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Remote online ergonomic assessment in the office environment as compared to face-to-face ergonomic assessment

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Abstract. Goal - remote online ergonomic assessment in the office environment as compared to face-to-face ergonomic assessment and examination of the applicability of remote online ergonomic assessment to office workers. 40 employees from a large Israeli hi-tech company were ergonomically assessed per the University of California computer usage checklist, according to the two assessment types (face-to-face and remote). An additional Ergonomist "assessor 2" examined the credibility of the process. Results: Research hypothesis 1 was verified: 21 out of 22 questions (95.45%) from the checklist indicated compatibility between "assessor 1" to the "Gold Standard" at an 80% level. Research hypothesis 2: examining the credibility between the assessors with regard to remote assessment. This hypothesis was partially verified, the correlation between the assessors was measured at 0.54. Research hypothesis 3: examining the extent of deviation of natural posture between distal body parts assessment (distant from the center of the body) and proximal body parts (close to the center of the body). This hypothesis was clearly verified. It has been proven that there is statistical significance between the results. Conclusions: The current research has proved that there is an additional method to assess musculoskeletal disorders risk factors remotely online at office environment.

Keywords: work related musculoskeletal disorder (WRMSD), ergonomics postural assessment, remote assessment, online assessment, office ergonomics assessments

1. Introduction

The concept Work Related Musculoskeletal Disorder (WRSMD) describes a wide variety of musculoskeletal disorders. This concept is defined by the American Ministry of Labor as injuries or disorders of muscles, nerves, tendons, joints, cartilages and inter spinal disc which are related to work related risk factors exposure. 34% of 1.4 million work related injuries in the US, in 2002, were caused by musculoskeletal disorders. WRSMD is responsible for third of the total illness related time away from work days due to work related injuries [2].

Reports of 20% of musculoskeletal disorders justify the need for ergonomic assessments [8], although the frequency of musculoskeletal injuries is relatively smaller in comparison to repeating industrial related injuries. The number of computer users is continually on the rise. 45.8% of the population in the US was using computers in 1993 as compared to 53.3% in 2001 [2].

Ergonomic assessment identifies a number of physiological risk factors for work related musculoskeletal disorders, such as excessive strength, static stress, vibrating, repetitiveness and mechanical stress. Literature documents the existence of a link between awkward postures and pain, symptoms and musculoskeletal disorders. Awkward posture is a significant deviation from the neutral posture of one or more joints. These postures normally include reaching backward, spiraling, looking up, wrist diverting and back diverting [16]. In order to assess the risk factors to the body postures related musculoskeletal disorders, a decision must be made with regard to the actual posture while performing the task [19].

Various methods were developed to assess neutral posture in order to examine the analysis of the loads working on the body and in order to assess the possible risk factors for work related musculoskeletal disorders.

These methods can be divided to three:

a) Direct assessments
b) Observatory assessments
c) Self report.

Tools such as advanced computerized tools or paper and pencil can be used in these methods. Cost and precision can be measured from 1-3 and the extent, diversity/difference and inclusion capabilities are factors that grow according to the order of the specified methods [20].

Direct assessments include tools and systems such as: electromyography, protractor, biomechanical analysis and optical methods, which provide information regarding muscular activity, angles and forces analysis according to the body postures.

Direct assessments are quantitative and very accurate but also expensive and time consuming. These limitations lead to an analysis of a small number of body parts and a small number of people that can be examined [12].

The observatory methods do not include direct physical contact (unlike the direct methods requiring body accessories). Indirect assessment is dependent upon the judgmental assessment of the examiner to identify various body postures [7].

The self report method includes gathering data from employees regarding their work related personal experiences, by means of questionnaires, interviews, journals, tagging lists, assessment and grading.

Self report seems to be the most suitable and practical method to use in large populations research. The self report method used to assess over time exposure is not credible or valid enough in order to assess postures and workloads in comparison to observatory or Direct assessments. In addition, there are different reports regarding the self assessment precision measure indicating inaccuracy of up to 4 times than the real exposure to computer usage [10 & 3]. Hence, the observatory method is a good compromise between expensive and low cost, subjective validity of the self report method [12].

2. Online methods

In remote learning literature there are researches dealing with learning that are expanding in the last few years. These researches specify four main reasons which are relevant to this research [1] to use technology (remote learning) in higher education, as follows:

- Improving learning quality
- Improving the accessibility to education/learning
- Lowering educations costs
- Improving education cost-benefit ratio.

Still, a successful remote learning process occurring in a complicated environment includes a number of stages. Failure in one of the process stages might cause the entire system to fail.

There are several remote assessment researches in medical literature, such as second opinion remote counseling and use of internet in order to link emergency medicine students to experienced mentors [4].

Although it is very tempting to expand the medical treatment to online treatment, such an expansion carries legal risk, including wrong treatment or unprofessional treatment and also breaking the law of several American states. In order to reduce the legal risk, the following steps should be followed:

1. The conversation/observation should be general and include guidance with regard to posture without providing remote medical treatment.
2. Providing general and not specific recommendations, such as materials that are accessible to the entire population.

It is recommended to have the examined/tested person sign a consent form specifying the purpose of the research/assessment, that the assessment does not replace medical treatment and that if needed, the person examined should consult his doctor and also that the recommendations are general [5 & 6].

3. Purpose of the research

Examining the feasibility of performing online remote ergonomic assessment to office employees.

Sub-purpose: to compare the new method to the face-to-face method.

Following the technological development we can examine the possibility of conducting an online ergonomic assessment in a relatively static environment (office station). To the best of the authors' knowledge no such research with reported results was conducted in Israel. Such a research holds legal, clinical and economical implications. Many employees report of musculoskeletal disorders. Many employees are forced to suffer from discomfort in the musculoskeletal system, pain and even days of absence due to these problems.

Due to lack of resources and knowledge, many of these employees are not aware of the possibility to receive ergonomic counsel.

A valid, credible, observational and feasible tool must be developed in order to examine the link between working in an office workstation and the risk factors to develop musculoskeletal disorders.

4. Research Query

Examining the link between online remote ergonomic assessment and face-to-face ergonomic assessment in an office environment.

5. Research hypothesis

The face to face assessment method and the remote assessment method will provide similar results (no significant difference will be found)

High credibility between the assessors in reference to remote observational assessment

Bigger differences will appear when assessing distal body parts as compared to assessing proximal body parts.

6. Methods

6.1. Research population

A group of 40 similar characteristics Israeli hi-tech employees, working for at least six months in their current workstation were undergo ergonomic assessment, using the computer usage checklist developed by the San Francisco California University [18] according to the two types of assessment (face-to-face and remote).

Criteria for the research population:

1. Employees who worked in an office space in front of a computer for at least 4.5 hours a week.
2. Employees who have been working in an office space for at least one year.
3. Employees who worked at least six months in the current workstation.

In the remote assessment, current research used a digital video camera in order to receive high resolution picture that was transferred to an assessor who sat in a remote room. Moreover, and due to the need to photograph from various angles in order to receive valid posture assessment, the video camera was held by an ergonomic champion who was posed as “living tripod” (with no further interference) in order to reduce the technological complexity of positioning several cameras, and in order to enable a more practical research model.

The ergonomic champion was provided with an hour training on the questions order according to the California - San Francisco University computer usage checklist.

In order to enhance the validity/credibility of the research, an additional ergonomist was also examined the 40 videos marking the remote assessment, as compared to the mark given to the remote assessment by the research conductor.

6.2. Research tool

The University of California, San Francisco, Ergonomics Program (1-8-02) 1 Computer Workstation Checklist was developed in 1994, and a final version was reported in 2002 [18]. The tool is composed of 25 questions, such as computer usage frequency, the type of work, etc. Most of the questions refer to body postures per various body parts, such as eyes, neck, hands, shoulders, palms, back and legs.

The questionnaire was developed in the US in order to assess the risk factors of working in office space. This questionnaire was given to professional ergonomic assessors to assess its credibility and any question that received a Kappa grade of less than 50% was deleted or modified. In addition, the effectiveness of the questionnaire was statistically high with regard to improving the workstation after being assessed by an ergonomic champion, but not after being assessed by self reporting or by another unskilled employee.

The employees group was randomly divided to two groups, one group were first assessed face-to-face, and the other group was first assessed remotely.

6.3. Dependent variable

The parameters of face-to-face or remote assessment according to the University of California, San Francisco, Ergonomics Program Computer Workstation Checklist. Face to face assessment was the “gold standard”.

Independent variable:
1. The type of face-to-face or remote assessment.

Inclusive variables:
1. Age
2. Gender
3. Time spent in the office station

7. Research process and data gathering

In order to verify the feasibility of remote assessment, a pilot study was conducted on three employees working in an office station in order to finalize the remote assessment process according to the California – San Francisco University computer usage checklist, in order to determine the directives communicated between the assessor and the ergonomic champion, and in order to determine the photographing angle.

After a week, the face-to-face and remote assessment were randomly scheduled, to a total of 40 employees (remote assessment first or face-to-face assessment first, 20 per group). The assessments were scheduled one after the other. Once the assessments were conducted, the employees were provided with the summary and findings of the ergonomic assessment, as well as with an ergonomic pamphlet for self usage. Then, the research conductor was grading the two types of assessments according to the California – San Francisco University computer usage checklist. A second ergonomist was invited to watch the remote assessments and grade them. The grades of the research conductor were compared to the external assessor grades in order to verify the validity/credibility of the grades.

7.1. Data analysis

a. Checking the validity of each of the assessors by means of comparing the results (research conductors and additional experienced ergonomist) to the “Gold Standard” (the face-to-face assessment). The result for matching between research conductor “assessor 1”, the experienced Ergonomist “assessor 2” and the “Gold Standard”: for each of the assessors and for each of the tested employees the question was: was the judgment of assessor 1 and assessor 2 identical to “Gold Standard” – the scores were “0” or “1”.
b. Checking the reliability of the general score for posture between the two assessors and the “Gold Standard”, checking the reliability between assessors for all questions by “Pearson test”: for each question for each employee, the question was: did the assessors give the same identical answer for the analyzed posture. The scores were “0” or “1”.
c. Creating the research variables: the calculations were for each question in the questionnaire. The percentage was calculated for each employee if they got score “1” for section “a” or “b”.
d. Comparing the results between different body segments: one-way analysis of variance between subjects, comparing the assessor 1 results within face-to-face assessment “Gold Standard” with assessor1 remote assessment with different body segments for head, body & hands.

The SPSS software analyzed the data. The statistical significance level was be set at 0.05.

8. Results

Research population characteristics are as follows: 40 participants participated in the research, 28 males and 12 females. Minimal reported age was 25, maximal reported age was 60. The average age was 38.48 and the standard deviation was 9.5 (see Table 1 and Table 2).

Table 1

Research Population Distribution per Gender

	Frequencies	Percentage
Male	28	70
Female	12	30
Overall	40	100

Table 2

Research Population Ages Distribution

	Participants	Min. Age	Max. Age	Average	SD
Age	40	25	60	38.8	9.50

The main hypothesis of the research is: is it possible to conduct a remote assessment which will be compatible with face-to-face assessment, constituting the “Gold Standard”? This hypothesis was tested by comparing the answers of each of the two assessors, conducting remote assessment and face-to-face assessment. The assessment was tested separately between Assessor 1 and Assessor 2.

The results of Assessor 1 as compared to the standard are presented in Table 3. This table presents the percentage of participants for which the remote assessment of Assessor 1 was identical to the face-to-face assessment for each of the questions describing posture (questions 7-25). Similarly, Table 4 presents Assessor 2.

Table 3 shows that 21 questions (95.45%) out of 22 have 80% compatibility between the results of Assessor 1. As the correlation coefficient does not support this data, and as far as the authors know there are no accepted criteria in literature for this type of data analysis, it seems that the data shows a good compatibility, hence the research hypothesis has been justified.

Table 4 presents the percentage of participants for which the remote assessment of Assessor 2 was identical to the face-to-face assessment for each of the questions describing posture (questions 7-25).

Table 4 shows that the compatibility of Assessor 2 to the standard is lower. This table specifies that 12 questions (54.5%) out of 22 questions received over 80% compatibility to the standard.

Table 3

Results of Assessor 1 as Compared To the Standard

Amount of Questions with Agreement	Percentage of Questions with Agreement	Frequencies in Percentage
0	Less than 40%	0
0	41%- 550%	0
4.55	56% - 70%	1
40.91	71% - 85%	9
54.55	86% - 100%	12

Table 4

Results of Assessor 2 as Compared To the Standard

Amount of Questions with Agreement	Percentage of Questions with Agreement	Frequencies in Percentage
2	Less than 40%	9.09
4	41%- 550%	18.18
4	56% - 70%	18.18
6	71% - 85%	27.27
6	86% - 100%	27.27

The data clearly shows that Assessor 1 assessed better/closer to the criteria than Assessor 2. Therefore, it is possible to claim that Assessor 1 better assessment resulted due to performing face-to-face assessment first and then recalling the results while conducting the remote assessment.

The following can be deduced from the findings:

a. There is no real difference between the accuracy of the remote assessment of Assessor 1 and the accuracy of his earlier face-to-face assessment.
b. The interaction between the order of assessments between Assessor 1 and Assessor 2 is close to 0. Namely, the difference assessment of Assessor 1 and Assessor 2 is not dependent upon the order of assessments of each Assessor. Meaning, if he conducted first face-to-face or remote assessment.
c. The averages clearly show again that the level of assessment of Assessor 1 is recognizably higher than that of Assessor 2.

In addition, the averages can be presented in a bi-directional variance analysis of Assessor 1 in the two assessments. This data shows that Assessor 1 conducted a better assessment that Assessor 2 (remote assessment which results are closer to the face-to-face assessment which is the “Standard Assessment”) without considering the order of assessments (first face-to-face assessment and then remote assessment).

With regard to the variance analysis test (Assessor 1 as compared to Assessor 2), when inserting the two methods to the equation: face-to-face and remote assessment, and the number of correct answers accordingly, the most significant test shows that the results of averages of Assessor 1, that could have been biased due to conducting face-to-face assessment first, shows that this is not the case and that the correlation between the assessments is not significant ($F(1,38)=0.57$, $p=0.45$).

An additional hypothesis was that bigger differences will exist between the distal body parts (distant from the center of the body) assessment and the non-distal body parts assessment.

In order to validate this hypothesis a comparison was made between the various body parts assessments, using a bi-directional variance analysis. The results are specified in Table 5.

Table 5

Comparison between Assessments of Various Body Parts

	Average	SD	Total Participants
Eyes	96.70	10.13	40
Body	92.50	11.30	40
Hands	84.30	15.00	40

This table clearly shows that the answers for questions related to the eyes and head posture, have the highest compatibility percentage. Answers for questions related to the body posture showed lower compatibility percentage rate, and answers for questions relating to the upper arms showed the lowest percentage rate.

Moreover, there is statistical significance between the results ($F(2,78) = 10.59$, $P< .001$).

9. Discussion

9.1.1. No significant difference was found between face-to-face and remote assessments

The first hypothesis of the research was justified. The remote assessment of Assessor 1 bore better results. It can be assumed that an Ergonomist or another content specialist can locate the relevant risk factors according to the proposed protocol, even for subjects that are physically located far from him.

Pre-action and implementing preliminary diagnosis of musculoskeletal disorders in the work places may assist in identifying those who suffer from musculoskeletal disorders at the early stages of the illness. Early detection may decrease the severity of the illness or may delay its progress. Delayed analysis or treatment may cause hardships in recovery, maintaining the work place and the rehabilitation. The Israeli economical system cannot afford a delay due to shortage of healthy workers, therefore preliminary intervention is vital. There is impressive evidence which prove that long periods of absence from work damage those who suffer from musculoskeletal disorders since the longer their absence from work, it is harder for them to go back to work [12].

9.1.2. There is a higher credibility between the assessors with regards to remote assessment

This hypothesis was partly justified. The correlation between the assessors is 0.54. This correlation coefficient is not low, however it cannot be considered as high enough for assessors' credibility. Possible reasons for this finding are:

- Training duration: due to lack of resources only one content specialist participated in the research that we conducted. This specialist volunteered. Having volunteered affected the duration of the training process. The assessment tools training including practice lasted one hour.
- Agreement of the content specialists: no advance compatibility check was performed between the assessors relating to the assessment tools.

Robertson's and others' research [17] reported an initial training process on a similar observational tool (RULA). The training process lasted 3.5 hours. Four content specialists participated in the research whose been trained until they reached a 90% agreement with the standard (in this research the instructor constituted the standard). Five practical practices were required in order to reach the desirable result. This report reported on 0.7 as good credibility between assessors.

In another research [11] five content specialists participated in order to develop the tools and three other content specialists conducted the office ergonomic assessments. In this research each item of the questionnaire resulting lower than (Kappa<0.5) was updated or taken off the list. The findings showed that the agreement average between the assessors reached 0.49 and the range was between 0.1 and 0.92.

Therefore, in future research it is recommended to invest time and resources in the training process and the assessors agreement, and also to perform this process actively on the assessment tools and to conduct the research only at the end of the process, when reaching high agreement level between the assessors.

9.1.3. Examining the extent of deviation of natural posture between distal body parts assessment and proximal body parts

This hypothesis of the research was justified. In previous postural observing research there was a need to have agreement between assessors to validate the tool, as research [17] reported on lower Interclass correlation coefficient of 0.75. The scores of this research for questions related to the eyes and head posture showed the compatibility percentage is the highest (0.96). Answers for questions relating to the body posture showed lower compatibility percentage rate (0.92), and answers for questions relating to the upper arms showed the lowest percentage rate (0.84).

Previous researches, current data analysis and extensive practical experience of this research conductor, can conclude that during examination of postural assessment of distal & proximal upper extremities there are diverse answers between assessors and there is a need to perform solid training time on the relevant postural tool and verify agreement between assessors on posture analysis.

10. Study limitations

Hill [9] defined in her article that women are more sensitive to the fact that they can be observed and they feel that they should fit themselves to the expected standards and norms. This study, where the employees were observed and photographed, showed women readiness to participate in this kind of study was lower than man and it affected the research population gender.

There is a need to perform Ergonomics postural analysis future research with the same method with additional assessors, minimum of six, after they have high agreement for the postural tool.

Additional interesting future research could be examination of remote Online Ergonomics assessment with different observing Ergonomics tool such as RULA or strain index [14, 13 & 15].

11. Conclusions

The current research has proved that there is an additional method to assess musculoskeletal disorders risk factors. This method can address the multiplying and existing challenges in the field of ergonomics in general and specifically office ergonomics. Remote Online assessment can now provide ergonomics researchers and specialists with an additional valid tool to continue researching the office environment musculoskeletal disorders risk factors.

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