How Users with RSI Review the Usability of Notebook Input Devices

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Abstract. Musculoskeletal problems are increasingly occurring and are predominately attributed to a frequent and highly repetitive use of input devices. Earlier studies [e.g. 1, 2, 3] showed that the exposure to input devices cause health risks. Even young and healthy users reported severe discomfort in finger and hand after executing cursor control tasks over 2-4 hours. For motion-impaired users also a distinct increase of discomfort was observed, but combined with longer work and rest periods compared to healthy users [4]. The present survey aims at RSI-impaired users. Three RSI-case studies were reported. Compared to healthy users RSI-impaired users were distinctly more sensitive towards exposure [cp. 3]. In can be concluded that RSI-impaired computer users limit the usefulness of notebook input devices as found for keyboard and mouse [4]. They face great barriers in terms of effort and highly rely on low demanding, low repetitive input tasks, and on adequate rest periods.

Keywords: RSI, Musculoskeletal Discomfort, Exposure, Notebook Input Device.

1 Introduction

Musculoskeletal problems are increasingly occurring and are predominately attributed to a frequent and highly repetitive use of input devices. Earlier studies [e.g. 1, 2, 3] showed that the exposure to input devices cause health risks. Even for young and healthy users [2, 3] severe discomfort in finger and hand was observed, with a significant increase of discomfort by 20-27% after executing cursor control tasks over 2-4 hours. However, input performance remained unaffected. Trewin and Pain [4] reported also a distinct increase of discomfort for motion-impaired users operating keyboard and mouse compared to healthy users. But at the same time a raise of work and rest periods was observed: Working periods were 2-3 times prolonged as for healthy users and errors occurred 8 times more often. For touchpad and trackpoint similar results were found [3]: For an RSI-patient (RSI = Repetitive Strain Injury) discomfort was concentrated on the right forearm, hand and fingers and symptoms rose by 40%. Input performance collapsed over the exposure and was by 16% slower compared to healthy users.

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The present survey aims at users suffering from RSI. The case studies reported deals with three computer users, who fell ill with tenosynovitis or cervical spine syndrome due to manual overuse and uncomfortable posture. Their jobs all highly depend on computer-based tasks. Thus, in spite of severe symptoms they all operate keyboard and mouse on a daily basis. As an alternative to these input devices this study will address the usability of notebook input devices for RSI-patients. Discomfort and input performance of motion-impaired users will be compared to the benchmark of young and healthy users [cp. 3]. The results provide an insight into the needs and barriers motion-impaired computer users have to face and will guide towards an adaptive hard- and software design.

2 Method

2.1 Variables

The *independent variable* was time on task with three measuring times: before the exposure (pre-test), after a 1st exposure with the touchpad (mid-test) and after a 2nd exposure with the trackpoint (post-test).

As *dependent variables* muscular discomfort and total time of task execution were assessed. The discomfort was estimated with the ISS [2]. This questionnaire specifically focuses on body parts that are involved in input device operation, i.e. fingers, hand, forearm, upper arm and shoulder separately for each body side as well as back and neck. For each body part discomfort was assessed by three verbal categories first: “relaxed”, “tense” or “impaired”. Second, the extent of discomfort was estimated on a 50-point category partitioning scale (= CPS-score). The CPS-score was single-weighted for “tense”-judgments and double-weighted for “impaired”-judgments. Each weighted discomfort score may range between 0 and 100 points. Body parts that were reported to be “relaxed” were not further considered. The performance of input device was measured by total time of task execution This is the time interval from pressing the space bar to releasing the mouse button at the end of the task.

2.2 Apparatus and Task

For the experiments the notebooks Toshiba Satellite 1700-300 with an integrated trackpoint and Dell Inspiron 7500 with an integrated touchpad as input device were used. The trackpoint is a small force-sensitive joystick. It is placed between the “G”, “H” and “B” keys on the keyboard, the mouse buttons are located in the wrist rest. The touchpad is a flat touch-sensitive panel (2” by 1.5”). It is integrated in the wrist rest beneath the keyboard with two mouse buttons underneath. For both notebooks the cursor velocity of the integrated input device was set at 1500 p/s [5]. To control the visual quality of display presentation each notebook was connected to an external TFT flat screen (Philips 150x; 1024x768).

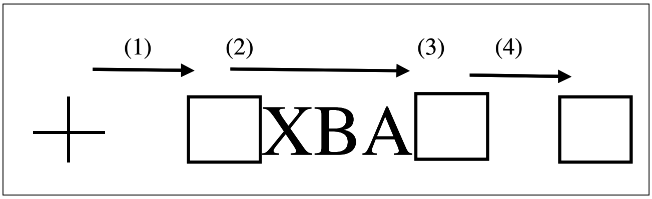

Fig. 1. Point-drag-drop task with clicking subtasks (1 & 3) and dragging subtasks (2 & 4)

The point-drag-drop task (Figure 1) represents a complex serial task and consists of several single actions that are executed one after another. Each trial gets started with the space bar. The task appears on the screen. In a point-drag action the centrally placed strings are highlighted (subtask 1&2). Then the object is picked up and moved inside the square target (drag-drop action: subtask 3 & 4). For the drag actions participants are instructed to drag the cursor by pressing the left mouse button. For every successful subtask a visual feedback is given (for further task features see [5]).

2.3 Participants

All participants were highly experienced with the mouse and neither of them had any experience with touchpad or trackpoint. The cases investigated suffer all from diseases appertaining to RSI: Case 1 (37 years of age, female) and Case 2 (30 years, female) are chronically impaired by tenosynovitis. Case 3 (32 years, female) suffers from a chronic cervical spine syndrome. The reference sample [cp. 3] consisted of 14 women and 7 men, aged between 16 and 42 years (m = 24; sd = 6.0 years). They were under- and graduate students who fulfilled a course requirement. All participants in the reference sample were in a very good physical shape and reported to have no ex ante muscular discomfort.

2.4 Procedure and Data Analysis

An interview provided demographic data, ex ante muscular discomfort and habits in computer usage. All cases were exposed to two conditions: (1) touchpad operation, (2) trackpoint operation. Participants were instructed to execute the input task as fast and accurate as possible. They were further instructed to operate the input device itself with the dominant hand and the mouse button with the non-dominant hand. Muscular discomfort was measured before the exposure (pre-test), at the end of the 1st condition (mid-test) and at the end of the 2nd condition (post-test). Within each condition Case 1 executed 256 trials of the point-drag-drop task. Case 1 aborted the 2nd condition after 60 trials due to severe pain. Thus, for the following two cases the exposure was decreased to 160 trials per condition. For Case 3 a record failure left only 60 trials of the 1st condition. For reference [3] 10 healthy touchpad users and 11 healthy trackpoint users executed 800 trials of the point-drag-drop task. The procedure included the interview, and a pre- and post-test of discomfort comparable to the cases. Since there were no differences found between muscular discomfort of healthy touchpad and trackpoint users average discomfort scores are used for reference to the cases.

3 Results

First, absolute and relative overall body discomfort scores are reported for the pre-, mid- and post-test. Second, the relative increase of each single body score is analyzed for the 1st exposure (pre-mid-test increase) and the overall exposure (pre-post-test increase). For comparisons between cases and healthy subjects data was analyzed by t-tests. The level of significance was set at 5 %.

3.1 Case Report 1

The participant is a 37 years old female and works as a self-employed occupational therapist. In 1990 a tenosynovitis was diagnosed. The disease involved inflammation of the tendon and tendon sheath of her right hand in consequence of manual overuse. Since conservative management had failed a surgical incision was undertaken. The surgical therapy had been successful and pain subsided for a short time. But, whenever manual activities were repetitively executed the disease chronically appears with severe pain in the right hand. She is completely unable to use a mouse or touchpad over a longer period of time and therefore limited her computer use strictly to half an hour per day only. She complains about numbness in the right thumb, and pain in wrist and lower arm during (begin after 30 minutes of work) and after operating an input device. Symptoms are most significant for tasks that require wrist extension (e.g. typing, browsing the WWW). With the completion of computer work pain alleviates slowly and it takes 24 hours until the participant is free of symptoms. Once a year the participant is seeing a doctor but without any medical treatment. Thus, her health condition was unchanged during the last years.

Overall discomfort: The participant reported to have major musculoskeletal symptoms in neck and back as well as the upper extremities. In comparison to the ex ante muscular discomfort of the reference sample her pre-existing symptoms have obviously increased. Considering the muscular discomfort the overall body discomfort score rose from 38 points (pre-test) to 224 points (mid-test = after 1st condition) and to 526 points (post-test = after 2nd condition). The body discomfort scores for Case 1 did not differ from the reference sample in the pre- (38 vs. 43 points, n.s.) and mid-test (224 vs. 197 points, n.s.), but were significantly higher in the post-test (526 vs. 197 points, $T_{(20)} = -14.3$, $p < 0.01$). In the 1st condition (pre-mid-test increase) the increase of discomfort is comparable to that of healthy users (Δ 186 vs. Δ 154 points, n.s.). However, in the 2nd condition discomfort rose further, the overall increase (pre-post-test increase) was significantly higher compared to healthy users (Δ 488 vs. Δ 154 points, $T_{(20)} = -17.2$, $p < 0.01$).

Specific body parts: The single discomfort scores are visualized in Figure 2 for the pre-test (solid line), mid-test (dashed line, circle) and post-test (dashed line, square) and the reference sample (dashed line only).

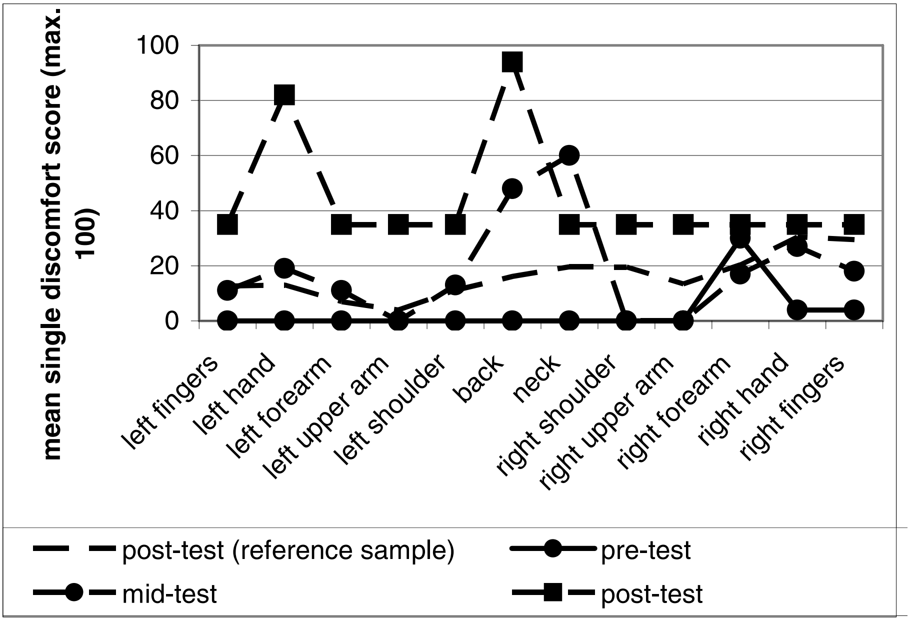

Fig. 2. Mean single discomfort score for pre-test (solid line), mid-test (dashed line, circle) and post-test (dashed line, square) and the reference sample (dashed line only)

After the 1st exposure (pre-mid-test increase) the increase of symptoms for neck and back was distinctly stronger compared to healthy users (neck: Δ 60 vs. Δ 21 points, $T_{(20)} = –7.0$, $p < 0.01$; back: Δ 48 vs. Δ 8 points, $T_{(20)} = –9.9$, $p < 0.01$). The increase of discomfort was comparatively low in the left side's shoulder (Δ 13 vs. Δ 15 points, n.s.), forearm (Δ 11 vs. Δ 18 points, n.s.) and hand (Δ 19 vs. Δ 23 points, n.s.). For the right upper extremity Case 1 reported less discomfort compared to healthy users (right shoulder: Δ 0 vs. Δ 20 points, $T_{(20)} = 4.2$, $p < 0.01$; right upper arm: Δ 0 vs. Δ 17 points, $T_{(20)} = 3.1$, $p < 0.01$; forearm: Δ -13 vs. Δ 33 points, $T_{(20)} = 7.2$, $p < 0.01$; right hand: Δ 23 vs. Δ 40 points, $T_{(20)} = 2.8$, $p < 0.01$; right fingers: Δ 14 vs. Δ 45 points, $T_{(20)} = 6.2$, $p < 0.01$). Also for the left upper arm (Δ 0 vs. Δ 7 points, $T_{(20)} = 2.4$, $p < 0.05$) and fingers (Δ 11 vs. Δ 25 points, $T_{(20)} = 2.2$, $p < 0.05$) discomfort rose significantly less compared to the reference sample. The 2nd exposure (pre-post-test increase) revealed overall a significant higher increase of symptoms for Case 1 compared to healthy users for the neck (Δ 35 vs. Δ 21 points, $T_{(20)} = -2.5$, $p < 0.05$), back (Δ 94 vs. Δ 8 points, $T_{(20)} = -21.3$, $p < 0.01$), shoulder (right: Δ 35 vs. Δ 20 points, $T_{(20)} = -3.0$, $p < 0.01$; left: Δ 35 vs. Δ 15 points, $T_{(20)} = -5.3$, $p < 0.01$), upper arm (right: Δ 35 vs. Δ 17 points, $T_{(20)} = -3.4$, $p < 0.01$; left: Δ 35 vs. Δ 7 points, $T_{(20)} = -9.8$, $p < 0.01$), left forearm (Δ 35 vs. Δ 18 points, $T_{(20)} = -4.1$, $p < 0.01$) and left hand (Δ 82 vs. Δ 23 points, $T_{(20)} = -10.1$, $p < 0.01$). Overall increase of discomfort was comparable to the reference sample for the right hand (Δ 31 vs. Δ 40 points, n.s.) and left fingers (Δ 35 vs. Δ 25 points, n.s.), and was lower for the right forearm (Δ 5 vs. Δ

33 points, $T_{(20)} = 4.4$, $p < 0.01$) and right fingers (Δ 31 vs. Δ 45 points, $T_{(20)} = 2.8$, $p < 0.05$). For both, Case 1 and the healthy users, discomfort concentrated on the distal upper extremities, i.e. fingers, hand and forearm. However, Case 1 reported up to 2.6 times stronger symptoms compared to healthy users.

With respect to the performance of input device the total time dropped enormously, by 419 ms, during the 1^{st} condition (= touchpad, 32 trials: 6874 ms to 256 trials: 6455 ms). This improvement came from an unspecific learning effect. In the 2^{nd} condition the case was not able to continue the experiment after 64 trials due to severe pain in the distal upper extremities and the back. The performance of the trackpoint was very bad (32 trials: 24020 ms to 64 trials: 16932 ms), however, performance still improved during that short period by 7088 ms. When input device performance was compared to the reference sample Case 1 was about 800 ms slower with the touchpad (6417 vs. 5610 ms, $T_{(9)} = 3.6$, $p < 0.01$). But, in the 2^{nd} condition performance difference enhanced and trackpoint performance was even worse for Case 1 (19510 vs. 6396 ms, $T_{(9)} = 55.4$, $p < 0.01$).

3.2 Case Report 2

The participant is a 30 years old female and a white-collar employee in the service sector. She operates a computer up to 8 hours a day. In 1993 a tenosynovitis was diagnosed. The disease involved inflammation of the tendon and tendon sheath of her right hand in consequence of manual overuse. The conservative management was so far successful and the case is free of symptoms as long as she restricts her computer use to less than 5 hours a day. She complains about pain and numbness in the wrist, hand and fingers of her right body side after 5 hours of computer and input device work. Symptoms are most significant for tasks that require wrist extension (e.g. browsing the WWW) and clicking actions (e.g. editing graphics). With the completion of computer work pain resolves slowly and disappears completely after 1 to 24 hours.

Overall discomfort: Case 2 reported to have major musculoskeletal symptoms in her neck and right hand and fingers. In comparison to the ex ante muscular discomfort of the reference sample her pre-existing symptoms are obviously higher. Considering the muscular discomfort the body discomfort score was constantly very low, about 34 points (pre-test), 32 points (mid-test) and 36 points (post-test). Only in the pre-test the body discomfort score of Case 2 did not differ from the reference sample (34 vs. 43 points, n.s.), in the mid-test (32 vs. 197 points, $T_{(20)} = 7.1$, $p < 0.01$) and in the post-test (36 vs. 197 points, $T_{(20)} = 7.0$, $p < 0.01$) overall scores of Case 2 were significantly lower. In the 1^{st} and 2^{nd} condition the increase of discomfort is below that of healthy users (Δ -2 vs. Δ 154 points, $T_{(20)} = 8.0$, $p < 0.01$; Δ 4 vs. Δ 154 points, $T_{(20)} = 7.7$, $p < 0.01$).

Specific body parts: The single discomfort scores are visualized in Figure 3 for pre-test (solid line), mid-test (dashed line, circle), post-test (dashed line, square) and the reference sample (dashed line only). After the 1^{st} exposure the increase of symptoms for the back were comparably low to healthy users (Δ 0 vs. Δ 8 points, n.s.). For all other body parts Case 2 reported a significant lower increase of discomfort as for healthy users: neck (Δ -7 vs. Δ 21 points, $T_{(20)} = 4.9$, $p < 0.01$), shoulder (right: Δ 0 vs. Δ 20 points, $T_{(20)} = 4.2$, $p < 0.01$; left: Δ 0 vs. Δ 15 points, $T_{(20)} = 3.8$, $p < 0.01$), upper arm (right: Δ 0 vs. Δ 17 points, $T_{(20)} = 3.1$, $p < 0.01$; left: Δ 0 vs. Δ 7 points, $T_{(20)} = 2.4$, $p < 0.05$), forearm (right: Δ 5 vs. Δ 33 points, $T_{(20)} = 4.4$, $p < 0.01$; left: Δ 0 vs. Δ 18 points, $T_{(20)} = 4.3$, $p < 0.01$), hand (right: Δ 0 vs. Δ 40 points, $T_{(20)} = 6.7$, $p < 0.01$; left: Δ 0 vs. Δ 23 points, $T_{(20)} = 4.0$, $p < 0.01$), fingers (right: Δ 0 vs. Δ 45 points, $T_{(20)} = 9.1$, $p < 0.01$; left: Δ 0 vs. Δ 25 points, $T_{(20)} = 4.0$, $p < 0.01$).

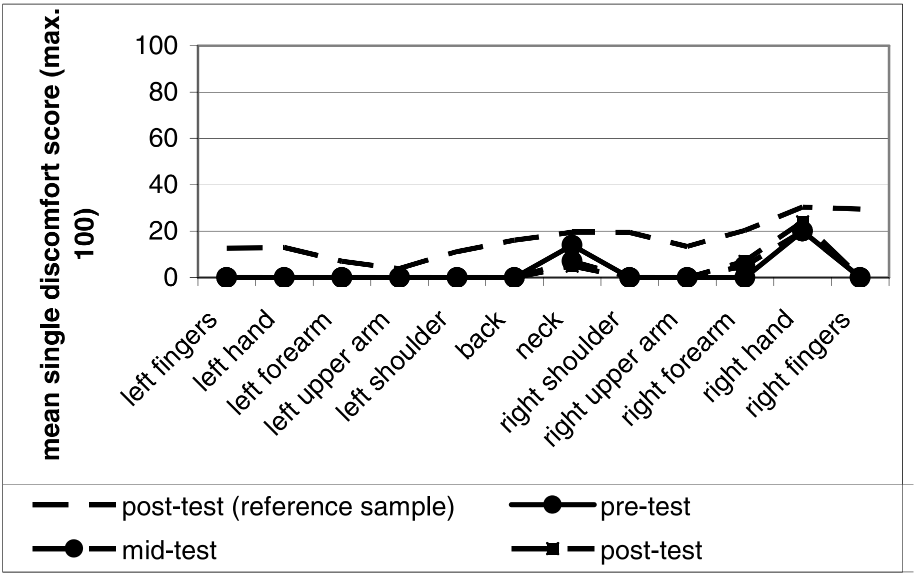

Fig. 3. Mean single discomfort score for pre-test (solid line), mid-test (dashed line, circle) and post-test (dashed line, square) and the reference sample (dashed line only)

The 2nd exposure revealed the same pattern of discomfort. Comparing pre- and post-test measurements Case 2 reported a comparable increase of symptoms to healthy users for the back (Δ 0 vs. Δ 8 points, n.s.). But, all in all Case 2 reported nearly no increase of symptoms at all, thus the increase of symptoms was significantly below that reported by healthy users: neck (Δ -9 vs. Δ 21 points, $T_{(20)} = 5.3$, $p < 0.01$), shoulder (right: Δ 0 vs. Δ 20 points, $T_{(20)} = 4.2$, $p < 0.01$; left: Δ 0 vs. Δ 15 points, $T_{(20)} = 3.8$, $p < 0.01$), upper arm (right: Δ 0 vs. Δ 17 points, $T_{(20)} = 3.1$, $p < 0.01$; left: Δ 0 vs. Δ 7 points, $T_{(20)} = 2.4$, $p < 0.05$), forearm (right: Δ 7 vs. Δ 33 points, $T_{(20)} = 4.1$, $p < 0.01$; left: Δ 0 vs. Δ 18 points, $T_{(20)} = 4.3$, $p < 0.01$), hand (right: Δ 4 vs. Δ 40 points, $T_{(20)} = 6.0$, $p < 0.01$; left: Δ 0 vs. Δ 23 points, $T_{(20)} = 4.0$, $p < 0.01$), fingers (right: Δ 0 vs. Δ 45 points, $T_{(20)} = 9.1$, $p < 0.01$; left: Δ 0 vs. Δ 25 points, $T_{(20)} = 4.0$, $p < 0.01$). Case 2 reported to have very light symptoms due to the exposure, and discomfort was for nearly all body parts lower compared to healthy users.

With respect to the touchpad performance the total time was very high and increased over time on task by 1551 ms (32 trials: 13112 ms to 160 trials: 14663 ms).

The performance of the trackpoint was very bad (32 trials: 22858 ms to 160 trials: 18572 ms), however, performance still increased over time by 4286 ms. This improvement came from an unspecific learning effect for the trackpoint. When input device performance was compared to healthy participants, Case 2 was about 8495 ms slower with the touchpad (14338 vs. 5843 ms, $T_{(9)} = -38.5$, $p < 0.01$). But with the trackpoint performance was getting worse for Case 2 (19782 ms) and performance difference between Case 2 and healthy users was even bigger (Δ 13126 ms: 19782 vs. 6656 ms, $T_{(9)} = -52.5$, $p < 0.01$).

3.3 Case Report 3

The participant is a 32 years old female and a white-collar employee in the administrative department. She operates a computer up to 4 hours a day. In 1998 a cervical spine syndrome was diagnosed. The disease involved pain in the neck that radiated to the left shoulder and upper arm. In the fingers of her left hand she felt prickling sensations and in the longer term numbness. Symptoms appeared in consequence of restricted posture at the visual display unit. The conservative management (duration 7 months) had been successful and pain subsided for a short time. But, whenever she works more than 1 hour at the computer the symptoms chronically appear with severe pain in the neck and left side's upper extremities. Symptoms are most significant for extensive display tasks (e.g. text reading or editing). With the completion of computer work pain alleviates slowly and it takes 24 to 48 hours until the participant is free of symptoms.

Overall discomfort: The participant reported to have major musculoskeletal symptoms in neck and back as well as the left side's proximal upper extremities. In comparison to the ex ante muscular discomfort of the reference sample her pre-existing symptoms are obviously more serious. Considering the muscular discomfort the body discomfort score rose from 95 points (pre-test) to 275 points (mid-test) and to 457 points (post-test). The body discomfort scores of Case 3 were significantly higher compared to the reference sample in the pre- (95 vs. 43 points, $T_{(20)} = -3.5$, $p < 0.01$), mid-test (275 vs. 197 points, $T_{(20)} = -3.3$, $p < 0.01$) and post-test (457 vs. 197 points, $T_{(20)} = -11.3$, $p < 0.01$). However, in the 1st condition the increase of discomfort is comparable to that of healthy users (Δ 180 vs. Δ 154 points; n.s.). But in the 2nd condition discomfort rose further, the overall increase was significantly higher compared to healthy users (Δ 362 vs. Δ 154 points; $T_{(20)} = -10.7$, $p < 0.01$).

Specific body parts: The single discomfort scores are visualized in Figure 4 for pre-test (solid line), mid-test (dashed line, circle) and post-test (dashed line, square) and the reference sample (dashed line only). After the 1st exposure the increase of symptoms for the left side's shoulder and upper arm was distinctly stronger compared to healthy users (left shoulder: Δ 70 vs. Δ 15 points, $T_{(20)} = -14.6$, $p < 0.01$; left upper arm: Δ 33 vs. Δ 7 points, $T_{(20)} = -9.1$, $p < 0.01$). For all other body parts the increase of symptoms was lower or comparable to the reference sample: back (Δ 8 vs. Δ 8 points, n.s.), neck (Δ 19 vs. Δ 21 points, n.s.), shoulder (right: Δ 11 vs. Δ 20 points, n.s.), upper arm (right: Δ -17 vs. Δ 17 points, $T_{(20)} = 6.2$, $p < 0.01$), forearm (right: Δ 32 vs. Δ 33 points, n.s.; left: Δ 0 vs. Δ 18 points, $T_{(20)} = 4.3$, $p < 0.01$), hand (right: Δ 9 vs. Δ 40 points, $T_{(20)} = 5.2$, $p < 0.01$; left: Δ 0 vs. Δ 23 points, $T_{(20)} = 4.0$, $p < 0.01$) and fingers (right: Δ 15 vs. Δ 45 points, $T_{(20)} = 6.0$, $p < 0.01$; left: Δ 0 vs. Δ 25 points, $T_{(20)} = 4.0$, $p < 0.01$). The increase of symptoms after both exposures was distinctly higher for Case 3 compared to healthy users for the left body side and the neck: neck (Δ 34 vs. Δ 21 points, $T_{(20)} = -2.3$, $p < 0.05$), shoulder (left: Δ 64 vs. Δ 15 points, $T_{(20)} = -13.0$, $p < 0.01$), upper arm (left: Δ 25 vs. Δ 7 points, $T_{(20)} = -6.3$, $p < 0.01$), forearm (left: Δ 30 vs. Δ 18 points, $T_{(20)} = -2.8$, $p < 0.01$), hand (left: Δ 40 vs. Δ 23 points, $T_{(20)} = -2.8$, $p < 0.01$), fingers (left: Δ 40 vs. Δ 25 points, $T_{(20)} = -2.3$, $p < 0.05$). Discomfort increased comparable to that reported by healthy participants in the back (Δ 6 vs. Δ 8 points, n.s.) and the right body side: shoulder (right: Δ 21 vs. Δ 20 points, n.s.), upper arm (right: Δ 8 vs. Δ 17 points, n.s.), forearm (right: Δ 30 vs. Δ 33 points, n.s.), hand (right: Δ 29 vs. Δ 40 points, n.s.) and fingers (right: Δ 35 vs. Δ 45 points, n.s.). For Case 3 symptoms increased severely in the left body side and the back. Additionally for the right body side Case 3 showed the same pattern of discomfort as healthy participants. However, symptoms of Case 3 were up to 2.3 times stronger compared to healthy users.

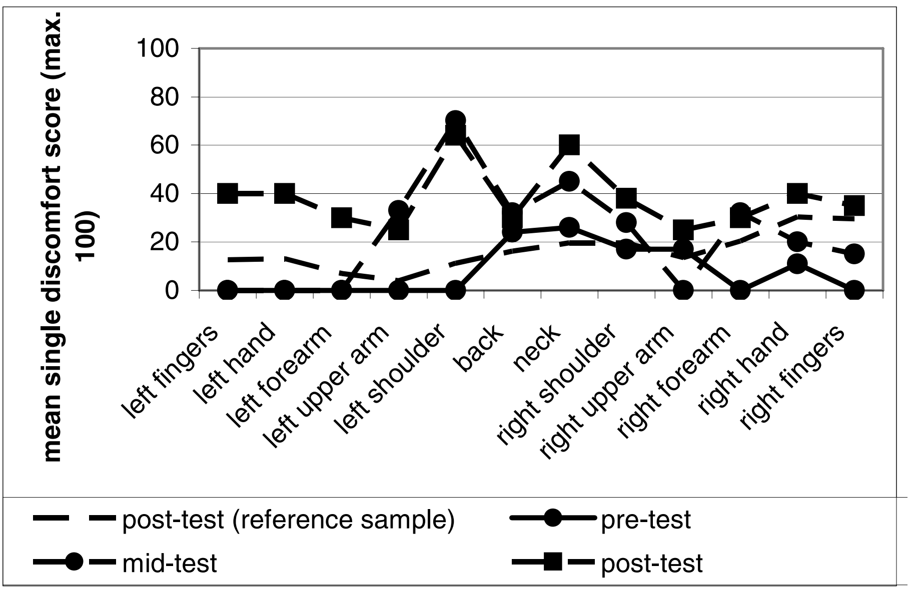

Fig. 4. Mean single discomfort score for pre-test (solid line), mid-test (dashed line, circle) and post-test (dashed line, square) and the reference sample (dashed line only)

With respect to the performance of input device the total time was about 4619 ms for the touchpad (32 trials: 4595 ms to 64 trials: 4653 ms). Only the first 64 out of 160 trials were recorded due to a system's failure. The performance of the trackpoint was constantly by 6387 ms (32 trials: 6499 ms to 160 trials: 6516 ms). When input device performance was compared to healthy participants Case 3 was about 1224 ms faster with the touchpad (4619 vs. 5610 ms, $T_{(9)} = 5.5$, $p < 0.01$). With the trackpoint the performance of Case 3 was comparably close to healthy users (6387 vs. 6396 ms, n.s.).

4 Discussion and Conclusions

The focus of the presented study was set on the usability of notebook input devices for motion-impaired users. A major result can be summarized from the case studies: All cases showed severe restrictions in the usage of the input devices from either distinct musculoskeletal discomfort and / or a dominant decrease of input performance. Even for young and healthy input device users discomfort rose by 20-27% after working periods of 2-4 hours [2, 3]. But in contrast to the RSI-cases musculoskeletal discomfort in the healthy user group was all in all very low and input performance still very good. RSI-cases showed a raise of discomfort that was up to 3 times higher (Cases 1 and 3) compared to healthy users [3], and musculoskeletal discomfort was assessed in the upper half of the discomfort scale. The localization of discomfort depended on the specific impairment, in contrast to healthy users, who reported most discomfort in finger, hand and forearm [2, 3]. Discomfort was up to 2.6 times higher than with healthy users (Cases 1 and 3). RSI-cases reported severe pain, which forced Case 1 to quit the experiment. On the other hand RSI-cases (Cases 1 and 2) remarkably slowed down their input performance and were by 3 times slower compared to healthy users. This finding confirms the motor restrictions of motion-impaired users of input devices [4]. It seems as if well-being and /or optimized input performance are unsustainable even for short working periods. Under exposure discomfort of RSI-cases rose very fast until they were nearly unable to continue their work or the effort to continue work was extremely high.

In conclusion findings show that RSI-impaired computer users limit the usefulness of notebook input devices as compared to keyboard and mouse [4]. They face great barriers in terms of effort. Therefore, they highly rely on low demanding (e.g. point task without click) and low repetitive input tasks, and especially on adequate rest periods.

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