From Hand Twister to Mind Twister: Computer-Aided Treatment in Traumatic Wrist Fracture

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Key Words: hand functions • physical disabilities, occupational therapy • technology

Objective. The use of computers as a treatment modality in the occupational therapy hand clinic is, as yet, not common practice. A computer interface for wrist movements was developed, and a study to justify the application of such a device is presented.

Method. Forty-seven patients in a day hand clinic who had traumatic fracture of one hand with limitation of wrist mobility participated in the study. Participants were divided into two treatment groups: computer-aided treatment (high technology) and traditional brush machine treatment (low technology). A device was developed based on the brush machine in which the brush machine's mechanism was converted into a medial–lateral joystick. Right-to-left movements were digitally transformed for the use of a computer game. Participants were treated for 5 weeks, and outcome measures included range of motion (ROM), grip strength, edema, and level of interest.

Results. Results showed significant improvement in ROM, grip strength, and edema across 5 weeks for all participants. Although no significant differences were found between the two groups in ROM, grip strength, and edema, the computer-aided group showed significantly more interest in treatment than did the brush machine group. Finally, the interaction between treatment group and the attitude toward computers was not significant.

Conclusions. These results indicate the potential for more interesting motor treatment and rehabilitation of the wrist through the use of computer games. The efficacy of using computers in occupational therapy clinics needs further investigation.

O ccupational therapy has long been associated with technological devices. Through the years, the technology involved in these devices has improved and become more sophisticated and complex and sometimes more expensive (Treflar, 1987). During this time, computers have become an essential part of the present world and of the occupational therapy clinic. One application of computers in occupational therapy, beyond administration and adapted access, is through the use of computer games as a treatment modality (Okoye, 1988). Software related to therapy for cognitive skills is very common.

The use of computers as a treatment modality in the occupational therapy hand clinic is, as yet, not common practice. Although the use of computers is perceived by many as a modern purposeful activity (Spicer & McMillan, 1987), almost no studies have been found that investigate the efficacy of computers as a treatment medium for the improvement

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This article was accepted for publication September 3, 1999.
of motor function. A few articles described various accessory devices for computers that are activated with hand movements (Crofts & Eames, 1988; Pashley, 1989; Roberts, 1986; Skjoten & Brooks, 1990; Thompson, Hards, & Bate, 1986). All stated that the devices used are beneficial and useful and seem to increase patient motivation; however, none of these articles presented empirical data to support these statements. King (1993) investigated whether use of computer games as a purposeful activity increases the repetition of movements during exercise for grip strength or pinch strength. Results of his study showed that patients repeated their movements more when they were involved in purposeful computer games than when they were involved in a nonpurposeful activity. Stewart, Ormond, and Seeger (1991) found no differences between the use of a toy (low technology) and computer (high technology) on scanning practice with nine children with motor disabilities; however, they stated that the use of computers increased the motivation of the children, but did not indicate how this was measured.

The complexity of technology is an obstacle because it may intimidate both the users and the service providers. Thus, it is important to investigate the attitude of patients toward technology and computers to determine whether this affects treatment. We are aware that working efficiently with computers can be important and useful for many aspects of life. However, negative attitudes can be created toward the computer through fear of the unknown, a feeling of helplessness due to difficulty in operating the computer, not understanding computer language, and the fear of destroying the computer (Dambort, Watkins-Malek, Silling, Marshall, & Garver, 1985). Loyd and Gressard (1984) claimed that experience with computers, age, and gender are related to attitude toward computers. Some studies found that experience with computers affects the attitude toward them, yet did not find an age or gender effect (Loyd & Gressard, 1984; Pope-Davis & Twing, 1991). Other studies found an effect of gender on attitude toward computers (Arch & Cummins, 1989; Lockheel, 1985). Boys’ and men’s attitudes toward computers were more positive than those of girls and women. Thus, in the current study, attitude toward computers was evaluated, and its effect on treatment outcomes was investigated. During the process of dividing participants into treatment groups, factors such as gender, experience with computers, and age were controlled.

To summarize, the use of computers in the hand clinic has been little investigated. The present study examined the effect of high technology, low technology, and attitude toward computers on the treatment of persons with traumatic wrist fracture. Additionally, patients’ interest in treatment was measured, thus allowing us to investigate the relationship between different treatment methods and motivation.

**Method**

**Participants**

Forty-seven patients referred to the occupational therapy hand clinic participated in the study. These patients included 38 (81%) women and 9 (19%) men, with an age range of 22 to 80 years ($M = 59.47 \text{ years, } SD = 12.97$). As inclusion criteria, participants must be posttraumatic fracture in one wrist, be in the rehabilitation stage (i.e., postcasting or fixation), have motor limitations in the wrist (i.e., decrease of at least 20% of range of motion [ROM] and grip strength), and demonstrate edema, as compared to the hand without injury. In 41 (88%) participants, the fracture was in the distal part of the radius; of these, 25 (61%) had Colles’ fractures. The rest of the participants (12%) had fractures of the ulna or carpal bones or mixed fractures. The participants were randomly divided into two treatment groups, with the restriction that groups were balanced for gender, age, education, profession, diagnosis, dominant hand, fractured hand, previous experience with computer, and whether they received physical therapy. One group ($n = 24$) received treatment with the brush machine, and the second group ($n = 23$) received treatment with the computer.

**Instruments**

The following instruments were used for data collection in this study.

**Universal goniometer.** ROM was measured with a goniometer, according to the 1965 recommendations of the American Academy of Orthopedic Surgeons, (Trombly, 1995). Four movements were measured: radio–ulnar supination and pronation and flexion and extension of the wrist.

**Jamar Dynamometer™**. Grip strength was measured according to the recommendations of the American Society of Hand Therapists (Fess, 1990). The average of three measurements was calculated.

**Volumeter.** Edema was measured by having the participant insert the injured hand inside a water-filled volumeter. The amount of water spilled was measured in a specially marked container.

**Attitude questionnaire.** A questionnaire developed by Lazar (1985) that included 37 statements about attitude toward the computer was used. The questionnaire, which was developed especially for the Israeli population, was based on a similar questionnaire developed by Zoltan (1982) and has adequate reliability and validity estimations (Lazar, 1987).

**Treatment interest.** A visual analog scale was developed to rate the degree of interest generated by the treatment. The scale ranged from 1 (not interesting at all) to 6 (very interesting). No reliability information was determined for this scale, and “interest” was not defined for the participants.

**Brush machine.** The brush machine (see Figure 1) was first built in an occupational therapy department in Great Britain and was first used in 1953 (Jones, 1964). Over the years, the machine was improved and became a common treatment modality in occupational therapy departments.
The machine, which is used to make brushes for cleaning bottles, can be modified to require engagement of different joints, muscles, and movements of the upper extremities (Everett, 1973; Jones, 1964). In the current study, two handles were used: one for pronation–supination movements and one for palmar flexion–dorsiflexion movements.

**Computer.** A 286 IBM/AT\(^2\) compatible computer was used in the study (see Figure 2). One component of the brush machine was transformed in such a way that it was connected to the computer as a joystick, allowing mediolateral movement only. This adaptation allowed the brush machine's handle to be used in such a way that movements of the hand moved the cursor on the computer and activated a game accordingly. A game called “Revenge of Doh”\(^3\) (also known as “Arkanoid”) was used. The modified brush machine allows calibration of the ROM required to play the game.

During their first visit to the occupational therapy clinic, participants were evaluated for ROM, grip strength, edema, and attitude toward the computer. The attitude questionnaire score was the sum of all items, and, on the basis of the median, the participants were assigned a dichotomic score: negative or positive attitude toward the computer. Of the 24 participants from the brush group, 10 had negative and 14 had positive attitudes toward the computer. Of the 23 participants from the computer group, 10 had negative attitudes and 13 had positive attitudes toward the computer. The difference between treatment groups in the distribution of participants according to attitude was not significant.

Participants received treatment 3 times a week for 5 weeks; each treatment session lasted for 50 min. Treatment included 10 min in the whirlpool, 10 min of massage and passive exercise, 10 min of work with theraplast, 10 min of work with a computer or the brush machine using supination–pronation movements, and 10 min of work with a computer or the brush machine using palmar flexion–dorsiflexion movements. At the end of each week (3 sessions), the participants were reevaluated for ROM, grip strength, edema, and treatment interest. Altogether, each participant was evaluated 6 times: once before treatment and once a week during the 5 weeks of treatment.

**Data Analysis**

For three of the dependent variables, the difference between the measurements of the hand without injury and the injured hand was calculated. The smaller the difference, the better the improvement. These dependent measures included the following:

- **ROM** was calculated as the sum in degrees of four movements: radio–ulnar supination and pronation and flexion and extension of the wrist. The score of the range of each measurement was the difference between the range of the noninjured hand and the injured hand. The smaller the difference, the better the improvement.
- **Grip strength score** was the difference in kilograms between the strength of the noninjured hand and the injured hand.
- **Edema score** was the difference in cubic centimeters of the water spilled by the participant from the noninjured hand and the injured hand.

For the interest variable, the score ranged from 1 (not interesting) to 6 (very interesting). For each dependent measurement a three-way analysis of variance (ANOVA) with repeated measures was performed: 2 (treatment group) × 2 (attitude) × 6 (time) design. Post hoc tests were then performed with a \(t\) test with a studentized range and Scheffé multiple comparison to test for significant differences between the means (Kirk, 1982; Rohlf & Sokal, 1981). The level of significance was set at .05 for all statistical tests.
Results

**Range of Motion**

The results of the ANOVA for ROM indicated a significant linear main effect for time (see Table 1). There was a significant difference among all six measurements of ROM, which demonstrated that participants improved from the first evaluation, before treatment, until the last evaluation, after 5 weeks of treatment (see Table 2 for total means). Additionally, the interaction between time and treatment group was significant (see Table 1). Post hoc analysis indicated that there was a significant difference between all evaluations within each group. There was no difference between the two groups in any of the evaluations (see Figure 3). The interaction between treatment group and attitude toward the computer was not significant (see Table 1).

**Grip Strength**

The results of the ANOVA for grip strength indicated a significant linear main effect for time (see Table 1). There was a significant difference among all six measurements of grip strength, which demonstrated that participants improved from the first evaluation, before treatment, until the last evaluation, after 5 weeks of treatment (see Table 2 for total means). In addition, the interaction between time and treatment group was significant (see Table 1). Post hoc analysis indicated that for the computer group, there was a significant difference among all evaluations within each group (see Table 2 for means). As depicted in Figure 4, the computer treatment group improved more in grip strength than the other group, starting with the third evaluation; however, these differences were not significant in any of the evaluations. The interaction between treatment group and attitude toward computer was not significant (see Table 1).

**Edema**

The results of the ANOVA for edema indicated a significant linear main effect for time (see Table 1). There was a significant decrease in the edema for all participants from one evaluation to the next (see Table 2 for total means). In addition, the interaction between time and treatment group was significant (see Table 1). Post hoc analysis indicated that for the computer group, there was a significant difference between the evaluation before treatment and the second evaluation (see Table 2 for means). For the brush machine group, there was improvement from evaluation before treatment, to first and second evaluations, to the third, fourth, and fifth evaluations. As depicted in Figure 5, the computer treatment group had less edema in the first two evaluations, whereas the brush machine group had less edema in the third, fourth, and fifth evaluations. However, these differences were not significant in any of the evaluations. The interaction between treatment group and attitude toward the computer was not significant (see Table 1).

**Interest**

The results of the ANOVA for interest indicated a significant difference between the two treatment groups (see Table 1). The computer group demonstrated a significant higher degree of treatment interest ($M = 5.3, SD = 1.16$) than the brush machine group ($M = 3.43, SD = 1.87$). In addition, the interaction between time and treatment group was significant (see Table 1). Post hoc analysis indicated that for the computer group, there was a higher rate of interest in all evaluations, with no significant differences between the

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**Table 1**

<table>
<thead>
<tr>
<th>Factor</th>
<th>df</th>
<th>ROM</th>
<th>Grip Strength</th>
<th>Edema</th>
<th>Interest</th>
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<tr>
<td>Treatment</td>
<td>1,43</td>
<td>0.26</td>
<td>0.23</td>
<td>0.18</td>
<td>15.10***</td>
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<td>Attitude</td>
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<td>0.39</td>
<td>1.30</td>
<td>0.12</td>
<td>3.47</td>
</tr>
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<td>Treatment x attitude</td>
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<td>0.95</td>
<td>0.43</td>
<td>0.14</td>
<td>2.19</td>
</tr>
<tr>
<td>Time</td>
<td>5,215</td>
<td>360.40***</td>
<td>71.17***</td>
<td>9.80***</td>
<td>2.02</td>
</tr>
<tr>
<td>Time x treatment</td>
<td>5,215</td>
<td>4.02**</td>
<td>2.79*</td>
<td>3.07*</td>
<td>3.59**</td>
</tr>
<tr>
<td>Time x attitude</td>
<td>5,215</td>
<td>1.24</td>
<td>0.69</td>
<td>0.45</td>
<td>0.46</td>
</tr>
<tr>
<td>Time x attitude x treatment</td>
<td>5,215</td>
<td>1.19</td>
<td>0.44</td>
<td>0.20</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Note. ANOVA = analysis of variance; ROM = range of motion.

*p < .05. **p < .01. ***p < .001.

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**Figure 3.** The interaction effect between time and treatment group on range of motion, displaying the difference between the injured and uninjured hand. *Note.* ROM = range of motion.

**Figure 4.** The interaction effect between time and treatment group on grip strength, displaying the difference between the injured and uninjured hand.
evaluations (see Table 2 for means). For patients from the brush machine group, there was a reduction in the degree of treatment interest from the first, second, and third evaluations to the fourth evaluation (see Figure 6). The interaction between treatment group and attitude toward computer was not significant (see Table 1).

Discussion
This study investigated the effect of high technology, low technology, and attitude toward computers on the treatment of persons with traumatic wrist fracture. Additionally, the interest of patients in treatment was measured, thus allowing the relationship between different treatment methods and motivation to be investigated. Results indicated improvement in ROM, grip strength, and edema from one evaluation to the next in both treatment groups.

As Naunton (1987) suggested, patients in therapy may benefit from both work (brush machine) and games (computer). Working with the brush machine is a goal-directed activity because it produces an end-product that the patient...
can use. Both tasks may be perceived as purposeful activities that draw attention to the task rather than to the process involved in achieving the task (King, 1993), thus both encourage the spontaneous and automatic use of the hand. Furthermore, frequent evaluations that enabled the patients to observe improvements from one evaluation to the next also may have contributed to the results. Visual feedback regarding the outcome of the response is termed knowledge of results. It is well documented that visual knowledge of results can provide a source of motivation for the performer (Magill, 1989). Providing patients with information regarding their performance will keep them moving toward a goal and motivate them to maintain interest and desire to keep practicing.

In addition, the fact that most of the participants were older may have contributed to the results. According to Schmidt (1988), there is a linear relationship between age and movement variability; the older one gets, the more variable is one’s output of movement. This increased movement variability was demonstrated in the higher within-group standard deviations. As within-group variability increases, the probability decreases of obtaining significant differences between groups as a function of treatment or attitude toward computers. These factors, in addition to the small size of treatment groups and the brief duration of therapy, may explain the lack of differences between the two treatment groups. The fact that a significant time effect was obtained for all measurements suggests that treatment itself was the most important factor contributing to hand performance. It is recommended that such a study be repeated with a larger sample.

As depicted in Figures 3 and 4, it seems that the computer treatment group, compared with the brush machine group, started from a slightly more limited point, both in ROM and in grip strength, and improved more from one evaluation to the next. Although these group differences are not significant in any of the evaluations, the gap between the two groups increased as treatment progressed. This trend coincides with the significant differences between the two groups in the degree of interest they found in the treatment. The higher degree of interest in the computer group than the brush machine group is maintained throughout the treatment.

The enhanced treatment interest in the computer group may have increased the motivation to repeat and continue to exercise and improve hand function (Crofts & Eames, 1988; Kaplan, 1986; Skjoten & Brooks, 1990; Stewart et al., 1991). It seems that the computer presented an interesting stimulus and sufficient variation in the activity to prevent boredom and monotony (Parry, 1966). Another possible explanation for the differences could have resulted from the fact that the computer group was engaged in a more purposeful, meaningful, and challenging activity with a cultural value (Katz, Marcus, & Weiss, 1994). Katz et al. (1994) claimed that goal-oriented activities that have a personal and cultural meaning may help develop feelings of competence and efficiency, and they considered the computer an example of such an activity.

Pashley (1989) claimed that a patient would repeat a specific movement more often while engaged in a purposeful activity than in a nonpurposeful activity. King (1993) added that if patients enjoy the activities in which they are engaged, they will be more motivated to persist and improve. Both perceived the computer as a purposeful activity, one that presents goals for the patient that encourage increasing repetition of exercises. The relation between the purposefulness of the activity to various aspects of motor performance has been supported in other studies (Bakshi, Bhambhani, & Madill, 1991; Bloch, Smith, & Nelson, 1989; Ferguson & Trombly, 1997; Miller & Nelson, 1987; Morton, Barnett, & Hale, 1992; Sietsma, Nelson, Mulder, Mervau-Scheidel, & White, 1993; Yoder, Nelson, & Smith, 1989). In fact, in the current study, the experimenter had to enforce the time limit for the computer group participants because they tended to keep playing in spite of pain and fatigue.

The purposeful activities used in this study were set for the patients by the experimenter and were not their own choices. Steinbeck (1986) raised the question of whether choice of activity or the presence of internal goals creates the motivation to act. Others may question whether a brush machine is a functional purposeful activity or a therapeutic, impairment-level modality. Additionally, the computer game might be purposeful only if it is tied to a relevant meaningful goal for the person. For some persons, playing a computer game again and again could be nonpurposeful with no functional outcome in mind. In addition, it would be important to measure the patient's goals as related to function in order to understand which activity would be purposeful for an individual person. What activity would the patient be likely to continue outside of therapy; what activity would have direct meaning to his or her life? To answer those questions, further study is needed in which patients are allowed to choose the type of treatment (i.e., computer or brush machine). In addition, it would be interesting to investigate whether allowing the patient to choose from a variety of computer activities—such as games or searching the Internet to find out about hand injuries or other topics of particular interest—would influence the results.

There was no significant interaction between treatment and attitudes toward the computer in any of the outcome measures. Further investigation is needed to clarify the effect of attitude toward computer use in therapy as relevant to other factors, such as gender.

This study did not measure changes in functional status and ability to perform activities of daily living as a result of therapy. It is important to include such measurements in future studies in order to validate occupational therapy as an intervention in general and the impact of therapy on function and occupational performance. From data collected in this study, it would be hard to make interpretations
regarding function and occupational performance.

To summarize, participants received treatment through two types of purposeful activity: one using the brush machine (a low technology activity) and the other using a computer game (a high technology activity). Both activities were found to be beneficial to the participants; the computer game, however, was more attractive and evoked more interest in the treatment. Reed (1986) claimed that many of the modalities that are still in use in occupational therapy are no longer relevant to the socioeconomic, cultural, and political reality. Alternative activities must be found to replace a few of those modalities in response to the changes in the culture, economy, politics, technology, and research. This study supports the use of high technology, such as computer games, as a treatment modality for patients with traumatic fractures of the wrist. ▲

References


