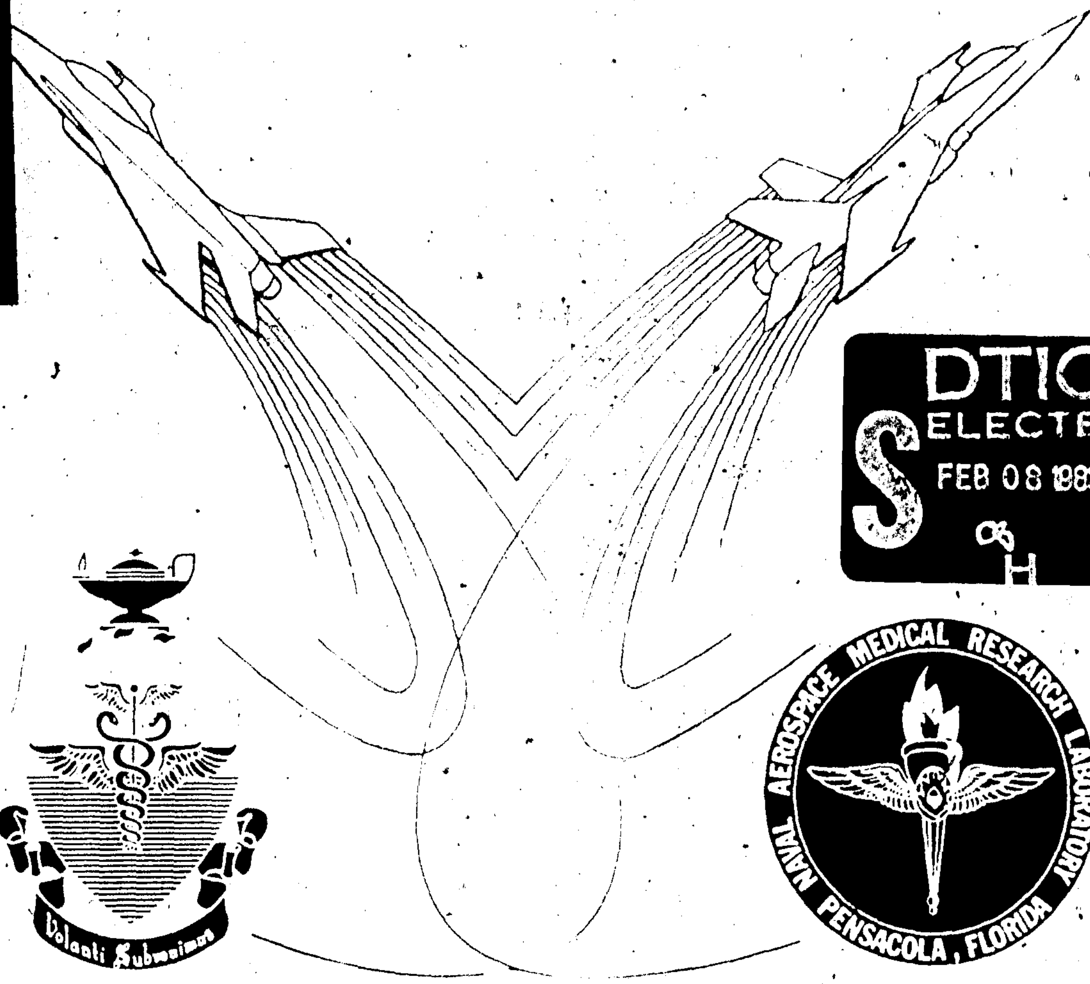
USAFSAM-SR-88-1 NAMRL-1334

PHYSICAL FITNESS PROGRAM TO ENHANCE AIRCREW G TOLERANCE



MARCH 1988

Approved for public release; distribution is unlimited.

USAF SCHOOL OF AEROSPACE MEDICINE
Human Systems Division (AFSC)
Brooks Air Force Base, TX 78235-5301

NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY
Pensacola Naval Air Station
Pensacola, FL 32508-5700

NOTICES

This final report was submitted jointly by personnel of the Crew Technology Division, USAF School of Aerospace Medicine, Human Systems Division, AFSC, Brooks Air Force Base, Texas, under job order 79301439 and Naval Aerospace Medical Research Laboratory, Pensacola Naval Air Station, Pensacola, Florida.

When U.S. Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

RUSSELL R. BURTON, D.V.M., Ph.D.
Project Scientist

RONALD P. CRISMAN, LCDR, MSC, USNR
Project Scientist

W. C. ALEXANDER, Ph.D.
Chief, Crew Technology Division

J. D. GRISSETT, Ph.D.
Head, Medical Sciences Department

JEFFREY G. DAVIS, Colonel, USAF, MC
Commander

JAMES A. BRADY, CAPT, MSC, USN
Commanding Officer

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a REPORT SECURITY CLASSIFICATION: Unclassified	1b RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited.
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): USAFSAM-SR-88-1, NAMRL-1334	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: USAF School of Aerospace Medicine; Naval Aerospace Med. Res. Lab — 6b OFFICE SYMBOL (If applicable): USAFSAM/VNB; NAMRL/00	7a NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code): Human Systems Division (AFSC), Brooks AFB, TX 78235-5301; Pensacola NAS, Pensacola, FL 32508-5700	7b ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: USAF School of Aerospace Medicine; Naval Aerospace Med. Res. Lab — 8b OFFICE SYMBOL (If applicable): USAFSAM/VNB; NAMRL/00	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code): Human Systems Division (AFSC), Brooks AFB, TX 78235-5301; Pensacola NAS, Pensacola, FL 32508-5700	10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO 62202F; PROJECT NO. 7930; TASK NO 14; WORK UNIT ACCESSION NO 39

11 TITLE (Include Security Classification)

Physical Fitness To Enhance Aircrew G Tolerance

12 PERSONAL ~~AUTHOR(S)~~ (Editors)
Crisman, Ronald P.; and Burton, Russell R.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 86/01/01 TO 88/06/30	1988, March	60

16 SUPPLEMENTARY NOTATION

17. COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	G tolerance, G-tolerance enhancement, G-induced loss of consciousness, Physical conditioning, Physical fitness, Weight training, Weight lifting, Anaerobics, Aerobics, Exercise
06	10		
06	04		

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A physical fitness program of resistance training, such as weight lifting, directed toward increasing strength and anaerobic capacity will increase G-duration tolerance. This tolerance increase is particularly useful for USAF/USN pilots flying high-performance fighters during aerial combat maneuvers. A weight-training program including exercise equipment to be used by aviators to increase (and maintain this increase) their strength and anaerobic capacity is described. Aerobics conditioning with precautions and limitations for G tolerance is discussed. Figures show recommended weight-training exercises. This special report is a combined U.S. Air Force and U.S. Navy effort that came from a 1987 Joint-Service G-Tolerance Conference that was hosted by the Naval Aerospace Medical Research Laboratory, NAS, Pensacola, FL.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT: [X] UNCLASSIFIED/UNLIMITED [ ] SAME AS RPT [ ] DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION: Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL: Russell R. Burton; James A. Brady	22b TELEPHONE (Include Area Code): 512-536-2446/904-452-3286 — 22c OFFICE SYMBOL: USAFSAM/VNB; NAMRL/00

PHYSICAL FITNESS PROGRAM TO ENHANCE AIRCREW G TOLERANCE

1987 Joint Service G-Tolerance Conference

Hosted by

Naval Aerospace Medical Research Laboratory
Naval Air Station
Pensacola, FL 32508-5700

CONFERENCE CHAIRMAN

Dr. J.D. Grissett
Head, Medical Sciences Department
Naval Aerospace Medical Research Laboratory
Naval Air Station
Pensacola, FL 32508-5700

CONFERENCE SCIENTIFIC EDITORS

U.S. NAVY
LCDR R.P. Crisman
Director, Physiology Section
Operational Medicine Division
Naval Aerospace Medical Research Laboratory
Naval Air Station
Pensacola, FL 32508-5700

U.S. AIR FORCE
Dr. R.R. Burton
USAFSAM/CA
Brooks AFB, TX 78235-5301

PREFACE

The U.S. Air Force and the U.S. Navy have conducted research programs to identify methods that will reduce the incidence of G-induced loss of consciousness. These efforts have provided a basis for designing physical fitness programs to better prepare the human body for operations in the high-G environment associated with air combat operations in the Air Force and Navy.

Dr. Russell Burton, USAF School of Aerospace Medicine, and LCDR Guy R. Banta, Naval Medical Research and Development Command, were instrumental in establishing a workshop to review the literature and make recommendations for physical fitness programs that would be consistent with scientific data and practical to implement in operational units. The Naval Aerospace Medical Research Laboratory (NAMRL) organized and conducted the workshop.

Representatives were selected from several disciplines, including line aviators, who would have knowledge of research data related directly to G tolerance, research related to the physiology of exercise, and the practical aspects of implementing physical fitness programs in operational units. The workshop was held 21-23 July 1987 at NAMRL.

Dr. Burton conducted a comprehensive review and discussion of the literature. MAJ Tony Giacobe and LCDR Wayne Dickey presented the rationale and a critique for existing and planned Air Force and Navy programs. CPT Bill Kraemer and LT Donna Murdoch presented a specific fitness program for consideration. LCDR Ron Crisman discussed the problem of neck strains in a high-G environment and proposed a neck strengthening program. LT COL Lew Epperson reviewed the benefits and detriments of aerobic training for tactical aviators. The remaining 1 1/2 days were used to discuss data and prepare the first draft of this report.

Additional USAF contributions to this document followed this workshop and were provided by Drs. Whinnery and Krock, from USAF School of Aerospace Medicine and MAJ Boehme and LT COL Green from 833rd Med Gp/SGT, Holloman AFB.

Each participant was invited to review and comment on both the first and second drafts. Participants from NAMRL and USAFSAM prepared the photographs and illustrations. USAFSAM provided the final editing. NAMRL was responsible for publication and initial distribution. Technical (computer set-up) and logistical support was managed by NAMRL staff, in particular, HM1 David L. Cubert and HM2 Tyrone L. Green.

G-TOLERANCE WORKSHOP PARTICIPANTS
21-23 July 1987

AIR FORCE

Joy de Armond-Kennedy
USAF ASD/ENECE/YPEC
Wright-Patterson AFB, OH 45433-6503

Dr. Russell R. Burton
USAFSAM/CA
Brooks AFB, TX 78235-5301

LT COL William L. Epperson, USAF
USAF AAMRL/BB
Wright-Patterson AFB, OH 45433-6573

MAJ Anthony J. Giacobe, Jr., USAF
HQ TAC/DOT
Langley AFB, VA 23665

ARMY

CPT W. Kraemer, USA
Director, Exercise Biochemistry
Exercise Physiology Division
U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

MAJ Madeline Rose, USA
Military Nutrition Division
USARIEM
Natick, MA 01760

COL David D. Schrakenberg
Commander
USARIEM
Kansas Street
Natick, MA 01760-5007

NAVY

LCDR Guy R. Banta, MSC USN
Program Manager
Naval Medical Research and Development Command
(Code 404)
Bethesda, MD 20814-5044

NAVY

LCDR Ronald P. Crisman, MSC USNR
Director, Physiology Section
Operational Medicine Division
Naval Aerospace Medical Research Laboratory
Naval Air Station
Pensacola, FL 32508-5700

CAPT F. R. Deane, MC USN
Force Medical Officer
COMNAVAIRLANT (Code 018)
NAS Norfolk, VA 23511

CAPT J. R. DeGiorgio, USNR
LATWINGPAC
NAS Lemoore, CA 93246

LCDR Wayne Dickey, MSC USN
Aeromedical Safety Officer
COMNAVAIRLANT (Code 018D)
NAS Norfolk, VA 23511-5188

Dr. James D. Grissett
Head, Medical Sciences Department
Naval Aerospace Medical Research Laboratory
Naval Air Station
Pensacola, FL 32508-5700

CDR W. O. King, USN
Office of Chief of Naval Operations
OP-596C5
Navy Department
Washington, DC 20350-2000

CAPT Robert Knudsen, MC(FS) USN
LATWINGPAC
NAS Lemoore, CA 93246

LT J. T. Luz, MSC USN
Naval Medical Clinic San Diego
Bldg #473, APTD
NAS Miramar
San Diego, CA 92145

Mr. Scott G. Meyer
Physiology Section
Operational Medicine Division
Naval Aerospace Medical Research Laboratory
Pensacola, FL 32508-5700

NAVY

LT Donna M. Murdoch, MSC USNR
Physiology Section
Operational Medicine Division
Naval Aerospace Medical Research Laboratory
Pensacola, FL 32508-5700

LT James P. Norton, MSC USNR
Naval Health Research Center
San Diego, CA 92138-9147

UNIVERSITY SCIENTISTS

Dr. Phillip D. Gollnick
Professor and Head
Department of Veterinary Medicine, Pharmacology, and Physiology
Washington State University
Pullman, WA 99164-6520

Dr. Charles M. Tipton
Professor and Head
Department of Exercise and Sports Medicine
Ina Gittings Building
University of Arizona
Tucson, AZ 85721

Dr. Christian Zauner
Professor and Chair
Department of Health and Physical Exercise
Oregon State University
Corvallis, OR 97331

VISITING SCIENTIST (UNITED KINGDOM)

Dr. Mary Winsborough
8031 Park Lane
Bethesda, MD 20814

CONTRIBUTORS TO THIS REPORT NOT INVOLVED
IN THE G-TOLERANCE WORKSHOP

Dr. James E. Whinnery
USAFSAM/VNB
Brooks AFB, TX 78235-5301

Dr. Larry P. Krock
USAFSAM/VNB
Brooks AFB, TX 78235-5301

Maj Michael P. Boehme
833rd Med Gp/SGT
Holloman AFB, NM 88330-5000

Dr. Ronald Bulbulian
Associate Professor
Exercise Physiology
University of Kentucky
Lexington, KY 40506

Lt Col John R. Green
833rd Med Gp/SGT
Holloman AFB, NM 88330-5000

CONTENTS

Page

PREFACE v

PARTICIPANTS vi

FIGURES x

INTRODUCTION 1

Hardware Developments to Improve G Tolerance 1
Educational Programs to Improve G Tolerance 2
Centrifuge Training to Improve G Tolerance 2
Physiologic Warm-up 3
Life-style Stressors 3
Nutritional Considerations 3
Physical Conditioning to Improve G Tolerance 4

HIGH-INTENSITY MUSCULAR CONDITIONING 5

Introduction 5
Strength Conditioning Program 6
Endurance Resistance Training Program 7

STRENGTH AND ENDURANCE EXERCISE PROGRAMS 7

Stack Machine Weight Equipment 9
Strength Emphasis Workout 9
Endurance Emphasis Workout 9
Free Weight Equipment 10
Strength Emphasis Workout 10
Endurance Emphasis Workout 10
Hydraulic and Cam-type Equipment 11
Strength Emphasis Workout 11
Endurance Emphasis Workout 11
Program Interruptions 12
Maintenance Program 12
Preflight/Preengagement Warm-up 12

AEROBIC CONDITIONING FOR FLYERS 13

Aerobic Fitness and G Tolerance 13
Suggested Programs 14
Alternatives to Running 14

SUGGESTED READINGS 15

FIGURES

Figure No.		Page
1.	Stretching Exercises	17
2.	Leg Press	18
3.	Bench Press	19
4.	Lat Pull	20
5.	Military Press	21
6.	Arm Curl	22
7.	Sit-up	23
8.	Leg Raise	24
9A.	Neck Series	25
9B.	Neck Series	26
9C.	Neck Series	27
9D.	Neck Series	28
9E.	Neck Series	29
10.	Leg Extension	30
11.	Leg Curl	31
12.	Shoulder Shrug	32
13.	Seated Row	33
14.	Upright Row	34
15.	Tricep Extension	35
16.	Squat	36
17.	Bench Press	37
18.	Pull-up	38
19.	Arm and Chest Pull Over	39
20.	Military Press	40
21.	Arm Curl	41
22.	Bent-over Row	42
23.	Upright Row	43
24.	Bar Dip	44
25.	Knee Flexion and Extension	45
26.	Chest Press and Row	46
27.	Shoulder Press and Lat Pull	47
28.	Abdominal and Low Back	48
29.	Neck Lateral Flexion	49
30.	Neck Extension and Flexion	50

PHYSICAL FITNESS PROGRAM TO ENHANCE AIRCREW G TOLERANCE

INTRODUCTION

This report provides a review of existing knowledge and descriptions of physical conditioning programs to enhance aircrew G tolerance. In addition, research findings on hardware and physiology in the high-G arena are discussed.

The performance envelope of tactical jet aircraft may exceed the aviator's physiological tolerance limits. Consequently, the most vulnerable factor in flying tactical jet aircraft to performance limits is frequently the aviator. New generation tactical jet aircraft are capable of rapidly reaching and sustaining 7-9 Gs; advanced design may raise the G capability even higher. This capability, together with increased maneuverability, survivability and weapon system accuracy, is critical in determining the winner during air combat.

Aviators can withstand G forces equal to or exceeding those of present aircraft, but require assistance of mechanical and physiological countermeasures to maintain blood flow to the brain. The primary methods to increase aviators' G tolerance are the anti-G suit and the anti-G straining maneuver (AGSM; also called the L-1 maneuver). The AGSM is used to increase blood flow to the brain through a voluntary isometric contraction of the body's entire musculature and an increase of pressure within the chest by exhalation against a closed glottis.

Hardware Developments to Improve G Tolerance

One of the factors placing aviators of high performance aircraft at risk from G-induced loss of consciousness (GLOC) is ejection seats which orient the crewmember in an upright position during high-G exposure. Until the advent of newer generation aircraft, e.g., F-15/18/16, previous aircraft G capabilities did not warrant the use of tilt seats. Engineering constraints and restricted aviator mobility and vision in a reclined position have limited seat-back angles to approximately 30 degrees from the vertical. However, it has been found that a 30 degree tilt seat does provide about one G improvement over the standard seat.

Another method, assisted positive pressure breathing (APPB), has also been tried using a chest counter pressure garment called a "jerkin." When positive pressure is applied to the mask at an amplitude proportional to the G force, chest pressure is increased, directly increasing arterial blood pressure. Test flights at the Air Force Flight Test Center (Edwards AFB, CA) generated a high degree of acceptance by both F-15 and F-16 pilots. The pilots claimed their G tolerance increased and fatigue levels decreased.

No significant improvements in the operational anti-G suit have been made since its introduction during World War II. Research in the last decade has shown that more complete coverage of the legs by the anti-G suit enhances G tolerance by reducing muscular fatigue during air combat maneuvers (ACM). Improving leg coverage in an operational anti-G suit has been difficult because of problems in suit design. Currently, a single-bladder suit that provides complete coverage appears to be the most promising. This design should minimize fitting and sizing problems and provide better leg support than the current multiple-bladder suits. Furthermore, it is expected to reduce fatigue from ACM by as much as 50%.

New concepts in anti-G valves have been explored, specifically, using faster inflation rates and electronic controls. Higher flow inflation valves have been retrofitted into all F-16 aircraft and are programmed for other USAF tactical aircraft.

Educational Programs to Improve G Tolerance

In 1984, Tactical Air Command (TAC) commenced a "spread the word" campaign to heighten the awareness of GLOC among tactical aircrew. Among these efforts were initial briefings at wing and squadron level on the physiology and prevention of GLOC episodes and the institution of annual "G awareness" briefings to be conducted during the Instrument Refresher Course. Additionally, TAC published TACP 51-17 entitled "G-awareness for Aircrews" which addressed the problem of GLOC and several methods of coping, especially guidance on physical conditioning. Unfortunately, TACP 51-17 did not receive widespread distribution among TAC aircrews. However, it is certain that the training efforts heightened the awareness of fighter aircrews and made them much more sensitive to the GLOC issue.

Centrifuge Training to Improve G Tolerance

Aviators should have sufficient instruction and opportunities to correctly perform the AGSM. The most effective and safest method of teaching the AGSM is to use the centrifuge. The USAF has demonstrated centrifuge usefulness and aviator acceptance. Presently, the USAF uses their research centrifuge (Brooks AFB, TX), the Dutch Air Force centrifuge (Soesterberg, the Netherlands) and the Japanese Air Self Defense Force centrifuge (Tachikawa, Japan) for training. Physiological theory of GLOC and AGSM are explained to aviators before they receive practical experience and instruction during rapid onset (6 G/s) centrifuge runs up to 9 Gs for 15 s. At Holloman AFB, the USAF is building a centrifuge solely for aircrew training. This base is used for Lead-In Fighter Training (LIFT) for all aircrew members entering the tactical inventory. All aircrew members who will fly fighter, attack, recce and Forward Air Control (FAC) aircraft will eventually experience this G training. The Navy presently operates a centrifuge (Naval Air Development Center, PA), which is used for research and not pilot training. They expect to have east and west coast training centrifuges operational by 1992.

Physiologic Warm-up

G-awareness turns have been made a mandatory part of almost all fighter sorties in the USAF Tactical Air Forces. While these were originally instituted to allow the aircrews to get a "feel" for the Gs and gauge their response and the aircraft's response, a side benefit of physiological "warm-up" is also realized. Sympathetic reflexes are stimulated and remain so for several minutes after sudden exposure to moderate Gs. Subsequently, the aircrew have a small "leg up" on the Gs when they enter an engagement. Currently, there is no standardization of the number of turns to be completed nor of the amount of G to be pulled in each turn. It has been postulated that the maneuvers need to be at least in the 3-5 G range for the appropriate response to occur.

Life-style Stressors

Life-style can have a significant effect on G tolerance. Smoking, alcohol, diet, illness (especially requiring bed rest), medication (particularly self-medication), and dehydration are some of the factors which can affect physiological performance. Illness and/or medications often interact with body processes in unpredictable ways in the flight environment. Flight surgeons should be consulted on these matters. Because the AGSM requires rapid movement of air through the lungs, smoking (known to increase airway resistance) should be kept to a minimum with complete abstinence being advised. Alcohol is known to adversely affect flight performance by interfering with mental, physiologic (hypoglycemia and ionic imbalance) and physical functions. Dehydration, known to reduce G tolerance, is common the day following a night of excessive alcohol consumption. Severe "hangover" can also adversely affect flight performance. Although the Navy and USAF prohibit alcohol consumption 12 h prior to preflight brief, no alcohol 24 h before flight is advisable. In addition, recent experience with flight simulators suggests that a 48 h period of moderation before flying is also indicated for peak performance.

The state of hydration is particularly important to aircrew members. If missions are flown during hot conditions, the aviator should prehydrate by consuming a minimum of one pint of water before flying. Rehydration after flight should provide 1 pint of water per pound of body weight lost. The sensation of thirst is not an adequate indicator of dehydration; therefore, aviators may have to force themselves to drink.

Nutritional Considerations

Sources of energy for optimal performance are enhanced by proper nutrition and physical conditioning. Energy stores available to the body are not primarily obtained from the preflight meal, but result from the previous diet and activity patterns.

Contrary to popular belief, a diet high in protein is not essential to develop muscle strength during this conditioning program. Total calories are important to ensure that protein in the diet is available for purposes of muscle development and maintenance. About 50-60% of dietary calories should be derived from complex carbohydrates such as pasta, breads and potatoes. Fruits and vegetables should also be prominent in the diet.

To perform at their best, aircrew must be well-rested, properly nourished and sufficiently hydrated when beginning a mission. An adequate recovery and replenishment period must be planned and taken after each sortie involving high-Gs, or after exercise. To ensure that adequate recovery has occurred, a minimum of 3 h or more is recommended between the end of strenuous exercise and the beginning of flight.

Physical Conditioning to Improve G Tolerance

Physical training for air combat is similar in many respects to the training required for athletic competition. Maximum performance during athletic competition requires a specific physical conditioning program, which is characteristic of the strength and endurance requirements for that event (exercise specificity). Training for a 100-m sprint is considerably different from marathon training. Sprints, or short-duration, high-intensity events, require relevant muscle groups to quickly provide large quantities of energy for brief periods of time. Conversely, distance running or long-duration events require relevant muscle groups to deliver a continuous energy supply for long periods of time. Thus, muscle groups respond to the stimulation of these two training procedures differently. Physiological adaptations occur that enable the muscles to accomplish specific tasks more effectively. In the sprinter, adaptive changes enable stored fuels to be quickly utilized by a biochemical process that does not require the immediate presence of oxygen. Training for this type of exercise response is called "anaerobic" (without oxygen). In the distance runner, adaptive changes enhance the capacity for stored fuels to be used by a biochemical process that requires the presence of oxygen. This exercise training is termed "aerobic" (with oxygen).

During air combat maneuvers, aircrews undergo high-G forces for short durations. The muscles involved in the AGSM expend energy at a rate analogous to those of the sprinter or weight lifter. Researchers have used aerobic and anaerobic subject training protocols to measure G tolerance during centrifuge testing before and after training. Results from these studies show that anaerobic weight training enhances the ability of subjects to perform the AGSM more effectively, allowing them to withstand increased G force longer during centrifuge testing. In addition, aerobic training was not demonstrated to benefit G tolerance. Consequently, anaerobic training should be given higher priority than aerobic training in a physical fitness program for aviators.

Besides GLOC, aviators should also be aware that neck injuries occur with increased frequency as high-G exposure increases. A recent Navy survey of G-induced neck injury in F/A-18, A-4, and A-7 pilots was completed at the Light Attack Wing, Pacific (NAS Lemoore, CA). The Navy found that 74% of F/A-18, 58% of A-4, and 30% of A-7 aviators surveyed reported some neck pain associated with high-G maneuvers. Twelve of 89 pilots were temporarily removed from flight status for an average of 3 days because of injury. Age was not a contributing factor to the incidence of neck pain in this survey. The USAF completed a similar survey with five wings at three TAC bases involving 437 F-5, F-15, and F-16 pilots. Neck injury rates of about 45% over a 3-month period of time were found in F-15 and F-16 pilots. Major injuries of 13% were reported for the F-16 pilots and were greatest in pilots over 40 years of age.

Specific recommendations resulting from the USAF neck injury survey were:

1. Neck exercise program
2. Neck stretching or G warm-up before air combat maneuvers
3. Cautious return to high-G after a long layoff
4. Minimize neck movement under high-G loads
5. Maintain good physical condition, nutrition and rest

During flight events that require visual scanning aft of the aircraft coupled with high-G maneuvers, the head and neck can be rapidly subjected to large increases in force. When high force loads on the head and neck exceed the ability of the muscles to maintain the position of the head, injury to the neck can result. This situation intensifies when the neck muscles become fatigued. Therefore, a neck conditioning program must involve all muscle groups to increase their force generation capacity and to increase their time to fatigue. This involvement would significantly enhance the ability of the neck muscles to resist injury during conditions of high-G loading.

HIGH-INTENSITY MUSCULAR CONDITIONING

Introduction

Effective countermeasures must be pursued to combat the problems associated with high-G exposure. One of these countermeasures is participation in an exercise conditioning program designed to increase muscular strength and endurance and enhance cockpit mobility. The rationale behind this recommendation is that increased muscular strength and endurance will allow the pilot to perform the AGSM with less relative muscular effort so that less relative subjective effort is required to maintain vision and consciousness during ACM. This is extremely important as the distraction of concentrating on performance of the AGSM will erode the pilot's ability to maintain situation awareness (SA). In combat, this may be fatal. Exercise programs that increase muscular strength and endurance under load (anaerobic capacity) are more likely to meet these objectives.

Before any specific program is undertaken, some basic exercise principles must be understood:

1. Exercise specificity. For optimal improvement in G tolerance, the exercise program must focus on the respiratory and skeletal muscle movements that are similar to the straining and tensing maneuvers required to resist high-G forces. To simulate the AGSM, a full breath should be taken before the lifting phase during a resistance effort. As the weight is raised, straining should continue against a partially closed glottis during the lift.

2. Exercise intensity. The exercise must tax the specific muscle groups involved. For maximal benefits in strength, the load should be 80-90% of the maximum weight that can be lifted one time (one repetition maximum or 1 RM).

3. Exercise duration. The conditioning program must be performed with 5-10 repetitions per set with 2 or more sets per exercise period.

4. Rest periods. Specific rest periods should be adhered to between sets and between exercises, depending on the program specifications. The duration of the rest period will affect the exercise program loads and the physiological stress of the workouts.

5. Exercise frequency. A minimum of 24 hours should elapse between exercise sessions. Seldom should more than four training sessions be completed in a 7-day period. For conditioning to improve G tolerance, both strength and endurance exercises must be performed. Perform exercise program on alternate days, e.g., strength on Monday, endurance on Tuesday, rest on Wednesday, strength on Thursday, and endurance on Friday.

6. Exercise order. Muscle groups most useful in performing the AGSM should be exercised first.

7. Warm-up and cool-down. The daily conditioning program should begin with a gradual warming up and stretching session of 5-10 min. Also, approximately 5-10 min of whole-body stretching should be performed after exercising to minimize soreness.

8. Program assessment. The effectiveness of any training program should be periodically assessed by examining some quantifiable performance parameter. In these recommended programs, progress can be evaluated by comparing changes of weight lifted during the specified number of repetitions for each exercise session. Participation in a 12-week conditioning program should result in a 10-20% improvement for most of the exercises.

9. Exercise timing. The demands of exercise on the cardiovascular and metabolic systems are such that 3+ h should elapse before assuming flight duties involving high-G. This timing is particularly important as intense exercise can lead to temporary fatigue due to exhaustion of stored muscle fuels, noticeable muscle tremor and possible postexercise hypotension (low blood pressure).

10. Conditioning. The benefits gained from a conditioning program can be lost rapidly. After 2 weeks or more of inactivity, the aviator should resume an exercise program at an intensity level between 80-90% of the weight used at the time of interruption.

Strength Conditioning Program

The strength conditioning exercise session should begin with a short period (5-10 min) of warm-up and stretching. Stretching movements should follow warm-up exercises and involve all muscle groups that will be used during the strength development session. Recommended stretching exercises are illustrated in Figure 1 (hamstring, shoulder, neck and trunk stretches).

Rest periods should occur between sets and between exercises, i.e., between each series of a given exercise, as well as in the transition period between specific exercises. Rest periods should be between 2-3 min and at least equal to the amount of time spent in performing the set.

The resistance for each exercise is the load which can be achieved for the indicated number of prescribed repetitions, called "repetition maximum" or "RM" load. For example, if one can "curl" 100 lb for 10 repetitions but no more, the exercise is a 10 RM movement. When the aviator can perform one or more repetitions beyond the specified limit, more weight or resistance should be added. In the muscle strength conditioning program, repetitions for the various exercises will range from 5-10, depending on the exercise.

A "set" refers to the number of repetitions completed. In the muscle strength conditioning program, sets for the various exercises will range from 2-5. The exercises are listed in the text in the order they should be executed. Repetitions should be performed in 3-5 s, and respiratory straining should be done against a partially closed glottis during the contraction. Exhale on the extension.

Following all workouts, a 5-10 min cool-down period of static stretching exercises should be done to minimize muscle soreness. The stretching exercises illustrated in Figure 1 are appropriate for this purpose.

Endurance Resistance Training Program

A 5-10 min warm-up and stretching period similar to that described for a strength conditioning workout should precede each muscle endurance conditioning session. See Figure 1 for examples.

Muscular endurance workouts are characterized by paired exercises. A set of the first exercise is performed, and without rest, a set of the second paired exercise is performed. For example, one might perform 10 repetitions of the bench press immediately followed by 10 repetitions of the shoulder shrug. This resistance training is known as a "super set." A super set is followed by a 30-60 s rest, whereupon a second super set is done. Two to three super sets per pair of exercises are used in this program. The number of repetitions per exercise set ranges from 10-20, depending on the exercise performed.

Paired exercises represent components of the high-intensity muscular endurance resistance training program. The specific order of the exercises within each super set should be maintained.

STRENGTH AND ENDURANCE EXERCISE PROGRAMS

The strength and endurance exercise programs have been divided into workouts using several different types of training equipment: stack machine weight equipment, free weight equipment, "Nautilus" cam-type machines and hydraulic equipment.

It is possible to shorten the time required to accomplish this exercise program yet achieve much of the positive benefit of strength training by using a modified or shortened version. The important point is to regularly engage in some strength enhancing exercise. A shortened exercise program can be accomplished by either (a) reducing the number of different types of specific exercises using the recommended numbers of sets or (b) performing all of the exercises but completing only 2 sets of each.

If a (the former) shortened version is to be accomplished, the exercise order is different from that recommended for the total program (see exercise priorities listed under the short version). This exercise order places emphasis on muscle groups thought to be most useful for pilots and contributive to enhanced G tolerance. The shortened programs provide a means for a crewmember to tailor an exercise program for a specific time schedule and maximize the benefits for a given time expenditure. We strongly recommend that if time permits, the total program be accomplished.

Stack Machine Weight Equipment

The exercises comprising the muscular strength workout for multistation weight stack machines are as follows:

Strength Emphasis Workout

Warm-up: 5-10 min, see Figure 1

Rest period: 2 min between sets

Exercise	Sets / Reps	Figure	Short Version
1. Leg press	4 / 5 @ 5 RM*	2	5**
2. Bench press	4 / 5 @ 5 RM	3	3
3. Lat pull	3 / 5 @ 5 RM	4	4
4. Military press	3 / 8 @ 8 RM	5	6
5. Arm curl	3 / 6 @ 6 RM	6	7
6. Sit-up	2 / 10-20	7	1
Leg raise	2 / 10-15	8	
7. Neck series (with self or partner)	3 / 6 @ 6 RM	9A-9E	2

* RM = repetition maximum level, the amount of weight that can be lifted for only that specific number of repetitions in good form.

** Exercise priority; e.g., sit-up or leg raise first followed by neck series, etc.

Cool-down: 5-10 min, see Figure 1

Endurance Emphasis Workout

Warm-up: 5-10 min, see Figure 1

Rest period: 30-60 s between super sets and exercise segments

Exercise	Super sets / Reps	Figure	Short Version
1. Leg extension/leg curl	3 / 10 @ 10 RM	10, 11	5
2. Bench press/shoulder shrug	3 / 10 @ 10 RM	3, 12	3
3. Lat pull/seated row	3 / 10 @ 10 RM	4, 13	4
4. Military press/upright row	3 / 10 @ 10 RM	5, 14	6
5. Tricep extension/arm curl	3 / 10 @ 10 RM	15, 6	7
6. Sit-up/leg raise	2 / 10-20	7, 8	1
7. Neck series (with self or partner)	3 / 12 @ 12 RM	9A-9E	2

Cool-down: 5-10 min, see Figure 1

Free Weight Equipment

The conditioning program can be performed using free weight or stack machine weights with minimal exercise modification, i.e., squat for leg press. Some locations will have only free weights. In these situations, the same workout schedule as listed previously for the machine weight should be used. A spotter must always be used in a free weight program because control of heavy weights can be difficult when fatigued. The exercises and the order they should be performed are listed next. The free weight exercises are listed opposite the equivalent machine weights.

Strength Emphasis Workout

Machine Weights	Free Weights	Figure	Short Version
1. Leg press	Squat	16	5
2. Bench press	Bench press	17	3
3. Lat pull	Pull up (arm and	18	4
	chest pull over)	19	4
4. Military press	Military press	20	6
5. Arm curl	Arm curl	21	7
6. Sit-up/leg raise	Sit-up/leg raise	7, 8	1
7. Neck series	Neck series	9A-9E	2

Endurance Emphasis Workout

Machine Weights	Free Weights	Figure	Short Version
1. Leg extension	Squat	16	5
Leg curl			
2. Bench press	Bench press	17	3
Shoulder shrug	Shoulder shrug	12	
3. Lat pull	Pull up (arm and chest pull over)	18	4
Seated row	Bent-over row	22	
4. Military press	Military press	20	6
Upright row	Upright row	23	
5. Arm curl	Arm curl	21	7
Tricep extension	Bar dip	24	
6. Sit-up	Sit-up	7	1
Leg raise	Leg raise	8	
7. Neck series	Neck series	9A-9E	2

The weights lifted should be increased when the crewmember can perform more than the specified number of repetitions in a set with a given resistance. Sufficient weights should be added to reduce the number of repetitions to the minimum.

Hydraulic and Cam-type Equipment

If hydraulic equipment is used, the general conditioning principles listed earlier will apply, but the mechanics of implementation will be somewhat different. Suggested dial settings for the strength and endurance emphasis workouts are listed next. Repetitions should be performed as rapidly as possible.

Strength Emphasis Workout

Warm-up: 5-10 min, see Figure 1

Perform 4 sets: 1 set at each dial setting of 3, 4, 5, 6

Work period: 20 s per set

Rest period: 2 min between sets

Cool-down: 5-10 min, see Figure 1

Endurance Emphasis Workout

Warm-up: 5-10 min, see Figure 1

Perform 4 sets: 1 set at each dial setting of 3, 4, 5, 6

Work period: 30 s per set

Rest period: 30-60 s between sets

Cool-down: 5-10 min, see Figure 1

The exercises to be performed are listed in sequence below and depend on equipment available:

Exercise	Figure	Short Version
1. Knee flexion and extension	25	5
2. Chest press and row	26	4
3. Shoulder press and lat pull	27	7
4. Chest press and row	26	6
5. Abdominal and low back	28	1
6. Neck lateral flexion	29	3
7. Neck extension and flexion	30	2

Program Interruptions

To minimize the effects of interruptions on an exercise program, the following guidelines apply. The aviator should arrange a schedule to obtain a minimum of 5 weeks of uninterrupted conditioning. In this time, sufficient training adaptation will have occurred to initiate gains in muscular strength and endurance. During interruptions, the participant should continue the training program by whatever means available (see previous sections) at least twice weekly to maintain previous gains. If standard exercise equipment is not available, the aviator should devote the exercise time to push-ups, sit-ups, leg raises, chair presses, back arches, neck flexion and extension movements, and isometric contractions of the major muscle groups.

The RM load used for each exercise will decrease during nontraining periods. Consequently, RM load determinations before resuming exercise can be used to select the proper load to begin the program after an interruption. If the break in conditioning is 2 weeks or more, the participant will probably return to the conditioning program using 80-90% of the load employed during the conditioning session immediately before the break.

Maintenance Program

After successful completion of the 12-week strength and endurance exercise program, aircrew members should continue exercising to maintain the strength and endurance gains acquired.

A 10-20% increase in strength and endurance should be achieved from the prescribed exercise program. To maintain this new fitness level, the recommended schedule should include a minimum of 2-3 workouts evenly distributed over 7 days. These workouts should be a combination of the different programs. As a general rule, two consecutive strength workouts per week are not recommended in the maintenance program.

The purposes, guidelines, and precautions outlined in previous sections apply to the maintenance component. Again, the workouts should not be performed on consecutive days and should represent complete workouts of an intensity equal to that performed when the program was completed.

Preflight/Preengagement Warm-up

To take full advantage of any physical conditioning program requires adequate preparation for the in-flight stress. Preparation for maximum G stress in an air combat engagement should include muscular warm-up in the immediate prestress period. Like athletes, aircrew should warm up before maximum exertion. These techniques not only reduce the risk of injury, but serve to enhance flying performance. For beneficial effects, the exercises should include those muscle groups that are specifically active in high-G maneuvers. Ideally, warm-up and stretching should begin 30 min before G exposure and taper to 5 min before the actual engagement. Since conditions are seldom ideal to permit this type of warm-up schedule, the minimum recommendations are as follows:

1. After preflight briefing, while in Life Support, perform stretching movements, trunk rotations, and neck rotations in all directions.

2. During aircraft inspection, perform front and back stretching, neck rotation, and neck stretching.

3. During taxi or while waiting for takeoff, perform neck stretching against resistance. This procedure requires neck flexion against the resistance provided to the head by the hand and involves movements in the four major directions. This procedure should simulate the movements anticipated in aerial combat maneuvers. Care should be taken to avoid applying too much resistance as it could be painful or cause muscle strain.

4. Before engagement, perform several moderately intense AGSM and several maximal neck stretches.

AEROBIC CONDITIONING FOR FLYERS

Aerobic conditioning occurs when exercise is performed at submaximal intensity for extended periods of time with the intention of improving the function of the cardiovascular system. This effect occurs when a person exercises several times a week at an intensity that can maintain the heart rate in a "target" range for at least 20-30 min. The target range is determined through calculation of the maximum rate (220 minus age) and multiplying by 60 and 80%. For example, a 20 year old has a calculated maximum heart rate of 200 and his exercise target range is 120-160 beats/min. Alternately, the crewmember may rely on his breathing rate to gauge his heart rate. Breathing should be accelerated, but not to the point of discomfort or where it would interfere with speech.

Aerobic Fitness and G Tolerance

Scientists in the aviation physiology community believe that high levels of aerobic conditioning will not directly enhance the ability of an individual to reach higher G levels. In a broader sense, the influences of aerobic fitness on repeated high-G exposure during a single mission, multiple missions in one day, or multiple daily missions have yet to be adequately assessed.

For aircrew involved in flying fighter aircraft, excessive time devoted to aerobic training, e.g., preparation for such events as a marathon, biathlon or triathlon, may be detrimental to G tolerance. Ongoing research suggests that effectiveness of the blood pressure control system can be reduced in endurance trained athletes, but this effect has not been confirmed in high-G studies. Some subjects with high levels of aerobic fitness have shown increased incidence of irregular heart rate (cardiac arrhythmias, some of which can adversely affect $+G_z$ tolerance) during exposure to centrifuge tests at the USAF School of Aerospace Medicine. Preliminary research findings indicate that incapacitation and recovery time from GLOC is prolonged in excessively aerobically fit individuals. Other studies suggest that certain individuals with high levels of aerobic fitness can have an increased susceptibility to motion sickness. For these reasons and because of the benefits of aerobic conditioning, only a moderate aerobic training program is suggested.

Suggested Programs

The basic element of aerobic conditioning is large muscle exercise that produces a sustained heart rate in a target zone (see preceding section). While several exercises can be performed to produce aerobic conditioning, running is the most common.

A running program of 20-30 min, 3 times per week, is suggested as adequate for maintaining good cardiovascular fitness while avoiding the possible adverse effects of excessive aerobic training. For aircrew who desire to run more, the maximum program suggested is 3-5 mi per day, no more than 4 times per week. If more than 9 mi per week, the running must be integrated with the recommended weight training program to achieve optimal results in a high-G environment. For the competitive minded, a 5 km (3.1 mi) race should be the longest event undertaken in any given week.

Persons unaccustomed to aerobic conditioning should begin the program by initially running short distances at a slow pace. The time and distance of running should then progressively be increased until the desired level of conditioning is attained.

Alternatives to Running

Aerobic exercises, e.g., rowing, cycling, swimming, cross-country skiing, aerobic dance, walking, etc., also use large muscle groups in a continuous fashion. These activities should be performed at an intensity that will achieve the targeted heart rate for at least 20 min. For lower intensity exercise, such as brisk walking, a longer duration may be necessary. For example, a 20-year-old man might achieve a heart rate of only 110 beats/min. In his case, he might extend the walking time to one hour to achieve benefit. However, a 40-year-old man with a heart rate of 110 is working in his target zone and need not unnecessarily extend his walking time.

SUGGESTED READINGS

AFP 50-56. U.S. Air Force aerobics physical fitness program. 17 Jul 1974.

Astrand, P-O, and Rodahl, K. Textbook of work physiology: Physiological bases of exercise, (2nd Ed), New York: McGraw Hill Book Co, 1977.

Astrand, P-O, and Rhyming, I. A nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during submaximal work. J Appl Physiol 7:218-221 (1954).

Blomquist, C.G., and Stone, H.L. Cardiovascular adjustments to gravitational stress, the cardiovascular system. In: Handbook of Physiology, Section 2, Vol. 3, Peripheral circulation and organ blood flow. Ed. Shepherd F.T., Abboud, F.M. Bethesda, MD: Am Physiol Soc 1050-1063 (1984).

Bonde-Peterson, F., Christensen, N.J., Henriksen, O., Nielsen, C., Norsk, P., et al. Aspects of cardiovascular adaptation to gravitational stresses. The Physiologist. Suppl S-7-S10 (1980).

Burton, R.R., and Whinnery, J.E. Operational G-induced loss of consciousness: Something old, something new. Aviat Space Environ Med 56:812-817 (1985).

Cooper, K.H. The aerobics way. New York: Bantam Books, 1977.

Cooper, K.H. The aerobic program for total well being. New York: Bantam Books, 1983.

Epperson, W.L., Burton, R.R., and Bernauer, E.M. The effectiveness of specific weight training on simulated aerial combat maneuvering G-tolerance. Aviat Space Environ Med 56:534-539 (1985).

Fisher, M.G.P., and Atkinson, D.W. Fasting or feeding? A survey of fast-jet aircrew nutrition in the Royal Air Force Strike Command. Aviat Space Environ Med 51:1119-1122 (1980).

Fleck, S.J., and Kraemer, W.J. Designing resistance training programs. Champaign, IL: Human Kinetics, 1987.

Greenleaf, J.E., Brock, P.J., Harnes, R.F., Rositano, S.A., Montgomery, L.D., and Keil, L.C. Effect of hypovolemia, infusion, and oral rehydration on plasma electrolytes, ADH, Renin Activity, and $+G_z$ tolerance. Aviat Space Environ Med 48(8):693-700 (1977).

Greenleaf, J.E., Matter, M., Jr., Douglas, L.G., Raymond, S.A., Bosco, J.S., Averkin, E.G., St. John, R.H., Jr. Effects of acute and chronic hypohydration on tolerance to $+G_z$ acceleration in man. NASTM X. 1285:1-39 (1966).

Greenleaf, J.E., Stinnett, H.O., Davis, G.L., Kollias, J., and Bernauer, E.M. Fluid and electrolyte shifts in women during $+G_z$ acceleration after 15 days bed rest. J Appl Physiol 42:67-73 (1977).

Houghton, J.O., McBride, D.K., and Hannah, K. Performance and physiological effects of acceleration-induced ($+G_z$) loss of consciousness. Aviat Space Environ Med 56:956-965 (1985).

Knudson, R., McMillan, D., Doucette, D., Seidel, M. A comparative study of G-induced neck injury in pilots of the F/A-18, A-7, and A-4. Submitted to Aviat Space Environ Med (1987).

Lesmes, G.R., Costill, D.L., Coyle, E.F., Fink, W.J. Muscle strength and power changes during maximal isokinetic training. Medicine and Science in Sports 10:266-269 (1978).

Position paper, American Dietetic Association. Nutrition for physical fitness and athletic performance for adults. J Am Diet Assoc 87:933-936 (1987).

TACP 51-17. G Awareness for aircrew members. USAF pamphlet available through the publications distribution system, USAF, 12 Sep 1986.

Tesch, P.A., Hjort, M.D., Balldin, U.I. Effects of strength training on G-tolerance. Aviat Space Environ Med 54:691-695 (1983).

Tipton, C.M. Consideration for exercise prescriptions in future space flights. Med Sci Sports Exerc 15:441-444 (1983).

Vanderbeek, R.D. TAC neck injury study. Ltr rpt dated 25 Jun 1987, USAFSAM/EDK, Brooks AFB, TX.

Whinnery, J.E. Acceleration-induced atrioventricular dissociation: hemodynamic consequences. Aviat Space Environ Med 53:432-434 (1982).

Whinnery, J.E., Laughlin, M.D., and Hickman, J.R., Jr. Concurrent loss of consciousness and SINO-arterial block during $+G_z$ stress. Aviat Space Environ Med 50:635-638 (1979).

Whinnery, J.E., Laughlin, M.H., and Uhl, G.S. Coincident loss of consciousness and ventricular tachycardia during $+G_z$ stress. Aviat Space Environ Med 51:827-831 (1980).

Wilmore, J.H. Athletic Training and Physical Fitness. Physiological principles and procedures of the conditioning process. Newton, MA: Allyn and Bacon, Inc.,1977.

STRETCHING EXERCISES
BEFORE AND AFTER WEIGHT TRAINING

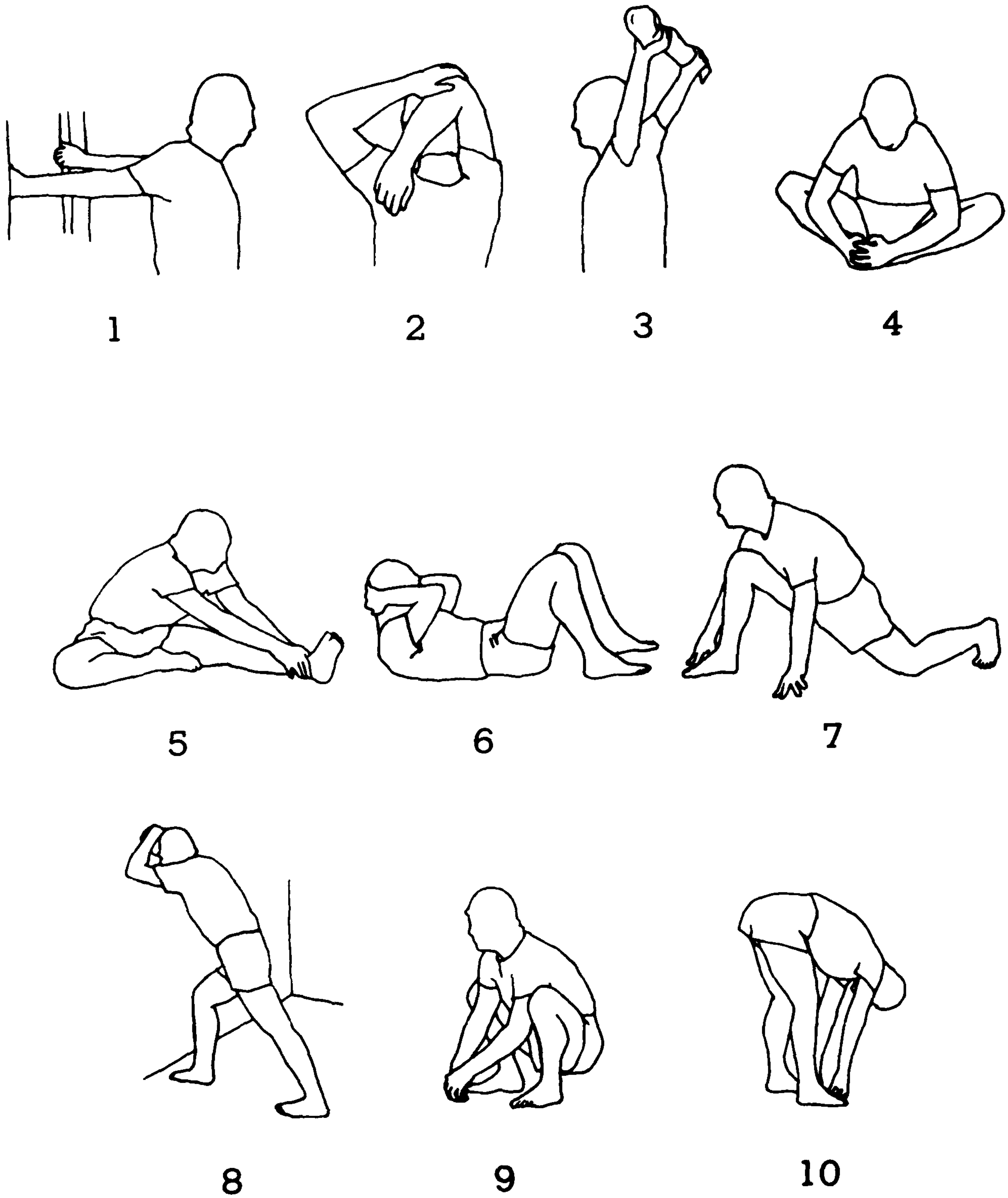


Figure 1. Stretching Exercises. Performed before and after each exercise workout. Full range of motion and slow, consistent movement throughout the stretching exercise should be concentrated on to the threshold of pain.

Figure [illegible]. Leg Press. Performed from a seated position with the feet on the pedals. The legs are extended, pressing the feet forward until the knees are slightly bent, but not locked in a fully extended position. Pause briefly and return to the starting position. The buttocks [illegible] maintain contact with the seat at all times. Do not arch the back.

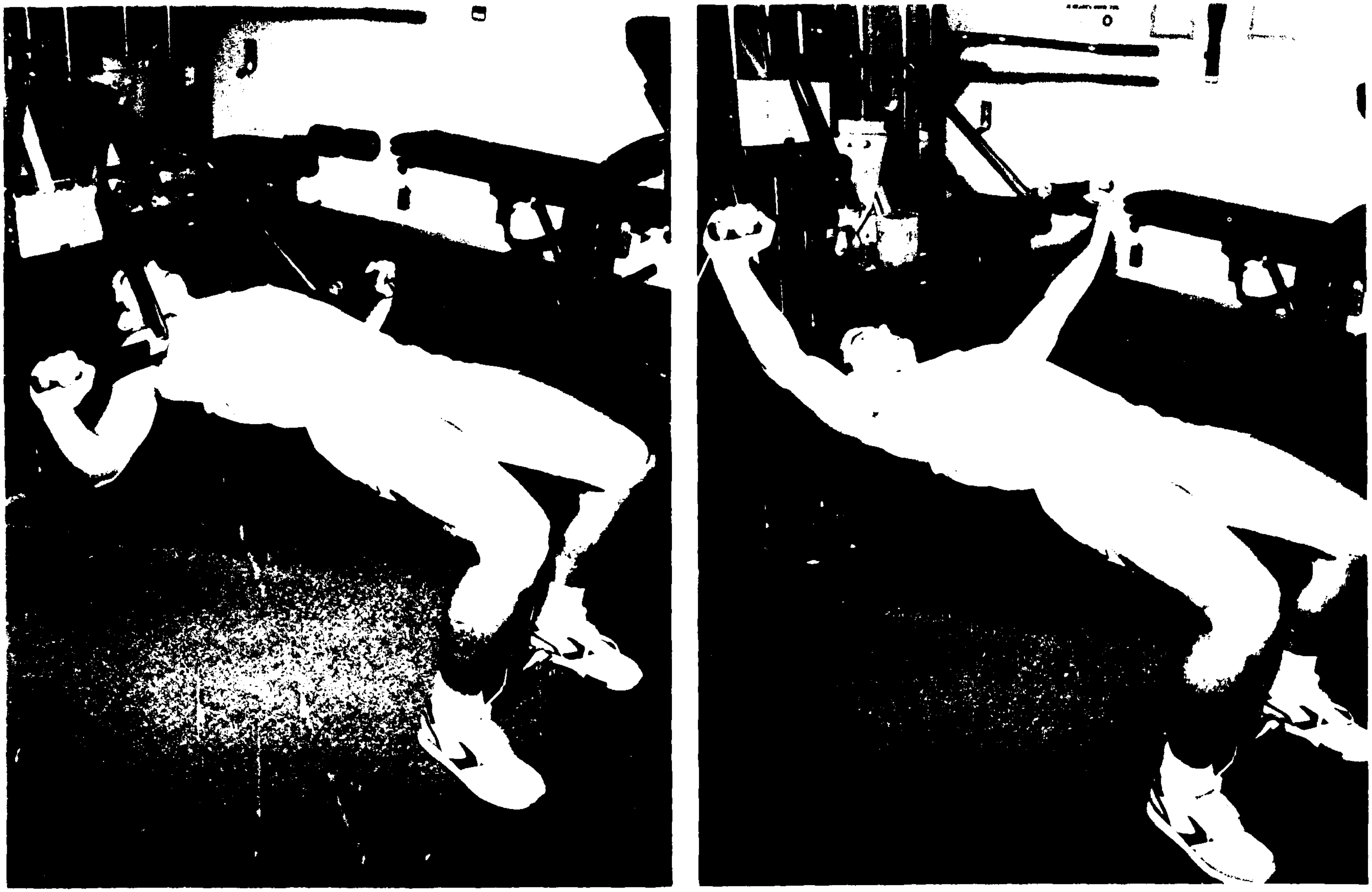


Figure 3. Bench Press. Performed from a supine position with the lifting bar in line with the middle of the chest. The bar is pressed upward to obtain full arm extension and then lowered slowly to the starting position. The head, shoulder, and buttock regions should remain in contact with the bench throughout the exercise. Do not arch the back.

Figure 4. Lat Pull. Performed by sitting or kneeling beneath the pulley, gripping the bar as preferred (wide or narrow grip, palms in or out), and pulling to either the chest or to behind the head position. After a brief pause, arms are fully extended, returning the bar to its original position.

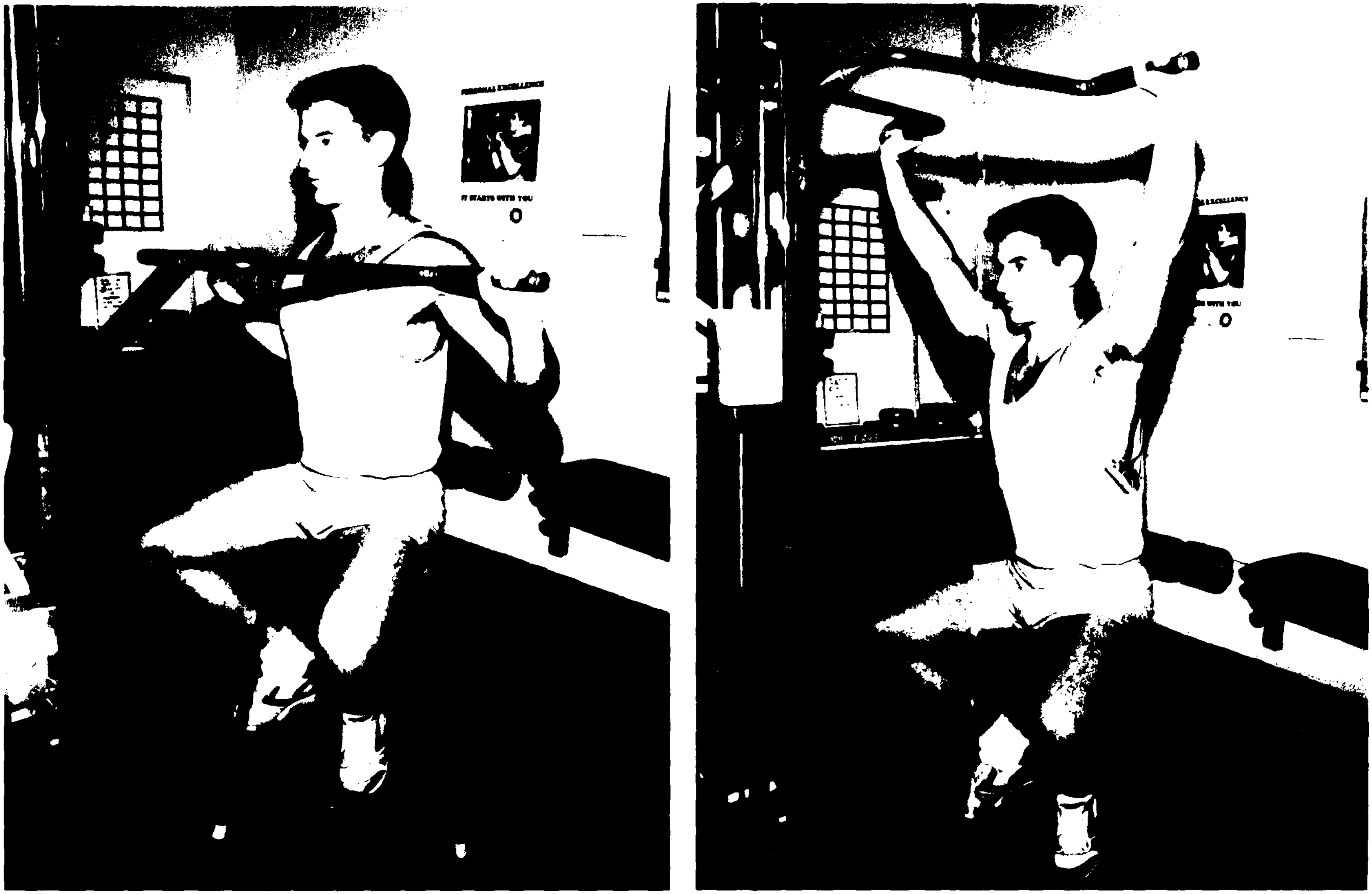


Figure 5. Military Press. Performed from a seated position facing the machine. The lifting lever is gripped and pressed upward to the full arm extension position. After a brief pause, the lever is returned to the starting position with the bar at shoulder level. Do not arch the neck or back.

Figure 6. Arm Curl. Performed from a standing position with an underhand grip on the bar, arms fully extended downward, elbows against the trunk. The arms are flexed upward, [illegible] the elbows [illegible], but unbraced against the trunk and back straight.

Figure 7. Sit-up. Performed on an incline board with knees bent and arms and hands crossed in front of the chest or with hands clasped behind the head. As the sit-ups become easier, the board should be inclined at steeper angles to increase the difficulty. Do not arch the back.

Figure 8. Leg Raise. Performed on an incline board, from a hanging position on the chinning bar, or from the leg raise apparatus on some equipment. The movement involves raising the legs forward, either straight or bent, until a 90-degree hip flexion position is achieved. Subsequently, the legs are lowered slowly back to the starting position.

Figure 9A. Neck Series (flexion). Performed lying face-up on a bench with the head and neck extended over the end of the bench. Full resistance is applied to the hands of the partner through a full range of neck flexion. Begin with the head fully extended toward the back. The partner provides constant resistance so that slow movement is maintained.

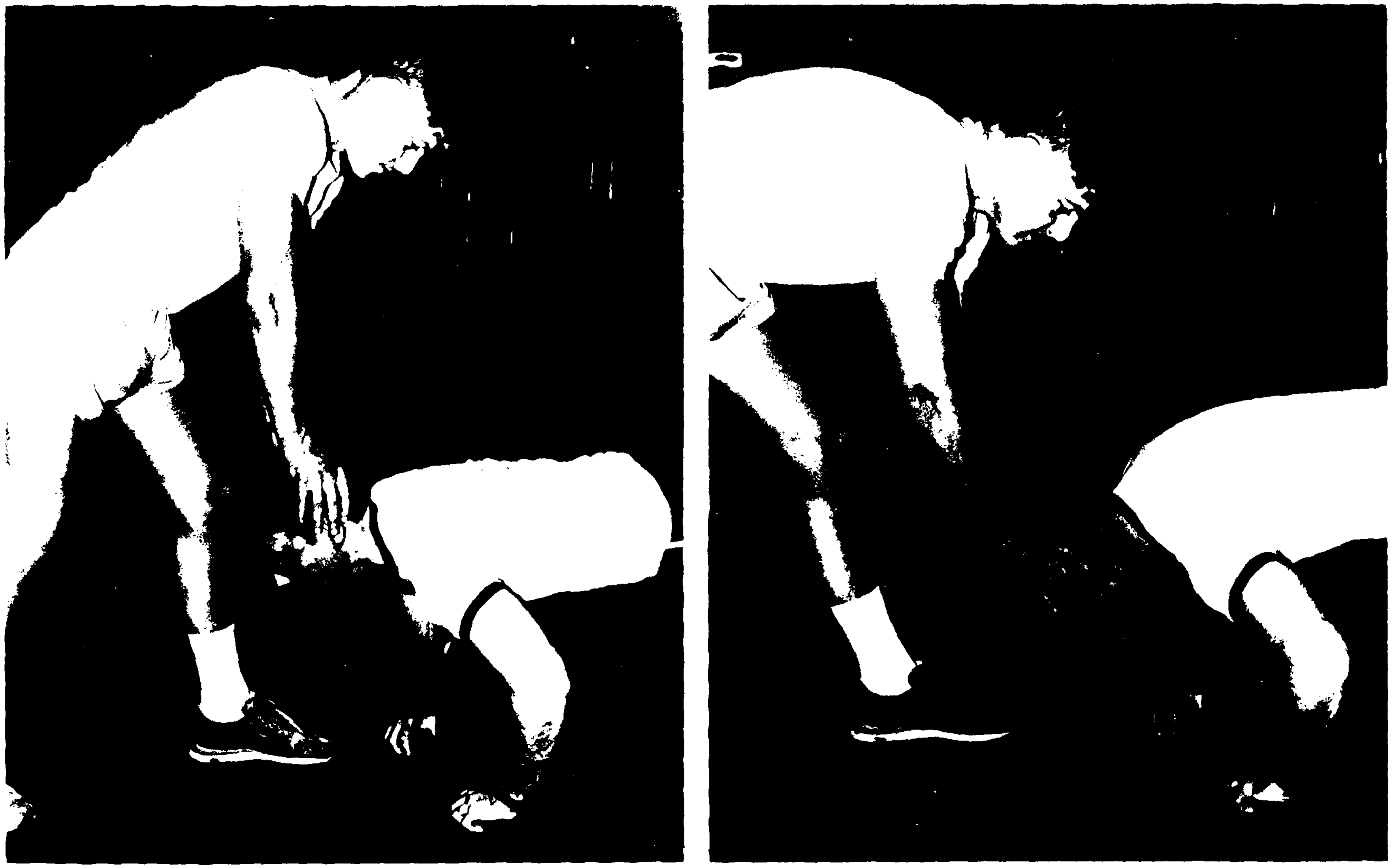


Figure 9B. Neck Series (extension). Performed lying face down on a bench with the head and neck extended over the end of the back. Resistance is applied to the hands of the partner through a full range of neck extension. Begin with the head fully flexed toward the chest. The resisting partner provides constant resistance so that slow movement is maintained.

Figure 9C. Neck Series (lateral flexion). Performed on the hands and knees with the shoulder supported by a rail or door frame. Full resistance is applied to the hands of the partner through a full range of neck lateral flexion. Begin with the head fully extended to the opposite shoulder. The partner should position himself so that a complete range of motion can be accomplished without losing his balance. Resistance should be applied so that slow movement is maintained. This exercise must also be performed to the opposing side of the neck. This is accomplished by changing positions, stabilizing the other shoulder and proper positioning of the partner on that side.

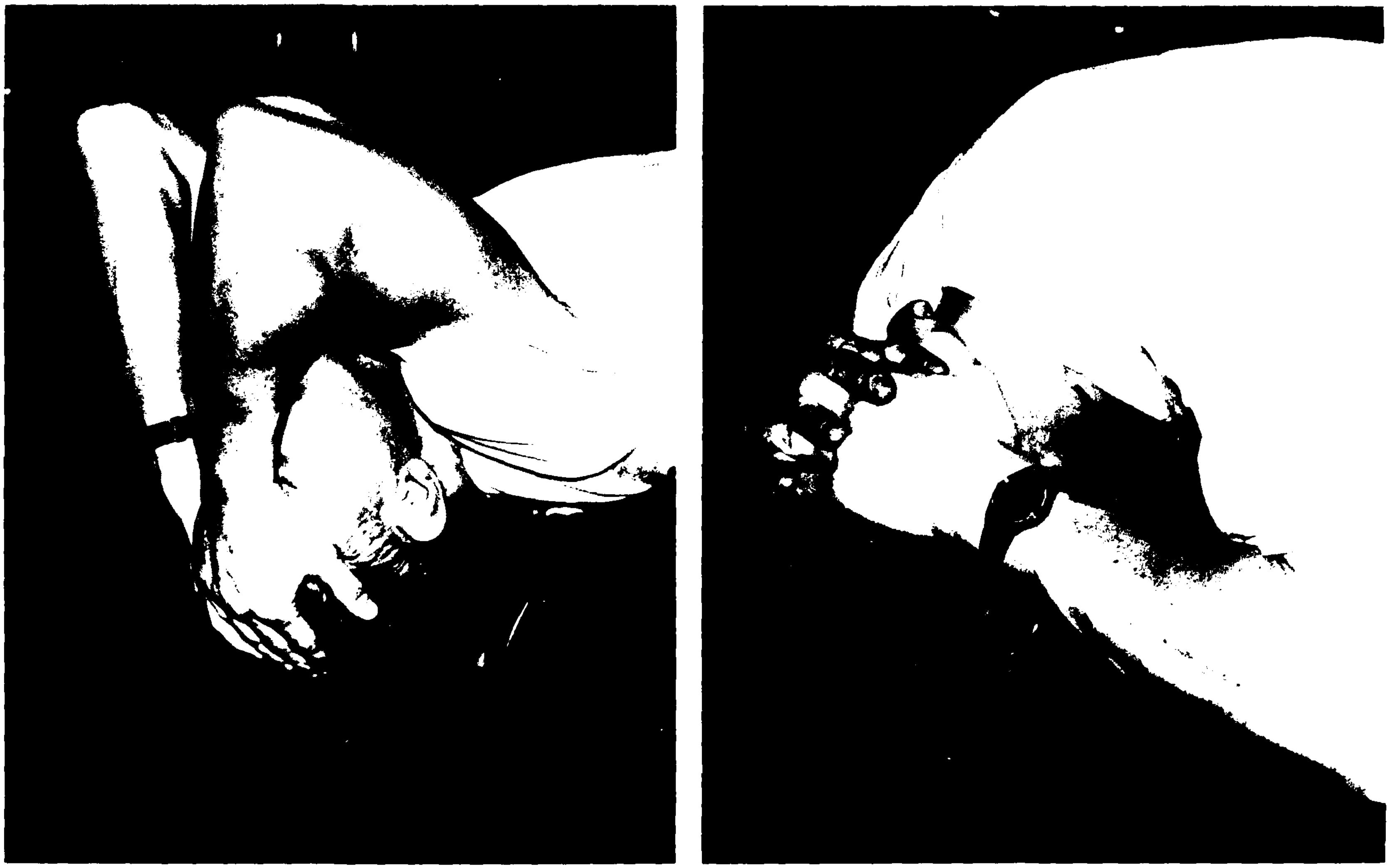


Figure 9D. Self-applied resistance neck series (flexion and extension). Positioning and starting positions of the self-applied resistance exercises are the same as in partner-applied resistance ones (Figs. 9A and 9B). Apply sufficient resistance so that slow continuous movement is maintained throughout the range of motion.

Figure 9E. Self-applied resistance neck series (flexion and extension). Performed seated with the fingers interlaced. The base of the one hand should be positioned just above the ear. Begin with the head fully flexed to one side and apply sufficient resistance so that slow continuous movement is maintained throughout the range of motion. This exercise must also be performed for the opposing side of the neck. This is accomplished by positioning hands on the other side of the head.

Figure 10. Leg Extension. Performed from a seated position utilizing knee extension against a given resistance.

Figure 11. Leg Curl. Performed from a prone position and achieved by knee flexion. The pelvis should not be elevated from the bench.

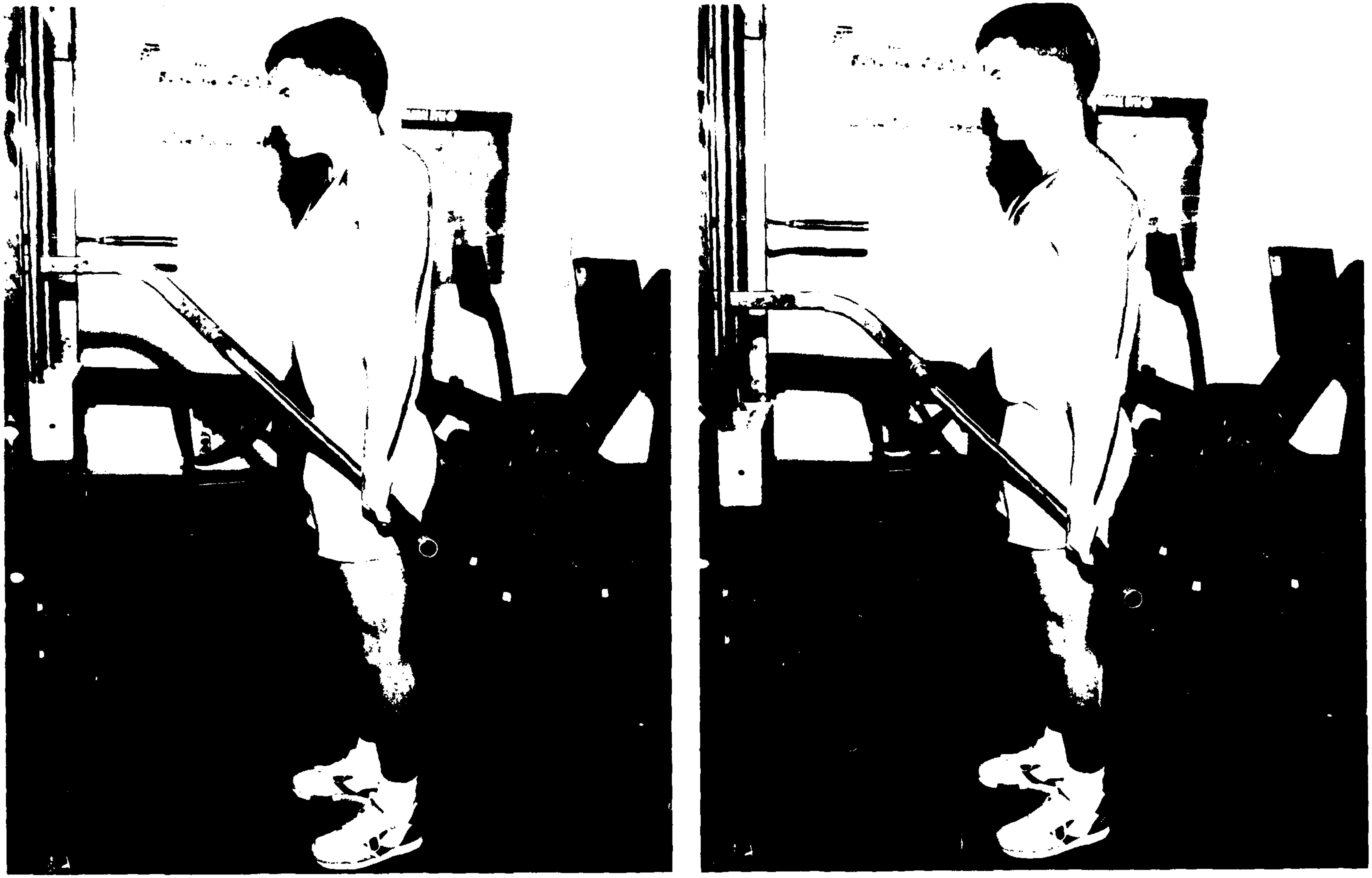


Figure 12. Shoulder Shrug. Performed by raising the shoulders while holding the bench press bar with the arms fully extended downward. The elbows should not be bent during this movement.

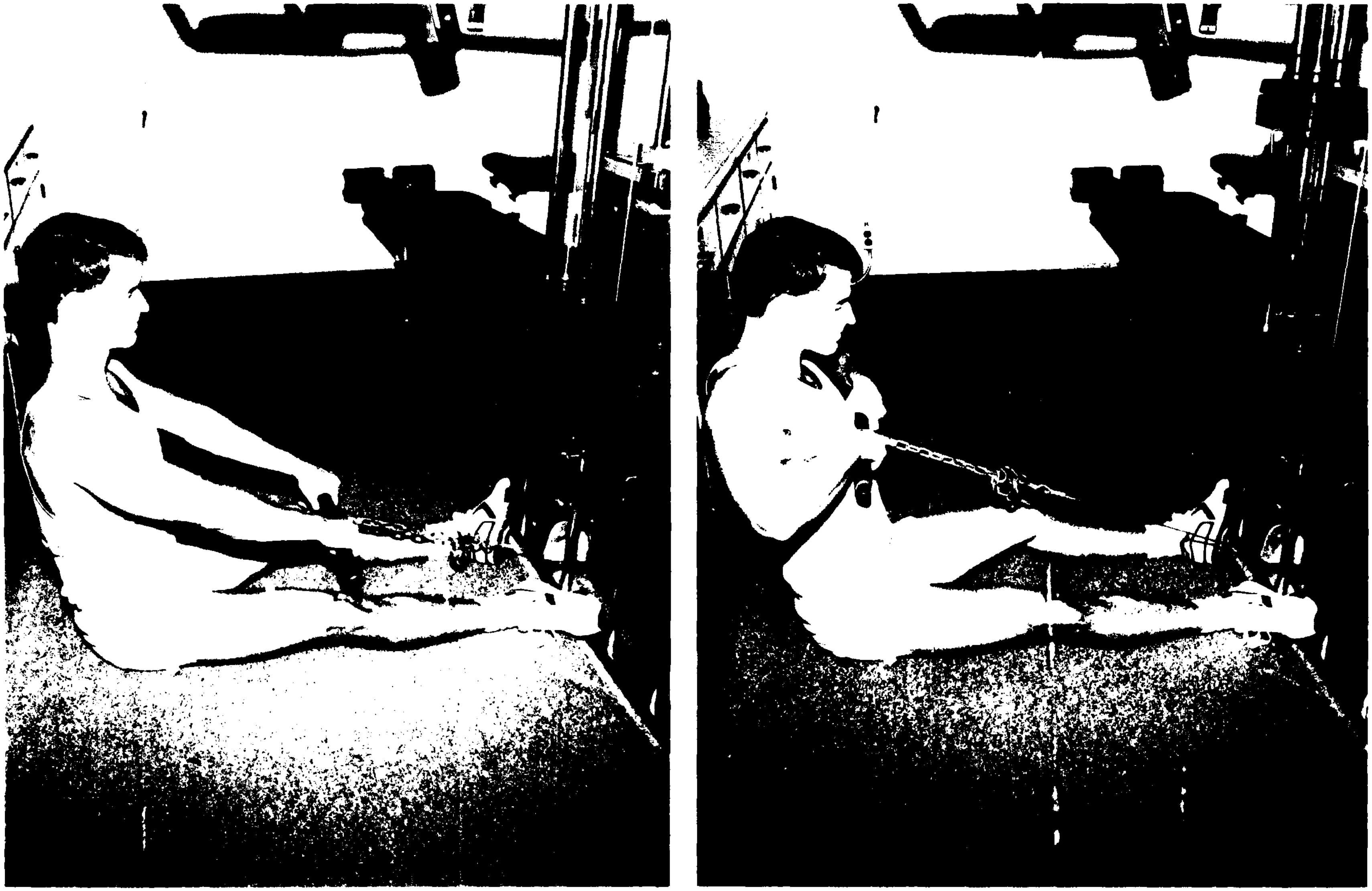


Figure 13. Seated Row. Performed by pulling against resistance with the feet braced and set into position. This is a two-handed exercise with alternate extension and flexion of the arms. The hands are drawn into the chest with elbows held high and then allowed to extend. The upper body should not move forward or backward.

Figure 14. Upright Row. Performed by pulling upward against resistance while in a standing position. The hands, with a narrow overhand grip, are drawn upward to just under the chin with elbows raised and then slowly allowed to extend.

Figure 15. Triceps Extension. Performed from a standing position with both hands on the pull bar, palms down, elbows bent, and close to the body. The bar is pushed down with the elbows close to the trunk until the arms are fully extended downward.

Figure 16. Squat. Performed with the bar resting on the shoulders. From a standing position, the knees are flexed until the thighs are parallel to the floor (half-squat). After a short pause, the legs are extended to the standing position. Do not arch the neck or back. A full squat should not be done. Spotter is required.

Figure 17. Bench Press. Performed from a supine position with the bar in line with the middle of the chest. The bar is raised upward to obtain full arm extension and then lowered slowly to the starting position. The head, shoulder, and buttock regions should remain in contact with the bench throughout the exercise. Spotter is required.

Figure 18. Pull-up. Performed from a fully extended body position suspended from a bar by a shoulder width overhand grip. The body's motion should be minimal while it is being raised to elevate the chin above the bar and then slowly lowered to the original position.

Figure 19. Arm and Chest Pull Over. Performed in the supine position on a bench. The bar is held in an overhand grip at chest level and extended past the head and then lowered to the floor as far as possible. After a brief pause, it is slowly raised upward and forward to the starting position above the chest. Spotter is required. Do not arch the neck or back.

Figure 20. Military Press. Performed from a standing or seated position. Starting with the bar at the level of the collar bone, it is pressed upward to full arm extension position. After a brief pause, the bar is lowered to the starting position. Do not arch the neck or back. Spotter is required.

Figure 21. Arm Curl. Performed from a standing position with an underhand grip on the bar, arms fully extended downward, elbows against the trunk. Flex the arms upward, keeping the elbows near but not against the trunk and the back straight.

Figure 22. Bent-over Row. Performed from a standing position, bent over at the waist. The bar is elevated from the fully extended position to the level of the chest. After a brief pause, the bar is lowered to the original position. If this exercise is incorporated as a regular part of the routine, the head should be supported to reduce force loading of the lower back. Head support required.

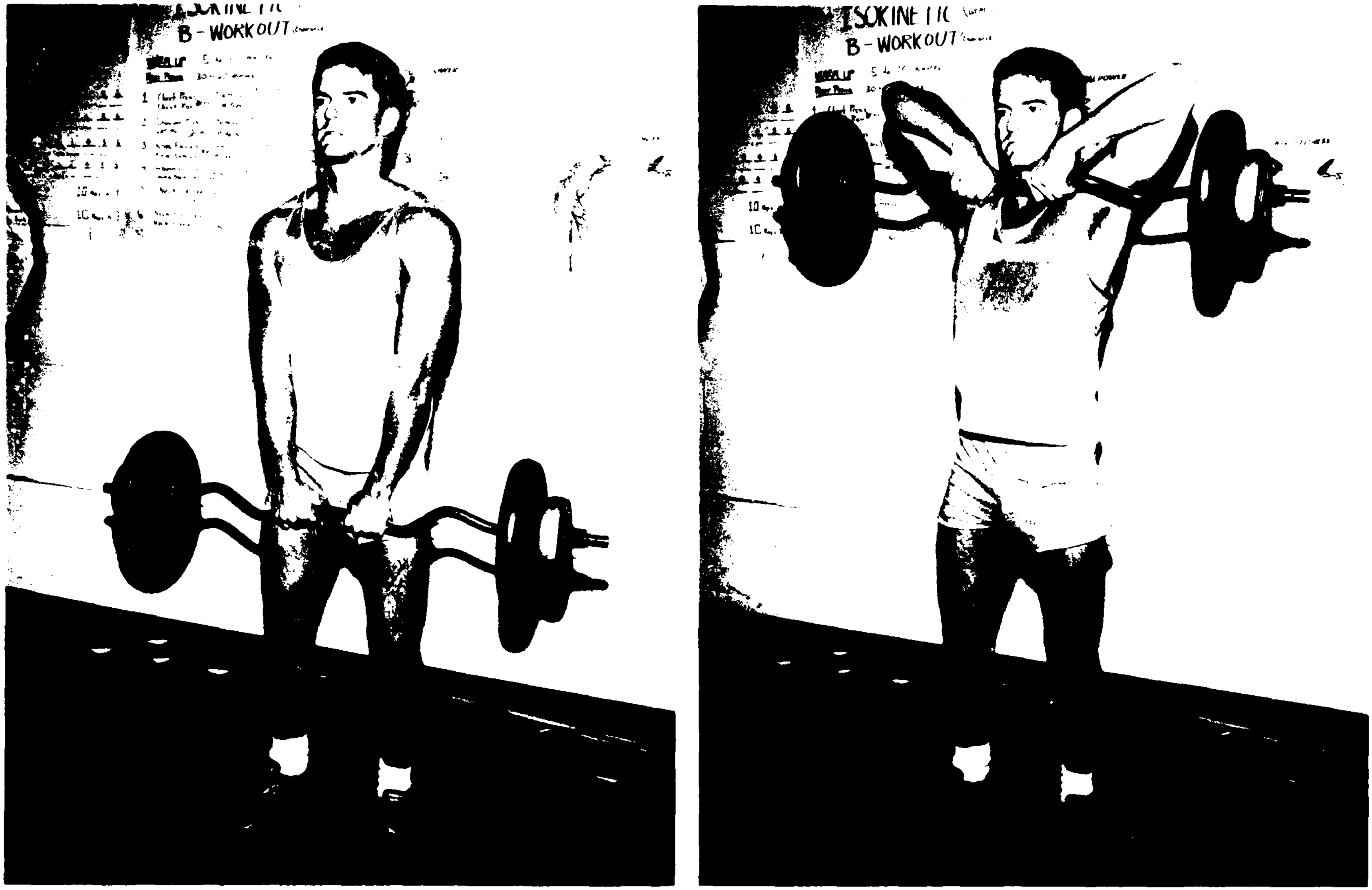


Figure 23. Upright Row. Performed from a standing position. The bar is elevated from the fully extended position to the level of the shoulders. After a brief pause, the weight is lowered to the original position.

Figure 24. Bar Dip. Performed on parallel bars which support the body suspended from the floor with the hands, arms fully extended. The body is lowered until the triceps are perpendicular to the bar, and after a short pause the body is elevated to the starting position. Motion should be minimized during the exercise.

Figure 25. Knee Flexion and Extension. Performed from a seated position with the legs flexed at the knee. The legs are fully extended and then flexed against the resistance of the machine. The movement of the upper body should be minimal during the exercise. The movement of the legs should be smooth and continual.

Figure 26. Chest Press and Row. Performed from a seated position with the arms flexed at the elbow. The arms are fully extended forward and then flexed back toward the chest against the resistance of the machine. The movement of the lower body should be minimal during the exercise. The movement of the arms should be smooth and continual. Do not arch the neck or back.

Figure 27. Shoulder Press and Lat Pull. Performed from a seated position with the arms flexed at the elbow. The arms are fully extended upward and then flexed back toward the shoulders against the resistance of the machine. The movement of the lower body should be minimal during the exercise. Do not arch the neck or back. The movement of the arms should be smooth and continual.

Figure 28. Abdominal and Low Back. Performed from a seated position with the arms extended at the elbow. The arms are fixed and the body is flexed at the waist fully forward and then fully backward. The movement of the upper body should be smooth and continual.

Figure 29. Neck Lateral Flexion. Performed from a seated position using the arms to stabilize the upper body. The head is fully flexed laterally. The neck is then flexed to the right and then to the left. The movement of the chest should be minimal, and the movement of the head and neck should be smooth and continual.

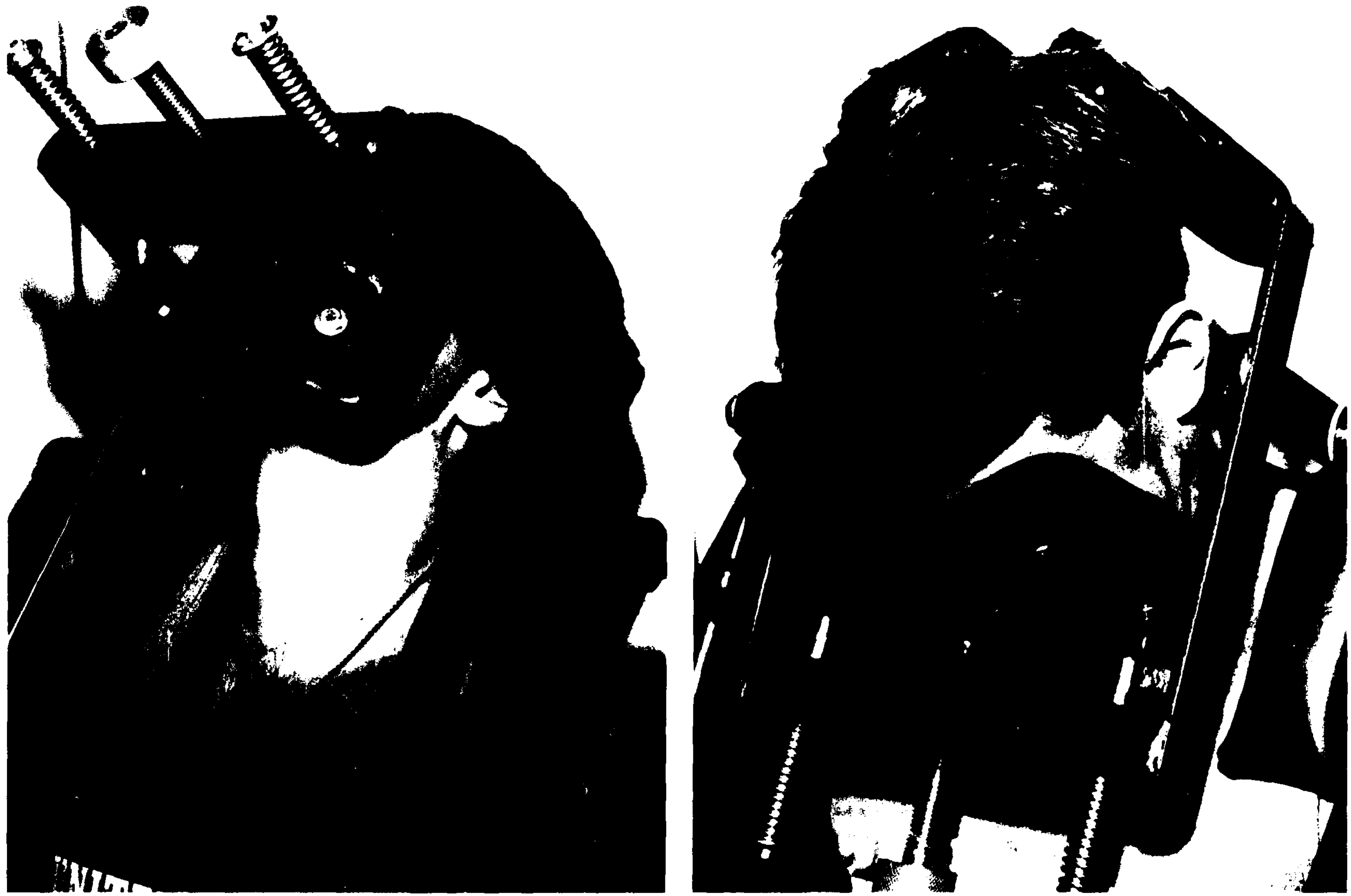


Figure 30. Neck Extension and Flexion. Performed from a seated position using the arms to stabilize the upper body. The head is fully flexed posteriorly. The neck is then flexed to the front and then to the back. The movement of the chest should be minimal, and the movement of the head and neck should be smooth and continual.