

**A BIOCHEMICAL/NUTRITIONAL APPROACH TO BEHAVIOR
PROBLEMS**

Key Words: nutrition, behavior problems, ADHD, trace mineral deficiency

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ABSTRACT

This study describes the preliminary results of a biochemical/nutritional early intervention program for children with behavior disorders. The participants were twenty-seven children aged three to ten years with attention deficit hyperactivity disorder, and/or conduct disorder, and/or oppositional defiant disorder. The children were given as the sole means of therapeutic intervention a nutrition supplement formulated with a broad diversity of thirty-one highly bio-active nutrients, with particular emphasis on trace minerals. The children were evaluated pre and post supplementation with seven neuro-biological factors selected from the Pediatric Behavior Scale which are recognized as predictors of violent, addictive and suicidal behavior. These included temper bursts, inattentiveness, learning problems, impulsiveness, compulsiveness, moodiness, and social inappropriateness. Supplementation yielded significant improvement ($p < 0.01$) in all seven factors. It is concluded that supplementation with bio-active vitamins and trace minerals is an effective, low risk, low cost approach to behavior problems in young children which specifically benefits the behaviors known to be precursors of adolescent violence, substance abuse and suicide. Index terms: nutrition, behavior problems, ADHD, trace mineral deficiency.

INTRODUCTION

This study reports the effects of a novel nutrition supplement upon children with disruptive, inattentive and aggressive behavior. Particular focus was placed upon evaluating neuro-biological indicators known to be predictors of violent and addictive behavior. To that end, the Pediatric Behavior Scale (PBS)¹ was utilized with isolation on seven criteria. These included impulsiveness, compulsiveness, learning problems, inattentiveness, temper bursts, moodiness and social inappropriateness.^{2,3}

Research has shown that the characteristic symptoms and behaviors associated with attention deficit hyperactivity disorder (ADHD) are often seen in children in combination with the other disruptive behavior disorders, conduct disorder (CD) and oppositional defiant disorder (ODD). The presence of aggression is common in all three of these disruptive behavior disorders.⁴

Mood and anxiety disorders are also present. Comorbidity is present in as many as two thirds of clinically referred children with ADHD, including up to 50% for ODD, 30-50% for CD, 15-20% for mood disorders and 20-25% for anxiety disorders.⁵

Adults presenting to ADHD clinics have revealed high comorbidity with substance abuse, anxiety disorder, antisocial personality disorder and dysthymia.⁶

In clinical populations of aggressive children, the treatment of choice has been methylphenidate (MPH). In reviewing the literature on studies examining the effects of MPH on aggression and other disruptive behavior symptoms it is commonly found that MPH produces significant improvements in both ADHD symptoms and aggressive behavior in children when evaluated in an educational or clinical setting. Unfortunately, much less improvement or even lack of improvement in ADHD and aggressive behavior are reported based on behavior observed when the children are at home. Failure of MPH to show significant benefits during home evaluation raises doubts about the long-term benefit of this stimulant medication to decrease violent and addictive behavior typical of teenagers and young adults with a history of ADHD, CD, or ODD. Another concern regarding the positive effects of MPH on disruptive behavior is the tendency for its efficacy to justify wholesale treatment of every child who presents with seemingly deviant behavior with stimulant drugs. There is even support in the literature for the possible bias or over-diagnosis of ADHD as a means to legitimize the prescription of MPH as a convenient crutch.⁷

Comorbidity with ADHD frequently necessitates augmentation strategies or second and third line treatments.⁸ Researchers and clinicians who advocate the use of stimulant treatment also caution that medical treatment should not replace consideration of behavior and psychosocial treatments and social or economic interventions.⁹

Yet, the administration of counseling services and special education programs has likewise yielded results which fall short of expectations.

In a most thoughtfully conceived early intervention program with aggressive hyperactive children, Barkley developed a project for ADHD and ODD children of kindergarten age.¹⁰ The treatments included in this project included parent training in child behavior management methods, behavior modification used in a special classroom, self-control training in a special classroom, as well as social skills training and anger-control training.

Despite spanning five years and being staffed with experienced child psychologists and special education teachers, the project yielded disappointing results. The parent training program was found to be ineffective. It produced no significant improvements in either child behavior problems, or academic achievement, or school behavior problems. The special behavior treatment classroom program was effective in reducing children's inattentive hyperactive and impulsive behaviors while in the classroom. Unfortunately, these behavioral and social improvements were limited to the school setting, with no evidence of any generalization of treatment effects from these special classes to outside the classroom. The project also failed to demonstrate any improvements in academic skills in children attending special classes.

Others have reported similarly unsuccessful attempts at community based parent counseling programs for families of children at risk for behavior disorders.¹¹

A Biochemical/Nutritional Etiology. Lacking consistent evidence that either stimulant medication or family counseling or special classroom programs yield treatment effects on disruptive, aggressive and anti-social behaviors that can be sustained over time, we were motivated to pursue another avenue to reach at risk children. It was our premise that early intervention would be essential to a program designed to reduce later risks for adolescent conduct disorder, school discipline problems, and violent or addictive behavior. We were also convinced that a successful program must address etiological factors in behavioral disorders

rather than merely palliate the symptoms. Our goal was to intervene as close to the source of the problem as possible.

A search of the literature yielded convincing evidence for a biochemical and/or nutritional etiology in many types of behavior disorders. One study showed that the emotional problems of aggression, anxiety, and irritability were shown to be more prevalent in children who were hungry.¹² Hungry children were more likely to have clinical levels of dysfunction. The prevalence of stealing was twelve times higher in hungry children versus those who were not hungry. The prevalence of fighting was seven times higher in hungry children compared with those who had adequate food. Children who were hungry were more likely to receive special education and mental health services than non-hungry children. Hunger was also related to academic failure.

A South African study demonstrated widespread under-nutrition and micronutrient deficiencies among children in their first two years at a rural school.¹³ The cognitive and behavioral effects of a school breakfast were explored. The results after six weeks indicated significant change from pre to post test assessments. The children showed a decline in both the occurrence and duration of off-task and out-of-seat behavior, and an increase in active participation in class and positive peer interactions.

Clinical experience had demonstrated to our satisfaction that the majority of at-risk children (but, indeed, the majority of all modern American children) ate a diet heavily favoring refined carbohydrates. Temple¹⁴ showed that refining of carbohydrate foods causes a sharp drop in the concentration of various vitamins and minerals. Estimates were made of the effect of refining on the total diet intake of many nutrients including folic acid and vitamin E as well as the minerals selenium, chromium, magnesium, zinc, manganese, and copper. The health implications of refined carbohydrates were discussed, concluding that the losses were certain to be detrimental.

Further search of the literature yielded compelling evidence that there are two major nutrition problems that are consistently shown to be causative factors in behavior problems: hypoglycemia, and trace mineral insufficiency.

One study investigated how hypoglycemia affects mood.¹⁵ Subjects were studied during a standardized step-wise hypoglycemic hyperinsulinemic clamp. A progressive negative change in mood was displayed for each hypoglycemic step. Furthermore, there was a significant increase for anger during hypoglycemia, and hostility significantly interacted with anger.

Hypoglycemic symptoms have also been shown to correlate with increased levels of the stress hormones epinephrine and norepinephrine.¹⁶ An increase in epinephrine and norepinephrine was demonstrated in all subjects during hypoglycemia, and symptoms were in proportion to the increase in epinephrine. Epinephrine is, of course, the “fight or flight” stress hormone. It can easily be imagined that excess epinephrine secretion could play a causative role in various aggressive behavior disorders.

This hyper-function of the adrenergic system has indeed been implicated in ADHD.¹⁷ It is also noteworthy that the most widely used drugs in the treatment of ADHD, the stimulants, affect the adrenergic system.

Trace mineral nutritional status shows up repeatedly in the literature regarding behavior and learning problems. It is interesting that much of the research on the association between trace mineral nutrition and behavior relates to the influence of trace minerals on hypoglycemia. Studies have shown that the trace mineral chromium is essential to normal function of the glucose/insulin system, particularly in subjects with hypoglycemia. It has also been shown that chromium supplementation has significant therapeutic activity in subjects with reactive hypoglycemia.^{18,19}

The dietary chromium intake of most individuals is considerably less than the suggested safe and adequate intake. Consumption of refined foods, including simple sugars, exacerbates the problem of insufficient dietary chromium since these foods are not only low in chromium but also enhance additional chromium losses. It has been shown that chromium also tends to normalize blood sugar. Chromium supplementation of subjects in one study resulted in an increase in glucose levels, increased insulin binding, and alleviation of hypoglycemic symptoms.²⁰

Another trace mineral that is discussed repeatedly in the literature in its association with behavior problems is zinc. Interestingly, the same condition of excess epinephrine mentioned above with respect to hypoglycemia is also a possible biochemical link between zinc and behavior disorders. It has been shown that a zinc deficiency causes a hyperadrenal condition.²¹

Zinc is an essential cofactor for over 100 enzymes. Maternal zinc deprivation during the latter third of pregnancy in rats and monkeys adversely affected subsequent behavior of offspring.²² Zinc deficiency has also been found to cause a hyperactive syndrome in rats.²³ Moderate zinc deprivation in prepubertal monkeys was found to adversely affect their performance in visual

attention and short-term memory tasks even without any overt signs of zinc deficiency.²⁴

In studies on humans it has been shown that at least some ADHD children may be mildly deficient in zinc, and furthermore that because of that zinc deficiency may not respond to treatment with stimulant drugs.²⁵ Toren²⁶ also showed that serum zinc levels of ADHD children were significantly lower than normal age-matched controls. Another study²⁷ showed a statistically significant correlation between low zinc levels and ADHD, and also that ADHD children had low serum free fatty acids. The findings indicated that zinc deficiency may play a role in the pathogenesis of ADHD, and, there was speculation that the low free fatty acid levels may have been secondary to the zinc deficiency.

Other research has looked at zinc in relation to the trace mineral copper in association with behavior disorders. Walsh²⁸ compared assaultive young males and controls with no history of assaultive behavior, and found a statistically significant difference in copper to zinc ratio between the two groups. It was also shown that normalization of the copper/zinc ratio with supplementation of zinc and other nutrients was found to improve violence-prone behavior.

Iron deficiency has also been implicated in the etiology of behavior disorders.²⁹ Children with iron-deficiency (and not other types of) anemia had elevated urinary norepinephrine, which returned to normal after a week of iron supplementation. The study concluded that elevated urinary norepinephrine may be a factor in behavioral changes in iron deficiency. (We again note a connection between elevated stress hormones and behavior problems in association with nutritional insufficiencies.) Children with iron deficiency exhibited irritability, signs of hyperactivity, disinterest in their surroundings, decreased attention span, and reduced IQ.

Another study determined that a deficiency of magnesium, copper, zinc, calcium, and iron in a group of 116 children with ADHD was higher than among healthy children.³⁰ Magnesium was found to be the most frequent deficiency in ADHD children.

Subsequent studies showed not only the prevalence of magnesium deficiency in ADHD children, but also the benefits of supplementation. In all scales assessing hyperactivity after magnesium treatment, subjects who had received the magnesium supplementation for six months had statistically improved results. Control subjects, meanwhile, showed an intensification of hyperactivity and behavior disorders over the six-month period.^{31,32}

Much evidence appears to support a biochemical and/or nutritional etiology for behavioral disorders in children. That etiology is associated with three clinically significant entities: a) elevation of the stress hormones epinephrine and norepinephrine, b) hypoglycemia, and c) nutritional insufficiencies of minerals and trace minerals. Furthermore, the hypoglycemic condition appears to be a causative factor in the elevation of stress hormones, while the nutritional insufficiencies appear to be causative in both hypoglycemia and stress hormone elevation.

Given this evidence, we formed the hypothesis that a broad base of nutritional support with specific attention to trace elements would yield objective improvement in the seven neuro-biological indicators of children with behavior disorders. While nutrition-related aberrant body chemistry may not be responsible for all manifestations of behavior disorders, the chemistry likely sets up a decreased threshold that, when combined with the appropriate emotional environment, can trigger altered behavior, including in many cases violent behavior.

METHODS

Participants

The participants in this study consisted of twenty-seven children aged three to ten years. Twenty-four of the subjects (89%) were male, and three (11%) were female. The children were participants in the Prevention Program of the Mountain View Community Medical Association in Mifflintown, Pennsylvania. . The Prevention Program serves the needs of children with disruptive behavior disorders.

The children all resided in a rural area. The county is underserved medically, and is a state designated mental health shortage area. All families had a history of either depression, anxiety, or drug or alcohol abuse.

All parents gave informed consent for their children to participate in the Prevention Program and entered the Program voluntarily. Each child was referred by family doctors, Children and Youth Services, Public Health Center, Child Development, the local Drug and Alcohol facility, or by parent to parent referral. Income levels consisted of poverty level to average income in a county with a median income of \$20,043. Most of the parents were high school graduates; two

parents had some post high school courses. Only one family had an intact original two parent household.

Thirteen of these children (48%) had taken stimulant medication (MPH), and responded negatively as reported by parents. These thirteen had been diagnosed/labeled as ADHD by either a psychiatrist, psychologist, school psychologist or family physician.

Nine (33%) of the children were currently taking a generic children's multivitamin supplement or a doctor prescribed supplement.

In a one to two hour session with a Master's level evaluator with 24 years of experience, parents were asked about family history, eating and sleeping habits of the referred child, school performance, onset of symptoms, medications used, health history of the child and the reason for coming to the Program. Overwhelming parents reported concerns about temper and moodiness. All but one of the children of school age were observed by the same evaluator in the school setting.

None of the children were referred for, nor received, therapeutic counseling services during the study. Two children were referred for vision exams. Two children with depression and obsessive compulsive symptoms were placed on 50 mg. of sertraline hydrochloride because of the apparent risk of attempted suicide. One child was placed on 5 mg. of fluoxetine hydrochloride for ADHD and depression symptoms. One child remained on 5 mg. of MPH per day. All children received the manufacturer's recommended dosage of the nutrition supplement chosen for this study and no other supplementation. No specific diet was recommended.

Measures

Upon admission to the program each child was evaluated using the PBS. The seven PBS criteria were isolated which are predictors of violent and addictive behavior. These neuro-biological indicators included impulsiveness, compulsiveness, learning problems, inattentiveness, temper bursts, mood swings, and social problems. The scale used for the seven indicators were rated pre and post by the parents as follows: 0 = not at all; 1 = sometimes or just a little; 2 = often or pretty much; 3 = very much or very often. The seven neuro-biological indicators from the PBS were evaluated upon each child's entrance into the program and then again within twelve months after beginning supplementation.

Procedures

Supplementation. The appropriate daily dosage of the supplement was given to each child. This consisted of two tablets daily for children aged five or less; and three tablets daily for children six or older.

The Supplement. Children were given the supplement (Mighty Mins, purchased from Nutri-Spec, a division of Diphasic Analysis Incorporated, Mifflintown, Pennsylvania) which was selected because of its novel quality and quantity of ingredients.

The supplement is designed to provide a broad base of nutrition support to all children. There are two distinctive features which set this supplement apart from other children's chewable multiple vitamin-mineral supplements. The first feature is the broad diversity of nutrients included in the product. No less than 31 nutritional factors comprise the formulation.

The second novel feature of this supplement relates to the high biological activity of the ingredients. That is to say that the nutrients are provided in forms that are easily absorbed and participate most efficiently in metabolic pathways.

To illustrate: The supplement contains B vitamins in their biologically active enzyme cofactor form. Vitamin B₂ exists in the form of riboflavine-5-phosphate one of the forms of the vitamin occurring naturally in the tissues and cells. Vitamin B₆ is found in this product as the active enzyme cofactor pyridoxal-5-phosphate, rather than pyridoxine hydrochloride, the form universally used in supplements and in enrichment of foods. Similarly, this supplement contains vitamin B₁ as thiamin pyrophosphate instead of ordinary thiamin hydrochloride. These enzyme cofactor forms of B vitamins, unlike the common supplemental B vitamins, require no conversion in order to be metabolically utilized.

Another noteworthy component of this supplement is vitamin C in fat-soluble form. Ascorbyl palmitate is retained and utilized far more effectively than water-soluble ascorbic acid.

An even more significant feature of this supplement (and the basis of its name) is its mineral and trace mineral content. Again, efficiency of absorption and utilization is the key. One illustrative example is the trace mineral chromium. This supplement contains chromium polynicotinate, which has been shown to be

eighteen times more bio-active than other forms of chromium, and further, which is the form of chromium that relates specifically to glucose metabolism.³³

Another distinguishing feature of this supplement is the high proportion of trace minerals to vitamins. The supplement is formulated with due consideration given to the diet of the typical child. Bread, cereal, and beverages are commonly fortified with B and C vitamins yet contain a paucity of micro-minerals. Micronutrient status is further jeopardized by the largely unrecognized fact that supplementation with vitamins can actually further deplete trace mineral levels. Milne³⁴ showed that copper activity was antagonized by supplementation with vitamin C. Nasolodin³⁵ showed that enrichment of food rations with vitamins only, using no trace elements, drastically increased the secretion of iron, copper, and manganese from the body.

RESULTS

A dependent t-test was used to compare the pre- and post-test mean scores for each of the seven individual traits and for an aggregate of those seven traits, as shown in Table 1. A significant difference was found between pre- and post-test scores of the aggregate [$t(26)=-10.07$, $p<.000$]. In addition, there were significant differences between the pre- and post-test scores of each of the seven individual traits, as illustrated in Figure 1.

These results suggest that administration of the supplement had a significant effect on parents' ratings of the seven behavioral traits.

Case Studies

Two interesting case studies suggest a strikingly significant relationship between the neuro-biological factors cited above and proper biochemical balance provided by the nutrient supplement selected.

A four year old boy was referred to the Program by his family doctor. In her interview upon entrance to the Program, his mother had this to say, "He typically wakes every hour through the night, screaming and begging me not to go to work the next day and complaining of stomach pain."

She described what she called compulsive/obsessive behavior, including his refusal to walk across the kitchen floor without stepping on certain squares in the

floor design. He also insisted on having his toys put away in a certain manner, and when playing with other children would put toys away as quickly as they got them out. "It didn't make for very friendly play," the mother commented.

At his preschool he insisted on being the last one to leave so that he could be sure the coat hangers were arranged by color. He also checked the hangers upon arriving at school each day. He insisted upon sitting in a particular chair and refused to sit anywhere else. His mother also reported that his diet consisted almost entirely of macaroni and cheese, white bread and fruit juice.

The boy was placed on two Mighty Mins per day. He was given no dietary recommendations. Neither he nor his family received counseling nor any other therapeutic intervention.

His mother reported that, "Within two weeks he was a different child." His nocturnal screaming and stomach pain had all but disappeared. He was participating normally in all preschool activities. One year after entering the Program this boy was photographed with Pennsylvania State Representative Dan Clark and was ceremoniously recognized for his kind behavior.

The second case study involves a three year old girl who was brought to the Prevention Program by her foster mother. The foster mother was contemplating returning the child to Children and Youth Services because of the serious nature of her behavior problems. The foster mother reported in her interview that the child would scream and run frantically from one activity to another. She would wake numerous times during the night and wet herself. When she talked her words slurred together incomprehensively. She ate non-food items like toothpaste and drank household cleaners, necessitating calls to the poison center on several occasions. The girl would run uncontrollably on to the road and had nearly been hit by a car.

After only one week on Mighty Mins, the mother had this to say: "She now sleeps through the night; her rowdy behavior disappeared and a new child emerged. She could comprehend things and express herself instead of just saying 'I don't know'."

Months later the mother reported that the child no longer ate non-food items; she did not wet at night; she did not run out on the road; and she communicated with an advanced vocabulary.

DISCUSSION

In summary, nutritional supplementation produced significant improvement in seven neuro-biological indicators isolated from the PBS which are known to be predictive of violent and addictive behavior.

Several points are worth noting in regard to the improvement experienced by these 27 children. First, is the quick response experienced by many of the children, particularly those who are six years old or under. While the length of time between the pre and post tests was up to 12 months, many children experienced dramatic improvement in their behavior within only one to three weeks on the supplement. It was noted throughout the study that in general, the younger children responded more quickly, while the older children took as much as several months to show symptomatic improvement.

Another pleasantly surprising finding in this study was that the supplementation obviated the need for medication in almost all subjects. While thirteen of these children had been medicated prior to participation in the program, only four children took medication at any time during the study. None of the children six or younger needed medication at any time during the study. Of the four children aged seven through ten who were medicated at the beginning of the study, two of those (the two who had been medicated for suicidal tendencies) were able to stop their medication completely after several months of supplementation.

Another important consideration is the low risk and low cost associated with the type of nutritional intervention employed by our Program. The children in this Program received a nutrition supplement which had little risk of detrimental side effects, yet, at the very least was likely to benefit their overall health, with the possibility of yielding the desired clinical improvements in behavior. The cost, both monetary and in terms of potential side effects, was negligible compared to the cost of medication.

We would be remiss in not pointing out the shortcomings of this preliminary study. The ideal would have been to conduct this study as a double blind using a placebo control group. Within the context of our type of Program, such was not possible. We are currently searching for a clinical or research setting where such a study can be conducted.

Other studies could be done to identify the mechanism(s) by which this supplement achieves its clinical benefit. Children could, for instance, be given glucose tolerance tests both pre and post. Another possibility would be to measure urinary excretion of epinephrine and norepinephrine pre and post.

Although nutritional aspects of childhood behavior problems have been of interest to researchers in the past, little clinical use has been made of the benefits shown to derive from dietary changes and especially from nutrition supplementation. Furthermore, those studies which have demonstrated clinical benefits of supplementation in at-risk children have concentrated on the use of a single nutrient. It only stands to reason that if single-nutrient supplementation benefits these children, that multi-nutrient supplementation would insure an even more favorable and more consistent clinical response. This report shows a significant benefit from a broad-based nutrition supplement that emphasizes the biological activity of its constituents as well as its trace mineral content.

These preliminary findings are encouraging. The second author notes that in her 24 years of experience working with disruptive, inattentive, and aggressive children, she has never seen any form of therapeutic intervention achieve results approaching those achieved in the Prevention Program. (It was the startling and immediate turn around in a few children immediately after beginning to take Mighty Mins that prompted this study.) Not only were the clinical improvements quickly and inexpensively achieved, but they have persisted. Those children who showed a turn around in their behavior within a few weeks have maintained that clinical improvement throughout the months of this study.

These findings also suggest that if the improvements in the seven neuro-biological indicators isolated from the PBS obtained in this program persist for a matter of years, that we may see a reduction of behavior and academic risks as the supplemented children reach adolescence. We would then expect to see a significant decrease in violence and substance abuse.

Figure 1: Comparison of pre and post scores

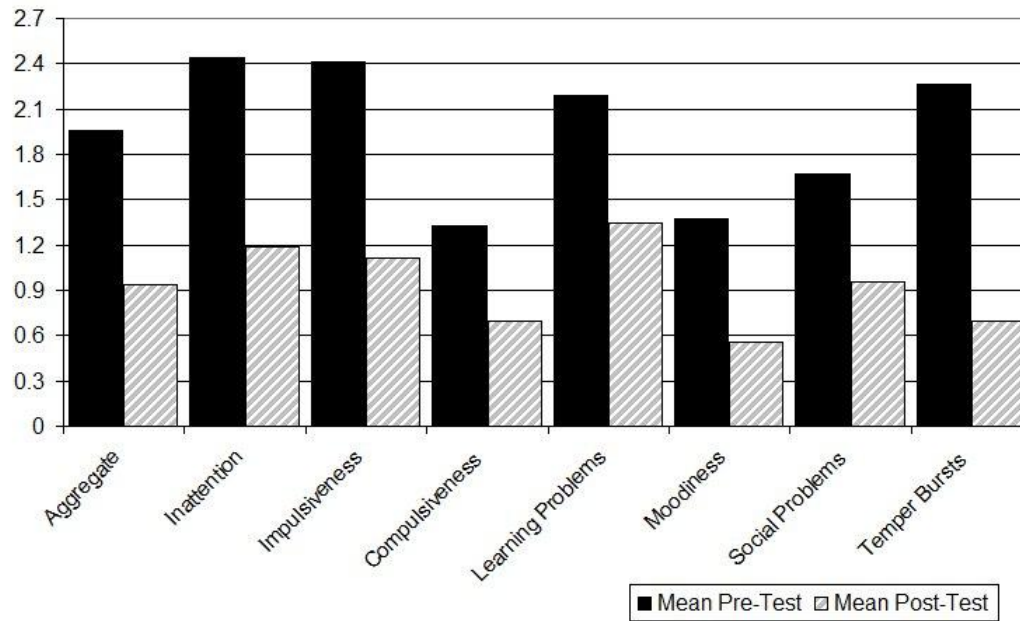


Table 1: Mean Pre-Test and Post-Test Scores

	Mean Pre-Test	Mean Post-Test	t(26)	p 2-tailed
Aggregate	1.96	.94	-10.07	.000
Inattention	2.44	1.19	-7.25	.000
Impulsiveness	2.41	1.11	-8.18	.000
Compulsiveness	1.33	.70	-4.41	.000
Learning Problems	2.19	1.35	*-4.12	.000
Moodiness	1.37	.56	-6.21	.000
Social Problems	1.67	.96	-5.05	.000
Temper Bursts	2.26	.70	-10.76	.000

* df = 25

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