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An Evaluation of Chiropractic Manipulation as a Treatment of Hyperactivity in Children

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ABSTRACT

The principle aim of this study was to determine the effectiveness of chiropractic manipulative therapy in the treatment of children with hyperactivity. Using blinds between investigators and a single subject research design, the investigators evaluated the effectiveness of the treatment for reducing activity levels of hyperactive children. Data collection included independent evaluations of behavior using a unique wristwatch type device to mechanically measure activity while the children completed tasks simulating schoolwork. Further evaluations included electrodermal tests to measure autonomic nervous system activity. Chiropractic clinical evaluations to measure improvement in spinal biomechanics were also completed. Placebo care was given prior to chiropractic intervention. Data were analyzed visually and using nonparametric statistical methods. Five of seven children showed improvement in mean behavioral scores from placebo care to treatment. Four of seven showed improvement in arousal levels, and the improvement in the group as a whole was highly significant ($p = 0.009$). Agreement between tests was also high in this study. For all seven children, three of the four principal tests used to detect improvement were in agreement either positively or negatively (parent ratings of activity, motion recorder scores, electrodermal measures, and X-rays of spinal distortions). While the behavioral improvement taken alone can only be considered suggestive, the strong intertest agreement can be taken as more impressive evidence that the majority of the children in this study did, in fact, improve under specific chiropractic care. The results of this study, then, are not conclusive, however, they do suggest that chiropractic manipulation has the potential to become an important nondrug intervention for children with hyperactivity. Further investigation in this area is certainly warranted. (J Manipulative Physiol Ther 1989; 12:353–363).

Key Indexing Terms: Chiropractic, Motor Activity, Galvanic Skin Response.

INTRODUCTION

Hyperactivity is a significant problem (1–3) in children with behavior and learning disorders. The major approach to treatment for this disorder has been treatment with stimulant medication (4). One alternative to drug treatment that has been investigated is behavior therapy (5).

For years, the fact that stimulant medication had an apparent calming effect on hyperactive children was referred to as a "paradoxical effect." In a study by Satterfield and Dawson (6) a hypothesis was formulated to explain the so-called paradoxical effect. The explanation offered by Satterfield and Dawson, based on data resulting from their study, was that in those cases having a positive response to stimulant medication, the hyperactivity was due not to over-arousal, as would be logically expected, but under-arousal. Specifically, these researchers hypothesized that reticular activating system-mediated central nervous system (CNS) arousal was below normal in their subjects. Thus, they argued that hyperactivity was the result of attempts by their subjects to increase arousal level through extraneous motor activity. When administered a stimulant drug, the arousal level was chemically increased thereby reducing the need to increase arousal level through motor

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activity. The result was an apparent calming effect produced by a stimulant.

While Satterfield and his associates have continued research along this line (7–11), other research focusing specifically on the questions of the interrelations between hyperactivity, stimulant medication and measures of electrodermal activity have reported findings which indicate that there is considerable complexity involved in these relationships. Alternative research also indicates that the "paradoxical effect" advanced by Satterfield, and its autonomic assumptions, are not clearly confirmed by other investigators.

The results of Firestone and Douglas (12) are in agreement with those of other researchers (13–15) that hyperactive and normal children do not differ in resting skin conductance levels and show similar increases to increased task demands. These studies do not lend support to the contention that hyperactive children are either over or underaroused, as proposed by Satterfield and Dawson (6). Additionally, these studies do support the view that hyperactive children show a lower level of specific responsivity to specific stimuli than normal children and this lower responsivity is associated with longer reaction times for hyperactive compared to normal children.

In this study autonomic data revealed that resting skin conductance was not different in hyperactive compared to normal children; hyperactives produced fewer specific autonomic responses to signal stimuli. Results for the autonomic activity measures indicated no differences between hyperactives and normals in resting skin conductance level (SCL), with group mean SCLs ranging from 24 to 30 μmhos. While the normals and hyperactives did not differ in phasic skin conductance response (SCR) for amplitude of response to warning or response stimuli, the controls showed a greater frequency of skin conductance orienting response (OR) than the hyperactives.

The authors conclude that the skin conductance results favor an arousal hypothesis to explain the increased impulsive responding in the reward condition for both groups. They conclude that tonic skin conductance may be viewed as an indicator of overall arousal and a sign that the organism is ready to take in and act on new information.

Chiropractic and Hyperkinetic Behavior

Initial evidence that chiropractic manipulative therapy (CMT) could reduce hyperactivity in children was produced by the Psychoeducational and Guidance Services at College Station, Texas (16). Independent investigators (a clinical psychologist, the superintendent of schools and the director of Psychoeducational and Guidance Services) monitored children with learning and behavioral impairments due to brain damage and/or neurological dysfunction and with emotional impairments. Results of two separate investigations revealed that hyperactivity and other impairments responded well to chiropractic care and even exceeded results seen from medication.

Certain anecdotal and case study evidence has suggested a role for chiropractic manipulation in treatment of various mental disorders. B. J. Palmer established a sanitarium in Davenport, Iowa that treated a wide variety of mental disorders often with apparent success. Others have reported the effect of spinal disorders on mental impairments and their improvement after chiropractic intervention (17).

While these unblinded case studies offered initial evidence for a chiropractic effect on autonomic function, Dulgar et al. (18), Wickes (19), Wiles (20), and others (21) have offered more controlled trials which suggest a somatoautonomic effect for chiropractic manipulation.

Indeed, recent controlled trials document that CMT has a significant effect on skin temperature (22), and the CMT causes significant elevation of plasma Beta-Endorphin levels (23). These studies lend further support to the initial uncontrolled case study findings of improvement in hyperactivity after chiropractic manipulative therapy, in that chiropractic manipulative therapy has been shown to have somatoautonomic effects which might be expected to include an effect on autonomic activity.

Rationale and Purpose of Study

Hyperactivity has been identified as a major problem among children with behavior and learning disorders. Administration of stimulant medication is the major approach to treatment for this disorder, but the mechanism of action of such drug treatments in influencing behavior remains unclear. Also, such drug treatments can have undesirable side effects.

There is provocative evidence that chiropractic manipulative therapy can alter levels of nervous system activity and thus; a) may provide a drug-free treatment for hyperactivity, thereby avoiding possible drug side-effects; and b) may represent a treatment of hyperactivity that achieves more long-lasting effects than that attained by drug treatment.

Given these relationships and potential benefits, the purpose of this research is to establish the efficacy of

chiropractic manipulative therapy in the treatment of children with hyperactivity. The viability of chiropractic as a nondrug intervention for hyperactivity could have important health implications due to the avoidance of the potential side effects of stimulant drugs in children, e.g., increased heart rate, arrested growth, insomnia and loss of appetite (3).

METHOD

Subjects and Design

Subject Recruitment and Inclusion Criteria: After newspaper advertising and referral from a pediatrician and others had produced eight candidates for study, subjects were selected according to several criteria. All candidates were of school age (7–13) and had objective and subjective clinical findings evidencing a chiropractic intervertebral subluxation complex (spinal lesion). In addition, candidates were selected only if at least three of the remaining four criteria were met: a) diagnosed hyperactive by a qualified professional, b) score on a parent rating scale of hyperactivity at or higher than that for a normal child three years younger than the subject, c) mean skin conductance level above 6 μmhos, and d) history of positive response to stimulant medication for hyperactivity. Finally, only candidates that were removed from medication during summer break from school were considered for inclusion. Seven of the eight applicants were accepted for inclusion in the study. The eighth applicant showed few objective clinical signs of spinal lesions and an unusually low mean skin conductance level (the remainder of the applicants had high or very high conductance levels), and was dropped from the study.

Use of the Parent Rating Scale for Screening: The parent rating scale used for screening of the applicants was that of Werry-Weiss-Peters. Applicants accepted for this study had initial scores ranging from 26 to 40 with a mean score of 33.2, which for their ages was well above norms established for normal children (24). In normal children scores on this measure decline with increasing age. For inclusion in this study a subject's score had to be at or above that for normal children three years younger than the subject.

Psychophysiological Screening: The resting skin conductance level (SCL) was obtained from each applicant according to the procedure described below. Since electrodermal activity (EDA) has been used relatively infrequently in previous hyperactivity research and since EDA measures are known to vary greatly between subjects, a specific cut score for inclusion in the study was difficult to determine. A further complication was that previous research is inconsistent in establishing whether hyperactive children tend to have relatively high or relatively low EDA levels. Consequently, it was decided to use a skin conductance level of approximately 6 μmhos as a minimum activity level for inclusion in the study. Much lower a level of electrodermal activity for a subject would present a "floor effect" situation in which improvement, defined as reduction in relatively high levels of electrodermal activity, would be increasingly difficult to demonstrate.

Use of Chiropractic Examination for Screening: Chiropractic screening examinations were carried out on all eight prospective research applicants. Parents completed a standard case history for their child, including questions regarding previous medical, psychological or other treatment for hyperactivity. With parent and child together the chiropractor consulted the participants, reviewing the case history and checking for any potential contraindications to manipulation (e.g., prior history of spinal pathology, history of cerebrovascular pathology, etc.). During the interview and consultation the parent and child were told that there is some case study and anecdotal evidence that chiropractic may be of benefit to children with hyperactivity. Parents were asked to sign a consent form that outlined the study and advised that, "There is little or no risk for physical or psychological harm from any of the procedures to be used. Successful results could result in drug-free treatment for hyperactivity." The form and the study were reviewed and approved by the Institutional Review Board of Mississippi State University which had determined that human subjects would not be at risk in the study. Parents were advised that the point at which intervention begins would vary from child to child and could not be revealed until the study was completed. They were asked to not allow their child to miss more than 1 week due to vacation, etc. However, all parents were advised that their child could, for any reason, drop out of the study at any time.

After consultation, clinical assessment was made, including recording of subjective complaints, objective orthopedic and chiropractic structural examination, and radiographic examination when indicated by objective clinical criteria. Initial chiropractic screening revealed significant subjective, structural, orthopedic and radiologic findings in all but two of the eight prospective candidates; however, one of the two was considered borderline and was included in the study,

while the other was dropped. Clinical assessment included those items listed in Table 1. Additionally, the children were screened for clinical signs of vertebrobasilar insufficiency.

Research Design: A single subject research design, the multiple baseline design across subjects, was used to evaluate the effect of chiropractic manipulative therapy on the overt motor behaviors and physiologic measures. Single subject designs are particularly useful with small sample sizes and, in this design, external validity is achieved by systematic replication across subjects (25).

While new to the chiropractic profession, single subject research designs have been used for some time in psychological, educational and physiotherapeutic investigations. Since their introduction to the profession (25, 26), single subject designs have been used in assessment of CMT for neck pain (21), and for assessment of CMT for incontinence (28). Their use here is particularly important in that a small number of subjects were studied in a clinical setting.

Data collection under nonmedicated conditions began during summer vacation (when children are taken off their stimulant medication) after a 2-week wash-out period. Baseline was a minimum of 2 weeks of data collection (six sessions of behavioral and two sessions of physiological measures), during which measurement indicated minimal variation or a trend away from that considered desirable in a normal subject. During this phase children received the placebo treatment described later. Due to time constraints of completion by mid-August (before school and the question of renewal of stimulant medication arose) the children began treatment by twos instead of singly. Phase changes were then ordered by interval rather than based on performance or nonperformance of prior subjects.

TABLE 1. Chiropractic examination: objective findings

I.	Palpation
	1. Static
	2. Motion
II.	Range of Motion
	1. Cervical
	2. Dorsolumbar
III.	Compression/Irritation
	1. Foraminal compression
	2. Shoulder depression
	3. Adson's Test
	4. Kemp's Test
	5. Soto-Hall
	6. Extremity Signs
IV.	Structural/Postural
	1. Head tilt
	2. Shoulder height
	3. Rib hump/bulge, scoliosis
	4. Hip height
	5. Short leg syndrome (measures)
V.	Radiography
	1. Anomaly
	2. Pathology
	3. Mechanical variance
	4. Subluxation

Subjects participated as patients at the Leach Chiropractic Clinic where they received chiropractic evaluation and therapy, and the behavioral measures of motor activity. Appointments were scheduled for three visits per week. Once per week subjects received their psychophysiological evaluation at the Psychophysiology and Biofeedback Laboratory in the Department of Psychology on the Mississippi State University campus.

Definitions: EDA measured directly as skin resistance level (SRL) by the constant current method was the psychophysiological measure employed in this investigation. EDA is primarily the result of physiological changes in the activity of the eccrine sweat gland. There is also some evidence (and theoretical debate) regarding a nonsweat gland epidermal component of EDA, particularly for skin potential measures. Since the sweat gland is controlled by the sympathetic branch of the autonomic nervous system, it is generally thought to reflect changes in the activity of the sympathetic nervous system, and secondarily, changes in the central nervous system. Contemporary research and theory on electrodermal activity is consistent with this statement but one of such brevity may be an oversimplification (29).

Psychophysiological Evaluation Procedure

SRL measures were taken on a Narco (E&M) Physiograph Six with an E&M GSR preamplifier which supplied a constant current of 20 μA D.C. Sensitivity was set at 2.5 Kohms/cm of pen deflection. Electrodes were disposable Ag/AgCl type (Biotrode Silver Plus) applied with Signa Gel (Parker Laboratories, Inc., Orange, NJ) electrode gel. Both were supplied by Biofeedback International, Guerneville, CA.

When subjects arrived at the laboratory for the first time, it was explained that each subject was to have his/her "physiological activity" measure for about 10 min. They were to sit quietly without talking during this period and were shown that they would be monitored on a closed-circuit TV. They were informed that after about 8 min of quiet, four moderately loud tones would come on about half a minute apart, and, after that, the session would be over and the sensors would be removed.

After any questions were answered, the subject was seated in a reclining chair, the application area was

cleaned with alcohol, and electrodes were attached to the medial phalanx area of the second and fourth digits of the nondominant hand. A nonfunctioning, clothes-pin-clip-style plethysmographic pulse transducer was also attached to the third digit to divert specific attention from the electrodes. The child was instructed to keep the hand in a comfortable position and as still as possible and not to move the arm since this would interfere with proper recording. A piece of masking tape was placed loosely over the arm at the wrist to serve as a reminder to the child not to move the hand or arm.

SRL measures were taken at 30 sec intervals for 7 min. At the 7 min mark, a tape recorder was activated. The tape contained four repetitions of 25 sec of silence followed by a 1000 Hz tone of approximately 50 db played through a speaker in the subject room. SRL was recorded during the 5 sec just prior to tone onset and the response to each tone was recorded as the maximum SCL during the tone and for 5 sec following the tone. This recording procedure was repeated for each tone, yielding eight measures.

Subject Management and Procedural Variations: A major problem in obtaining physiological measures from children in the age range of those in this study is subject movement and movement artifacts in the data recordings. This problem was exacerbated by the fact that all children in this study were hyperkinetic and not participating in their usual medication regimen. Individual differences in movement tendencies during data recording were considerable. There were rare occurrences that necessitated interruption of the recording sequence. These occasions were caused by extreme movement, electrodes becoming unattached, equipment malfunction, etc. When these disruptions occurred, the research associate followed the procedure of halting the recording of data, taking the actions necessary to remedy the problem—such as reattaching the electrodes—and then resuming recording at a point in the recording sequence approximately 1 min before the disruption occurred.

Overt Motor Behavior Measurement

Reliability of the motion recorders (actometer, a mechanical accelerometer) used in this investigation (Timex, Model 101, Karlis & Willis, Middlebury, CT) has been shown to be quite high. Reliability studies by Tryon (30) demonstrated that by attaching a device at varying intervals along a motorized pendulum which was oscillating at varied intensities, coefficients of variation ranged from 0.90 to 0.99.

Detection of movement is considered an optimal measure of overt motor behavior, applicable to research on hyperactivity. Some researchers prefer direct observation of motor behavior in a naturalistic setting as the best behavorial measure of hyperactivity. However, it may be argued that use of the accelerometer (30) combined with physiologic measures of arousal (6) provide a satisfactory means of assessing not only current activity levels, but are helpful in more accurately predicting future activity levels as well (31).

During each visit to the practitioner's office, prior to placebo or intervention chiropractic manipulative therapy, a graduate student placed the actometer on the child's dominant ankle and nondominant wrist (determined by having the child write his name as well as kick a styrofoam footfall. The nondominant wrist was used because the subjects were asked to work on a simulated school task during data collection that required writing. Since there was no confounding activity involving the legs, the ankle of the dominant foot was used for the second actometer. The actual motion data used for each session was the average of the data obtained for the arm and leg combined in order to obtain an overall motor activity.

Each child was asked to complete a computer generated activity sheet simulating a school task while wearing the actometer. The children were seated in chairs high enough off the floor such that their feet were free to swing and their arms and hands were unrestricted. The graduate student monitored each child during the 15 min sessions from a booth (the practitioner's X-ray booth with the leaded glass covered by tinted material), hidden from the view of the children.

The conditions of the room were comfortable throughout the study. Children were tested by twos due to time constraints (having to conduct the study during the practitioner's normal lunch hour), but in one case due to scheduling difficulties and missed appointments one of the subjects was tested 9 of 12 times during pretreatment with another subject, yet was only tested 5 of 11 times with another subject during the treatment phase. Due to this inconsistency this subject was dropped from the statistical analysis after the graduate student commented during the study that the children acted differently when tested alone from when tested together.

Chiropractic Measures

Chiropractic measures included objective procedures that are used in the profession (Table 1). While most are fairly reliable including motion palpation for cervical joint fixation (32), range of motion testing with a

goniometric device, structural tests including leg length assessment and radiographic evaluation (33, 34) there is concern about inter- and intraexaminer reliability (35). In this study no attempt was made to use a separate examining and treating doctor, so some bias in pre- and posttesting might be expected. However, an attempt to predict chiropractic success during initial screening and rate the degree of improvement in chiropractic measures after intervention (psychophysiologic and behavioral measures were blinded from the practitioner until after chiropractic measures were revealed) offered some protection against this potential bias. Measurements and all chiropractic evaluations were made in the clinic under normal operating conditions.

During the baseline data collection phase of the research each child received placebo treatment. Nonspecific contact points were used and the practitioner "pretended" to be treating the child with a detuned mechanical manipulating device (i.e., Activator instrument) adjusted down to zero thrust but with audible "popping" sound (36). During initial use of the device, it became apparent that the hand could not trigger the device without some force being distributed to the child. The practitioner then developed a technique whereby he held the tip of the instrument between his index and long finger so that the instrument never actually touched the child; even with this delivery some light force was distributed to the child; however, nonspecific contact points were used and specific spinal dysarthrias were deliberately avoided. In this way the instrument made a "noise," and it was the practitioner's perception that the child assumed that there was some benefit to the procedure. Furthermore, the child received the same "gentle touch" before and after treatment with the placebo as was received during the actual intervention. The practitioner made every effort to be pleasant and conversational, asking about hobbies and sport interests and summer vacation plans; during the baseline phase the children were told often by the practitioner that "different types of treatments are being used, and we want to see if they help calm you down." During baseline and intervention both the practitioner and scientists were blinded from the other's data collection.

Chiropractic adjustive intervention was varied according to the spinal needs of the individual child. All the children were treated by standard diversified and Gonstead techniques. Specific upper cervical correction for some children was indicated after analysis (Table 1), including one child with a demonstrable kyphosis of the C2-C3 motion segments, while most had intervention for juvenile idiopathic scoliosis. In every case intervention was selective for the specific spinal dysarthrias detected by examination. The chiropractic intervention involved the use of light but specific high velocity, low amplitude thrusts for the correction of chiropractic intervertebral subluxation complexes.

RESULTS

Chiropractic Measures

Pretreatment radiographic findings were compared with independent baseline skin conductance level (SCL) for each subject. The rank order correlation was high [$r_{(s)} = 0.714$] although not quite significant at the 0.05 level due to the small sample size. The fact that the correlation between independent radiographic findings and resting SCL was so high is, in itself, a truly remarkable finding of this investigation. Correlations of this magnitude between electrodermal activity measures and other measures of physiological activity are typically much lower.

Chiropractic data are summarized in Table 2. There was not significant symptomatic improvement in the group in terms of pain relief (category I findings) essentially because there were few musculoskeletal complaints to begin with. In terms of objective clinical improvement such as palpatory, structural, and orthopedic findings (category II), there was at least some improvement in all cases, although dramatic in four of the seven, in terms of structural assessment of spinal deviations, notably so in the 7-yr-old girl who presented with the initial radiographic finding of a C2-C3 reversal subluxation. Posttreatment radiographic assessment revealed correction.

Motor Behavior

Motion recorder scores by subject for each measurement session are shown in Figure 1. There was some reduction in overt motor behavior in five of the seven children. One child (subject 3) was measured 9 of 12

TABLE 2. Number of positive clinical findings before and after CMT

	Pretreatment			Posttreatment		
Subject	Cat I	Cat II	Rad	Cat I	Cat II	Rad
						1
						1
						2
						1
						2
						2
						2

Cat I, Category I or subjective findings; Cat II, Category II or objective clinical findings; Rad, Radiographic findings (grade 1 is least severe).

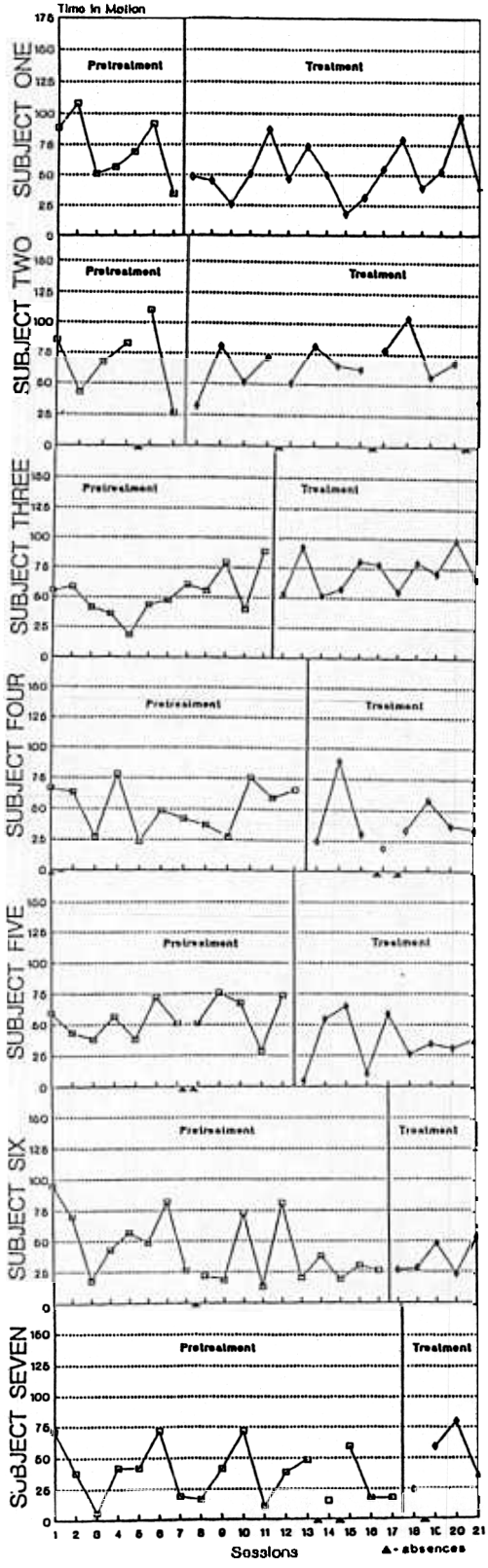

Figure 1. Motion recorder scores by subject.

times during pretreatment baseline together with another subject in the experiment, but was measured only 5 of 11 times together with another subject during the treatment phase. Due to this procedural variation caused mainly by scheduling conflicts and the failure of other subjects to keep appointments, subject 3 was dropped from statistical analysis of this dependent measure. Subject 7 was also excluded from this analysis because of signficant injuries sustained at summer camp during his 2 weeks of intervention, which required medical intervention including medication.

While there is some debate concerning the use of statistics in single subject research, some have argued that properly applied statistics can aid in analysis of the data (37). Using the Walsh test the mean change in motion recorder scores of the remaining five subjects were analyzed for significant changes from baseline to intervention. Results indicated that the reduction in mean motion recorder scores from pretest to treatment period was significant for these subjects ($p < 0.03$).

Results of all subjects were analyzed visually by graph as well, however, visual interpretation appears unconclusive.

Electrodermal Activity: Conductance Level (SCL)

These measures were obtained by repeated sampling during a 7 min resting period at the beginning of each physiological assessment session. Due to the fact that subjects had different numbers of physiological assessment sessions during the treatment, necessitated by time constraints and design modifications, the three averaged skin conductance level (SCL) scores obtained from each subject during each assessment session were treated as a set of observations during pretreatment and a set of observations during the treatment phase. This approach made possible the use of statistical analyses in the single-subject design plan for this investigation. Although somewhat controversial, the argument has been made in favor of the use of statistical techniques in single-subject designs in specific situations (38).

Analyzing the SCL observations (Figure 2) from all subjects for the pretreatment phase in comparison to the observations from the treatment phase yielded a significant reduction in means SCL (Pretreatment M = 11.88 μmhos; Treatment M = 9.53 μmhos), $t(187) = 2.65$, $p = 0.009$.

The same comparisons for the skin conductance response (SCR) to the first two tones did not attain significance for either tone. For tone 1, $t(61) = -0.28$, $p = 0.78$; for tone 2, $t(61) = 0.24$, $p = 0.808$.

It should be noted that all analyses of the electrodermal activity data included the data from all 7 subjects,

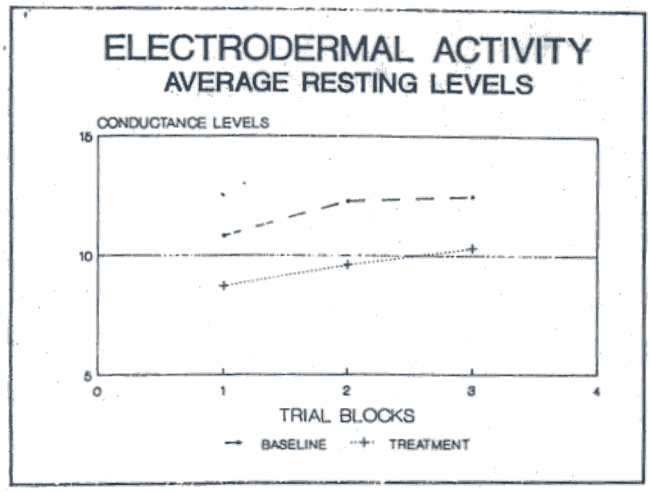

Figure 2. Electrodermal activity and average resting levels.

including subjects 3 and 7, who showed spurious changes in electrodermal activity. Thus the significant reduction in mean skin conductance level noted above was a robust effect able to "tolerate" the extraneous variability associated with subjects 3 and 7. SCL profiles for all subjects are seen in Figure 3.

Parental Rating Scale

These results are shown in Figure 4. Four of the seven subjects showed decreases in parental ratings of hyperkinetic behavior in the home environment from the start of participation to the end of the treatment phase. Subjects 3 and 7, excluded from the analysis of the above motion recorder analysis, showed no change on this measure. Excluding these subjects, four of five, or 80% showed reductions in parental ratings of hyperkinetic behavior.

DISCUSSION

Examination of the results for each of the main dependent measures and including all subjects yielded the followed results summary:

1. 57% (4 of 7) showed improvement in chiropractic radiographic findings.
2. 71.4% (5 of 7) showed a reduction in overt behavioral activity (mean actomotor scores).
3. 57% (4 of 7) showed improvement in level of autonomic activity (SCL).
4. 57% (4 of 7) showed improvement in parental ratings of hyperactivity.

There was also considerable consistency between outcome measures for each subject. One subject showed

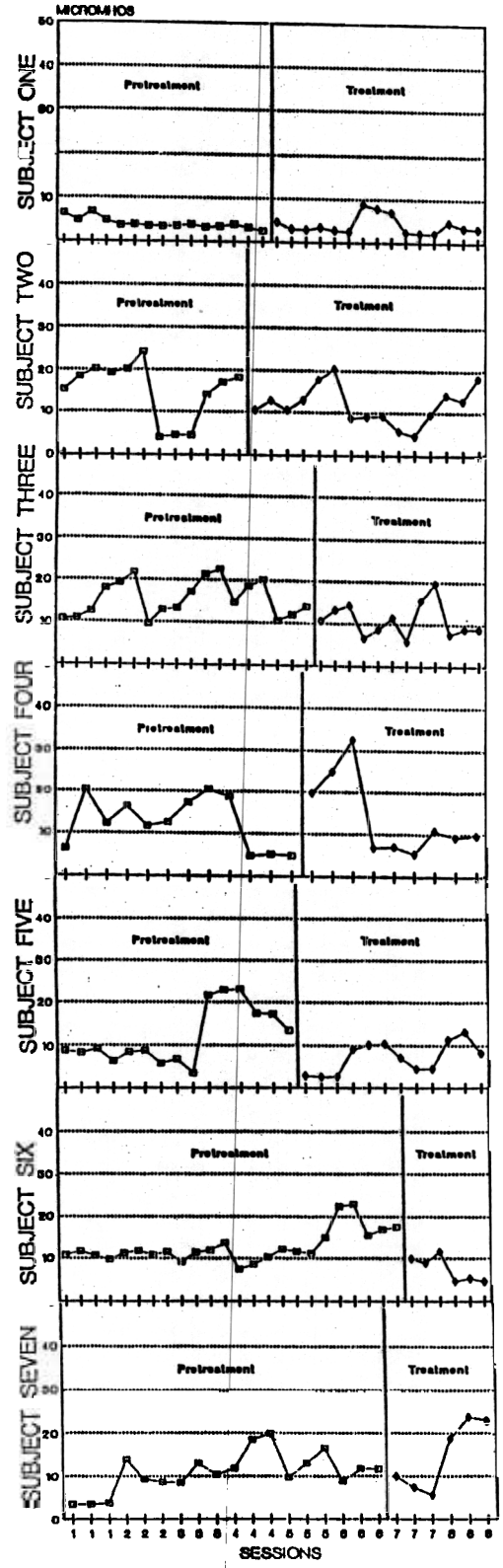

Figure 3. Skin conductance levels at rest by session for each subject.

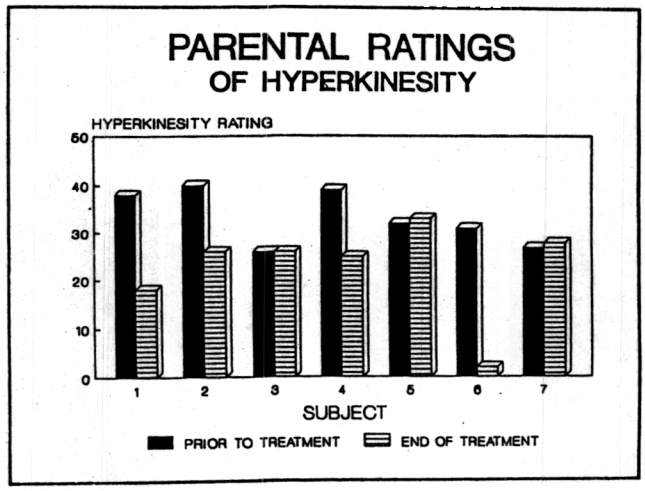

Figure 4. Parental ratings of hyperkinesity.

improvement on all four of the above dependent measures. Four subjects showed improvement on three of the four outcome measures. One subject showed improvement or no change on three of the four outcome measures. Thus, five of the seven showed improvement on at least three of the four outcome measures. Considering the short duration of chiropractic intervention, and the diverse domains tapped by the four outcome measures, these results suggest a clinically significant effect of chiropractic manipulative therapy on hyperactivity and its autonomic substrate in the hyperactive patients participating in this investigation.

The greatest problem encountered in attempting to use a multiple baseline design across subjects in this study was the variable data obtained. A single-subject design depends to a great extent on control of measurement variability. Traditionally, variability in this type of design is best handled by an investigation to determine the source of the variability and subsequent control of same. When this is not possible, the baseline phase should be extended and an attempt made to identify some predictable pattern to the variability. If there is a predictable pattern to the variability then this pattern can be taken into account when analyzing the data. Finally, if neither of the above is possible, the only recourse left is a statistical analysis of the data. This latter recourse is the least satisfactory of the three approaches to this problem. Unfortunately, because of severe time constraints already discussed, it was not possible to either take the time to investigate the source of the variability or to extend the baseline period. Thus, this investigation had to use the least desirable of the available solutions to this problem.

The investigators are uncertain if the variability observed in the behavioral data are typical of the disorder under investigation or due to some controllable variable in the data collection procedure. It would be interesting to know if the motor behavior of these subjects is equally variable under more naturalistic conditions, e.g., in public school classrooms.

If so, there is probably no way to obtain experimenter control over this variability without introducing new confounding variables into the investigation. If the motor behavior were not found to be highly variable under more naturalistic conditions, the implication would be that there was some variable in the experimental condition contributing to it.

In particular, one practice in the experimental condition may have contributed to the observed variability. This was pairing subjects during data collection. There may well have been an interactive effect between subjects. Under natural conditions, it would be unlikely that two hyperactive children would be seated together. It is quite possible that this practice contributed to the variability. While an attempt was made to always pair the same subjects, it was not always possible due to missed appointments and late arrival for appointments. This too may have contributed to the observed variability, since it is likely that different children will affect one another differently.

Another major design difficulty encountered was the necessity of having to use time rather than performance data to determine phase shifts for the subjects. Multiple baseline designs depend upon data based criteria for phase changes. Without this it is difficult to be certain that the influence of extraneous variables has been adequately controlled for in the study. Unfortunately, the time constraints imposed on the study by the length of the summer vacation made it impossible to fully use performance data to make phase change decisions. An attempt was made to base these decisions on performance data, but the decision process was not satisfactory because of the limited time and the variability of the data.

At best, from a behavioral and design perspective, this study might be considered a pilot investigation. The results are suggestive of improvement. The study was valuable in that it made clear certain problems that need to be solved in future studies of hyperactivity in children using single subject research methodology and chiropractic intervention. Before such a study is attempted again, investigations (perhaps many) focused on the nature of the behavioral variability observed in this study need to be conducted and a way to control this variability found. Also, in any subsequent study of this type the investigators should plan the study so that the severe time constraints encountered in this investigation are not present.

Handling the problem of time constraints is closely associated with potential confounding effect of stimulant medication on the subjects during the investigation. On the one hand, subject response to medication is the best available indicator that the hyperactivity is associated with an arousal level problem. It is the type of subject that responds positively to intervention with stimulant medication that is needed for the study. On the other hand, the subject needs to be off the medication in order to get the best demonstration of potential effect from chiropractic intervention. The only time that these subjects are typically taken off stimulant medication is during periods when they are not in school. Unfortunately, the longest of these periods, i.e., summer vacation, does not appear to be long enough to conduct this type of investigation. The only apparent solution would be to locate subjects who respond positively to stimulant medication but whose parents want them off of the medication for reasons unrelated to effectiveness of the medication.

CONCLUSION

There was clinical evidence to suggest a beneficial effect of chiropractic manipulative therapy (CMT) on this group of children, in terms of specific correction of spinal disrelationships. This study suggests a beneficial effect of chiropractic manipulative therapy on various measures of hyperactivity in children. Its purpose in terms of scope and design was not to demonstrate that CMT corrected specific vertebral subluxation complexes, but rather that CMT administered by a field practitioner could impact positively on hyperactivity in children. In fact, radiographic evidence did not reveal remarkable improvement in the group as a whole—partly owing to lack of appropriate length of intervention—however, in the case of subject 2 radiographic improvement was striking considering only one month of care was administered.

This effect of CMT on specific spinal dysarthrias, combined with physiological, behavioral and parental assessment of improvement in hyperactivity, is classically demonstrated in the patient (Subject 2) who was documented to have cervical hypolordosis (evidence of whiplash) by radiography. Posttreatment assessment revealed correction of this significant type of subluxation complex. Motion recorder assessment revealed improvement from 69.33 to 64.81 (average movements per recording session). Electrodermal tests revealed a reduction in skin conductance. Finally, parental assessment of activity from pretest to the final week of intervention reveal a significant change from 40 to 26 on the parental rating scale. This was one of two patients that the practitioner predicted would respond best to chiropractic during initial pretreatment assessment (the other patient predicted to respond best, subject 1, in fact responded best of all the children in terms of reduction on the motion recorder average; from 71.29 average movements to 52.47). The practitioner predicted improvement based solely on findings of the chiropractic examination.

That a partial "whiplash" could have an effect on neural integrity at the C2-C3 segmental level is well known. However, until this study there was no documentation that such an injury with resultant neurological involvement could affect arousal. We believe that radiographic demonstration of correction of this lesion, combined with psychophysiological evidence of significant improvement in arousal after chiropractic manipulative therapy, suggests a somatoautonomic effect of chiropractic manipulative therapy that may go beyond treatment of hyperactivity.

For example, there are a number of "stress syndrome" diseases and disorders that, like hyperactivity, have some degree of neurological imbalance as a central defect. Classically, the defect in children with hyperactivity is thought to be in arousal levels. The implications for treatment of other functional disorders of the nervous system by chiropractic manipulative therapy are unclear. However, this study presents an exciting challenge to the profession in that regard, and does point to CMT as a possible nondrug intervention for children with hyperactivity.

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