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Age differences and transfer on control solution testing with blood glucometers

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Abstract. The elderly are at an increased risk for being diagnosed with diabetes. While previous studies have examined technique errors when a patient used his or her current blood glucometer or a single novel glucometer, no study has measured errors as a patient transferred to using a second, novel experimental glucometer. Results support findings that older adults perform more slowly and less accurately than younger adults when transferring between pieces of equipment. Implications for future blood glucometer design and training are discussed.

Keywords: healthcare, aging, medical devices, blood glucose monitor

1. Introduction

The elderly are at an increased risk for being diagnosed with diabetes, with those 65 and older comprising 38% of those with diabetes (Centers for Disease Control and Prevention, 2007). One approach to managing diabetes is through the use of technology such as blood glucose monitors. While previous studies have examined technique errors when a patient used his or her current blood glucometer (McLaughlin, Rogers, & Fisk, 2004) or a single novel glucometer (Mykityshyn, Fisk, & Rogers, 2002), no study measured errors as a patient transferred to using a second, novel experimental glucometer. At the same time, while it was repeatedly found that control solution testing was a large source of error in the results of self-monitored blood glucose (SMBG) testing, no single study has been found that focuses on transfer and errors during the control solution testing process. Thus, the research reported here helps to close that gap by measuring near and far transfer in control solution testing.

2. Method

2.1. Participants

The current research used an age (2: Young adults[YA] vs. Older adults [OA]) by order of meter use (2: OneTouch UltraMini vs. Nova Max Link) between subjects factorial design. Eighty-four participants were recruited. To prevent confounds from previous experience, non-diabetics were desired as participants. Non-diabetics were also used to simulate newly diagnosed diabetics who had not received any training on the use of glucometers. Equal numbers of OAs (M=70.23, SD=3.29) and YAs (M=19.62, SD=1.40) were recruited. Participants completed the Digit Symbol Substitution (DSS) test as a measure of information processing, the Shipley Vocabulary test as a measure of semantic memory, a test of inferential ability, and the Computation Span as a measure of working memory (Weschler, 1997; Shipley, 1986; Ekstrom, French, Harman, & Dermen, 1976; Salthouse & Babcock, 1991). Overall significant differences in ability scores were found such that YAs used significantly more pieces of handheld technology per day, reviewed instructional materials provided for significantly less time, progressed significantly further in the DSS, remembered signifi-

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cantly more symbols from the DSS, scored significantly higher via the absolute method of grading on the Computation Span, and scored significantly lower on the Shipley Vocabulary test than OAs. The only significant difference noted on abilities by order of meters used was that individuals using the Nova MaxLink followed by the OneTouch UltraMini scored significantly higher than other groups via the simple scoring method of the Computation Span.

2.2. Procedure

YAs were recruited through an introductory psychology pool offering course credit as compensation. OAs were recruited via phone calls to numbers on an existing volunteer list and were offered $30 compensation. Meters used in this experiment were the OneTouch UltraMini and the Nova MaxLink, counterbalanced to determine if the order in which meters are used influences errors committed when transferring to a new model. Participants completed 2 sessions roughly 24 hours apart. Day 1 consisted of completing informed consent and demographic paperwork, as well as completing the aforementioned cognitive test battery. Day 1 also asked participants to complete 4 CSTs with a meter. Participants were given photocopied instructions noted as relevant to performing a CST from the meter manual. Investigators were not permitted to give feedback concerning the correctness of an action. Day 2 began by asking participants to perform 2 CSTs with the meter from the previous day without instructions provided. Participants were then asked to use a new meter and complete 4 CSTs without any instructions provided. A post questionnaire was then administered after which participants were debriefed and compensated. CSTs were timed, videotaped, and observed for errors in testing protocol. Error was operationally defined as an action that: 1) directly refuted glucometer instructions such as pouring solution into the device, 2) actions not mentioned in the manual that could impact CST results such as wiping solution from a testing strip, and 3) actions that should not occur given proper design of device or materials such as tests taking so long the meter turned itself off. Participants completed a NASA-TLX after every trial to measure subjective workload (Hart, 2006).

3. Results

Eighty-four participants were involved in data collection though several participants were dropped from analysis at random to deal with violating variance-covariance assumptions. For this reason, a subsample of only 68 participants was used in the final statistical analyses.

To determine if participant age and the order of meters used influenced the amount of time on task, number of errors committed with an initial meter, number of near transfer errors, or number of far transfer errors committed with a second meter, a multivariate analysis of variance (MANOVA) was conducted. Time was measured in seconds and averaged between all 10 trials. Due to differing numbers of possible errors for each meter each type of error (training, near, or far transfer) was calculated into a percentage of possible errors for each trial, and all trials were averaged together. Results revealed a significant main effect for age, $F(4, 61) = 18.26$, $p < .05$, $\eta = .55$ and order of meter use $F(4, 61)=53.46$, $p<.05$, $\eta=.78$ (see Table 1). Results should be interpreted with caution as far transfer errors and task time were not normally distributed in some conditions. Follow-up ANOVA's revealed a significant main effect of age for task time $F(1, 64)=45.15$, $p<.05$, initial errors $F(1, 64)=32.23$, $p<.05$, and near transfer errors $F(1, 64)=29.92$, $p<.05$, as well as a significant main effect of order of meter use for near transfer $F(1, 64)=40.46$, $p<.05$ and far transfer $F(1, 64)=100.76$, $p<.05$ errors committed. Results indicated YAs took significantly less time to complete control testing, and performed significantly fewer initial and near transfer errors than OAs. Individuals using the OneTouch UltraMini first performed significantly fewer near transfer errors while those using the Nova MaxLink first performed significantly fewer far transfer errors.

4. Discussion

MANOVA results supported the hypotheses that YAs would take less time to complete CSTs, and commit fewer training and near transfer errors. These results suggest that future meters should be designed with more input concerning the needs of OAs to minimize differences due to age.

Table 1
Summary Errors and Time on Task by Age and Glucometer Counterbalance

DV	IV	M	SD
T Errors	YA	0.04	0.02
NT Errors	YA	0.03	0.03
FT Errors	YA	0.49	0.24
Time	YA	69.20	26.42
T Errors	OA	0.07	0.03
NT Errors	OA	0.07	0.04
FT Errors	OA	0.52	0.20
Time	OA	148.68	62.73
T Errors	M1	0.06	0.03
NT Errors	M1	0.03	0.02
FT Errors	M1	0.68	0.17
Time	M1	106.03	52.76
T Errors	M2	0.05	0.03
NT Errors	M2	0.07	0.04
FT Errors	M2	0.35	0.13
Time	M2	111.85	71.32

*Note:T=training, NT=near transfer, FT=far transfer, M1=use of OneTouch followed by Nova, M2=use of Nova followed by OneTouch, Time measured in seconds, Errors reported as averaged percentages for all applicable trials.

Results did not support the hypothesis that YAs would commit significantly fewer far transfer errors. Failure to support this hypothesis may be due to the nature of the possible far transfer errors in the current research. The Nova MaxLink is capable of sending glucose test results to an insulin pump. This feature can be avoided by marking a test as a CST or by turning the feature off completely. Participants transferring to the Nova MaxLink were likely equally unaware this feature existed due to lack of feedback from the device. Participants successfully starting a test with the OneTouch UltraMini were confronted with a prompt of "C" followed by a number between 1 and 50. At this point participants were likely equally capable of inferring a match was needed between the code number in the meter and on the vial of testing strips.

Findings concerning the order of meter use were unexpected. While meters differed in the number of possible errors in a trial, all errors were analyzed in terms of percentages. Examination of the trends suggests that fewer far transfer errors may have occurred when using the OneTouch UltraMini than the Nova MaxLink due to the visibility of features associated with possible far transfer errors. Future research should examine how to best make users aware of possible far transfer issues in the absence of instructional materials. Future investigation should also examine how best to prevent these errors once users are aware of them. Examination of the trends for near transfer errors suggests that fewer near transfer errors occurred when using the Nova MaxLink than the OneTouch UltraMini due to the design of testing materials, flexibility of testing procedure, or the presentation of information in the instruction manuals. Future research should examine the physical design of testing equipment and interface prompts on usability. Additionally, research should identify what elements of initial training influence rates of transfer errors.

While these findings are potentially interesting, methodological shortcomings must be considered. Diabetics may receive live training with corrective feedback when learning to use their first glucometer. However diabetics are not guaranteed live training with their initial meter or any other meter. OAs in this study were individuals capable of coming to a laboratory setting. While diabetic individuals may have greater experience with CSTs, diabetes is associated with increased risk of several cognitive and motor impairments (Christman, Vannorsdall, Pearlson, Hill-Briggs, & Schretlen, 2010; Lin, Northam, Rankins, Werther, & Cameron, 2010; McNally, Delamater, Rohan, Drotar, & Pendley, 2010). Future research should incorporate diabetics and those having experience with meters such as diabetes educators to verify that these results generalize.

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