DOCUMENT RESUME

ED 125 169 EC 090 264

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TITLE The Response of Hyperkinesis to EMG Biofeedback.
PUB DATE Mar 76
NOTE 33p.; Paper presented at the Annual Meeting of the Biofeedback Research Society (7th, Colorado Springs, Colorado, March, 1976)

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS Attention Span; *Behavior Change; Electromechanical Aids; Elementary Secondary Education; Exceptional Child Research; *Feedback; *Hyperactivity; *Kinesthetic Perception; *Self Control
IDENTIFIERS *Electromyography Biofeedback

ABSTRACT

A study was conducted involving eight hyperkinetic males (11-15 years old) to determine if Ss receiving electromyography (EMG) biofeedback training would show a reduction in frontalis muscle tension, hyperactivity, and lability, and increases in self-esteem and visual and auditory attention span. Individual 45- and 30-minute relaxation exercises which involved tension and relaxation of all muscle groups combined with visualization techniques were presented to all Ss. The experimental group (n=4) received nine 20-minute feedback sessions in which each S was instructed that his goal was to lower his overall body tension--to be relaxed--and that the reading on the EMG meter display would be the measure of his relaxation. Pre- and post-EMG training test batteries were given to all Ss and included the Student Self-Liking Rating, Draw A Person Test, Wechsler Intelligence Scale for Children, and the Wide Range Achievement Test. All Ss significantly reduced hyperactivity and lability, and increased auditory attention. There were no significant changes between the experimental and control groups. (Author/SE)

The Response of Hyperkinesis to EMG Biofeedback

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Presented at the Seventh Annual Meeting of the Biofeedback Research Society, Colorado Springs, CO, March, 1976.

Abstract

Will hyperkinetic males who receive EMG biofeedback training show a reduction in frontalis muscle tension, hyperactivity, lability, and an increase in self-esteem and visual and auditory attention span? The E Grp. (N = 4) received nine twenty-minute feedback sessions. There were no significant changes between the groups. All of the subjects (N = 8) significantly reduced hyperactivity and lability, and increased auditory attention span.

DESCRIPTORS: Hyperkinesis, EMG Biofeedback, Frontalis Muscle, Lability, Self-esteem, Visual and Auditory Attention Span.

The Response of Hyperkinesis to EMG Biofeedback

Hyperkinesis, or hyperactivity, is a designation applied to a varying set of problems occurring in childhood. With continued and increasingly popular use of the term, problems of definition, lack of homogeneity in the population to which the definition refers, uncertain implications for intervention and contradictory research findings have surfaced. Although the symptoms of hyperkinesis usually diminish with age, many hyperkinetic children continue to experience lags in their educational and emotional development into adulthood. These continuing handicaps obviously affect a person's ability to make satisfactory life adjustments in interpersonal relationships and vocational settings. Because of the associated learning disabilities and the feelings of failure that produce a negative self-image, hyperkinesis is considered to be a major problem in children.

The following traits, when seen together, help to differentiate hyperkinetic from from normal youngsters; impulsiveness, excitability, forgetfulness, poor concentration, perseveration, perceptual disturbances, and impairments in speech, hearing and gross motor and fine motor coordination (Adler & Terry, 1972). Teachers must contend with children who fidget, waste energy by unproductive movements, or maintain too much tension in their muscles. The hyperkinetic child frequently has no awareness of his tenseness; his mind has accepted the adaptation of his body.

Hyperkinesis is often coupled with the Minimal Brain Dysfunction syndrome (Clements, 1973). A history of complications in preganancy, difficult and prolonged labor and birth trauma is more often identified with hyperkinetic children than with normal children (Burks, 1960). Etiological variables currently being explored include abnormal glucose tolerance curves (Powers, 1974), allergic reactions to artificial flavors and colors (Feingold, 1973), and deficiencies or dysfunctions in the monoamines (norepinephrine, dopamine, serotonin) (Silver, 1971) and genetics (Cantwell, 1972).

The existence of the hyperkinetic syndrome is presently being challenged. Sociological and environmental causes are claimed to be responsibile for the symptoms and/or diagnosis of hyperkinesis in children.

Treatment modalities for hyperkinetic children have included pharmacotherapy, hypnosis, psychotherapy, behavior modification and biofeedback, with stimulant drug therapy the preferred form of treatment. The stimulants (amphetamine, Ritalin, Cylert) have been successful in reducing overactivity and increasing attention span, resulting in improvements in cognitive and perceptual motor tasks (Conners, 1971). However, drug therapy does not permanently alter maladaptive behavior patterns (Feigner & Feigner, 1974). By itself, medication cannot produce a permanent alteration in learned neuronal behaviors for functional disorders, and is, at best, a crutch (Whatmore, 1968).

Electromyograph (EMG) biofeedback, as a tool for reduction of muscular tension, is being studied as a treatment modality for hyperkinesis. As subjects for his study, Long (1974) selected educationally maladjusted adolescents who had a high frontalis muscle tension. This study showed that standard relaxation techniques, taped relaxation procedures, and EMG biofeedback were all successful in decreasing frontalis tension levels, but the mean change was greatest for the EMG trained group. Short-term memory increased and behavior problems decreased in the biofeedback subjects.

Eversaul (1974) reports that EMG biofeedback training of hyperkinetic children seems to facilitate the reduction of test anxiety and to help eye movement training, which can be used to increase reading speed as well as reading comprehension.

In an uncontrolled study undertaken to establish a working protocol for EMG biofeedback training with school age hyperkinetic children, Conley et al. (1974) reported significant reduction in post frontalis muscle tension levels and improvement on tasks requiring fine visual-motor functioning.

In a comparative study of the effects of EMG biofeedback and progressive relaxation on hyperactivity, Braud (1975) found that both modalities reduced EMG defined muscle tension, with biofeedback producing significantly larger decreases. The biofeedback subjects scored significantly greater decreases on a post-training behavioral rating measure.

The contribution of feedback to the reductions in EMG over sessions in trained subjects reported (Budzynski & Stoyva, 1969; Alexander, et al. 1975, Kinsman, O'Banion, Robinson & Staudenmayer, 1975) has been generally accepted as adequately demonstrated. The present study was designed as a strictly pilot feasibility and demonstration project to investigate EMG biofeedback as a treatment agent for hyperkinesis in male adolescents. Specifically, would the subjects who received the biofeedback training show the following changes: a reduction of frontalis muscle tension; reduction of hyactivity; reduction in instability level; increase in self-esteem; and increase in visual and auditory attention span.

The notion that decreasing the tension level of the frontalis muscle would lead to general relaxation of other muscles was postulated by Budzynski and Stoyva (1972) and was the rationale in this study for training the frontalis muscle. The lowering of frontalis tension levels with concomitant decreases in hyperactive and lability measures would probably demonstrate the generalization effect.

Method

Subjects

The subjects were eight male students attending a private school for emotionally and learning disabled children. Ages ranged from eleven to fifteen years. The subjects met the criterion of hyperactivity on two behavioral rating measures, the Hyperactive Rating

questionnaire portion of the Operational Assessment Tool (OAT) (CHILD Center, 1974), the Hyperkinesis Indexes of the Conners' Parents' Questionnaire and the Conners' Teachers' Questionnaire (Conners, 1972).

The OAT Hyperactive Rating Questionnaire contains twenty questions, and a combined total of ninety or more points on the forms completed by the students, parents and teachers qualifies for a hyperkinetic determination. The Conners' Parents' Questionnaire contains twenty-eight items, with scores of fifteen or more on each questionnaire required. The questions on the Conners and the OAT refer to lability, self-esteem, concentration and coordination.

The eight boys were randomly assigned to two groups of four -- biofeedback (E Grp.) and control (C Grp.). IQ's, as measured by the Wechsler Intelligence Scale for Children, ranged from sixty-two to ninety-seven. Average grade level of achievement, as determined by the mean of the reading, spelling, and arithmetic scores on the Wide Range Achievement Test, was 4.6 years.

Apparatus

EMG activity was detected and analog feedback was transmitted to the subjects by the Biofeedback Technology 401 Feedback Myograph. The rectifier output is a D.c. voltage proportional to the peak value of the amplified EMG signal. This D.C. voltage drives a meter calibrated in microvolts and also a voltage controlled oscillator which produces an audio tone whose frequency is proportional to

the peak amplitude of the EMG signal. A conventional audio amplifier provided power to drive an external speaker. The monitored readings were recorded by a Biofeedback Technology 215 Time Period Integrator, which performs integration of the instantaneous peak-to-peak envelope and is then divided by the time period. During the twenty-minute training period, the subject held the remote control switch of the integrator in his hand and checked his tension level, which was integrated over a ten-second time period.

The use of a speaker and the EMG meter display assured that both the audio and visual feedback modes were represented by analog feedback. The subjects were given the instructions that a falling tone and a needle drop to their left indicated relaxation of the frontalis muscle. The integrator provided the subject with a quantified score as an added mode of visual feedback. He pushed the remote control starter button as often as he wished and was instructed to either try for a lower score or to maintain his present level to demonstrate self-control.

Differential surface EMG recordings were obtained by using the standard electrode set (supplied with the unit), with the headband located approximately one inch above the eyebrows. One centrally located reference electrode was flanked on either side by an active

electrode. The skin site was prepared by cleansing the forehead with seventy percent Isopropyl Alcohol, and BFT Electrode Gel was employed as an interference. The sensitivity setting of the EMG was adjusted to the pre-session baseline reading.

The experimental sessions were conducted individually by the principal experimenter in a quiet, dimly lit basement room of the school. The subject sat in a comfortable chair and the experimenter sat in a chair on the opposite side of the table which held the equipment which was placed directly in front of the subject. During the baseline monitorings, the EMG and the integrator were turned away from the subject, facing the experimenter, with no audio feedback. The experimenter recorded the five time period scores, as shown on the integrator, by hand on a form designed for data collection for this study.

Procedure

The list of pre- and post-EMG training test batteries which were given to all of the subjects included:

OAT Hyperactive Rating Questionnaire

Conners' Abbreviated Rating Scale

Student Self-liking Rating

Draw A Person

Detroit Tests of Learning Aptitude:

Auditory Attention Span for Unrelated Words

Auditory Attention Span for Related Syllables (sentences)

Visual Attention Span for Objects (pictures)

Visual Attention Span for Letters (lower case)

Motor Speed and Precision

Oral Directions

Memory for Designs

Wechsler Intelligence Scale for Children:

Digit Span

Coding

Durrell Analysis of Reading Difficulty:

Visual Memory of Words

Wide Range Achievement Test.

The experimenters met with the subjects and their parents at the school to explain the purpose and methodology of the project. The project was described as a pilot study to explore a possible alternative to pharmacology in the treatment of hyperkinesis. The EMG biofeedback unit was demonstrated, the human subject's statement was read by the parents, and consent forms were signed (Appendix 1 & 2). At this time, the subjects had not been assigned to a group.

Because the experimenters feel that the hyperactive child frequently has no awareness of muscle tension, all eight subjects were presented with an individual forty-five minute relaxation session. The relaxation exercises were a modification of Jacobsen's technique of systematic alternate tension and relax-

ation of all muscle groups combined with visualization techniques developed by the experimenters (Jampolsky & Haight, 1975).

Fourteen individual thirty-minute experimental sessions were held distributed over seven weeks. Sessions one and two were pre-training baseline monitorings for all eight subjects, with no feedback given. The subjects were told that the investigators needed to know how relaxed their forehead muscle was. They were instructed to sit still, not to talk, and keep eyes open with the lids feeling heavy. The instructions to the subjects emphasized that baseline readings were not tests; that they would not be graded on how they performed. Sessions thirteen and fourteen repeated sessions one and two for post-training readings. The pre- and post-integrated measures were recorded over five time periods, ten, twenty, thirty, sixty, and one hundred and twenty seconds, for a total of two hundred and forty seconds. The pre- and post-means were recorded as the measure of muscle tension.

During the subsequent ten biofeedback sessions, the control subjects attended regular school activities while the experimental group was individually released from class at regular times two times a week.

The E Grp. became familiar with the instrumentation, with no baselines noted, during the third session. They were free to adjust the volume on the audio feedback and they experimented with

techniques, such as holding the eyes tightly closed and wrinkling the forehead, while observing meter and sound changes.

The nine EMG biofeedback training sessions' pre- and post-baseline monitorings were identical to the technique described above. Each subject was instructed that his goal in each session was to lower his overall body tension--to be relaxed--and that the reading on the integrator would be the measure of his relaxation. The notion of self-control was discussed and he was told that if he could control the needle on the EMG meter--make it go up or down or hold it steady--make his 'frontalis' muscle tense or relax at his will, he would be exhibiting self-control.

He was given homework directions to practice the relaxation techniques during quiet periods, such as watching television or resting in bed.

The mean of the pre- and post-baseline scores were given to the subject at the end of each EMG training session, and the mean scores were plotted and shown to the subjects at the beginning of each session. The plotted mean baseline measures were an added visual feedback.

Results

Parametric statistics (T-Test paired and unpaired) were employed to analyze the experimental data, and Pearson's Product

Moment Correlation measured the reliability of the hyperkinesis and psychological tests.

The mean microvolt pre-baseline score for all of the subjects was 8.06μv and the post-mean was 8.69μv ($p > .10$).

The pre- and post-mean tension levels of the E Grp. were 8.75μv and 7.85μv, a change of -.90μv. The C Grp. pre- and post-mean tension levels were 7.37μv and 9.52μv, a change of +2.15μv. The improvement of the E Grp. was not significant.

Insert Figure 1 about here

Data from the pre- and post-behavioral rating questionnaires showed some significant changes in all of the subjects. The combined Conners' Teachers' and Parents' Rating Scale yielded a total pre-measurement of 36.75 and a post-mean of 30.00 ($p \cong .05$). The OAT Hyperactive Rating Scale was examined in its entirety as well as by two subtests for lability and self-esteem. A pre-rating mean, combining the subject, parent and teacher's questionnaires totaled 90.25 and a post-rating mean of 80.00 ($p \cong .01$) on the entire test showed a significant decrease in hyperactivity in all eight subjects. Self-esteem changes, as measured by the OAT, Draw A Person, and the Student Self-liking Rating were not significant. The pre-lability level was 29.00 and post-level was

22.5 ($p < .05$). The above data indicates that all of the subjects could not be considered hyperkinetic nor as having a lability problem at the conclusion of this study. The improvement on the subtest for auditory attention span for sentences ($p = .05$) was significant for all of the subjects and close to significance level of improvement was scored for motor speed and precision and visual attention span for letters ($p < .10$).

Insert Table 1 about here

The data yielded no significant changes between the two groups on the pre- and post-psychological measures. The improvements on the subtests for lability, visual attention span for letters, and auditory attention span for digits in the E Grp. were close to significance ($p < .10$).

Insert Table 2 about here

The OAT Hyperactive Rating Questionnaire was developed from the complete OAT for this study. The four sections pertaining to lability, self-esteem, concentration, and coordination were extracted and designated as a subtest for hyperkinesis. The correlation

(r = .97, p<.001) was significant.

Discussion

The present study did not demonstrate that EMG biofeedback training with a small population of hyperkinetic males will result in a reduction in frontalis muscle tension and lability level, and an increase in self-esteem and visual and auditory attention span. All eight of the subjects did reduce muscle tension, but not to a significant degree. The theory that lowering the tension level of the frontalis muscle would result in a generalization of the relaxation response was assumed in this study, but a recent report by Alexander (1975) does not substantiate the generalization theory. The hypothesis that relaxation of the frontalis muscle will generalize to other muscle groups, with a decrease in hyperactivity, deserves further research.

The control group increased the tension level +2.15μv, while the biofeedback group decreased it -0.90μv. It is interesting to speculate that without the biofeedback intervention, the E Grp. might also have measured an increase over the eight week period.

The subjects were diagnosed as hyperkinetic by two reliable tests, yet the pre-EMG levels were not abnormally high, as reported in the previously mentioned studies. The literature does not contain enough reports of frontalis tension levels of hyperkinetic adolescents to warrant the judgment of abnormality.

The "experimenter," or placebo effect, is an uncontrollable variable in the reported methodology. It is a possibility that the forty-five minutes of directed relaxation exercises, the differential attention paid to all eight of the subjects, the manner of the experimenter, and the expectancy or "set" to relax of the subjects could have induced the low baseline scores. Individually or collectively, these methods could be treatment for hyperkinesis. Biofeedback in this study cannot be stated as responsible for the reduction in hyperactivity and lability and the increase in visual and auditory attention spans because these changes resulted in all of the subjects. The continued placement of the students in the special education setting also could have been an agent for the improvement in attention span.

The eight subjects' increased ability to attend to visual and auditory stimuli from their environment also appeared to influence the development of more reality-boun' self-perception. On the pre-study self-liking measure the subjects were almost uniformly inclined to assign themselves exaggeratedly low or high scores. The post-study scores revealed tremendous changes in both positive and negative directions and the perception ratings of six of the eight subjects, for the first time, were consistent with the

parents', teachers', and other professionals' continuing estimates of the subjects' feelings about themselves. The two subjects who assigned themselves the highest ratings during the pre-study evaluation (98 and 99 on a scale of 1-100) and only shifted their scores one and two points upward to 100, were the two youngest subjects, had the highest self-assigned OAT lability and low self-esteem scores, the highest total teachers' scores on the OAT (the lowest self-esteem subtest-scores in particular), and were adjudged to be especially inclined to rely on the defense mechanisms of denial. It appears that the older, less tightly defended subjects were more capable of using their improved ability to attend to auditory and visual environmental stimuli to attain more reality-appropriate perceptions of themselves.

The visual feedback, or "attention-focusing training" of the E Grp. yielded observable benefits in two major areas of functioning--lability and learning. Although not statistically significant, the decreases in lability could have permitted the freeing of energy which then could be redirected toward the acquisition of basic learning skills. The improvements in the performance levels noted on the subtests for Auditory Attention for digits and Visual Attention span for letters suggest that major channels for learning (auditory and visual) were positively affected by the biofeedback training.

The improvements were on extremely elementary types of immediate auditory and visual attention span tasks, especially for students in the age range of these children. This suggests that the procedure facilitated accelerated development of some of the most basic, simple units of learning that had been deficient in the subjects. It is possible that continued remediation with EMG biofeedback and "attention-focusing training" could lead to the expansion of skills for increasingly complex units of learning in the auditory and visual channels and that the student's emotional, social, and academic functioning would be positively affected.

In previous EMG biofeedback studies, the contrast between the performances of trained and control subjects has been made on the acceptance of a real biofeedback training phenomenon. While there is little question that the reputation of biofeedback, the instructions to subjects, and the mere presence of a truly muscle-contingent feedback stimulus have conspired to adequately motivate the subject receiving training and to bring their behavior under some degree of stimulus control, it would appear to remain an open question whether or not the control group has been motivated sufficiently to perform to their levels of capability. If so, they do not constitute an adequate control group (Alexander, 1975). The present study could indicate motivation in the control group, especially the

hyperactive variable.

The experimenters recognize some serious problems in the research design. The low power afforded by the size of the samples to discriminate significant differences could lead to a false conclusion from negative results. Unless the effects of the treatment procedures were massive, it could be concluded that this treatment method should not be pursued further. With a larger population, subclasses of hyperkinetic children could be examined. The subjects of this study, although diagnosed as hyperkinetic, were not characterized by high muscular tension, and a third group, with higher tension levels, may have added valuable data to the study.

As previously stated, the rationale for measuring only frontalis muscle feedback is questionable. Perhaps subjects should be trained on more than one muscle group to obtain results that would benefit hyperactivity.

The possibility of underestimation of the significance of a study is greatest when there are only two experimental condtions and all available subjects are used (Campbell & Stanley, 1966). For external validity, the present study was conducted in the school, a setting in which testing is a regular phenomenon. The school has a small number of students and only ten male students met the

criteria for hyperkinesis. In the general population, four-fifths of the hyperkinetic patients are males.

Although significant positive results of EMG biofeedback training with hyperkinetic male adolescents were not identified in this study, the notion that many of the long-term emotional and learning problems seen with hyperkinetic children, long after they have "outgrown" overactivity, could be minimized if physical relaxation were taught, needs further exploration. Unpleasant emotions, such as anxiety, fear, and anger can impede learning, as can too much emotional arousal (Haight, 1975). Teaching the hyperkinetic child to recognize and maintain the physiological states associated with moderately pleasant feelings, while he is engaged in learning activities, could offer a possible alternative to the present reliance upon drugs.

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Table 1

Mean Pre- and Post-Scores of 8 Subjects

With and Without Training

Test	Pre	Post	T Ratio
EMG	8.06 µv	8.69µv	0.44+
Conners	36.75	30.00	2.33 *
OAT	90.25	80.00	3.47 *
Lability (OAT)	29.00	22.00	1.86 *
Self-esteem (OAT)	24.00	22.50	0.80
Draw a Person	78.38	80.63	0.67
Like Self Rating	73.62	82.13	1.04
AAS for unrelated words (months)	87.38	103.50	1.50
AAS for digits (months)	95.00	109.00	1.29
AAS for sentences (months)	95.25	108.38	2.32 *
Oral Dir. (months)	99.00	102.75	0.68
Visual Att. Span for Letters (months)	118.50	125.63	0.49+
Motor Speed & Precision (months)	92.75	126.75	1.23+

* $p < .05$
+ $p < .10$

Table 2

Mean Pr. . and Post-Improvement Scores

Test	E Grp. (N= 4)	C Grp. (N = 4)	T Ratio
EMG	0.90µv	-2.15 µv	1.24
Conners	3.50	10.00	1.14
OAT	14.00	6.50	1.34
Lability (OAT)	9.50	6.25	1.23+
Self-esteem (OAT)	1.25	1.75	0.12
Draw a Person	27.00	30.00	0.07
Like Self Rating	-9.75	-7.25	0.14
AAS for unrelated words (months)	19.65	41.89	0.23
AAS for digits (months)	33.00	-5.00	2.15+
AAS for sentences (months)	5.25	21.00	1.51
Oral Dir. (months)	2.25	9.00	1.02
Visual Att. Span for Letters (months)	12.00	2.25	1.17+
Motor Speed & Precision (months)	39.75	28.00	0.54

* $p < .05$

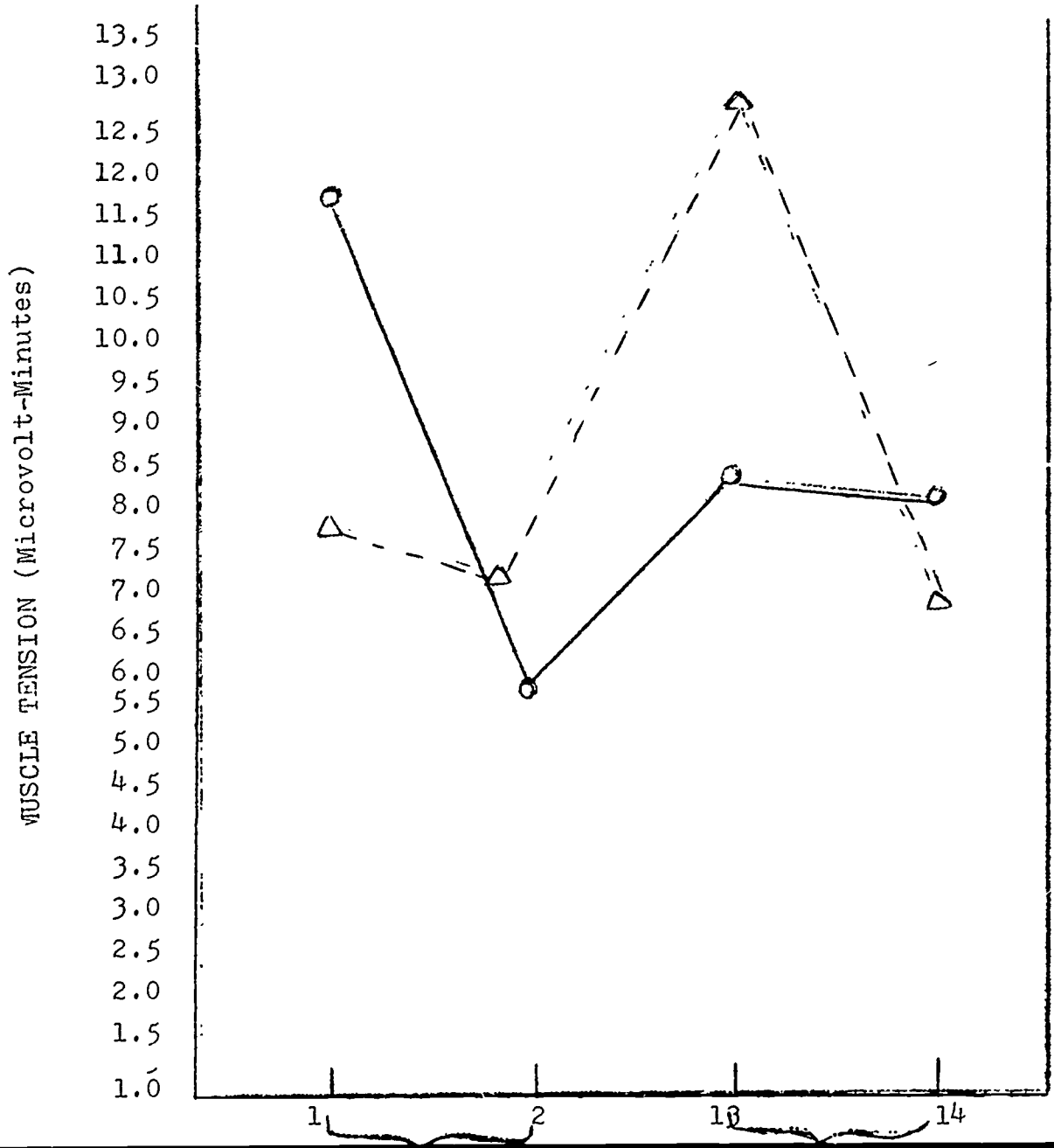
+ $p < .10$

Figure Caption

Figure 1. Mean EMG baseline readings.

(E = experimental group)

(C = control group)


E (Biofeedback)
C (Control)
MUSCLE TENSION (Microvolt-Minutes)
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
1
2
13
14

Appendix

1. Human Subjects
2. Consent Form

Appendix 1

Human Subjects

1. EMG biofeedback has been effective in producing muscle relaxation in adults, and most investigations have been reported to have been directed to the adult population. It is worthwhile to explore its usefulness with school age hyperkinetic children.
2. The only possible attendant discomfort and risks involved in the procedure are as follows:
   a. Discomfort from hook-up to the instrument. A headband contains the electrodes and is placed around the subject's head. There is no pain involved, only a new experience. The staff will work with each subject to assure a comfortable experience with the instrument.
   b. Possible psychological risks: unrealistic goals for success could be formed, resulting in disillusionment. Failure to achieve control over muscle tension could lead to discouragement. If discouragement does occur, the project principal investigator will be consulted. All project work with Ss will be carefully supervised by the senior research assistant. A close contact will be maintained with the principal investigator and the school psychologist.

3. Benefits to be expected:

   a. The child will benefit from learning muscle relaxation levels, which will result in an increase in self-esteem, self-awareness of physiological processes, attention-span, and a decrease in arousal level. His ability to learn in the school environment will increase because his motor activity will show a decrease.

   b. The biofeedback training will offer an alternative to the use of drugs. Society will benefit because the maladapted adolescent will stand a better chance to make a satisfactory life adjustment in family relationships, vocation and interpersonal relationships. Because of his increase in self-esteem, he stands less of a chance of becoming a potential school drop-out.

   c. The slight risk to the subject is negligible when compared to the major benefits that will accrue to the hyperactive learning disabled child, his family, the educational system, and to society in general.

Appendix 2

Consent Form

I have received a verbal presentation of the research proposal and have read the human subject statement and the research proposal. I have received an explanation of the procedures to be followed including:

(1) identification of those which are experimental (Section C, 1,2,3); (2) a description of the attendant discomforts and risks (human subject statement 2, a & b); (3) a description of the benefits to be expected (Section A 1; human subjects statement 3a, b,c); (4) a disclosure of appropriate alternative procedures that would be advantageous for the subject (consultation with the principal investigator). I have also received an offer to answer any inquiries concerning the procedures and have been instructed that I am free to withdraw my consent to discontinue my child's (ward) participation in the project or activity at any time without prejudicing the treatment of my child (ward).

I hereby give consent for Gerald G. Jampolsky, M.D. and the staff of the CHILD Center Annex, Tiburon, Ca., under the supervision of Dr. Jampolsky, to carry out the studies detailed in the proposal on

our child (ward). I also give permission for the project staff to review my child's (ward) school records on file at the Challenge to Learning School. The only inducement offered to me for participating is the possibility that this study may benefit children and educators.

Note: Must be signed by parent or by actual legal guardian.

Signed

_____

_____

(Relationship)

_____

Witness

_____

Date