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**Title: Development of Theoretical Evaluation Model For Adolescents with Handwriting Difficulties
(Dysgraphia): Body Functions, Activity, Participation and Quality of Life".**

By: Liat Hen Herbst

Supervised by: Prof. Sara Rosenblum

Abstract

Background and Rationale: Writing is a complex human skill that is a central and vital human occupation. Studies show that during approximately half of the time spent by children and adolescents in school, they are required to engage in tasks that involve writing. According to the fourth edition of the Diagnostic and Statistic Manual of Mental Disorders, (DSM-IV-TR) (American Psychiatric Association,1994), dysgraphia is a developmental deficit that is expressed in bad writing. Literature describes heterogeneity among sufferers of dysgraphia. In order to succeed in writing, one must possess basic abilities, including executive functions (EF), fine motor control, in-hand manipulation skills and sensory function of the hand. Moreover, existing research literature discerns between two key terms: writing and handwriting. Evidence exists for interactions between the mechanical skill of producing writing and the ability to produce a quality written product in terms of content and structure (product).

Research has also shown that difficulties in writing have long-term implications throughout and beyond adolescence and the school years. Various models that deal with the individual, his work and surroundings and the connection between them enhance the understanding that difficulties in writing may negatively affect the adolescent's participation, involvement, choice of leisure activities and quality of life. Despite the need to gather information concerning the developmental and functional characteristics of adolescents with writing difficulties and their unique difficulties, we were unable to find focused research that has assembled such data.

The model that was used to choose the terms for characterizing adolescents participating in this study was the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) (WHO, 2007) that focuses on the individual's functioning and his involvement in various day to day activities. The model defines three levels through which adolescents' functioning can be measured: 1) Level of body structures and body functions; 2) Activity (writing); 3) Participation.

The current research goals

This study has three main goals: the first is to serve as a primary link in the composition of a corpus of knowledge about the characteristics of adolescents with dysgraphia, by way of collecting developmental-functional data about the characteristics of their writing (process, product and content) and the characteristics of their participation based on the ICF-CY model. Another goal of the study is to define the variables through which it will be possible to distinguish between adolescents with dysgraphia and those without writing problems. The third goal is to suggest an evaluation model to evaluate adolescents with dysgraphia.

Hypotheses:

1. Differences will be found between adolescents with problems in writing and adolescents without problems in the following indexes:
 - 1.a. Background variables: possible history of diagnoses: Developmental Coordination Disorder (DCD) and Attention Deficit and Hyperactivity Disorder (ADHD).
 - 1.b. Body Functions: in pinch strength, levels of in-hand manipulations skills, levels of sensory reaction, sensorimotor functions, memory abilities, attention abilities and executive functions.
 - 1.c. Activity (writing): handwriting skills (process) in terms of measurement of time, space and pressure in copying a text and writing an essay, legibility (product) and quality of content (content indices).
 - 1.d. Participation: participation levels in leisure activities.
 - 1.e. Quality of life: in self-perception of the quality of life .

2. Significant positive connections will be found in the following indices:
 - 2.a. Body functions and writing (process, product and content indices).
 - 2.b. Participation in leisure activities and writing.
 - 2.c. Perception of quality of life and writing.
 - 2.d. Features of participation in daily functions requiring coordination, attention and writing (process, product and content indices).
3. The level of functioning in various body functions will predict writing capability in terms of process, product and content.
4. Indices of body functions, level of participation and the subjective perception of quality of life, as expressed in the various diagnostic tools utilized in this study, will facilitate a distinction between adolescents with and without writing difficulties.

Method:

The Study Population: The size of the sample was determined according to G*Power software. The study included 80 randomly-convenience sampled male and female adolescents aged 13-18. All participants were residents of Israel and studying in the regular state-educational system. Participants were Hebrew speakers, physically and mentally healthy, with normal vision and hearing.

The research group comprised 40 adolescents who have studied in the Israeli educational system from first grade onwards and have writing difficulties according to the criteria of dysgraphia in the DSM-IV-TR (APA, 2000).

The control group comprised 40 adolescents, matched in age, gender and mother's level of education.

Research Process:

A theoretical model for the evaluation of adolescents with writing difficulties was constructed based on an extensive literary review, and from which a battery of diagnostics for assessment was derived.

The study was approved by the Ethics Committee of the Faculty of Social Welfare and Health Sciences at the University of Haifa.

The subjects were collected through messages that were circulated on the Internet. Each applicant received an HPSQ-C questionnaire. A semi-structured questionnaire was then sent to parents to confirm the presence/absence of difficulties in writing, and a written page from an exercise book was submitted for an impression evaluation. After the adolescents were classified into one of the research groups, their parents received a background demographic and health questionnaire to fill out and permission forms to be signed by the subject and his/her parents. At this stage, the parents received a questionnaire pertaining to functioning and development to be filled out at home. After completion of the questionnaire, a three-hour meeting was arranged, to take place in the adolescent's home. Each adolescent who met the criteria for inclusion in the research group and both he and his parents had completed the process, was matched by a teenager without writing difficulties according to his self-report, and according to age, gender and educational level of his/her mother. The adolescents in the control group underwent a full assessment.

Research Tools

Background questionnaires

1. Demographic and developmental history questionnaire (adapted to the requirements of the present research).
2. Handwriting Proficiency Screening Questionnaire - HPSQ / HPSQ-C (Rosenblum, 2008; Rosenblum & Gafni-Lachter, 2015).
3. Child Evaluation Checklist - CHECK A + B (Rosenblum, 2012),
4. The Adult Developmental Coordination Disorder Checklist - ADC (Kirby, Edwards, Sugden & Rosenblum, 2010),
5. Adult ADHD Self-Report Scales - ASRS-v.1.1 (Adler, Kessler, & Spencer, 2005),

Body functions

1. Pinch Gauge; Purdue Pegboard Test (Tiffin, 1948);

2. Sensory Responsiveness Questionnaire- SRQ (Bar-Shalita, Seltzer, Vatine, Yochman & Parush, 2008);

3. WebNeuro (Silverstein, Berten, Olson, Paul, Williams, Cooper, et al, 2007);

4. Behavior Rating Inventory of Executive Function - BRIEF-SR (Guy, Isquith, & Gioia, 2004);

5. Behavior Rating Inventory of Executive Function - BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000).

Activity

1. Israeli Handwriting Quality Diagnostics for Junior High Schools (Weintraub, Drury Asayag, Dekel, Yakobovitz, Wolfson, Parush & Lahav, 2007)

2. Computerized Penmanship Evaluation Tool - ComPET (Rosenblum, Parush & Weiss, 2003);

3. The Six-Trait Writing method. (Spandel & Stiggins, 1990)

Participation

1. Children's Leisure Assessment Scale - CLASS (Rosenblum, Sachs, & Schreuer, 2010).

2. Children's Leisure Assessment Scale - Parent Version - CLASS - P ((adapted to the needs of the research(

Quality of Life

1. The World Health Organization WHOQOL-BREF quality of life assessment, (WHO, 1998).

Data Processing

The data was processed using IBM SPSS Statistics 23.0. The demographic variables of the participants were described through descriptive statistics theories, indices, percentages, means and standard deviations.

In order to build the research variables, a Cronbach's α was used to measure internal consistency for the items of the scales, and the scales were constructed from the average of the items or their sum.

A MANOVA was used to examine the differences between the research group and the control group, taking in account background characteristics vis-à-vis other diagnoses (ADHD and DCD),

characteristics of body functions, activity and participation, and indices of quality of life. A t-test checked continuous variables, and a chi- chi-square (χ^2) was used to test cross-tabulation.

Relationships between independent and dependent variables were examined using a Pearson product-moment correlation coefficient. Prediction of writing indices through body functions was first tested with a Pearson product-moment correlation coefficient, and, later on, using three multivariate hierarchical regressions.

A discriminant analysis was used to predict the fourth hypothesis about the capability of battery diagnostic test to differentiate between adolescents with and without writing difficulties.

Main Findings: Significant findings regarding daily EF indicative of DCD and ADHD were found among a large percentage of adolescents with dysgraphia. Significant differences were found between the groups regarding in-hand manipulation skills, attentional functions, memory functions and EF. Significant differences were also found between the capabilities of the two groups in the three processes of execution, product and content. Finally, a significant difference was found between the groups in their perception of quality of life.

Significant relationships were found between body functions and the presence of previous diagnoses to the indices of the writing process: time, space and readability (product). Functional levels of the various body functions were found to be as predicted for writing capabilities in terms of process, product and content.

A model for diagnosing adolescents with dysgraphia was built upon this evidence. Moreover, it was possible to distinguish between adolescents with and without writing difficulties with the aid of the indices of body functions and participation that were expressed in the assessment model.

Discussion and Conclusions: The theoretical contribution of the research is the development of a model that can define the characteristics of adolescents with dysgraphia. The model describes the significant effect of basic functions on the occupations and participation of adolescents, and reinforces

the assumption pertaining to a basic neurological mechanism for developmental disorders including LD, DCD and ADHD. The writing characteristics of adolescents with dysgraphia are expressed in the model in terms of the mechanical process (including measures of time, space and pressure), the written product (formative assessment) and content. Initially, the model highlights the significant relationship between the writing process and its morphological characteristics and content of the writing among adolescents. Significant relationships were found between previously assessed characteristics of the subjects' functioning on all three levels.

The practical contribution of the research is the proposal of a model for the evaluation of adolescents with dysgraphia. The model reflects the findings of the research and constitutes a clinical development based on the theoretical model. The goals of the assessment model are to distinguish between adolescents with and without dysgraphia, and help identify areas of weaknesses and strengths of adolescents with dysgraphia in their execution of various activities and analysis of the tasks confronting them.

Limitations of the study and recommendations: To consolidate the findings of the study, examination of the hypotheses must be on a larger sample. Additionally, some of the questionnaires were not wholly suitable for adolescents (for example, the study lacked a questionnaire designed especially for teens to examine their concept of quality of life). Moreover, the assessment meeting was too long for some of the participants.