The modulation of upper extremity musculoskeletal disorders for a knowledge worker with chiropractic care and applied ergonomics: a case study

Charles W. Sherrod DC, MPH, CIE^{a,*}, George Casey DC^b,
Robert E. Dubro DC, DACBOH^c, Dale F. Johnson PhD^d

^a Director of the Ergonomics Institute of LifeWest, Life Chiropractic College West, Hayward, CA

^b Faculty Associate, Life Chiropractic College West, Hayward, CA

^c Private Practice, Fremont, CA

^d Director of Research, Life Chiropractic College West, Hayward, CA

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Abstract

Objective: This report describes the case management of musculoskeletal disorders for an employee in a college work environment using both chiropractic care and applied ergonomics.
Clinical Findings: A 54-year-old male office worker presented with decreased motor function in both wrists; intermittent moderate-to-severe headaches; and pain or discomfort in the neck, both shoulders, left hand and wrist, and lumbosacral region resulting from injuries sustained during recreational soccer and from excessive forces and awkward postures when interacting with his home and office computer workstations.

Intervention and Results: Ergonomic training, surveillance, retrofitted equipment with new furniture, and an emphasis on adopting healthy work-style behaviors were applied in combination with regular chiropractic care. Baseline ergonomic job task analysis identified risk factors and delineated appropriate control measures to improve the subject's interface with his office workstation. Serial reevaluations at 3-month, 1-year, and 2-year periods recorded changes to the participant's pain, discomfort, and work-style behaviors. At end of study and relative to baseline, pain scale improved from 4/10 to 2/10; general disability improved from 4 to 0; and hand grip strength (pounds) increased from 20 to 105 (left) and 45 to 100 (right). Healthy work habits and postures adopted in the 3-month to 1-year period regressed to baseline exposures for 3 of 6 risk priorities identified in the ergonomic job task analysis.

Conclusion: The patient responded positively to the intervention of chiropractic care and applied ergonomics.

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* Corresponding author. Director of the Ergonomics Institute of LifeWest, Life Chiropractic College West 136B Research, 25001 Industrial Blvd, Hayward, CA 94545. Tel.: +1 510 450 2359; fax: +1 510.

E-mail address: csherrod@lifewest.edu (C. W. Sherrod).

Introduction

According to Brandt et al,¹ “two thirds of employees in the industrialized countries use a computer on a daily basis and one in five interact with a computer at least 3/4 of the total work-time.” This escalation in the use of technology has increased the risk exposures for knowledge workers to work-related musculoskeletal disorders (MSDs), which are also known as *repetitive motion injuries* (RMIs) or *cumulative trauma disorders*. From the US Bureau of Labor Statistics from 1982 through 1994, the injury rate of RMIs increased 1200%; and from the mid-1990s to 2000, the trend followed a 27% decline in all standard industries codes except for knowledge workers.² Successful risk management of RMIs can have far-reaching effects on morbidity, quality of life, and productivity in the American workplace.³ The US Occupational Safety & Health Administration identified musculoskeletal disorders as the most prevalent, most expensive, and most preventable injuries in the American workplace today.⁴

A landmark study⁵ of 22,000 workers by the National Safety Council revealed the occurrence of MSDs to be predominantly behavior based, with 88% of the injuries associated with postural deviations and poor compliance to federal and state Occupational Safety & Health Administration safety management regulations. Poor workstation design accounted for 10% of the MSDs, and 2% were of unknown etiologies. Rempel et al^{6,7} demonstrated that placement of the computer monitor at a distance greater than 73 cm (28 in) with a constant font size contributed to forward head posture (FHP) with resultant visual and neck symptomatology.

Interventions combining ergonomics and chiropractic care have been sparsely reported in the literature. A case study⁸ reported improvement for a participant with neck and shoulder pain subsequent to receiving diversified chiropractic care and a retrofit of the computer workstation layout and equipment. A study of a small population of bank employees (N = 25) demonstrated that implementing ergonomics interventions with chiropractic care improved the working environment and increased worker comfort and productivity and yielded a valuable return of investment.⁹

This case study is a 2-year prospective report of the long-term care of an ergonomic intervention combined with chiropractic care for the management of MSDs of an adult male worker.

Case history

This 54-year-old, right-hand-dominant, male college executive presented with a symptom complex of moderate to severe headaches, dizziness, neck and left wrist pain, low back pain, and decreased motoricity in the left hand. The participant's employment was primarily sedentary and included 12- to 14-hour days of computing with extensive use of a pointing device (computer mouse) at work and home. The participant had been an established patient of the study doctor of chiropractic (DC) for 9 years preceding the commencement of this study; and in this time, an accumulation of work stress, sedentary postures, intensive computer use, and injuries associated with his participation in weekend soccer led to a variety of musculoskeletal complaints manifesting in the neck, right hip and groin, right low back, left shoulder, left elbow, left wrist, and left hand.

He was comanaged with one or more medical doctors and specialists throughout that period. The participant had comorbidities and complicating factors, which included high blood pressure and non-insulin-dependent diabetes mellitus—both conditions being pharmaceutically managed. Spinal and extremity radiographs dating back to 1990 provided an adequate history of the integrity of his spine and joints.

Findings from radiography, ultrasonic imaging, and magnetic resonance imaging following a traumatic injury to the left hand from a fall in April 2005 identified a swollen left median nerve, a posteriorly translated left capitate with mild capitate-lunate degenerative joint disease but with no ligament tearing. Examining a second injury to his left hand in 2008 while playing soccer, radiographs revealed “no fracture with ligamentous sprain and mild joint effusion and subtle osteophyte formation.” The participant sustained an initial injury in early May 2006 to his right groin and right sacroiliac (SI) joint playing indoor soccer and then reinjured the area 3 weeks after the initial injury. The first injury resolved quite rapidly with chiropractic treatment; however, subsequent to the second injury, he experienced intermittent symptoms that included localized pain to the right side of the lumbar spine and right SI joint. Magnetic resonance imaging in 2008 revealed cervical stenosis of the region C4-C7, a finding that contraindicated chiropractic manipulation at these levels. The radiologist and study DC consulted and agreed that upper cervical spinal adjustments at the C1-C2 levels should be well tolerated.

At baseline of this study, the numeric pain score inclusive of the 3 regions of the head, neck, and lumbosacral spine was 4 of 10; and the general pain disability index questionnaire (GPDI) was 4 of 10. The GPDI is a measure of a participant's ability to perform social, recreational, and work-related tasks as well as personal activities of daily living. The physical examination revealed a limited range of motion (ROM) in the cervical spine: 15° of extension and 45° of left lateral flexion with localized pain. In addition, there was limited ROM in the lumbosacral spine: extension of 15° and left lateral flexion of 30°—both motions elicited localized pain that was non-radicular in nature. Lumbar flexion was moderately limited with fingertips 7" from the ground but without associated pain. At presentation, the left and right hand grip strengths measured with a JAMAR Dynamometer (Lafayette Instruments, Lafayette, IN) (see "Methods" section) were 20 and 45 pounds of force, respectively.

Chiropractic care throughout the study consisted of high-velocity, low-amplitude manipulation to the C2 vertebra of the cervical spine (2C PL-L subluxation and supine diversified correctional adjustment), left shoulder (anterior-inferior misalignment and reverse correctional manipulation), left wrist (posterior metacarpal misalignment and reverse correctional manipulation), and right lumbosacroiliac areas (5L PR-M subluxation with Gonstead Technique pelvic bench, finger-pull correctional adjustment, and left PI ilium subluxation with Gonstead Technique pisiform push correctional adjustment).¹⁰ The patient expressed tolerance of the correctional adjustments and manipulations, and he reported reductions in discomfort or pain that were either immediate or effective within 24 to 48 hours.

Chiropractic care was provided at a minimum of once per week, but most often 2 to 3 times per week. The basis for this frequency of care was the informed choice of the participant who agreed to the care plan for several reasons. (1) The care was provided by a colleague of the chiropractic college at which the participant worked; it was readily accessible and could be obtained conveniently with a flexible schedule on most weekdays. (2) The care often proved itself efficacious in the immediate relief from frequently occurring symptoms, especially his headaches. (3) The participant proclaimed that the chiropractic care he was receiving was the best treatment that helped abate his symptoms. (4) The participant felt that, by using chiropractic, he could avoid a trend toward polypharmaceutical management of his complaints and conditions; he was averse to taking additional medications that he felt might compromise his general health or

interact with those necessary prescriptions he was taking. (5) The participant not only tolerated the chiropractic care procedures, but preferred them to alternatives, found them to be the most effective, and reported no known detrimental effects. (6) The participant was unable, or perhaps unwilling, to reduce the hours and associated stress of his employment and lifestyle that appeared to associate with, and perpetuate, the recurrent symptomatology that could not be alleviated without intervention. (7) Had any adverse effects been reported by the participant or observed by either the treating DC or any of the treating doctors (via periodic reevaluations, radiographs, magnetic resonance imaging, heart monitoring, blood tests, etc), a decision to reduce the frequency or halt chiropractic care would have been made.

When stabilization was not achieved for these complaints, a referral for an ergonomics evaluation was made. Because the participant experienced prolonged periods of computer interaction for both his office and home workstations, an ergonomic evaluation and intervention occurred for the office workstation. Interviews, discussions, and verbal appraisals were conducted for suggestions to improve his home workstation.

Methods and intervention

The initial and annual renewals of the institutional review board approvals were obtained (no. 00007071) for this study, and the participant consented to participate. Chiropractic care was provided throughout the 2-year period in combination with an ergonomic intervention instituted at baseline. Periodic surveillance of the participant was conducted by the study ergonomist to monitor the adoption of recommended changes in work behaviors. Serial reevaluations at 3-month, 1-year, and 2-year periods were performed. An ergonomic job task analysis (EJTA) was performed at baseline and in accordance with the American National Standards Institute/Human Factors Ergonomics Society guidelines for computer engineering (100–2007).¹¹ The EJTA was performed with the following 4-step methodology:

Step 1a

The initial passive surveillance step consisted of collecting all relevant demographic and personal data such as height, hand and eye dominance, job

description, job tasks and functions, computer interactions including keyboarding and mousing, work pace, work flow, and work style. A focused history was taken of work-related activities, material handling, work-style behaviors, past injuries, and presenting complaints.

Step Ib

The active surveillance step of the EJTA consisted of an unobtrusive observation of the participant while he interacted with his computer workstation components. Fig 1 provides the side view photograph of the participant interfacing with his computer work environment. Risks of the participant (the host) and probable causative factors are identified in this part of the ergonomics evaluation to assess their association with the occurrence of MSDs. Physical and anthropometric measurements were obtained of the participant interacting with the computer workstation and its support, manual, and visual interfaces for comparison with the American National Standards Institute/Human Factors Ergonomics Society 100-2007 standard.¹¹

Step II

The passive and active surveillance data were organized into a 4×7 array called the *risk analysis matrix* (RAM). This matrix organizes the data to analyze all of the risk and exposure information collected, prioritize the risks of developing an MSD, and generate appropriate ergonomic interventions (ie, control measures) for the participant. Table 1 is the RAM at baseline for this participant with the rows ranked in descending order of prioritized risk for developing an MSD. The columns represent the

influencing factors underlying each prioritized risk and the proposed corrective actions and timeline to address them. Column 1 (host factors) identifies this participant's physical characteristics and behaviors as he works. Column 2 identifies the factors (aka agents) at the workstation interface and general environment of the office that may accentuate or precipitate an MSD. Column 3 provides the specifically proposed control measures (aka components of the ergonomic intervention), and column 4 provides the timeline for implementation.

Step III

The implementation of the ergonomic intervention occurs at this step. The intervention includes participant training, retrofitting of the workstation, and the installation of office furniture and software accessories specified in the RAM of Step II.

Step IV

This evaluation step was carried out after the participant had been interacting with his new workstation for 4 weeks. The participant was observed for adoption of newly learned safe work behaviors, and quality assurance inspections were performed for office furniture and software functionality. Corrections and reinforcement of training were applied when indicated.

Serial reevaluations were conducted at the established intervals (3 months, 1 year, and 2 years), and ad hoc surveillance of the participant by the study ergonomist was performed randomly to observe consistent adoption of sustainable work behaviors.

Goniometers (McCoy Health Sciences, Maryland Heights, MO) were used for joint angles; tape measure, for gathering anthropometric data; and the JAMAR Dynamometer, for hand grip strength.¹² A proprietary device, the Laser Posturometer (LP), was used to assess FHP. The LP measures FHP as the displacement from the tragus of the ear relative to the lateral aspect of the acromion when viewed along the sagittal axis (termed the *sagittal T-Ac displacement*). The device uses plumb laser lines and a precision digital caliper. The device and its protocol were standardized against a FaroArm Platinum CMM, a high-accuracy coordinate measuring machine (IMT Precision Company, Hayward, CA). Against the FaroArm Platinum CMM, the LP device measured the sagittal T-Ac displacement of a human torso mannequin accurately to within 2.8 ± 2.2 mm (95% confidence interval). The study ergonomist used the LP to evaluate the participant when seated and

Fig 1. Baseline EJTA: preintervention.

Table 1 Risk analysis matrix (at baseline)

Risk level	Host risk factors	Probable root causative agent	Control measure	Action item and timeline
R1	FHP – 2.5 in	Laptop and monitor interface too high (18") and too far away (38")	New Mayline Sit-Stand Desk with Kensington Docking Station	Immediately
R2	Ulnar deviation of 25° (left) and 20° (right) and 15° of extension in both wrist	Poor keyboard design creates negative angle and promotes ulnar deviation.	Kenesis Keyboard Split Pro	Immediately
R3	Forceful keystrokes	Pointing device too small to fit size of hand.	Contour Perfit Mouse	Immediately
R4	High-risk work style	"Hunt-and-peck" keystroking style	(change to Contour Roller Mouse)	Changed out at 2 wk
R4	TTM stage of readiness for behavioral change	"Hunt-and-peck" keystroking style	Mavis Beacon Typing Tutorial	Immediately
R5	Prolonged sitting and no backrest support	Task chair without lumbar support and sliding seatpan	Training with touch-typing skill set	Immediately; (however, not performed)
R6	Slouching and nonneutral body postures and contact stress underarm surface	Oak wood desk at 31"	PT-78 Office Master task chair	Immediately
R7	Work organization/Pace	Excessive work pace	Workrite Sit-Stand Workstation OccuCom System Training RSI Guard timed breaks	Reassessment

The matrix is derived from the initial ergonomic job task analysis.

FHP, forward head posture; TTM, trans-theoretical model of behavior change.

actively tasked at the computer workstation. The Myovision 3G Wireless System (Myovision, Seattle, WA) recorded active ROMs of the cervical paraspinal and sternal cleidomastoid muscles in 6 directions.¹³

Serial reevaluations and results

The serial reevaluations were performed by the study DC and ergonomist using the instruments, questionnaires, and devices relevant to the data of interest for their respective disciplines. The DC acquired the numeric pain and GPDI data, whereas the ergonomist acquired the remaining data presented in [Tables 2 and 3](#). Both investigators conducted their reevaluations within 1 week of one another except for the 3-month ROM reevaluation with the MyoVision system that was performed at 6 months.

Three months

The study DC acquired a history update, performed orthopedic tests, and administered the numeric pain and GPDI instruments. The study ergonomist interviewed the participant regarding compliance to training, the adoption of safe working behaviors, and difficulties with equipment; and he directly observed the participant interacting with the computer workstation. The participant self-reported reduced frequencies and intensities of his neck pain, headaches, left wrist discomfort, dizziness, and lumbosacral pain. However, prior to this scheduled reevaluation at 72 hours into the intervention and subsequent to retrofitting his workstation, the participant reported severe pain (9/10 on numerical pain scale) in the right wrist and right thumb. This pain was associated with excessive use of the thumb-scroll wheel on the medial side of the Contour Perfit Mouse pointing device, which was the specified control measure for prioritized risk R2 ([Table 1](#)). Following change out of this pointing device with a Contour Roller Mouse (which possessed no thumb scroll feature), the participant's right wrist pain gradually abated; and after 4 months, he reported no further complaints with the right hand, thumb, or wrist.

[Figs 1 and 2](#) display the implemented changes to the workstation and are representative of how the participant was interfacing with his modified working environment. The anthropometric data in [Table 2](#), columns 1 and 2, reveal that the participant's postures and interactions with his workstation changed between baseline and the period of the first reevaluation. The

Table 2 Baseline and serial clinical and ergonomic reevaluations at the beginning of study and at 3-month, 1-year and 2-year intervals

	Baseline	3 mo	1 y	2 y
NPS	4	2	2	2
GPDI	4	2	2	0
Grip strength				
Left	20 lb-f	NA	NA	110 lb-f
Right	45 lb-f	NA	NA	100 lb-f
FHP (mm)	64.0	25.0	56.0	74.0
Ulnar deviation				
Left wrist	25°	4°	15°	25°
Right wrist	20°	7°	8°	20°
Wrist extension	15°	5°	12°	10°
Monitor-to-eye distance (in)	37	31	22	34
FRD (in)	31	31	31	31
Visualization angle (° declination)	30°	12°	12° (32°) *	20° (30°) *

FRD, functional reach distance; lb-f, pounds of force; NA, not available; NPS, numeric pain scale.

* The visualization angles for the participant when adopting a “hunt-and-peck” typing behavior with the neck in flexion and eyes focused upon the keyboard (see text and Figs 1-4).

behavioral changes observed by the study ergonomist included improved spinal postural habits and upper extremity movement strategies regarding his interactions with the manual, visual, and support interfaces of his retrofitted workstation.¹⁴⁻¹⁷ The participant reduced the ulnar deviation of his left wrist from 25° to 4° and that of his right wrist from 20° to 7°. He reduced his monitor-to-eye distance from 37 to 40 in to 30 to 33 in, reduced his visualization angle relative to the center of the screen from 30° declination to 12° declination, and reduced his FHP from 64.0 mm (2.5 in) to 25.0 mm (1.0 in). The study ergonomist observed that the participant had adopted a more upright and neutral seated posture with appropriate use of the backrest. These adopted postures reduced his behavior of perching on the edge of his seat and also established the recommended 90° seated thigh-torso body angle. The participant self-reported compliance with scheduled microbreaks for stretching as recommended in the ergonomic training.

Fig 2. Reevaluation after implementation of recommendations.

It is noteworthy, however, that he refused to comply with the suggested control measure of learning touch-typing skills with the Mavis Beacon Typing Tutorial, prioritized risk R3 (Table 1).

One year

Fig 3 reveals that the participant's postures and interactions with his workstation changed between the periods of the 3-month and 1-year reevaluations. At this point in the study, the participant independently chose to replace the laptop docking station with 2 parabolic screens to accommodate changes to his work pace, tasking activities, and work style. At this reevaluation, the participant self-reported continued improvement for his presenting MSDs. Chiropractic visits were maintained on a weekly basis; and high-velocity, low-amplitude adjustments were delivered as necessary in the management of the intermittent complaints of mild to moderate headaches, right SI joint pain, upper back stiffness, and left shoulder stiffness and pain. The numeric pain and GPDI scores were both 2 and were unchanged relative to the previous 3-month reevaluation.

Table 2, column 3, presents the results of the 1-year ergonomic reevaluation. The study ergonomist found an

Table 3 Cervical range of motion at baseline and serial reevaluations using Myovision 3G Wireless System

Cervical motion							
	Flexion	Extension	Flex-ext full range	Left lateral flexion	Right lateral flexion	Left rotation	Right rotation
Baseline	33°	50° *	83°	36°	39°	51°	21°
6 mo	41°	34°	75°	41°	31°	42°	39°
1 y	50.°	55°	105°	42°	30.°	44°	47°
2 y	60°	56°	116°	38°	22°	38°	44°

* Cervical extension measured by the study doctor of chiropractic at baseline was 15° (see range of motion subsection within “Results”).

Fig 3. Reevaluation at 1 year after intervention.

increase in the participant's FHP from 25.0 mm (1.0 in) to 56.0 mm (2.2 in), an increase in the ulnar deviation of the left wrist from 4° to 15°, but no significant change for the right wrist from 7° to 8°. He exhibited an increase in wrist extension from 5° to 12° and a decrease in the eye-to-monitor distance from 31.0 to 21.5 in, and he maintained a visualization angle of 14° declination. The ergonomist observed and Fig 3 reveals accentuated neck flexion of the participant when he was typing—he visually focused on the keyboard with a “hunting-and-pecking” typing work style that increased the declination of his visualization angle to 31°.

Two years

Fig 4 presents the side view image of the participant interacting with his office workstation after 2 years. The participant removed the parabolic screens and

Fig 4. Reevaluation at 2 years post-EJTA.

replaced them with a single 21-in LED monitor, and he also replaced the split keyboard and Contour Roller Mouse with a standard keyboard and pointing device. During this reevaluation period, the participant continued receiving chiropractic spinal adjustments and extremity manipulations at a frequency of 2 to 3 visits weekly to manage the intermittent discomfort and pain of his right SI joint, headaches, general back and body soreness, and left shoulder pain. At this final reevaluation, the participant reported a numeric pain score of 1 and a GPDI score of 0. Dynametric measures of his hand grip strengths were 110 pounds of force (left hand) and 100 pounds of force (right hand). Forward head posture while touch-typing increased to 74.0 mm (2.9 in), and positioning of his monitor declined his visualization angle to 20°. Fig 4 reveals that the participant continued to engage in the risky behavior of “hunting-and-pecking” typing that, when adopted, further increased his visualization angle to 30°. The participant stated that his compliance with the overall ergonomic intervention was “sixty-five percent, although I have had limited use of ergonomic accessories.”

Range of motion

Table 3 presents the ROM findings using the MyoVision 3G Wireless System and assessment protocols for the neck and upper back developed by the manufacturer.¹³ Ranges of cervical motions are presented for flexion-extension, left lateral flexion-right lateral flexion, and left rotation-right rotation at baseline and at 6-month (not at 3 months), 1-year and 2-year intervals. The full dynamic range of cervical flexion-extension is computed and presented in Table 3 as well.

For cervical flexion/extension, the full ROM increased from 83° at baseline to 105° at 1 year and 115° at end of study. The study DC visually estimated baseline extension at 15°, and the disagreement between the 2 measurements (MyoVision: 50° vs investigator estimate: 15°) arises from a protocol deviation. For the DC's examination, the participant extended his neck only as far as the first onset of discomfort; but for the evaluation with MyoVision, he elected to extend as far as possible despite a sensation of discomfort. The discrepancy in the data and the deviation in the protocol were noticed and corrected upon comparison of the 2 baseline evaluations. At all 3 of the subsequent serial reevaluations, there was no associated pain with the cervical extension; and the measurements in Table 3 reflect the participant's ROM

to his biomechanical limit. Left cervical lateral flexion held relatively constant through the course of the study, whereas right lateral flexion decreased (from 39° to 22° at end of study). Left cervical rotation trended to lower ROMs (from 51° to 38°), and right cervical rotation trended to increase ROM values (from 21° to 44°).

Discussion

Improvement in the participant's chief concerns occurred in the first 3 months of the study. The participant reported reductions in the intensity and frequency of his headaches, right side neck pain, and right SI joint pain; however, these complaints did not fully resolve. In this initial interval, compliance and adoption of safe work habits were reported by the participant and observed by both the study DC and ergonomist. Reductions in reported pain, discomfort, and disability (numeric pain and GPDI scores in Table 2) were accompanied by compliance to all but one of the recommended control measures of the ergonomic intervention (risk R3, Table 1).

The final outcomes obtained at end of study were improved numeric pain and GPDI scores, 2 and 0, respectively, and increased grip strength, from 20 to 110 pounds of force (left hand) and from 45 to 100 pounds of force (right hand). Despite alterations independently applied by the participant to his workstation and resistance encountered in compliance with the touch-typing control measure, the participant reported improvement in the GPDI score of discomfort and disability and its impact on social, personal, and work-related activities. This is interpreted as a dramatic stabilization of his health status. At the end-of-study interview, the participant reported an overall 65% improvement in his symptoms and complaints; and he did achieve one of his primary objectives: managing his condition with alternative practices that minimized his reliance on pharmaceutical prescriptive drugs.

Given the medical history of injuries to his left wrist, SI, and groin from soccer participation and the comorbidities associated with his condition of non-insulin-dependent diabetes mellitus, the clinical success reported here is considered significant for this participant. A tear to soft connective tissue, particularly tissue exposed to repetitive use, will generally heal and remodel with scar tissue, resulting in a functional recovery of up to 72% of its original strength within 52 weeks with even the best possible and appropriate intervention.¹⁸ It is important to recognize the

functional and general health of the participant improved substantially, and the investigators of this study did not devise the clinical care plan with an end point of "no pain" or the intention of "treating to zero." The outcome of this intervention is considered good, and perhaps optimal, for the presenting conditions of the participant.

Two noteworthy observations occurred in conjunction with this investigation. First, the participant was resistant to learning touch-typing skills. Despite surveillance and reinforced training, the participant failed to complete the Mavis Beacon Typing Tutorial to eliminate the "hunt-and-peck" style of keyboarding. When queried, the participant claimed, "You can't teach an old dog new tricks." This high-risk task behavior of a "hunting-and-pecking" typing style remained as a causative factor increasing risk exposure throughout the study (risk R4, Table 1). The authors hypothesize that this typing behavior contributed to the observed increase in the end-of-study FHP of 74.0 mm after it had initially improved from a baseline value of 64.0 to 25.0 mm in the initial 3 months. Second, within the first days of use of the Contour Perfit Mouse, the participant developed acute right wrist and right thumb pain associated with repetitive use of this device's thumbwheel. His injury was diagnosed as proximal tendonitis of the right fifth metacarpal. The condition improved substantially with the exchange for a second pointing device, a Contour Roller Mouse. The retrofit of pointing device was combined with clinical management including active release technique and microcurrent electrostimulation. The participant had 6 mild to moderate exacerbations until complete resolution of the right wrist pain after a 4-month period.

As noted above, the participant elected to modify his workstation configuration approximately 6 months into the study; and he continued to independently modify his station throughout the course of the study. Two parabolic computer screens were installed by year 1 and then later replaced by a single LCD flat screen. The participant retrofitted his manual interface with a standard keyboard and standard Logitech pointing device that reestablished the awkward wrist postures and pronounced ulnar deviations. The authors note that the compliance to the ergonomic intervention observed in the initial first half year regressed to a collection of less compliant behaviors. The participant retained use of the ergonomic task chair, and he positioned his computer screens to acceptable monitor-to-eye distances and visualization angles; but it must be noted that his failure to acquire touch-typing skills counteracted the more favorable screen positioning and is believed to

have contributed to the increased FHP because head positioning follows the eyes.¹⁹ Cumulatively, these actions and behaviors reestablished the majority of the initial risk exposures identified in the baseline EJTA because they restored many of the participant's host factors and the work environment's causative agents. The continued and consistent use of the task chair is argued to have modulated a number of his risk exposures—particularly those of slouching and perching in a seated posture—despite his apparent abandonment of many of the other specified control measures.

Adoption of healthy behaviors is hypothesized to be a critical factor in risk management and prevention of MSDs. The resistance to adopt a healthy work style, work pace, and task-related behaviors may have limited further improvement for this participant in this case. The behavioral science underlying the competing tendencies of humans to adopt or resist change has been researched by Prochaska et al²⁰⁻²² using the transtheoretical model for behavior change (TTM). Zeidi et al²³ recently applied the TTM to a cohort study investigating the adoption of recommended control measures provided in a training program for a population of 134 computer users. The intervention group who received the transtheoretical-based training significantly improved their ergonomic knowledge, self-efficacy, and the balance of pros vs cons that influence decision-making to adopt a new behavior in comparison with control.

The US Centers for Disease Control & Prevention state that injuries are as predictable as infectious diseases; they follow the same principles as infectious diseases and, therefore, are just as preventable.²⁴ As the global knowledge worker population increases, the less physically demanding and more sedentary job tasks are expected to increase the risk exposure and incidence of MSDs in future populations. This is particularly evident in the increasing occurrence of slumped postures from prolonged sitting in task chairs, a behavior argued to increase the risk of developing low back pain by inhibiting intrinsic muscle function and reversing lumbar lordosis.²⁵ It must be noted that the proper use of the task chair throughout the course of this study was the sole control measure that the participant did not change.

It is important that the practitioner extract information from her (his) knowledge worker patients regarding the nature and magnitude of exposures to various computer tasking activities. Measurements of the duration of exposure to risky behaviors and work habits (such as the number of forceful keystrokes, mouse clicks, aberrant postures, and overreaching

beyond the FRD) may now be acquired with technology available to investigators in human factors ergonomics. It is expected that research in this field will soon address the long elusive question: "How much computer use is too much?" as posed in the systematic review by IJmker et al.²⁶

This case report is an example of how a collaborative intervention of ergonomics and chiropractic improved the participant's symptoms, comfort, and overall health status.²⁷ It also reveals that the adoption of healthy behaviors is a challenge in this transdisciplinary approach to the management of MSDs. Reduced compliance to the recommended control measures was observed, and several of the main risk and causation factors such as the FHP and awkward wrist postures reemerged by the end of the study. The authors interpret these observations that understanding and managing the psychosocial stage of readiness to adopt behavior change are critical factors influencing success of this intervention.

Limitations

This work did not obtain data of the duration of exposure of the participant to risky activities or behaviors, which are predominantly behavior-based risks as opposed to human-factors design risks. A time-based, continuous data acquisition system would provide valuable surveillance data of visual and manual interfacing during tasking activities. Such capability is important because the risk exposure of an upper extremity MSD is both time dependent and force dependent. Secondly, the transtheoretical model was not used during the ergonomic training phase of the study when the participant's responsiveness and readiness to adopt new work-style behaviors may have been favorably developed.²⁸ Finally, the study did not formally intervene at the participant's home office, and neither an ETJA nor a risk analysis matrix similar to [Table 1](#) was created for that work environment.

Conclusion

The reported pain, discomfort, and productivity improved and stabilized for the worker in this 2-year prospective case study using an ergonomic and chiropractic intervention. In the initial 3 months, compliance to the intervention was high; and his presenting symptomatology of headaches, right SI joint

pain, pain in the left wrist and hand, decreased motoricity in both wrists, bilateral shoulder discomfort, and neck pain had reduced 50% compared with baseline. At the end of the study, the participant reported continued reduction in pain with increased productivity and functional health; he also reported a general pain disability score of 0. At 2 years, however, several of the work-style behaviors were observed to have regressed to their baseline behaviors, which reestablished 3 of the 7 risk exposures associated with excessive FHP: ulnar deviation, wrist extension, and a “hunt-and-peck” style of typing. Compliance with recommended work-style behaviors is linked to the participant’s psychosocial readiness to adopt such behaviors and incorporate them as his norm. The transtheoretical model for behavior change is proposed to be of value in promoting the adoption of healthy behaviors associated with ergonomic interventions for the management of musculoskeletal disorders.

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