identify the seriousness of the problem faced by a woman when she is required to perform chin-ups for the first time; i.e., uncertainty about whether she can do any at all because she has never been previously tested. The data also indicate that some women can exert an arm-shoulder flexion force equal to their body weight. This supports the concept that females have the inherent capability to develop adequate arm and shoulder strength needed to perform chin-ups.

Given the above, one must look for explanations other than sex-related intrinsic musculo-physiological factors to explain differences in chin-up performances of females vs. males. In this search for explanations, the reviewer must also remain aware of the fact that many males cannot complete even one chin-up and that some females can perform several repetitions.

The matter of similarities and differences in basic strength performance measures of males and females has been researched by a few scientists. The anticipated outcome might be that there exist basic differences in fatigue rates, exertional tolerance or motivation that would account for the observed differences in strength performances between the sexes. For example, Kroll (2) has studied the isometric fatigue patterns of 31 female college students who performed maximal wrist flexion trials. The fatigue patterns showed marked similarity to comparative data for similar age males even though the males were nearly twice as strong as the females. A second similarity was that the most discrepant fatigue patterns for both males and females were demonstrated by the low level strength subjects. These data indicate that females fatigue at similar rates to males when requested to voluntarily contract a small group of muscles to their maximum and hold this effort for as long as possible.

Somewhat different results have been presented by Heyward and McCreary (3) for female athletes. They have shown no relationship (r=.00) between maximum static grip strength and the length of time a given standard percentage (30% of maximum voluntary contraction was used) can be gripped and held. For men, the finding is usually a negative correlation between the variables; i.e., high-strength men are usually less capable of sustaining submaximal force levels than are low-strength men. The lack of any negative correlation for female athletes led to speculative discussion of possible sex differences in muscle hypertrophy, capillarization of muscle tissue, critical occluding tension level and intramuscular occlusion.

As an additional contrast to these data for athletes, Bowie and Cumming (4) have reported a significant negative correlation between grip time and maximal strength at 40% of maximum grip strength for 82 girls and boys, 13-17 years of age. The girls were weaker than the boys (means of 38 kg. vs. 52 kg.), but displayed longer grip times at 40% MVC (means of 234 sec. vs. 185 sec). Since holding a handgrip to the breaking point is both a painful and tedious task which requires considerable self-motivation, the authors reasoned that the endurance measure might be used as an indicator of an individual's motivation to intensely train. This position was rendered untenable, however, by large day-to-day variations in grip time measures, technical measurement difficulties and an absence of any positive correlation between grip times and athletic performances. While these data are of interest, they do not offer any reasonable explanation for the vast differences in maximal or near maximal strength performances by males and females.

Some researchers have investigated different technical approaches to performing chin-ups to determine the effects of hand grip and kip-kicking. A study by DeWitt (5) of 144 men indicated that about 2 more chin-ups could be performed using the palms in (palms towards) grip as opposed to the palms out (palms away) grip. Mean performances were 9.71 and 7.63, respectively. Slightly more chin-ups could be performed, $\bar{X}$=10.37, using a kip-kick method which was judged as a skill factor independent of arm and shoulder strength and which therefore should not be used. McGray (6), however, has reported no difference in chin-up performances for 51 male college Physical Education Majors using grips of palms away, palms toward or

one grip of each type. Scores varied just as much on a day-to-day basis using the same grip position as they did for different positions. This latter finding is viewed as important since 35% of those tested varied as much as 2 chin-ups for trials conducted on consecutive days with 7% displaying a difference of 6 or more chin-ups between trials. Similar findings were reported for isometric strength tests of the arms when different grips and combinations were used and it was concluded that hand position is immaterial. Certainly, these technical considerations could be applied with equal advantage by either sex and would not explain the great differences in performance.

A more reasonable explanation for the relatively poor chin-up performances of females was likely first identified by McCloy (7). Interestingly, the study was conducted on 33 elementary school boys who were outstanding young athletes. The number of chin-ups that could be performed was determined and retested on subsequent days after adding 5 pounds of weight each day to a backpack. This process was continued until no chin-ups could be completed. There was nearly a perfect rectilinear regression of 0.95 indicating that added weight reduced the chinning ability an equal amount for each equal increase in eight. This demonstrated the important part played by fat weight in reducing the number of chin-ups. It is commonly known that the body weight of most females is composed of a higher percentage of fat tissue which must be elevated during a chin-up exercise. This fat weight offers a considerable extra load that must be overcome by arm and shoulder muscles that are poorly developed and weak.

Berger (8) used the above weighting procedure to determine the single repetition maximum chinning strength of 92 male college students. IRM - chin was defined as the body weight of the individual plus the added weight with which only one chin-up could be completed. A high correlation of 0.85 was calculated between this measure and a measure of total dynamic strength as determined by 6 weight training lifts which utilized most of the large muscle groups of the body (curl, military press, bench press, sit-up, deep knee bend and bend-over rowing.). These combined findings indicate the important relationships among arm, shoulder, and overall body strength and the negative influence of extra fat tissue (either related to sex or obesity) when individuals attempt to demonstrate their ability to vertically elevate their own body weight such as in a chin-up test. For these reasons, females may be unable to perform chin-ups while still being capable of doing push-ups. The main explanation being that the center of gravity of most women is lower than that of men (females frequently carry proportionally more weight in their thighs and buttocks and less in their arms and shoulders) and they consequently have to elevate proportionally less weight when doing a push-up as opposed to a chin-up. This is a likely explanation for the comparatively different performances of women Physical Education Majors on chin-up and push-up tests as reviewed earlier in Section III.

Wilmore (9) (10) has identified even more likely reasons for the discrepancies in arm and shoulder strength performances of females vs. males and within females as a group. He cites recent evidence that accounts for males becoming stronger and more proficient in motor skills at the age of

puberty with these differences increasing in magnitude through full maturity. The accounting has its basis in social or cultural restrictions imposed on the female either at or just prior to the onset of menarche rather than as a result of true biological differences in performance potential between the sexes. A salient example is that while women are typically weaker than men in upper body strength (43 to 63% weaker), the quality of their muscle tissue is identical to that of males (contractile properties and ability to exert force) and the weakness is due to less use of their upper body. A second example is that while there are certainly sex specific differences in body composition of males and females, the substantial difference observed between normal college age males and females are probably largely the result of a more sedentary life style of the female.

A summary of this review indicates that few studies have been done on the chin-up abilities of females mainly because the tests are not considered appropriate to use in evaluation or experimental settings. There appear, however, to be no documented physiological or structural differences in muscle makeup which would indicate that females lack the inherent capability to develop the strength and alter their body composition so as to be able to lift their body weight in a vertical plane using the arm and shoulder girdle muscles. It appears likely that most of the sex-related weaknesses in the upper body musculature are related to lack of use primarily as a result of socially or culturally imposed factors which govern female participation in certain physical activities and their level of motivation to acquire such strengths.

Interrelationships of Chin-Up Performance Ability and Arm and Shoulder Muscular Strength

As usually measured, strength is defined as the maximum force exerted by a group of cooperating muscles against a moveable (dynamic or isotonic test) or nonmoveable object (static or isometric test). The objects are frequently pieces of test apparatus but can be progressively heavier weights or the lifter's own body weight. Cureton and Larson (11), in their early writings on "strength as an approach to Physical Fitness", concluded that strength scores are functions of external leverage, internal leverage, educability, psychical states, constitutional type, neuromuscular conditioning, and nutritive state in the muscle fibers and that what the scores mean exactly is difficult to tell in an individual case. Lamphiear and Montoye (12) have indicated that body weight and size also enter into strength measurements and that it is well known that large persons on the average are capable of exerting more force than small persons. They cite the early work of Martin in 1918 who reported high correlations between muscular strength and weight in boys (r=.93) and girls (r=.86) which led to the common ratio expression of strength as force in kg. to body weight in kg. Martin and Rich (1918) also reported the correlation coefficient between strength and body weight to be much lower in adult males (r=.58) as compared to boys.

Jackson and Frankiewicz (13) have more recently identified four basic factors that define individual differences in muscular strength of male

tests, controlled for individual differences in height and weight and employed multiple factor analytical models. The four independent factors were static force of the arms, explosive power of the arms, dynamic work of the arms, and static force with the legs. In essence, the identification of these factors as independent means that they must each be separately tested for, since there would exist only limited predictive potential from the results of one type of test to another. As related to this review, it would mean that if static arm force and dynamic arm work are both important to carrying out the job tasks of a State Police Trooper, then both factors should be measured; i.e., one cannot assume that an individual who has a high static strength will necessarily be capable of doing large amounts of dynamic work with their arms. Unlike arm strength factors, the constructs of force, work and power were not clearly differentiated for the legs in this study.

Heusner and Van Huss (14) have accurately defined the terms static strength, dynamic strength, power, static muscular endurance and dynamic muscular endurance. Future mention will be made of static strength as measured with dynamometers, stain guages or cable tensiometers and dynamic endurance as measured by push-ups, chin-ups and sit-ups. At this point it is considered important to clarify three definitions as they relate to performance of chin-ups and hand grip dynamometer tests. The chin-up test can be one of dynamic strength as well as dynamic endurance. It is a test of strength in so far as the examinee must possess minimal strength to lift his/her body weight as a fixed load or resistance. The same would be true for push-up and sit-up tests. The hand grip tests, however, involve single maximum exertional efforts and therefore are simply measures of the static (isometric) strength of the muscles that contribute to gripping. Each of these dimensions of strength and endurance are viewed as important to the job tasks of State Police Troopers as will be discussed further in Section V.

The major muscles of the arms and shoulders that contribute to a chin-up performance are the pectoralis major, latisissimus dorsi, teres major, biceps and brachialis. McCloy (7) has indicated that after one pulls about half-way up, the pectoralis major muscle stops its action, and the other muscles pull at progressively more acute angles. These would be the major muscles to consider in any specific strength tests or in optimal training programs designed to improve muscular strength needed to perform a chin-up. Provins and Salter (15) have studied the maximum torque exerted about the elbow joint when different joint angles (45^{o}, 90^{o}, or 135^{o}) were used and the forearm was positioned in various positions of rotation. A 90^{o} angle was favored for maximum torque and this greater strength measure related to a change in efficiency or number of muscles involved. There is general agreement that the major muscles involved across the elbow joint are the brachialis, biceps, brachioradialis and pronator teres. This emphasizes the importance of the brachioradialis and pronator teres, especially if different hand grips are used on the bar during chin-ups.

Roberts et al (16) have studied the interrelationships of some of these muscle groups in 75 male Navy personnel. Hand grip strength correlated 0.56 with elbow flexion strength, while elbow flexion and elbow extension

strength correlated 0.63. The correlation between these measures and body weight were 0.42 (hand grip), 0.47 (elbow flexion), and 0.68 (elbow extension). These correlations were statistically significant and judged to be "quite high" but still account for only about 25 to 50% of the shared variance about the variables. The correlations are not judged to be high enough to preclude the need for independent testing of the strengths of the muscle groups in question.

Significant contributions in the area of strength testing and determination of correlations between strength and various measures of physical performance were made during the late 1930's and early 1940's, likely as a result of our involvement in Word War II. Many of these studies were directed toward defining the single strength measure or minimum combination of measures that would yield the best prediction of a person's overall strength or physical fitness.

In 1935, Wendler (17) used a Universal Dynamometer to study the strength of 47 different muscle groups in 474 men and women. These were summed to yield an expression of "total strength" and 21 of the strength tests selected for additional intercorrelative study using multiple regression analyses. Short test batteries were developed that correlated most highly with total strength for males (r=.94) and females (r=.94). Muscle strengths that contributed significantly were different for males (thigh flexors, leg extensors, arm flexors and pectoralis major) as compared to females (thigh flexors, thigh extensors, leg extensors, pectoralis major, deltoids, and hand flexors). Note that measures of arm flexor strength were not included in the test batteries for women.

Carpenter (18), in 1938, tested 100 college age women to determine the relationships between specific strengths of selected muscles (latissimus dorsi, posterior deltoid and forearm flexors) and the ability to perform chin-ups, dips using parallel bars and static push and pull tests using the arms. Pulling force correlated more highly (about r=.61) with the individual muscle strength measures than did chin-up strength as scored by the McCloy formula of 1.2 chins + .67 body weight + 52. The conclusion was that the arm pulling test is superior to chinning as an index of arm and shoulder girdle strength. She also contrasted the relationships of dipping performance and an arm push test to the strengths of the anterior deltoid, pectorals and forearm extensors muscles and came to a similar conclusion; i.e., a push test is superior to dipping as an index of the shoulder girdle and arm strengths involved in this extension activity.

The correlation coefficients between push strength and individual muscle strength measures were not as high as for the pull test (pectorals = 0.45, anterior deltoids = 0.33, forearm extensors = 0.54). A combination of grip strength measures, push strength and pull strength correlated 0.65 with "total strength" as determined by other tests which included these same items plus back and leg lifts, chins, dips and 10 measures of individual muscle strength. It is likely that a portion of the lack of correlation between performance tests like chinning and dipping vs. strength measures is due to the different components, static strength vs. dynamic endurance, being measured. These results emphasize the potential for using push and pull tests to better evaluate the static strength components of women but these tests could be used to equal advantage in the evaluation of males.

Larson (19) has pointed out the importance of measuring dynamic "strength" (defined as the ability to lift the body weight and propel it upward) when one is interested in predicting a composite index of motor ability. In his study of 160 college students in which a combination of eight strength tests and fifteen motor ability tests were used to establish individual composite indices of general motor ability, he found that dynamic strength was three times more important than static measures in its relative contribution toward prediction of the composite index. He emphasized that strength registered on instruments may not be indicative of sufficient strength for effective control of body weight which is fundamental to good large-muscle motor performances.

Three additional studies of the interrelationships between performance tests and strength measures of women have been published. In 1944, Mohr (20) and Wilson (21) reported on the physical fitness and arm and shoulder girdle strength of college women. Mohr administered a variety of strength, performance, and agility tests to a total of 686 women in required physical education classes. Arm and shoulder "strength" was measured using modified push-ups and a static pull test while abdominal "strength" was evaluated by a sit-up test. Students from a variety of activity classes (no weight training included) showed improvement in their sit-up ability but no change in push-up ability over the course of one semester. The author cautioned against administering push-up tests en masses since only individually supervised tests where form is carefully monitored yield valid measures of arm and shoulder girdle strength. Wilson used standard and modified tests of both pull-ups and push-ups to relate to a composite strength index proposed by F.R. Rogers (known as the short index which included grip strength, pull-ups, push-ups and corrections for height and weight). No raw data were presented to indicate how many push-ups and pull-ups the 52 women graduate and undergraduate Physical Education students could perform. Correlation coefficients indicated higher correlations between the strength index criterion and standard pull-ups (r=.79) than for modified pull-ups (r=.57). Modified push-ups, however, correlated more highly (r=.72) with the index than did standard push-ups (r=.63).

The third study was done more recently by Thorsen (22) who was interested in determining the relationships between performance and 43 measures of body structure and design as measured photogrammetrically; i.e., length, breadth, area and other non-linear expressions of body build. Physical performance was determined by tests of speed, muscle strength, explosive power, cardiorespiratory endurance and Rogers PFI. The highest consistent relationships were found between performance and area measurements. The author felt that discrepancies might also be accounted for by the difficulties encountered in motivating women to maximum performance, particularly in static tests of back and leg strength. In this writer's opinion, some of the low correlation may have been due to individual factors of compensation for extremes in overall body build or segments thereof.

Clarke (23) used multiple correlational analysis techniques to identify the muscle strength factors that enter dominantly into coordinated strength movement of the arm and shoulder girdle. Nine strength measures were made on 62 male college Physical Education majors along with various physical performance tests. The three strength tests that contributed most often

and prominently were: shoulder flexion, elbow flexion and shoulder adduction in this same order. The range of correlation coefficients between these measures and push-up or pull-up tests of arm strength ranged between .39 and .59 which Clarke judged to be "fairly high".

The relationship between measures of static strength and maximum speed of limb movement has fostered controversy among scientists for several years. Henry and Whitley (24) have studied this matter in 35 male Physical Education instructors and major students. Subjects were tested for static strength and maximal speed of lateral arm movement over a four foot distance of hand travel. No significant correlation between static strength and "strength in action" was found. Nelson and Fahrney (25), however, reported significant positive r's of .74, .79, and .75 between strength and speed of elbow flexion movement. They reasoned that the differences in findings were due to differences in type of movement, starting position or type of velocity measured.

Some research has been reported on the relationships between strength and endurance. In these studies, strength is usually statically tested to determine the maximum strength (100%) and endurance tests conducted using a fixed percentage of the individual subject's maximum strength; e.g., 30% MVC, 75% MVC, etc. A common finding is that weaker subjects perform better than stronger subjects when holding a relatively light load. Carlson (26) has reported this for 37 college age males performing forearm flexion isometric endurance tests. It appears that different results occur when the endurance tests are isotonic in nature. Shaver (27) has reported positive rather than the usual negative r's between maximum isometric strength and relative endurance measures. The main difference between his and other experiments was that the endurance task involved the use of the forearm flexor muscles in the performance of isotonic work. The stronger subjects were at an advantage when assigned light to moderate intensity relative endurance tasks. In support of these findings Eckert and Day (28) have reported an r of .76 between average isometric strength (mean from measures in down and up phase of modified push-up position) and push-up "work load" for 15 well-conditioned college women.

The interrelationships of hand grip strength to subject size as expressed by body weight are of interest to this reviewer. Values of r=.39 and .37 have been reported for college males (29) and females (30), respectively. An r of .41 was calculated for the 20 female Physical Education majors tested as part of this project. While these values are nearly the same, they are much different than the r's calculated by Sahakian (31) for college age males (r=.93) and females (r=.11). In this latter study, women subjects were found to be 53% weaker in grip strength than male subjects with this difference reduced to 36% when strength was expressed relative to body weight. None of the females exceeded the minimum grip strength score (sum of right and left grips) of 50 kg. used in the California Highway Patrol Screening Examination (41).

A summary of relevant points from this section indicates: a) that large persons on the average can be expected to exert more force in muscle strength tests than small persons, but can be handicapped when required to lift their own body weight as in a chin-up; b) that a chin-up test can be viewed as both a dynamic strength and endurance test while grip tests

measure static strength; c) that positive relationships exist among most tests of strength and endurance (fixed load static or dynamic and relative load dynamic but not relative load static), power and work, but are not great enough to preclude separate tests of these known independent factors; d) that major muscle groups involved in performing chin-ups have been identified; e) that positive relationships exist between strength measures of some of the above arm and shoulder girdle muscles and performance of chin-ups or push-ups which validates the selection of these test items; f) that chin-ups and push-ups are important measures of an individual's muscular strength and endurance for raising and lowering their own body weight; and, g) that many tasks performed by State Police Troopers would utilize static as well as dynamic strength of hand grip, forearm flexor, forearm extensor, and shoulder girdle muscles.

Reasonable Time to Acquire Needed Strength to Perform Chin-Ups

Although few studies have been directly concerned with determining progress rates for performing chin-ups, the following review should provide some valuable insights; especially as they relate to improving strength-acquisition rates through optimum progressive resistance exercise (weight) training. Capen (32) has studied the effects of 11 weeks of systematic weight training on measures of power, strength and endurance of male college students. A comparative group trained for 11 weeks in general conditioning activities. Although both groups improved in all endurance measures, the weight trainees improved more in strength tests (grip, back, leg, chins, and dips) and athletic power (various jumping tests for height and distance).

The question has frequently been raised about whether strength gains are greater using isometric rather than isotonic training. Rasch and Morehouse (33) contrasted improvements in muscular strength and hypertrophy in separate groups of male college students who trained for six weeks. During this short training period, those training isotonically showed the greatest improvement in forearm flexion and arm elevation strength. These gains were not apparent, however, when subjects were tested in an unfamiliar position indicating that noted improvements were largely due to acquired skill. O'Shea (34) reported different findings after six weeks of isotonic training of the muscles used in the deep knee bend. Subjects improved in both static and dynamic strength with no significant difference between the number of repetitions (2-3, 5-6, 9-10 reps) performed.

These latter findings are supported for both static and eccentric training of the knee extensor muscles. This study by Laycoe and Marteniuk (35) employed an actuated hydraulic piston attached to a chair as the mode of eccentric training. Both training groups improved in static strength (17% for static, 42% for eccentric), but there was little correlation between the gains (r=.27). The static strength gains of about 3% per week agreed with other reports. Nobel and McGraw (36) have found a nine week isotonic training program to be superior with respect to gains in relative-load isometric endurance and the capacity to perform either isometric or isotonic "work". They concluded that the development of muscular endurance

is not necessarily proportional to strength improvement, but is a function of the training method with isotonic training being superior.

Since a one-mile run is included in the maintenance exam, it seems appropriate to review a limited number of studies related to the rates of improvement in cardio-respiratory endurance and maximum oxygen consumption shown by women. Michael and Horvath (37) reported no significant improvements in a variety of measures of cardio-respiratory function at either submaximal or maximal levels of work for 21 untrained female college students. These students participated in "normal" college activities and recreational sports over 10-12 weeks, but none were involved in strenuous physical conditioning programs. On the other hand, Profant, et al (38), in their study of 144 middle-aged women (age range = 29 to 70 years) found measurable differences in the work capacities of subjects classified as physically active as opposed to sedentary on the basis of weekly histories of occupational and recreational activity levels.

The dramatic effects of involvement in training have been shown by Hanson and Neede (39) for eight previously sedentary females, age 20-44 years, who have participated in walk-jog-run and other physical activities. Work capacity was improved 19% over 4 months after which improvements leveled off. Importantly, these investigators concluded that the trainability of non-athletic females and their oxygen transport systems does not differ from that of their male counterparts, and that identical benefits can and should be gained from regular activity by both sexes. This conclusion is supported by Burke (40) who reported similar improvements in maximum oxygen consumption for untrained males (17%) and females (24) who followed similar run-training programs (75%-85% of maximum heart rate) for eight weeks.

Some limited evidence exists for the expected rate of improvement in chin-up strength by females who are not using weight training methods. Parviainen (42) studied four women recruits assigned to the Michigan Department of State Police 87th Recruit School. In addition to the regular calisthenics and run training used in academy training, the women practiced chin-ups and modified push-ups each day with weekly progress noted over 14 weeks. Weaker recruits increased from 10-50 modified push-ups and from 0-2 chin-ups while stronger recruits increased by about 4 chin-ups (1-5, 2-7 and 4-8).

Further insight has been provided by a California study of women Highway Patrol recruits (41). During training male and female recruits performed the same physical training test including pull-ups, push-ups, sit-ups and an obstacle course. The average score of women recruits improved from 35.6% at four weeks to 70.7% after 12 weeks. It has been suggested that these gains would have been even greater if progressive resistance exercise programs using free weights or weight training machines had been available in the academy. Gains in strength are known to proceed at a faster rate if weight training rather than calisthenic methods are used. This may particularly apply to women who have lighter upper torsos that afford a relatively low resistance against which to work after initial strength gains have been realized. The California State Highway Patrol Training Academy has installed a Universal Gym to help cadets who have

problems with physical training, but all cadets were required to use the apparatus in addition to their regular physical training. In the opinion of their Physical Education consultant, Dr. Jack Wilmore (41, pg. 39), women recruits could improve their strength by as much as 50% over a 10-week period by using the equipment.

Such gains do not seem unreasonable since Wells, et al (42) reported strength gains of 17% to 60% for a group of teen-aged school girls who followed an unspecified weight training program for 18 weeks. Brown and Wilmore (43) studied seven nationally ranked women track and field athletes after three and six months of strength training. Maximum bench press and half-squat leg extensions were used as criterion measures. These athletes who were already strong improved by 15% to 44% (bench press) and 16% to 53% (squat extension).

Further studies of improvements in strength by women who practice weight training are those of Capen et al (44) and by Wilmore (45). Capen studied women of similar age (18-31 years), height (mean of 5'5"), and weight (126 lbs.) to Troopers and Majors included in this report. Their subjects trained three times per week for 10 weeks using heavy dumbbells and barbells so that only a few repetitions could be performed. Strength, endurance and power tests were administered to disclose significant gains in grip strength (about 4 kg. for summed grips), modified pull-ups (about 4 repetitions), and sit-ups (about 3/minute).

Wilmore (45) has reported similar relative strength gains in women and men who trained twice per week for 40 minutes over a 10 week period. The training format was essentially identical in terms of sets (2/workout), reps (7-9 progressing to 14-16, then add weight), and lifts performed. Men were stronger than women for all criterion measures of leg press (1.5X), curl (2X), bench press (3X), and grip strength (2X), but women showed relatively greater percentage improvements in all except elbow flexion strength. The percentage improvements for the above lifts for males and females, respectively, were 29.5 vs. 26%, 10.6 vs. 18.9%, 28.6 vs. 16.5%, and 12.8 vs. 5%. It is important in the above studies of women to note that the strength improvements were made with little or no measurable increase in the muscle girth or hypertrophy, a matter of cosmetic concern for many women who shy away from strength training for fear that they will develop unattractive increases in the size of their muscles.

In summary: a) improvements in the chin-up performances of women occur at a rate of about 4 repetitions over 14 weeks of practicing the act of chinning; b) more rapid improvements could be anticipated through the use of progressive resistance weight training; c) initial gains in strength are likely due to considerable skill acquisition; d) isotonic training using heavy loads and few repetitions is recommended since it provides the best associated improvements in power, work and endurance performance; e) women benefit similarly to men in terms of cardio-respiratory and strength improvements but frequently begin at lower levels and have the potential for greater relative improvement; f) a predictable range of strength improvement rates appears to be 1-4% per week depending on the muscle group tested, yielding gains of roughly 15-50%

over a 14 week period; and, g) women can greatly improve their strength without accompanying enlargement of the muscles being trained.

Impact of Aging on Performance and Strength Acquisition

The reader is referred to classical review papers (46, 48) on the matter of strength changes with age, as only the highlights will be summarized here. Hunsicker and Greey (48) reviewed many studies and concluded that strength increases with age over the first 25 years, remains generally constant for the next 5 to 10 years, and then gradually decreases throughout the remainder of life. Furthermore, that the age-related improvement and decline patterns are about the same for both sexes and, importantly, that participation in physical exercise can delay the onset of decline.

Interestingly, Astrand (46) has reported similar patterns for various cardio-respiratory measures for both men and women and offered the same encouraging message with regards to the beneficial aspects of physical training. Eisenman and Golding (47) have compared the rates and amount of improvement in maximum oxygen consumption of girls (12-13 years) and young women (18-21 years) to 14 weeks of training by running and bench stepping for 30 minutes three times per week. The most rapid rates of improvement occurred during the first two weeks with girls and women displaying the same overall magnitude and rates of change in Vo2-max over the course of the study. They concluded that within this age range, the effect of training on the Vo2-max is independent of age.

More recent insights into changes in the arm and grip strength of males and females with aging are presented by Montoye and Lamphiear (1). Their data indicate that from about age 20 to 50 years, there is little decrease in absolute grip strength, arm strength or in strength index (a combination of measures). When these measures are expressed per unit body weight, the peak strength is still reached in the early 20's for males and a little later for females. However, the decrease in strength per unit weight from about age 25 on is clearly greater in both males and females than the decrease in absolute strength. This reflects a gain in weight, and particularly a gain in fat, and the resulting change in percent body composition in older subjects. These writers reference three other sources that would likely be of help to readers interested in the general area of strength and aging (Reference No. 3 by Hettinger, No. 9 by Norris, et al, and No. 10 by Rodahl and Issekutz).

For the above reasons, State Police Troopers would be expected to be able to continue to perform well on static strength tests of their arm and shoulder muscles even as they accumulated more years of service. On the other hand, if they were allowed to accumulate excessive body fat as they accumulated experience, it is unlikely that they could continue to successfully pass the tests of arm and shoulder dynamic strength and endurance; i.e., the push-up and chin-up tests.

V. SUGGESTED MODIFICATION OF MAINTENANCE PHYSICAL PERFORMANCE EXAM AND REMEDIAL PHYSICAL TRAINING PROGRAM COMPONENTS

Based on the accompanying test results and literature review, the following points seem justified in terms of recommended modifications of evaluation procedures and remedial training programs. The rationale for implementing maintenance physical training and periodic evaluations seems clear and appears to be shared by all parties involved. Incumbent State Police Troopers have given high ratings to task description No. 1 - performs physical exercise on a regular basis to maintain physical strength, agility and health and to perform dimension No. 77 - willingness to keep proficient in physical skills and abilities (52, see Tables 1 and 2).

Milton, et al (49) have pointed out the challenge posed to the use of applicant screening tests of physical performance when required maintenance programs are not also used; i.e., it is unjustified to have entry standards when officers, once hired, are not required to maintain the same level of physical fitness demanded at entry. A review of initially recommended performance and entry minimums (52, pg. 8) indicates that maintenance tests are generally more demanding than entry tests. The rationale supporting lower screening performance minimums, purposeful exclusion of certain test items having a high disparate impact (either because of known sex-related muscular weaknesses or a specific skill aspect that can be learned) and the important interrelated responsibility of academy training to correct weaknesses in otherwise well-qualified applicants has been previously described (52).

Our ultimate goal is the devisement of a maintenance physical fitness program that the Troopers themselves view as essential to the maintenance of their general health, appearance and vigor as well as to the effective delivery of job-related tasks having a significant physical component. For their own well-being and that of others, it is understandably important that these services be carried out in a competent, confident and efficient manner even though the Trooper is undergoing an aging process. To delay the onset of fat weight gain and dynamic strength-endurance loss requires continual involvement in maintenance programs.

The recommendations which follow are directed toward this final objective. They are based on a review of the components of numerous other maintenance or screening tests being used or evaluated in other jurisdictions (50, 51, 53, 54, 57, 58, 59, 60) and the general principles outlined by Hubbard, et al (57). Special mention is warranted here of the number of defensive tactics currently taught in the Michigan State Police Academy (55) which require significant arm and shoulder static strength as well as acquirable "leverage" strength and skill. Secondly, it appears that chin-ups are not included as part of the current physical training program used in the Michigan State Police Recruit Training School (56).

It is recommended:

1. that the maintenance test as previously described (52, pg. 8) be retained without modification or alteration of test items or minimum performance standards;

2. that consideration be given to the inclusion of the 100 lb. dummy drag-lift test as part of the maintenance exam, perhaps using a heavier dummy;

3. that chin-ups using the palms-toward grip be included in the daily physical training of recruits and that standard push-ups be continued;

4. that the maintenance exam be required on initial entry into the training school, periodic intervals thereafter, and at the completion of basic training (this should serve to identify those recruits who need special training);

5. that the maintenance exam be administered at the completion of the probationary period and annually thereafter (these should identify those for whom remedial training is indicated);

6. that the academy purchase weight training machines and that detailed optimal strength and endurance programs be devised to help recruits who are having difficulty meeting minimal performance standards (by requiring all recruits to work out on the equipment, each will learn the important principles of progressive resistance exercise training; this form of strength maintenance can be continued as needed);

7. tests of static strength such as hand grip and arm push and pull should be considered for inclusion in the test battery (these would require the purchase and maintenance of test apparatus and other logistics);

8. a re-evaluation of minimum passing performance standards for the maintenance and screening exams should be undertaken in view of all available current data; and finally,

9. serious consideration should be given to initial (on entry to recruit school) and semi-annual evaluations of cardio-vascular health, using graded exercise stress test-ECG procedures. This might also be coupled with evaluations of the Troopers' percentage of body fat and blood-borne coronary heart disease risk factors.

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