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Title: Characterization of forces applied during writing among age and sex groups and its influence on the written product.

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Abstract

The purpose of this study was to characterize grip forces during handwriting among typical children with no handwriting difficulties in varied groups of gender and age. The measurements were conducted by a novel instrument for evaluation of grip force (PIP - Pressure Indicator Pen), whose validity was founded as an outcome of the research.

Handwriting is a complex human activity and a major occupation for schoolchildren. The skill of writing has a great amount of influence on the child self esteem and his/her academic performance and behavior.

One of the demands of skilled handwriting is the maturation of the ability to regulate use of force. Force regulation was found in previous research as a skill that improves with age and as a significant factor in handwriting process. However, those researches focused on the pressure applied on the paper, and less attention was given to the forces applied on the pen itself. The few researches which measured grip force, dealt with an ab-normal handwriting and not with normal writing, or with its developmental characteristics. Therefore, the present study suggests reference to grip force in proficient handwriters and deals with developmental aspects.

In addition, unlike the wide range of literature that discusses the differences between the two sexes in concern of written product and legibility, there are no articles talking about grip force in that matter. This study shed light on this aspect of handwriting and represents a comparison between boys and girls on their use of grip force during handwriting and discusses the influence of it on the legibility. Since the force's values were measured using the PIP, which was never used before, it was necessary to examine it's validity as an integral

part of the research. **The research assumptions** arranged accordingly to the types of validity that were examined. For the concurrent validity the assumption was that correlation will be found between the grip force (PIP) and the pressure on the paper (ComPET) (Rosenblum, Parush, & Weiss, 2003a) and between the grip force and the written product (HHE) (Erez & Parush, 1999). The grip forces in relate to the age and gender groups examined for the discriminate validity, and the assumption was that a difference in grip force will be found among the groups.

Method: The research included 61 children, Hebrew Speakers with typical development and with no handwriting difficulties. The research tools included: subject locating tool – "handwriting proficiency screening questionnaire" (HPSQ) (Rosenblum, 2008), demographic questionnaire was used to control the interfere variables, and measuring tools: PIP for measuring pen force and ComPET (Rosenblum et al., 2003a) for measuring pressure towards the paper. Further more, the Hebrew Handwriting Evaluation (HHE) (Erez & Parush, 1999) was used for the evaluation of the written product. The data collection was taken in school and each subject performs four handwriting tasks with different characteristics, first using the ComPET and then using the PIP.

Data analysis was first carried out for the descriptive statistic and then according to the assumptions of the research. The mean and standard deviation of the demographic variables were analyzed for the descriptive statistic. The differences among the research variables were examined in relation to demographic variables using the statistic tests: t-test and chi-square.

In order to examine the research assumptions and to establish concurrent validity for the PIP, Pearson test was used to investigate the correlations between grip force (PIP) and pressure applied on the surface (ComPET) and between grip force and the written product (HHE). One Way Manova analysis conducted to examine the differences in grip force among age and sex groups and for establishing discriminate Validity for the PIP. Check for interaction effect among age and sex took place using two-way MANOVA test.

Results: Significant correlation was found between grip force and the pressure applied on the paper for the entire sample. No Significant correlation was found between grip force and the written product. Further more, significant differences in grip force were found among sex group, which pointed out that girls significantly put more effort and strength into the grip force than boys. For the age groups significant differences in grip force were found as well, although not consistent and task related. This difference shows that the younger applied significantly less force on the pen in the extended long writing task and significantly more force in the short automatic task.

Conclusions: The results of the research implied that girls apply significantly more force on the pen while writing and they control it better than boys. In the developmental aspect this research suggests that younger children apply significantly less force on the pen than older children in long writing tasks probably as a result of fatigue. The main outcome of the current research involves the idea that a strong enough grip force requires for an efficient motor control on the writing instrument.

The present study is a first step of examine the validity of the PIP. It shows that this system can provide objective sensitive measures of grip force. In this research the system was able to distinguish between ages and sexes and also correlations were found with the measures of pressure that were collected with the ComPET . Those findings suggests a good validity for the PIP, although it must be noted that the sample of this study was limited and small and therefore more studies are necessary. More researches that will use this system in a variety of conditions and samples are needed in order to establish a stronger validity for this instrument.