Behavioral and Physiologic Response Measures of Occupational Task Performance: A Preliminary Comparison Between Typical Children and Children With Attention Disorder

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OBJECTIVE. To compare performance on the Assessment of Motor and Process Skills (AMPS), a measure of functional task performance and physiological responses (salivary cortisol levels) during AMPS administration, between typically developing children and children diagnosed with attention deficit hyperactivity disorder (ADHD).

METHOD. In this quasi-experimental study, independent *t* tests, and mixed, repeated measures analysis of variance were conducted to compare a group of typically developing children ($n = 21$) with a group of children with ADHD ($n = 12$) on two dependent measures: (a) the AMPS and (b) salivary cortisol. Salivary cortisol, a stress hormone, was taken at three time points, baseline, mid-way through AMPS administration, and 20 min following AMPS administration.

RESULTS. Significant differences were found on the activities of daily living (ADL) process ability measure of the AMPS ($p = .001$) and the ADL motor ability measure ($p = .04$), with the ADHD group performing more poorly than typical children. There was no significant group (ADHD vs. control) by time period interaction effect on cortisol levels. Overall, the cortisol levels of the ADHD group were higher than the levels of those in the control group ($p = .02$). Cortisol levels tended to drop significantly over time ($p = .01$) for both groups, however the patterns differed somewhat between groups. Cortisol levels of the typical children dropped at the final time period (20 min post-AMPS administration) whereas the levels of the children in the ADHD remained higher during this time period. This interaction effect approached, but did not reach, statistical significance ($p = .15$).

CONCLUSION. The results of this investigation suggest that the AMPS is sensitive to detecting functional performance concerns, and both motor and process skill deficits, associated with ADHD, and therefore may be a useful assessment tool with this population. Data also suggests that cortisol expression to a well-known ADL task may be lower if the task is not overly challenging for the individual, and provides support for further study of the role of cortisol with disorders of attention.

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Introduction

The purpose of this study was to compare functional performance between children with attention deficit hyperactivity disorder (ADHD) and typical children without behavioral concerns, using the Assessment of Motor and Process Skills (AMPS; Fisher, 2003a; 2003b). In addition, salivary cortisol, a stress hormone, was collected during the assessment session to explore whether children with ADHD respond differently under a mild stress condition than typical peers. The AMPS is one of the only performance-based, functional assessments available for children that is context-relevant and objective, and thus could play an instrumental role in diagnosing children with ADHD. The AMPS measures functional performance in both activities of daily living (ADL) such as dressing, and instrumental activities of daily living (IADL), such as homemaking tasks (Fisher, 2003a). The American Academy of Pediatrics' *Clinical Guidelines for Diagnosing ADHD* (Committee on Quality Improvement and Subcommittee on Attention-Deficit/Hyperactivity Disorder [CQI], 2000) suggested that functional performance should be considered as part of an ADHD assessment protocol. This reinforces adherence to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM–IV; American Psychiatric Association, [APA], 1994) guidelines that state an assessment of functional impairment should be included when making the diagnosis of ADHD. However, the Clinical Guidelines state "*No instruments used in primary care practice reliably assess the nature or degree of functional impairment of children with ADHD*" (CQI, p. 1166).

Research demonstrating the utility of the AMPS in helping to determine the extent to which function is impacted in children being assessed for ADHD may lead to greater use of this tool in clinical practice. To date, there are very few published studies using this assessment tool specifically with children with attention disorders. However, the tool has been used extensively for other conditions that affect functional performance in ADL, such as brain injury, Alzheimer's, and aging (Darragh, Sample, & Fisher, 1998; Duran & Fisher, 1999; Fisher, 2003a, 2003b; Hartman, Fisher, & Duran, 1999) affording some confidence that the tool might be sensitive to the types of behaviors noted in ADHD. Moreover, personal communication with the author of the AMPS (A. G. Fisher, personal communication, August 8, 2002) suggested that using the AMPS with children with ADHD would be an appropriate application.

Salivary cortisol was added to the study because of some suggestion in the literature that children with ADHD may express stress or arousal hormones differently than children without behavioral concerns. The assessment challenge in this study was expected to generate some degree of alerting or arousal response and provided an opportunity for a comparison probe between groups.

Attention Deficit Hyperactivity Disorder

ADHD constitutes one of the most common childhood behavioral and functional performance complaints in the United States (Barkley, 1997b, 1997c; Brown et al., 2001; Diller, 1998). Currently, ADHD is believed to be composed of at least two forms; one being a primarily inattentive type (Attention Deficit Disorder; ADD) and the other combined with hyperactivity features (ADHD) (APA, 1994; Barkley, 1997c; Wolraich, Hannah, Baumgaertal, & Feurer, 1998). This study was not designed to distinguish between the two types, nor were the children who were recruited to participate assessed differentially for subtypes by their primary care providers and school personnel. Thus, the term ADHD used in this paper describes children who fit one or both behavioral clusters.

Prevalence estimates for ADHD vary widely, from 3–26% depending on location within the United States, socioeconomic status (SES), level of parental education, race, gender, age, and adherence to diagnostic criteria (Angold, Alaattin, Egger, & Costello, 2000; Brown, 2000; Brown et al., 2001; Costello et al., 1996; LeFever & Dawson, 1999; Zito et al., 2000). This disparity in diagnostic prevalence estimates is a current focus of concern (Hoagwood, Kelleher, Feil, & Comer, 2000; LeFever, Arcona, & Antonuccio, 2003) and may be in part linked to inconsistent diagnosing procedures. The literature suggests that diagnosing protocols differ greatly among health care providers and geographical locations within the United States, and indeed between the United States and other countries (National Institutes of Health Consensus Development Conference Statement: Diagnosis and Treatment of Attention-Deficit/Hyperactivity Disorder, 2000).

Some of the variability in diagnosing ADHD may be due in part to the degree to which functional performance is considered when assessing children who are suspected of having ADHD (Brown et al., 2001; Jensen, 2000). Although most ADHD-specific rating scales and assessments appear to have adequate sensitivity and specificity to gather information from parents and teachers about the existence of perceived ADHD-type behaviors in children (Arnold, 1997; Barkley, 1997a, 1998; Brown, 2000; Campbell, 2000), the information provided is not necessarily sufficient to determine the effect of any existing behaviors on actual functional performance across a variety of settings (Brown et al., 2001; Costello et al., 1996; Jensen, 2000). Consistent with DSM–IV (APA, 1994), a differential diagnosis of ADHD should be made when the behavioral symptoms are determined to impair functional performance within a developmental perspective, exist for at least 6–12 months, and be the final diagnostic choice once other possibilities for the behaviors have been ruled out (Barkley, 1998; Brown et al., 2001).

A number of widely used ADHD assessment instruments use noncontextual tasks (e.g., attending to visual cues on a computer screen, working memory tests, visual-motor tests, and continuous performance-type tasks) that are distal to realistic situational demands, or rely heavily on subjective reports from parents and teachers (Grant, Illai, Nussbaum, & Bigler, 1990). The research literature suggests that these assessments are generally not sensitive enough when used alone to distinguish ADHD behaviors sufficiently well for diagnostic purposes. Therefore, a combination of assessments is recommended (CQI, 2000; Dewey, Kaplan, Crawford, & Fisher, 2001; Gordon & Barkley, 1998; Manly et al., 2001).

Assessment of Motor and Process Skills

The AMPS is a criterion-based measure of functional ability. The client's abilities are assessed while performing meaningful tasks. This approach to evaluation differs from the approach taken by most other assessment tools that tend to measure specific component skills such as visual perception, motor planning, or attention. Even though 36 motor and process skills are scored in an AMPS assessment, each of these component skills is scored within the context of task performance. Thus, successful task completion performed efficiently and safely is the criterion by which motor and process skills are scored in the AMPS.

Evaluation of skills within the natural context of functional tasks is what may afford the AMPS its greatest potential for use with the ADHD population. Current thoughts about ADHD suggest that it is not comprised by the breakdown of specific capacities such as attention per se, but rather as a breakdown of the broader adaptive and regulation capacities associated with frontal lobe function (Castellanos, 1997; Castellanos et al., 2002; Grant et al., 1990; Kempton et al., 1999; Nigg, 2001; Posner & Rothbart, 1998; Quay, 1996; Steger et al., 2001). This more extensive view of ADHD conceptualizes it as an executive function disorder rather than as an ADD (Arnold, 1997; Barkley, 1997a, 1997b; Campbell, 2000; Sadeh, Gruber, & Raviv, 2002; Rubia et al., 2001; White, 1998).

Although the AMPS was not designed to measure executive functions specifically, its focus on functional task completion in the natural context makes it highly attractive as an assessment of executive function integrity. Duran & Fisher (1999) argued that adaptive, purposeful behaviors can be observed as skills that influence functional human performance in daily tasks. Further, Schwartz and colleagues (Schwartz, Mayer, FitzpatrickDeSalme, & Montgomery, 1993) noted that known executive function impairments (e.g., following traumatic brain injury) were reflected and measurable in ADL performance, particularly as errors in intention or planning for action. Functional performance problems in daily activity were also documented by Ylvisaker and DeBonis (2000) who studied both adolescents with ADHD and adolescents following traumatic brain injury. The AMPS was used in this study to see whether children who were identified as having ADHD, and thus executive function disorder, displayed less-skilled functional behavior when performing ADL or IADL.

Based on this literature, it is believed that some of the functional behaviors and process skills needed to successfully perform AMPS ADL or IADL tasks might reflect certain capacities that are described as executive function abilities. These capacities may include: (a) impaired behavioral inhibition leading to impulsiveness, impaired adaptability, and questionable judgment in relation to situational demands, (b) impaired emotional regulation leading to misappraisals of others' behavior or actions as well an impaired sense of self-worth and efficacy, (c) impaired interference control leading to less flexible selective attention skills, (d) impaired working or short-term memory, (e) decreased ability to internalize self-speech that in turn helps regulate behavior and support adaptive learning, (f) decreased ability to apply knowledge adaptively, (g) impaired temporal pacing (e.g., performance is too slow or too fast), and (h) variable activity levels (e.g., hyperactivity and fidgetiness, or sluggishness) (Barkley, 1997a; Campbell, 2000; Castellanos et al., 2002; Goldstein & Goldstein, 1998; Jensen, 2001).

In addition to process skills, the AMPS measures motor skills such as fine and gross motor performance, and balance and postural control, in the context of functional task performance (standing, reaching, grasping, etc.). It is well-documented that many children with ADHD have mild motor deficits such as clumsiness (Holborow & Berry, 1986; Mulligan, 1996). For example, Mulligan identified a number of sensory motor deficits in children with attention disorders including poor visual-motor skills, poor balance, and motor planning difficulties. Therefore, the AMPS may also be useful in detecting some differences in motor performance between children with and without ADHD.

Salivary Cortisol

Another purpose of this study was to explore potential relations between functional behavior performance and stress responding. The human stress response system is influential in regulating neurohormones that support arousal and alert states necessary for adaptive, functional behavior (McEwen, 2002). Although a number of researchers have been interested in relations between ADHD and the Hypothalamic-Pituitary-Adrenal (HPA) axis (King, Barkley, & Barrett, 1998; Lurie & O'Quinn, 1991; Lyons, Lopez, Yang, & Schatzberg, 2000; Scerbo & Kolko, 1994), no studies in the literature have been reported that investigated stress responding during a functional task in children with or without ADHD.

The HPA axis is primarily responsible for the production of cortisol as part of a stress or arousal response to environmental challenges (Kirschbaum & Hellhammer, 1989;

McEwen, 2002; Sapolsky, 2004). Cortisol is an essential and naturally occurring hormone that is produced continuously as part of a daily cycle in humans (Spangler, 1991). One of the human glucocorticoids, cortisol, is implicated in a variety of processes including memory, attention, and the metabolizing of glucose for physical activity (McEwen; Sapolsky). Healthy individuals show a matured pattern of cortisol production by 3–4 months of age (Larson, White, Cochran, Donzella, & Gunnar, 1998; Spangler). Although fluctuations in cortisol levels within individuals occur as various challenges and tasks arise throughout the day, an expected pattern of cortisol production is one in which highest concentrations are in the early morning, with a gradual dropping off of levels through the late afternoon and evening (Gunnar & White, 2001). Cortisol is easily collected through saliva, which is subsequently analyzed in a laboratory using assay technology. Patterns of cortisol response to specific challenges can be investigated by comparing multiple samples among and between individuals over specified time periods (e.g., pre, during, and post a specific stress event). Moreover, the adaptability and responsiveness of the HPA system is sometimes assessed by administering substances such as dexamethosone, a synthetic adrenocortical steroid, which typically suppresses cortisol production temporarily.

A recent primate study in which two groups of squirrel monkeys were compared (Lyons et al., 2000) suggested that monkeys with higher cortisol tended to show poorer response inhibition behaviors, a skill linked to executive function. The authors hypothesized that higher amounts of cortisol may disrupt the neurotransmission of dopamine in the frontal areas of the brain that support executive functions. This theory had also been suggested by other researchers working with primates (Sánchez, Young, Plotsky, & Insel, 2000).

Several researchers have suggested that the HPA response may be affected in some children with ADHD. Kaneko and colleagues (Kaneko, Hoshino, Hashimoto, Okano, & Kumashiro, 1993) found differences in daily cortisol rhythm patterns in some children with ADHD, particularly those with more severe symptoms. When compared to adult controls, only 43.3% of the children with ADHD expressed normal daily cortisol rhythms compared to 90% in the adults. Although the "normal" adults all responded to a challenge to the HPA system using dexamethasone by a normal suppression of cortisol production, only 46.7% of the children with ADHD displayed normal suppression. Consistent with this finding, King et al. (1998) suggested that children with ADHD may have less adaptive HPA responsivity to environmental challenges, as measured by salivary cortisol. Their data suggested that children who remained ADHD/ADD labeled over a 3-year period had a less-than-optimal stress response to examinations when compared to children who no longer fit the diagnosis.

Lupien and colleagues (Lupien et al., 1998, 2002) have observed the influence of cortisol and other neuroactive steroids on cognitive performance in studies investigating both the aging process in the elderly and memory skills in young children. Findings from these studies suggest that cortisol is necessary for cognitive function and that cortisol levels may be adaptive. It appears that "just the right amount" is required for successful performance in certain tasks, and too little or too much may alter performance significantly. Ultimately, these studies demonstrate that stress and arousal responses to life situations as measured by salivary cortisol are far from being well understood, especially in individuals with executive function disturbances. Further study is needed in order to better understand potential relations between HPA response and disorders of attention or behavior regulation and functional performance.

The hypotheses of this study were that: (1) Children with ADHD would demonstrate less ability on the AMPS when compared to typical controls, and (2) Children with ADHD would demonstrate a different pattern of cortisol response to the task challenge (AMPS assessment), although the nature of the difference was unpredictable. This research was designed as exploratory, to determine whether the AMPS may be a useful assessment tool with ADHD populations. Second, this study aimed to determine whether further investigation into the usefulness of salivary cortisol as a measure of stress response has application in the study of individuals with ADHD.

Methods

Participants

Children from the Northeast United States were recruited for this study through friends, colleagues, flyers, and newspaper ads. Twenty-one typically developing children without behavioral concerns (typical controls), and 12 children with a primary diagnosis of ADHD confirmed by both a physician (all pediatricians) and a psychologist or special educator were recruited. Using online statistical software, a power analysis was conducted to determine adequate sample size for being able to reject false null hypotheses. As a preliminary pilot study, power was set at .7, and mean expected change in AMPS logit measures was set at .5, yielding a goal of 15 participants per group for conducting the independent *t* tests. (http://www.stat.uiowa.edu/~rlenth/Power/index.html)

Recruitment efforts resulted in a total sample of 33 children. All of the children in the sample came from within a 45-mile radius of each other, and were self-described by parents as within a middle-income socioeconomic status (SES). All but two children came from two-parent homes. Ninety-eight percent of the sample were Caucasian. All of the parents with children in the ADHD group (n = 12) had BS/BA degrees or higher, while 89% of parents in the typical group (n = 21) held BS/BA degrees or higher. Seventy-nine percent of the typical children and 83% of the ADHD sample were male. Using independent t tests, children's ages between groups were not significantly different and ranged from 5–12 years (mean = 8.55 years) in the typical group and 6–13 years (mean = 8.2 years), in the ADHD group. Baseline cortisol levels taken prior to task performance were also not significantly different between groups.

Of the 12 children diagnosed with ADHD, two had secondary diagnoses including (a) Tourette's syndrome and obsessive compulsive disorder and (b) anxiety disorder. Eight children in the ADHD group were taking at least one medication [e.g., Ritalin(r), Concerta(r), Adderall(r), Paxil(r), or Clonodine(r)] regularly, and two children were not prescribed medications. In order to assess the children's behavior while not under the influence of stimulant medication, the parents of all the children but the two with comorbid diagnoses agreed to a washout period of at least 5 hours prior to testing (if taking Ritalin) or by skipping the prior dose if taking Concerta or Adderall. The peak effect time for methylphenidate (active ingredient in Ritalin and Concerta) is approximately 1.9 hours in tablet form (Ritalin) and 4.7 hours for extended-release (Concerta) whereas the peak effect for amphetamine (Adderall) is approximately 2–3 hours (*Methylphenidate hydrochloride*, 2001); (Dexmethylphenidate-Novartis/Celgene, 2002). Several studies suggest that stimulant medications taken for ADHD (including methylphenidate) do not affect cortisol levels (Maayan et al., 2003; Scerbo & Kolko, 1994; Weizman et al., 1987). Therefore, it was felt that the cortisol levels of the 2 participants who were medicated during testing would not be significantly affected by the medication. Permission to conduct the study was given by the investigator's Institutional Review Board, Human Subjects Committee, and the study was conducted in accordance with accepted ethical principles.

Functional Activities of Daily Living Performance Measure: Assessment of Motor and Process Skills

Once parents consented and children assented to participation, phone or personal interviews were conducted to establish a variety of home tasks (approximately 3–5 tasks) in which the children participated independently or with minimal assistance. Of these, children chose two tasks for which they agreed to be assessed. The children were assessed in either their homes (n = 31) or in a university setting designed to mimic a typical home kitchen (two children in the typical group).

The AMPS (Fisher, 2003a, 2003b) measures a variety of functional skills available to an individual while he or she performs two–three tasks of his or her choosing, in either *personal activities of daily living* (PADL; e.g., basic hygiene and dressing skills such as donning shoes and socks) or *IADL* (e.g., household tasks such as making a sandwich, vacuuming, or making a bed) within a familiar context. Each individual observation is rated on 36 different aspects of task performance, divided into two ability dimensions: motor and process. Together, the 20 motor and 16 process item scores provide evaluation information about the quality and efficiency of goal-directed actions while performing a specific task (Fisher, 2003a). Assessment results, based on multifaceted Rasch analyses (Fisher, 2003a), are expressed as ADL motor and ADL process ability measures. The AMPS is a criterion-referenced tool, with both ADL motor and process measures indicating relative performance along a continuum of less–more competence in specific skills. In addition, normative data is available (www.ampsintl.com) for reference to same-aged peers.

The AMPS has been researched extensively regarding its psychometric properties and both clinical and research applications (Duran & Fisher, 1999; Fisher, 2003a, 2003b; Fossey, 2001). The first author was calibrated (an indicator of consistency of individual rater severity) as a reliable AMPS rater and assessed all of the children in the study. Because of recruitment and resource limitations, the researcher was aware of the group status for nine of the children in the ADHD group. Although this posed a possible threat to objectivity during assessment, the AMPS format affords some degree of bias control because the motor and process measures (*logits*) are logarithmically derived using three assessment dimensions: (a) task difficulty, (b) individual performance, and (c) evaluator rating severity. Thus, an evaluator does not have any information about an individuals' relative performance until the data are computer analyzed and all three data contributions are assimilated into an ability measure. Moreover, the AMPS software is designed to catch any illogical scores, based on an overall pattern of scores (Fisher, 2003a), providing an additional protection against systematic examiner bias. All AMPS assessments for this study were scored by computer and double-checked by an AMPS faculty-trainer. The researcher recalibrated on the AMPS at the end of data collection to identify any possible drift in rating severity that may have affected objective scoring. Calibration severity remained stable.

Multifaceted Rasch methods allow for diversity in task items and difficulty, such that the children were given a choice of tasks. All of the children chose age-appropriate tasks within difficulty ranges of easier-than-average to harder-than-average for which they had some prior experience. Standardized AMPS assessment procedures require that clients demonstrate knowledge of the task to be assessed and expectations for performance before beginning the task. This is accomplished by telling the examiner what they are being requested to do and by indicating that they know where necessary items to complete the task are kept. This helped to ensure that all children knew what was expected of them before proceeding. All AMPS assessments were completed without disruption within the 20-min time period between saliva samples, with two exceptions. These two children needed an extra 5–7 min to complete the tasks. Although the researcher was mindful of the time between samples, the children were not aware of any time constraint and were encouraged prior to the assessment to complete the tasks at a natural pace. Tasks on which the skills were rated included a variety of personal and IADL tasks, including brushing teeth, donning socks or shoes, making sandwiches, watering plants, making a bowl of cereal and a glass of juice, vacuuming, folding laundry, making beds, and making soups or hot beverages.

Hypothalamic-Pituitary-Adrenal Axis Measure: Salivary Cortisol

Cortisol as a distal measure of HPA response in humans is well-documented in the literature (Kirschbaum & Hellhammer, 1989). Saliva samples are an easy, relatively non-intrusive method for assessing biologically available levels of cortisol and have been demonstrated in a number of studies to correlate highly with blood levels (Bober, Weller, & Tait, 1988; Riad-Fahmy, Read, Walker, & Griffiths, 1982; Woodside, Winter, & Fisman, 1991).

Methods for saliva collection and storage were consistent with other studies in the literature (Gunnar & White, 2001; Kirschbaum & Hellhammer, 1989). Saliva samples were collected within the first 10 min of the assessment period as an index of baseline cortisol levels. The second sample, reflecting an initial response to the assessment, was taken approximately 20 min (mean = 23 min, range = 20–26 min) after the beginning of the AMPS tasks, and the third sample, reflecting cortisol levels at the completion of the assessment period, was taken approximately 20 min following the completion of the tasks (mean = 24 min, range = 21–29 min). Saliva samples were collected into airtight vials directly or through a straw, depending on each child's preference. A number of children elected to use sugarless gum [Original Flavor Trident(r)] to stimulate salivation (Gunnar & White). Salivary cortisol samples were collected at least one hour after a meal to control for postprandial surges in cortisol associated with digestion (Riad-Fahmy et al., 1982).

All AMPS assessments were completed in the afternoon between 1:45 p.m. and 5:01 p.m. ($N = 33$) over a 9-month study period. Control samples (aggregate saliva) were placed in each batch and individual samples and control samples were analyzed within the same batch. Laboratory technicians were blinded to control vials of aggregate saliva. Once samples were collected, they were stored in a freezer at -20 F. until they were transported on dry ice to Dartmouth Reference Laboratory, Lebanon, New Hampshire, for analysis. Each sample was assayed in duplicate using the DPC Coat-A-Count salivary cortisol radioimmunoassay (Diagnostic Products Corp., Los Angeles, CA). The analytical measuring range of this assay is 0.1–5.0 µg/dL, with inter-assay coefficient of variation of the assay being < 6.4% across the measuring range. Intra- and inter-assay coefficients of variation were 6.1% and 6.2% for mean concentrations of .25 µg/dL (control samples) and .152 µg/dL (study samples), respectively. All duplicate samples correlated significantly ($N = 125$, Pearson $r = .98$, $p < .001$).

Data Analyses

Statistical analyses were conducted using SPSS 11.0 software. Prior to conducting statistical analyses, cortisol data were log transformed to control for a positive skew (Gunnar & White, 2001). Measures for group comparison included the AMPS motor (ADL motor) and process (ADL process) logits, calculated by AMPS assessment software (Fisher, 2003a, 2003b), and salivary cortisol gathered over three time points. Independent t tests, with alpha set at $p < .05$, were conducted to determine group differences with the AMPS measures. One-tailed tests were used since there is substantial evidence in the literature to suggest that children with ADHD are likely to perform less capably than typical peers. A repeated-measures mixed analysis of variance was used to analyze group differences in salivary cortisol levels over the three time points.

Results

On the ADL process measure of the AMPS, statistically significant differences were found between the children with ADHD and the typical group, $t(31) = 3.47$, $p = .001$ (see Table 1). Statistically significant differences were also found on the AMPS ADL motor measure, $t(31) = 1.79$, $p = .04$. When compared to the normative data, the typical children's average motor and process logits were similar to average 7–8-year-old expectations while the ADHD group average

Table 1. Group Comparison of Assessment of Motor and Process Skills Scores

	Mean ADL Motor Logit (Se)	AMPS ADL Motor *t*	*p* (< .05)	Mean ADL Process Logit (Se)	AMPS ADL Process *t*	*p* (< .05)
ADHD Group (*n* = 12)	1.39 (.54) range (.49–2.32)	*t* (31) = 1.79	*p* = .04	-.10 (.15) range (-.80–.91)	*t* (31) = 3.47	*p* = .001
Typical Group (*n* = 21)	1.81 (.71) range (.25–3.30)			.81 (.82) range (-.33–2.81)		

Note. ADL = activities of daily living; AMPS = Assessment of Motor and Process Skills.

motor and process logits were lower than average. (http://www.ampsintl.com/documents/NormativeData.pdf)

To examine group differences in cortisol levels over the three time periods, a mixed, repeated measures analysis of variance was conducted with cortisol as the dependent measure, ADHD/Typical group as a between subjects factor, time of cortisol sample as a within-subjects, repeated measure factor. The results indicated no significant interaction effects, $p = .15$. The main effect for group was significant, $F(1, 31) = 5.7$, $p = .02$, indicating that overall, the cortisol levels of the children in the ADHD group were higher than the levels of those in the control group. The main effect for the repeated measure variable, time, was also significant, $F(2, 62) = 4.97$, $p = .01$. In examining the mean cortisol levels over the three time periods, it was evident that cortisol levels tended to drop over time. A graph of the data (Figure 1) does however illustrate a pattern difference between groups, of cortisol expression over the three cortisol samples. The children with ADHD stayed relatively stable from time point-2 to time point-3, while the cortisol levels of the typical children dropped during this period of time. As noted above, this interaction effect approached, but did not reach, statistical significance.

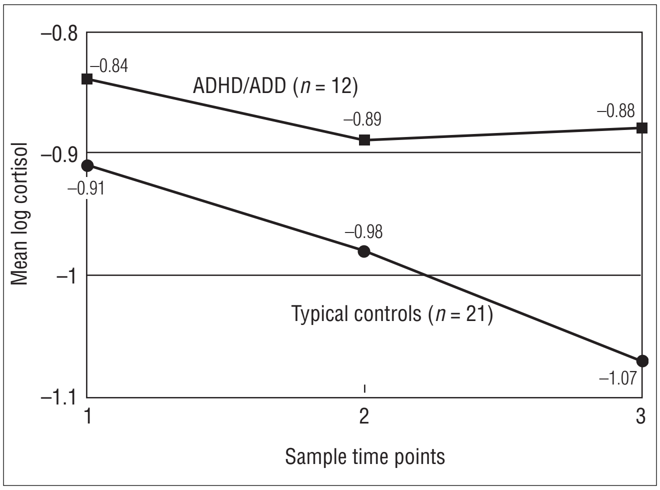

Figure 1. Comparison of salivary cortisol between groups at each time point.

Discussion

The finding that children with ADHD score lower on the AMPS ADL motor and process measures than typical children suggests that the AMPS is capable of capturing the essential functional behaviors of concern to parents and teachers. Additionally, the AMPS provided rich details revealing how behaviors characteristic of children with ADHD affected functional performance in everyday activities. For example, the AMPS scores were able to identify subtle motor deficits or clumsiness during tasks such as bumping into things or dropping items. Previous research identifying motor-control problems in children with ADHD was therefore supported by the results of this study. Mild weaknesses in motor control surfaced as errors in motor inefficiency, disorganization, and incoordination. In the process area, difficulties following multistep tasks, sensitivity to distractions, and lack of skill in accessing help and learning from mistakes, were some of the common problems that interfered with task performance. These problem areas measured by the AMPS are consistent with recent conceptualizations of ADHD as a disorder of executive function involving problems with timing, sequencing, refined motor coordination, memory, attention to task, and organization (Arnold, 1997; Sadeh et al., 2002).

Occupational therapists may therefore consider using the AMPS with children who have symptoms consistent with ADHD. This test provides an effective alternative to self-report measures of function by providing objective, detailed information regarding a child's functional capabilities. In addition, AMPS scores provide information about the effects that subtle motor and executive function challenges have on the child's ability to complete meaningful tasks. Another advantage of the AMPS as a measurement tool is that it can be given repeatedly over time to determine changes in performance. Thus, the AMPS could be used widely to determine if medication and/or nonmedication interventions are successfully addressing the functional behaviors associated with ADHD. This particular use of the AMPS could be valuable in evaluating effective treatments for children accurately diagnosed with ADHD.

Although no directional hypotheses were identified regarding cortisol response to the AMPS, the authors anticipated that the AMPS challenge would elicit a different pattern of response between the two groups. Surprisingly, in the typical children, instead of an increase in cortisol that would reflect a mounted response to a challenge, the AMPS task appeared as either a neutral stimulus (eliciting no response) or as promoting a drop in cortisol levels. Either explanation is possible. More extensive baseline data of home samples documenting each child's natural daily rhythm for comparison as well as additional samples postassessment period, would have been useful in addressing these possibilities. The statistically significant drop in cortisol over the three data points in the typical children, paired with age-competent AMPS performance, suggested that adaptive behavior in a well-known functional ADL task occurred in the presence of lowered cortisol. It may be that the cortisol decrease reflected an organized response to an individual's competency when faced with a familiar ADL task. This possibility is further suggested by data showing that the children in the ADHD group who performed less competently on the AMPS had higher cortisol level at the end of the assessment. In other words, cortisol dropped only a little over the assessment period for the children with ADHD, and actually increased slightly from the second to the third sample. One possible interpretation is that the difference found at the final sample may reflect a less-flexible stress response system in the children with ADHD, as suggested by King et al. (1998). As noted previously in the literature review, cortisol decreases have been associated with enhanced performance for some types of tasks (Gunnar, 1992, 1998; Newcomer et al., 1999; Skosnik, Chatterton, Swisher, & Park, 2000), whereas others have suggested that increased cortisol may negatively affect executive function tasks (Lyons et al., 2000). However, the documentation of differences in cortisol response in this study does not provide information about the possible nature of those differences. Further study is indicated to address, for example, whether more competent task performance is supported by lowered cortisol or whether competent task performance elicits lowered cortisol. The information gathered from this study supports the need to further investigate (a) the use of the AMPS as an appropriate assessment tool for children with ADHD, (b) the possibility that the AMPS can be applied as a client-centered contextually based assessment of executive functions, and (c) the possibility that children with ADHD may display differences in stress response physiology when completing tasks within the natural environment.

Limitations

The possible implications of the salivary cortisol differences paired with differential ability on the AMPS are interesting and have possible implications for occupational therapy. However, only three saliva samples taken at the time of the assessment limit the conclusions that can be drawn from the salivary cortisol decrease observed in this study. The nature of human cortisol is that it typically decreases over the day, with highest levels in the morning and lowest in the late afternoon (Kirschbaum & Hellhammer, 1989). This pattern makes it difficult to evaluate lowered cortisol response in the afternoon to specific events without a control comparison taken from another day in the individual's life. Therefore, in designing future studies, it is recommended that more comprehensive, daily baseline data be collected, especially when the direction of cortisol response to the stimulus used in the study being designed is uncertain.

Additional limitations of the study should be considered. These include a small sample, minimal diversity in the sample, and a lack of evaluator blinding to group status at the time of the assessment for the majority of the children. Although a number of characteristics about the AMPS (e.g., Rasch methodology and computerized scoring, a large normative database), as well as evaluator recalibration, provide some protection against these validity threats, any future study should strive to control for them through larger numbers of varied participants and multiple, blinded evaluators.

Another limitation is that although executive function (EF) behaviors are conceptually aligned with descriptions of behaviors that reflect adaptive, functional performance in meaningful occupations and activities, there is minimal research to suggest that EF abilities are reflected in ADL tasks specifically. Further study is needed in this area in order to explicitly link the quality of performance in ADL tasks to performance on common assessments of executive function integrity.

Conclusions

Based on the current literature, few assessments exist that can provide objective information regarding functional task performance within natural contexts and from an occupational performance perspective. For children who may be suspected of having ADHD, few assessment options are available in community settings for differential, objective diagnosis that is both cost-effective and relevant to daily life skills. Further study using the AMPS may reveal its benefit as part of a comprehensive school- and home-based assessment protocol that includes a measure of functional performance as an essential part of diagnosing ADHD. As suggested earlier, comprehensive assessments that include functional ability are more likely to disentangle true problems with performance from a myriad of other factors that could produce behaviors that may be perceived by others as "attention disordered." Most importantly, occupational therapists are already in place in schools and clinics servicing children with ADHD and can be easily prepared to provide functional assessments based on the AMPS.

Finally, the inclusion of physiological measures such as salivary cortisol when investigating behavioral responses is appealing and shows promise in enhancing our understanding of internal substrates that support behavioral performance. This research is important to pursue since lowered cortisol with competent performance in meaningful, context-relevant and familiar tasks may introduce new information about the possible physiological implications of meaningful engagement in occupations. However, these are complex, dynamic systems that are currently not well-understood in any field. Additional studies that include physiological measures alongside behavioral measures may lead to a better understanding of the nature of these complex interrelationships as they relate to skill performance in context, an important contribution to not only occupational science, but other behavioral science fields as well.▲

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