AAMRL-TR-90-087 AD-A257 734

EFFECTS ON G TOLERANCE WHILE BITING DOWN ON A MANDIBULAR ORTHOPEDIC REPOSITIONING APPLIANCE (MORA)

T. L. Chelette
L. Tripp
C. Leonard
V. Skowronski

HARRY G. ARMSTRONG AEROSPACE MEDICAL RESEARCH LABORATORY

C. D. Goodyear

LOGICON TECHNICAL SERVICES
DAYTON, OHIO

R. S. Kaufman

OCEANSIDE MEDICAL CENTER

A. D. Newton

WRIGHT-PATTERSON AFB USAF MEDICAL CENTER

OCTOBER 1990

FINAL REPORT FOR THE PERIOD OCTOBER 1986 TO DECEMBER 1989

HARRY G. ARMSTRONG AEROSPACE MEDICAL RESEARCH LABORATORY
HUMAN SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-6573

92 1 6

NOTICES

TECHNICAL REVIEW AND APPROVAL

AAMRL-TR-90-087

The voluntary informed consent of the subjects used in this research was obtained as required by Air Force Regulation 169-3.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Peter A. Lurker

PETER A. LURKER, Lt Col, USAF, BSC
Acting Director
Biodynamics and Biocommunications Division
Armstrong Laboratory

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
October 1990

3. REPORT TYPE AND DATES COVERED
Oct 86 - Dec 89

4. TITLE AND SUBTITLE
Effects on G Tolerance While Biting Down on a Mandibular Orthopedic Repositioning Appliance (MORA) Levels

5. FUNDING NUMBERS
62202F 7231 25 D3

6. AUTHOR(S)
T. Chelette, L. Tripp, C. Leonard, V. Skowronski, C. Goodyear, R. Kaufman, A. Newton

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
HARRY G. ARMSTRONG AEROSPACE MEDICAL RESEARCH LABORATORY
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6573

8. PERFORMING ORGANIZATION REPORT NUMBER
AAMRL-TR-90-087

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approval for public release; distribution is unlimited

12b. DISTRIBUTION CODE
Unlimited

13. ABSTRACT *(Maximum 200 words)* Biting down against a Mandibular Orthopedic Repositioning Appliance (MORA) that properly aligns the temporo mandibular joint (TMJ) requires voluntary contraction of the masseter and temporal's muscles. The purpose of this study was to evaluate the effects of mouthpieces by a dentist qualified in TMJ alignment. Non-invasive PB, ECG, and facial EMG were recorded at 1 G during isometric straining in 2 sessions of 2 strains with biting and 2 strains without biting. Using no anti-G suit, subjects were then exposed to sessions of 0.5 Gz increasing 20 second G plateaus on the WPAFB Dynamic Environment Simulator (Human centrifuge) until loss of peripheral vision. Seven physiological variables were recorded including facial EMG, ear pulse, and transcranial doppler signals of cerebral artery flow. G tolerance was recorded for 3 exposures using the MORA and 3 without. The resulting EMG and RMS EMG recordings indicated that subjects were not maximally contracting the involved muscles during biting and that muscle fatigue did not occur. Using the MORA resulted in a 0.3 Gz mean increase in tolerance compared with not using the MORA ($p=0.0345$).

14. SUBJECT TERMS

15. NUMBER OF PAGES
13

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std. Z39-18
298-102

GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to ***stay within the lines*** to meet ***optical scanning requirements***.

Block 1. Agency Use Only *(Leave blank)*.

Block 2. Report Date. Full publication date including day, month, and year, if available (e.g. 1 Jan 88). Must cite at least the year.

Block 3. Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g. 10 Jun 87 - 30 Jun 88).

Block 4. Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume number, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

Block 5. Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

C	- Contract	PR	- Project
G	- Grant	TA	- Task
PE	- Program Element	WU	- Work Unit Accession No.

Block 6. Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

Block 7. Performing Organization Name(s) and Address(es). Self-explanatory.

Block 8. Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

Block 9. Sponsoring/Monitoring Agency Name(s) and Address(es). Self-explanatory.

Block 10. Sponsoring/Monitoring Agency Report Number. *(If known)*

Block 11. Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with...; Trans. of...; To be published in.... When a report is revised, include a statement whether the new report supersedes or supplements the older report.

Block 12a. Distribution/Availability Statement. Denotes public availability or limitations. Cite any availability to the public. Enter additional limitations or special markings in all capitals (e.g. NOFORN, REL, ITAR).

DOD - See DoDD 5230.24, "Distribution Statements on Technical Documents."
DOE - See authorities.
NASA - See Handbook NHB 2200.2.
NTIS - Leave blank.

Block 12b. Distribution Code.

DOD - Leave blank.
DOE - Enter DOE distribution categories from the Standard Distribution for Unclassified Scientific and Technical Reports.
NASA - Leave blank.
NTIS - Leave blank.

Block 13. Abstract. Include a brief *(Maximum 200 words)* factual summary of the most significant information contained in the report.

Block 14. Subject Terms. Keywords or phrases identifying major subjects in the report.

Block 15. Number of Pages. Enter the total number of pages.

Block 16. Price Code. Enter appropriate price code *(NTIS only)*.

Blocks 17. - 19. Security Classifications. Self-explanatory. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED). If form contains classified information, stamp classification on the top and bottom of the page.

Block 20. Limitation of Abstract. This block must be completed to assign a limitation to the abstract. Enter either UL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.

PREFACE

The experiments described in this report were made possible by the Harry G. Armstrong Aerospace Medical Research Laboratory (AAMRL) In-House Laboratory Independent Research (ILIR) Program. Fiscal year 88 funds were provided under element 61101F, work unit 723125D2. This effort was conceived and initiated by Dr Thomas Jennings, whom the authors wish to thank. Dr Jennings was a Flight Surgeon in the Acceleration Effects Branch of AL from 1981 to 1985.

The authors wish to extend their appreciation to Mr Marvin Roark (Raytheon Service Co.), who developed the acceleration profiles on the Dynamic Environment Simulator and to the rest of the Raytheon operations and maintenance crew including Greg Bathgate, Don McColler, Dick Szulewski, and Bud Gould. The authors also acknowledge the contributions of TSgt Mike Swisher, SSgt Jim Swinhart, John Frazier, and Tom Shriver, all of AL/CFBS.

Also acknowledged are the valuable contributions of Dr Newton and the staff of the Dental Clinic of Wright-Patterson AFB Medical Center; Dr Kaufman and his staff at Oceanside Dental Medical Center; Joe Bill Dryden of General Dynamics Corporation who originally suggested the poential benefits of this study; and the staff of Systems Research Laboratories Inc who assisted in every aspect of this experiment.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The masseter muscles connect the zygomatic bones (cheekbones) and the mandible (jawbone) to close the jaw when contracted. The pivot point of the mandible rests against a contoured surface of the temporal bone of the skull. Uneven, broken, sensitive, or missing teeth as well as uneven bone growth, malocclusion, or bad oral posture may cause the Temporo Mandibular Joint (TMJ) to gradually become misaligned. The masseter and other muscles that stabilize the joint can become involved in a stressful battle to maintain joint position and to speak, chew, or swallow (5). Many articles and books have been published on the use of a Mandibular Orthopedic Repositioning Appliance (MORA) to realign the joint (Figure 1). Realignment is claimed to not only relieve the painful symptoms of TMJ dysfunction, but also to position the joint for optimal contraction of the masseter. Such optimum contraction is credited with balancing the upper body biomechanism and thus increasing strength throughout the body (15). Proper TMJ alignment is also credited with improving balance and posture (9). It is also reported that the relief of muscle strain in the TMJ area leads to neurological changes in the electrical firing patterns of motor cortex nerves that pass near the joint resulting in more coordinated muscle contractions throughout several major muscle groups (8).

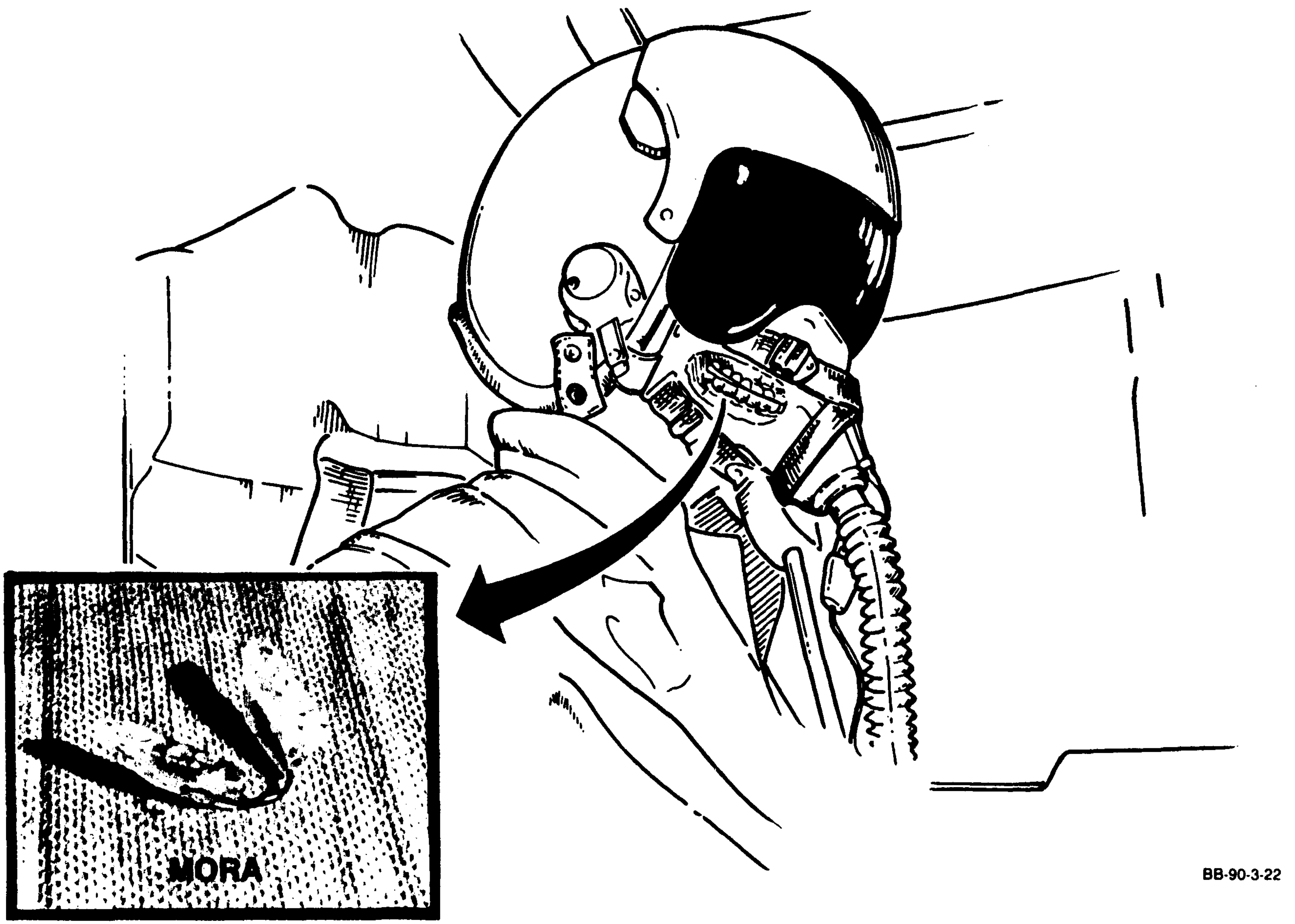
The benefits of the MORA have been described in the literature through case studies and subjective ratings of comfort, strength, and/or athletic performance. In contrast, at least five controlled studies have found no significant increase in measured muscular strength due to use of a MORA (1,2,7,11,16). At least one reviewer believes the phenomena of improved performance is due to the placebo effect (10).

Amidst the controversy, there are many athletes who believe their MORA gives them the edge in concentration and performance. The Armstrong Laboratory became interested in the device when a high performance aircraft test pilot reported a substantial increase in the effectiveness of his Anti-G Straining Maneuver (AGSM) while biting down on his personal MORA (4). **A controlled study was undertaken to determine if a difference in Gz tolerance with use of a MORA was significantly detectable.**

The AGSM consists of a total body isometric contraction accompanied by a retention of air pressure in the lungs (6). Incorporation of the masseter into the straining maneuver was verified and quantified by recording the electromyogram (EMG) of one of the masseter muscles. The signal was processed through a root mean square computer program to characterize the muscle tension and fatigue. During fatiguing isometric contractions, there is an increase in the amplitude of the EMG and decrease in its frequency (12, 13). The RMS EMG should increase with a truly fatiguing contraction (14).

FIGURE 1.

MANDIBULAR ORTHOPEDIC REPOSITIONING APPLIANCE — MORA



The objective of Phase I of this study was to investigate Mean Arterial Pressure (MAP = 2/3 diastolic + 1/3 systolic pressure) and heart rate (HR) changes during AGSMs at 1 G with and without incorporation of a MORA.

The objective of Phase II was to investigate G tolerance with and without incorporation of the MORA into the AGSM; and to investigate occurrence of fatigue of the masseter muscle.

METHODS

Facility

The exposures to substantial levels of Gz were accomplished on the Dynamic Environment Simulator (DES) by the experienced staff of the Combined Stress Branch at the Armstrong Laboratory.

Subjects

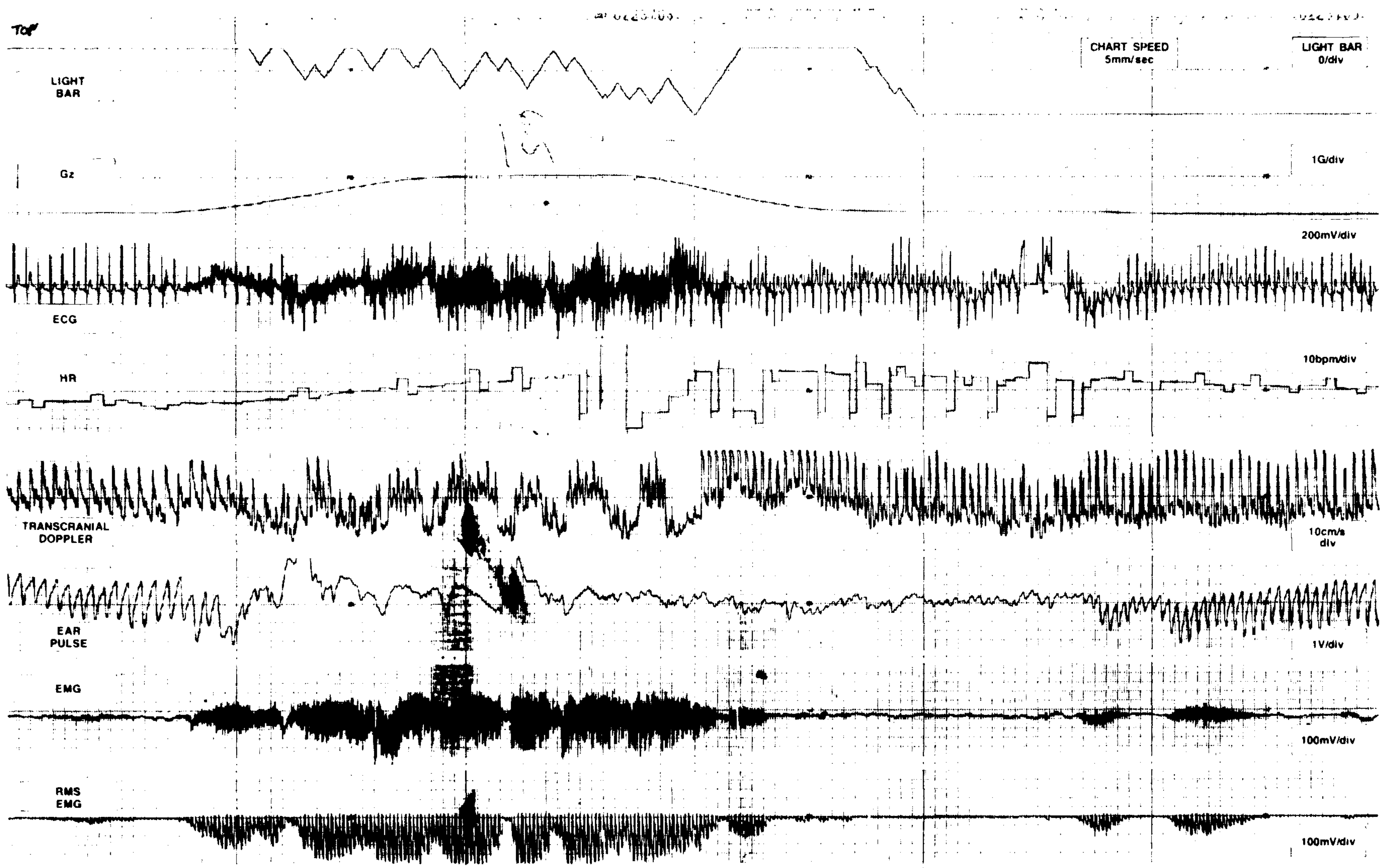
Subjects were selected for participation from the Sustained Acceleration Stress Panel of the DES. They consisted of 9 men and 1 woman who are all active duty Air Force personnel and physically qualified to undergo Gz exposures on the DES. Each subject was evaluated for TMJ problems and fitted with a custom MORA.

Instrumentation

During 1 Gz straining maneuvers, subjects were monitored by medical personnel using manual sphygnomanometry, as well as ECG and EMG. During higher Gz exposures, subjects were monitored with television cameras, ECG, EMG, ear pulse plethysmography, G suit pressure, peripheral light perception, and at some times transcranial doppler signals of cerebral blood flow (Figure 2). The EMG signal was acquired by a computer and integrated over one second intervals to display the rectified mean amplitude.

Experimental Design

After receiving their MORA, subjects were given approximately one month to wear the device during any strenuous activities in order to get accustomed to it and to assure its comfort. The first phase of the study was performed at 1 Gz during which the mean arterial blood pressure (MAP) and heart rate (HR) of subjects were measured before and during a AGSM. (Note: subjects did not perform the Valsalva portion of the AGSM at 1 Gz due to the potential for excessive blood pressure elevation.) Each subject visited the lab twice, performing four AGSMs during each visit. Each visit consisted of alternating AGSMs with the MORA and without. The experimental matrix to minimize order effects is shown in Table 1 of the Appendix.



TOP
LIGHT BAR
Gz
ECG
HR
TRANSCRANIAL DOPPLER
EAR PULSE
EMG
RMS EMG
CHART SPEED 5mm/sec
LIGHT BAR 0/div
1G/div
200mV/div
10bpm/div
10cm/s div
1V/div
100mV/div
100mV/div

Figure 2

The second phase of the study was performed on the DES at increasing Gz levels. Subjects visited the lab eight times and each visit involved exposures to a number of Gz plateaus of increasing Gz until their peripheral light tracking task reached the Crosbie threshold (3). Plateaus were 20 seconds duration with 1 Gz per second onset rate. Subjects were not aided by the use of an anti-G suit. The first two lab visits were training days to allow subjects time to incorporate the use of the MORA into AGSMs while under Gz. During 3 of the remaining 6 visits the subjects used their MORA. The experimental matrix to minimize order effects is shown in Table 2 of the Appendix.

ANALYSIS

The RMS EMG signal amplitude was recorded throughout the exposures (Figure 2). However, the final comparison involved a binary notation by the investigator as to the signal's tendency to decrease or increase in amplitude during periods of continued biting. Further quantitative analysis was made difficult due to the occurrence in some subjects of drastic signal shifts during the gasping portion of the AGSM.

Data analysis was performed using a statistical software package (SAS Version 5.18) on a DEC VAX computer. All tests were performed at the 0.05 level of significance.

In Phase I, each straining MAP value and HR value was expressed as a percent increase from the prestrain values. Using Analysis of Variance (ANOVA), each subject's average percent increase for strains with the MORA was compared to their average percent increase for strains without the MORA.

In Phase II, Analysis of Variance was used to compare subject's average Gz tolerance for exposures with the MORA and for exposures without. Gz tolerance was defined as the maximum Gz level plateau completed plus the pro-rated fraction of the last partial plateau (3).

Finally, a correlation algorithm was used to determine the relationship between the percent increases in Phase I and the performance changes in Phase II.

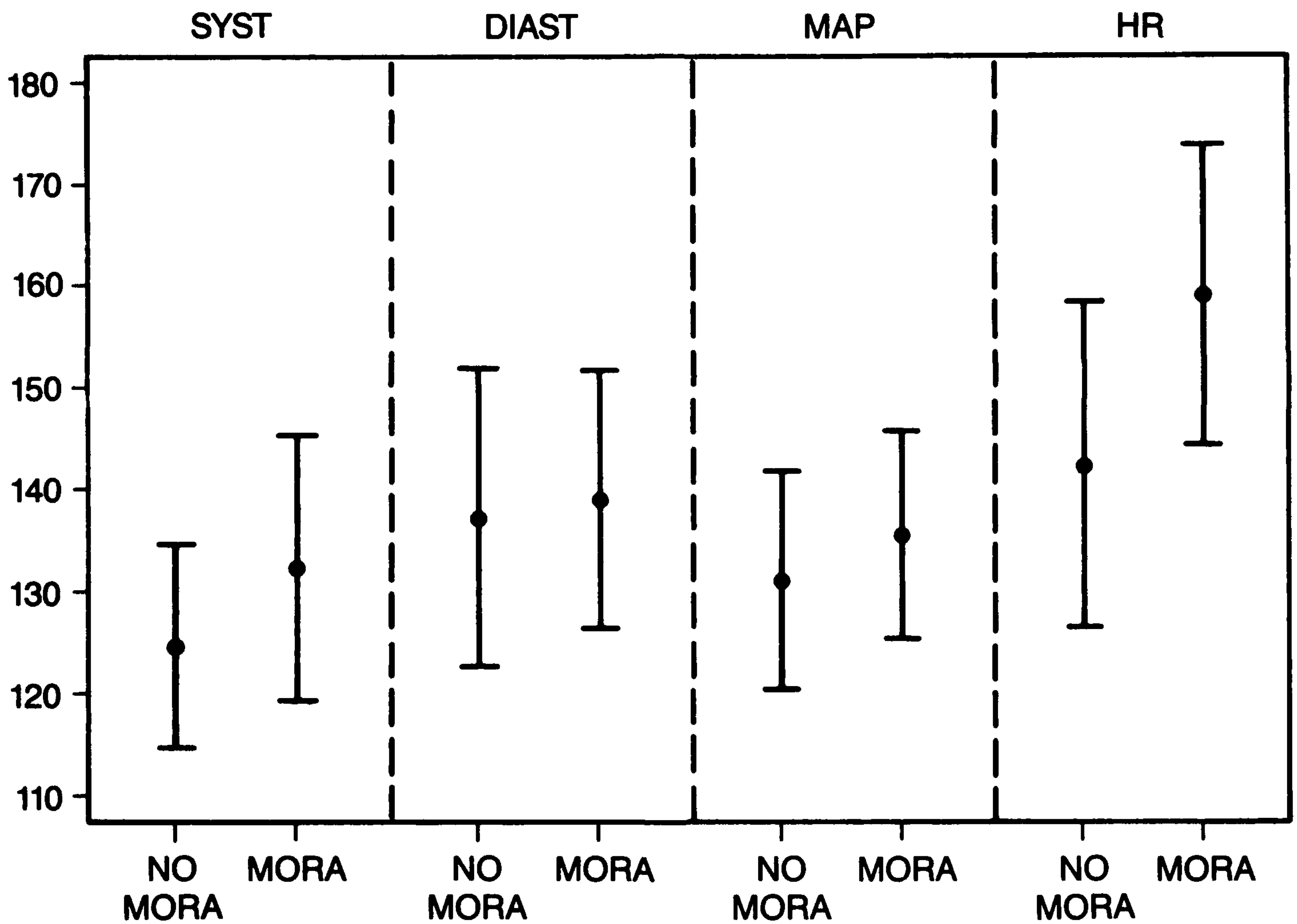
RESULTS

Seventy percent of the Gz exposure sequences showed a decrease in RMS EMG amplitude as Gz increased. Only 3 percent showed an increase in amplitude while the remainder showed no change.

FIGURE 3.

PERCENT OF PRE-STRAIN (N = 13)

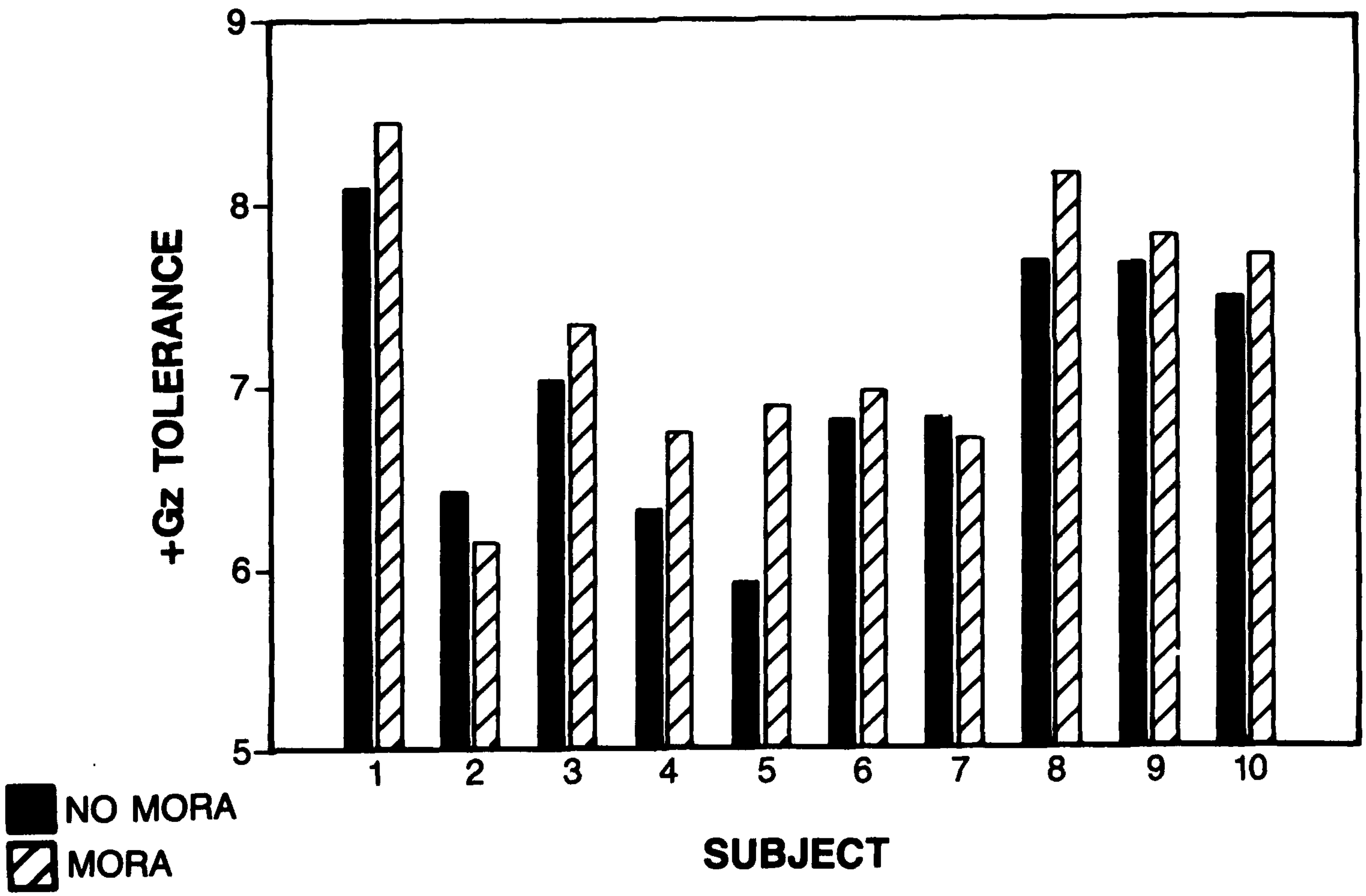
(MEAN AND STD OF SUBJECTS)



BB-90-5-23

FIGURE 4.

+Gz TOLERANCE FOR EACH SUBJECT



BB-90-5-22

The static portion of the study (Phase I) showed subject's average percent increase in MAP and HR to be 36% and 60% respectively while using a MORA. Without the use of the MORA, subject's average increase in MAP and HR were 31% and 43%, respectively (Figure 3). Thus the MORA was found to significantly improve the percent increase of MAP and HR by approximately 5 percentage points and 17 percentage points, respectively ($p < 0.0011$).

The dynamic portion of the study showed a mean tolerance of 7.3 Gz for exposures with the MORA, and a mean tolerance of 7.0 Gz for exposures without the MORA (Figure 4). The difference between the means was statistically significant ($p = .0345$).

There were no significant correlations by subject found between percent changes in MAP and HR during phase 1 and changes in G tolerance in phase 2 ($p > 0.5044$).

DISCUSSION

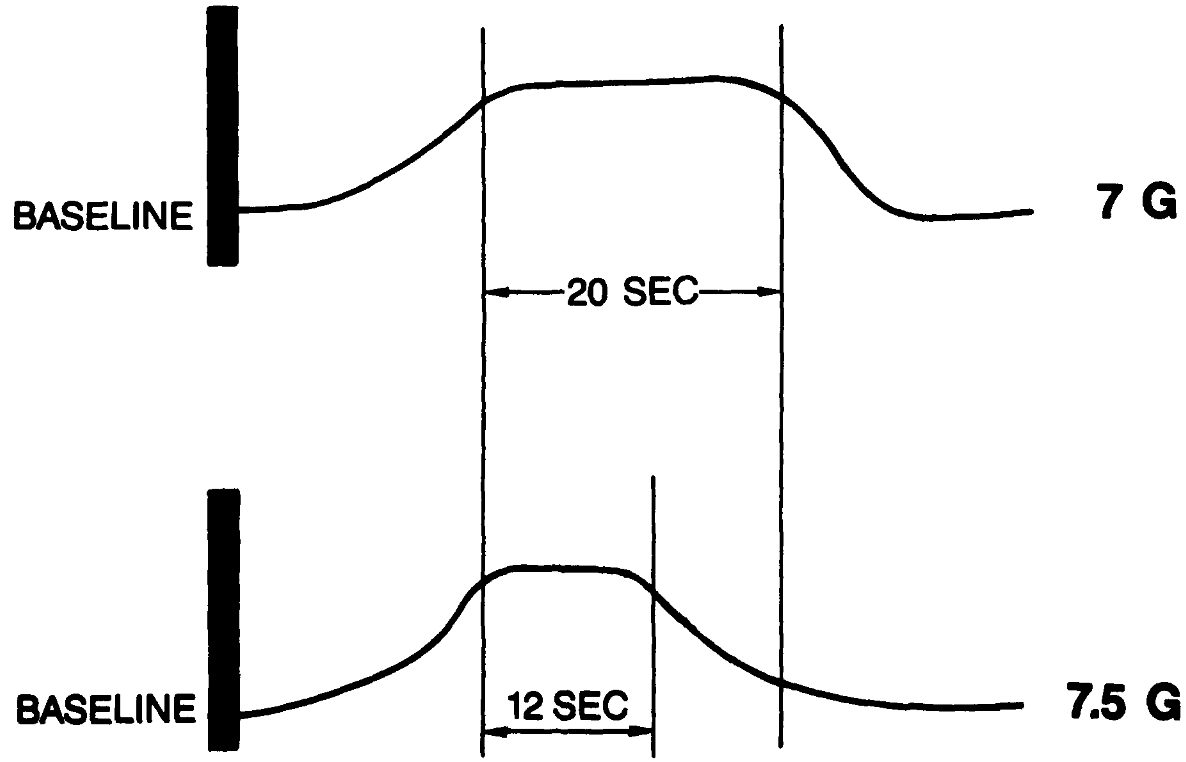
The RMS EMG signal was very useful for training subjects to incorporate the biting into their AGSM. It also showed that subjects did not use the masseter muscle to the point of fatigue indicating that concentration and energy were diverted to other isometric contractions at higher Gz levels.

Phase I demonstrated that the MORA helps to elevate blood pressure and heart rate. Phase II demonstrated a significant improvement in Gz tolerance across the subject population, as measured by the Crosbie technique (Figure 5). Comparing these results to the EMG data suggests that the MORA is of some service during AGSM at lower Gz levels (3-5 Gz) but becomes difficult to incorporate into the straining maneuver at higher Gz levels (6-8 Gz). Future studies of the MORA's contribution to Gz endurance and fatigue in low Gz aircraft may be of value. It may also be necessary to conduct these future studies with the use of an anti-G suit. TMJ alignment and masseter isometric contraction may interact with the mechanisms of Gz tolerance differently when the lower body is protected from blood pooling.

Although no subjective ratings were included in this study, several observations were made that merit mentioning. The most important consideration for use of the MORA under Gz was the problem of increased salivation combined with difficulty in swallowing. Several subjects coughed or swallowed under high Gz levels resulting in loss of breathing rhythm. Most were able to recover and continue the exposures. However, a heavily tasked individual may have further problems. One subject reported difficulty in swallowing as well as a flared eustachian tube on each exposure with the MORA. Another subject reported not being able to swallow with the MORA in place. These problems may be addressable through modifications and adjustments to each MORA.

FIGURE 5.

G TOLERANCE



$$GTOL = 7 + \frac{12}{20}(.5) = 7.3\ G$$

(CROSBIE 1983)

BB-90-5-24

CONCLUSIONS

The RMS EMG signal is a useful indicator for masseter contraction and level of fatigue. This experiment indicated that subjects did not use the masseter muscle to the point of fatigue.

This experiment has shown that the MORA can be of assistance to some individuals during execution of the anti-G straining maneuver. Some individuals are more comfortable with something to bite on during the strain, and have relatively little problem with swallowing or speaking with the MORA in place. Thus, a MORA should be considered as an available option to those pilots who choose to use one, provided it is well fit and tested prior to flight.

REFERENCES

1. Allen M.E., Walter P., McKay C., Elmajian A. Occlusal splints (MORA) vs. placebos show no difference in strength in symptomatic subjects: double blind/cross over study. Canadian Journal of Applied Sports Science, 9(3):148-52 (1984).

2. Burkett L.N., Bernstein A.K. Strength testing after jaw repositioning with a mandibular orthopedic appliance. Physician and Sportsmedicine; 10(2):101-7 (1982)

3. Crosbie R.J. A servo controlled rapid response anti-G valve. Proceedings of SAFE Annual Symposium, 1982.

4. Dryden J.B., Semper Viper. Code One Magazine, General Dynamics, 1987.

5. Gelb H. Clinical management of head, neck and TMJ pain and dysfunction; Published by Saunders Co, 1977.

6. Gillingham K. Effects of the abnormal acceleratory environment of flight; USAFSAM-TR-74-57, AD-A009593 (1974).

7. Greenberg M.S., Cohen S.G., Springer P., Kotwick J.E., Vegso J.J. Mandibular position and upper body strength: a controlled clinical study. Journal of American Dental Assoc; 103:576-9 (1981).

8. Hatfield F.C. Mandibular Orthopedic Repositioning Appliance. Muscle & Fitness Magazine, May 1989.

9. Kaufman A., Kaufman R.S. An experimental study on the effects of the MORA on football players. Functional Orthodontis; 2(4):37-44 (1985).

10. Kerr I.L. Mouth guards for the prevention of injuries in contact sports. Sports Medicine; 3(6):415-27 (1986).

11. Moore T.J., Santa-Maria D.L., Hatfield B.D., Ryder M.N., Weiner L.B. The mandibular orthopedic repositioning appliance and its effect on power production in conditioned atheletes. Physician and Sportsmedicine (Minn.); 14(12):137-45 (1986).

12. Petrofsky J.S. Quantification through the surface EMG of muscle fatigue and recovery during successive isometric contractions. Aviation Space and Environmental Medicine, 52(9);545-50 (1981)

13. Petrofsky J.S., Philips C.A. Discharge characteristics of motor units and the surface EMG during fatiguing isometric contractions at submaximal tension. Aviation Space and Environmental Medicine; 56:581-6 (1985).

14. Williams C.A., Martin J., Moffatt J., Douglas J.E. The effects of combined L-1 maneuvers and fatiguing isometric contractions on acceleration tolerance. 1988; AAMRL TR in print.

15. Williams M.O., Chaconis S.J., Bader P. The effects of mandibular position on appendage muscle strength. Journal of Prosthetic Dentistry; 49(4):560-7 (1985).

16. Yates J.W., Koen T.J., Semenick D.M., Kuftinec M.M. Effect of a mandibular orthopedic repositioning appliance on muscular strength. Journal of American Dental Association; 108(3):331-3 (1985).

APPENDIX

TABLE A-1. EXPERIMENTAL MATRIX PHASE I

	MORA used during AGSM			
Order Code A	Yes	No	Yes	No
Order Code B	No	Yes	No	Yes

	Subject #									
	1	2	3	4	5	6	7	8	9	10
Day 1	A	B	A	B	A	B	A	B	A	B
Day 2	B	A	B	A	B	A	B	A	B	A

TABLE A-2. EXPERIMENTAL MATRIX PHASE II

	MORA used during AGSM					
Order Code A	Yes	No	No	Yes	No	Yes
Order Code B	No	Yes	Yes	No	Yes	No

	Subject #									
	1	2	3	4	5	6	7	8	9	10
Assignment	A	B	A	B	A	B	A	B	A	B

★U.S. Government Printing Office: 1992 — 648-069/60304