Computer Methods and Programs in Biomedicine 140 (2017) 241–248

Contents lists available at ScienceDirect

Computer Methods and Programs in Biomedicine

journal homepage: www.elsevier.com/locate/cmpb

Reliability and validity of DS-ADHD: A decision support system on attention deficit hyperactivity disorders

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ARTICLE INFO

Article history:
Received 29 March 2016
Revised 23 October 2016
Accepted 5 December 2016

Keywords:
Attention deficit hyperactivity disorder (ADHD)
Decision support system (DSS)
System development
Reliability and validity analysis
ROC curve

ABSTRACT

Background and objectives: The purpose of this study is to examine the reliability of the clinical use of the self-built decision support system, *diagnosis-supported attention deficit hyperactivity disorder* (DS-ADHD), in an effort to develop the DS-ADHD system, by probing into the development of indicating patterns of past screening support systems for ADHD.

Methods: The study collected data based on 107 subjects, who were divided into two groups, non-ADHD and ADHD, based on the doctor's determination, using the DSM-IV diagnostic standards. The two groups then underwent *Test of Variables of Attention* (TOVA) and DS-ADHD testing. The survey and testing results underwent *one-way ANOVA* and *split-half method statistical analysis*, in order to further understand whether there were any differences between the DS-ADHD and the identification tools used in today's clinical trials.

Results: The results of the study are as follows: 1) The ROC area between the TOVA and the clinical identification rate is 0.787 (95% confidence interval: 0.701–0.872); 2) The ROC area between the DS-ADHD and the clinical identification rate is 0.867 (95% confidence interval: 0.801–0.933).

Conclusions: The study results show that DS-ADHD has the characteristics of screening for ADHD, based on its reliability and validity. It does not display any statistical differences when compared with TOVA systems that are currently on the market. However, the system is more effective and the accuracy rate is better than TOVA. It is a good tool to screen ADHD not only in Chinese children, but also in western country.

1. Introduction

When children are constantly easily distracted, impulsive, or present a lack of organizational skill, these behaviors may no longer be explained by laziness or unruliness. They may be suffering from *Attention Deficit Hyperactivity Disorder* (ADHD), which is a cognitive behavioral disorder condition commonly seen in adolescence and childhood, affecting about 4% of school-age children [1]. ADHD patients usually display certain symptoms, such as the inability to focus on regular routines, which affect their academic and social functioning, where they are unable to reach the general standard. However, if ADHD is diagnosed early on, it can be treated as soon as possible. In addition to doctor's diagnostic rating scale, other related clinical screening support systems are also very important tools amongst today's screening methods, such as the well-known *Test of Variables of Attention* (TOVA) [2–7] and *Conners' Continuous Performance Test* (CPT) [8–13], which are used overseas.

Test of Variables of Attention-Visual (TOVA-V) [14], which is a computerized continuous performance test comprising a target stimulus and a non-target stimulus. In the TOVA-V, stimuli appear individually and are presented according to a set, randomly determined ratio. The test subject is required to immediately press a button after seeing a target. The computer records reaction times, omissions and commissions. The two targets appear a total of 648 times. The test must be completed in 22.6 min. The ratio of target stimuli to non-target stimuli in the first section of the test, which tests a subject's impulse control, is 36:126. The variables measured are omissions, commissions, response time, response time variability and response sensitivity (D'). An omission is scored when a tar-

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http://dx.doi.org/10.1016/j.cmpb.2016.12.003
0169-2607/

get stimulus appears and the participant does not press the button. The score represents the subject's degree of inattention. A commission, which is scored when a target stimulus does not appear but the participant presses the button, represents the participant's inability to control impulses. Response time is the time taken (measured in milliseconds) to respond to each trial. Response time variability, the variability in response time, is calculated based on deviation from the mean time for giving a correct response. D', an evaluation of the response sensitivity, which represents the ratio of hit frequency to frequency of false responses (*i.e.*, response to a target not present), measures the ability to accurately distinguish a target from a non-target and is interpreted as a measure of perceptual sensitivity. An ADHD score is derived from the total subscores. The advantage of TOVA is that it is not influenced by cultural biases and results can be compared worldwide.

The computerized CPT involves the presentation of target and non-target stimuli. The test runs for 14 min and primarily assesses attention and impulse control. Briefly, participants are required to respond to the stimuli on a computer screen by pressing a space bar for every letter except for the letter " X " . Multiple dependent measures exist, and commonly used indices include Omissions, Commissions and Detectability (D'). In the reliability of Conners' CPT II [15], the pill-half reliability is 0.66–0.95, and test–retest reliability after 3 months is 0.55–0.84. The "confidence-index" showed the summary of the subsections of the CPT: the higher score comes with higher possibility to be abnormal. The omission-T score shows results when the target is present while the commission-T score shows results when no target is present. The Hit-RT-T score is a measure of response speed consistency. The Hit-RT standard Error-T score measures the speed consistency. The "variability-T" score calculates the standard deviation of every standard error values calculated for each sub-block. The "Detectability-T" score is a measure of discriminative power. The "higher-response-style-T" score shows degree of cautiousness to avoid "commission-error", with lower score showing responding more freely to make sure that there is a response to each target. The "perseverations-T" score shows the frequency of responding time lower than 100 ms. The "Hit-RT-block-change-T" score shows the response –trend toward slower or faster responses.

In existing diagnostic computer systems, however, most of the other screening methods are exported from European and American (E-A), ADHD norm (reference database) fit well for world-wide ADHD assessment because the clinical diagnostic criteria may be different in the different areas. Due to the limitation of non-Asian norm database, the diagnosis results are not fully consistent with the real situation. One example of this is that the criteria (ADHD norm) used in European-American area could be too low or high to differentiate the Asian patients, thus leading to an inaccurate assessment. On the other hand, there is less data collected from domestic (Taiwan) patients, so an ADHD norm is needed to be standard criteria for domestic diagnosis.

This paper proposes a *diagnosis-supported ADHD* (DS-ADHD) system which not only can screen ADHD symptoms, but also builds domestic ADHD norm. Therefore, by probing into the indicating patterns of the screening support systems for ADHD in the past, this study can further develop a screening system that's more suitable for the Taiwanese population, called DS-ADHD.

According to the Diagnostic and *Statistical Manual of Mental Disorder* (DSM)-IV [1,16,17], ADHD can be classified into three different types [11,18–20]. Therefore, the ability to screen and classify ADHD patients will be the first challenge for DS-ADHD. Other than examining the reliability of usage of the self-built DS-ADHD, this study hopes to also obtain the clinical screening rate for ADHD, after completing a certain amount of sample testing. In addition, information on domestic children's norms can be collected and checked against the overseas information system, to identify the level of differences between domestic and foreign children of the same age, and to discuss whether racial, cultural, as well as parenting style differences can cause these variances.

2. Materials

The following will be discussions centered on the references regarding the introduction to ADHD, the behavioral rating scale, the cognitive function system, and the assessment tools used to evaluate the detection systems.

2.1. Attention deficit hyperactivity disorder (ADHD)

Referring to the DSM, the ADHD symptoms can be classified into the following subtypes [9,16,18,19,21]: *ADHD-Inattentive* type (ADHD-IA), *ADHD-Hyperactivity impulsive* type (ADHD-HI), and *ADHD-Combined* type (ADHD-C).

Willcutt stated that, of the three subtypes, ADHD-IA makes up the majority of the cases, affecting 3.6% of children. ADHD-C comes in second, affecting 2.2% of children. Lastly, ADHD-HI affects 1.3% of children [17]. In addition, the ratio between boys and girls suffering from ADHD is 3:1 [22], indicating that boys are more likely to be noticed as having ADHD.

Survey results also vary depending on the different types of research tools and methods used, as are the obvious differences in the diagnosis within each region, as well as in the degree of prevalence in each country. The research results of the initial prevalence study could be affected by factors such as the operational definition of the study and research tools (screening tools), the research subject (sample characteristics: age, gender, region, cultural background), and the research method. As a result, different percentages could emerge. However, there will be variances in the degree of prevalence produced by these reports, depending on the different research [23].

Students with ADHD often display anti-social behavior or are involved in juvenile crimes, as well as suffer from social, emotional and learning difficulties. Their academic performance is usually not as good as the academic performance of normal children of the same age. Their ability to learn and their academic achievement are comparatively poor [24]. As a result, in addition to a lack of attention, children with ADHD are often affected by academic, emotional, behavioral and interpersonal relationship problems [21,25].

Due to the fact that these children show higher levels of autonomy, impulsiveness, and inability to take orders from others, they are more likely to get into arguments and conflicts with others in a group setting over insignificant matters. They are also more likely to get angry or throw a tantrum, and in some severe cases, display aggressive behavior. Therefore, these children often get ostracized by their peers and become problem students in the eyes of the teachers [26,27]. The causes of ADHD are currently uncertain, but the majority of the research reports indicate that the causes of ADHD could be related to injuries to the brain's nerve function.

2.2. ADHD behavioral disorders rating scale and cognitive function system

(1) ADHD behavioral disorders rating scale tools research

Within the assisted evaluation process for detecting ADHD, the behavioral rating survey is one of the necessary tools. Physicians can gain an understanding, through interviews with the parents during the office visit, of whether a child has reached a developmental level that is consistent with other children of the same age at the current stage of their developmental process. When a doctor suspects ADHD, or needs to do more discriminatory diagnosis, the child will be required to undergo further testing, in order to increase the accuracy of the doctor's diagnosis. The most common