Development of Predictive Methods for the Risk of Wrist Disorders based on the Work and Activity Pattern of Present Times

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Abstract

Work pattern changes along with the changing socio-technical system. An example of this is the present situation. The increasing influence of digital technology and Industry 4.0 is rapidly changing the work pattern and other activities. Most of the jobs presently have typical characteristics of sedentary nature and extensive use of hand and wrist. Due to the current work pattern, hand-wrist musculoskeletal disorder occurrence is on the rise. In this context, it is important to understand the interaction of different risk factors associated with wrist disorder. It is also required to formulate predictive models and methods in this regard. To fulfil the research objectives, a three-phased study was conducted where the dynamics of wrist disorders with lifestyle and design were initially studied. Further combined risk factors were extracted from data gathered using a questionnaire by PCA. Finally, the model was established, tested in various contexts, and discussed.

Keywords: Conceptual models, Digital technology use, Hand-wrist musculoskeletal disorders, Predictive methods, Risk factors, Wrist disorders.

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Introduction

The presence of digital technology in modern life is evident in current days. In recent days, hands and wrists are the most extensively used body parts for most jobs. These types of activities are a very obvious cause of the rise of upper extremity-related problems such as wrist disorders.[1] However, the interaction between the risk factors and the relationship pattern still needs to be explored.[2] Also, the impact of physical and psychosocial risk factors on the development of wrist disorders, individually or in combination, is unexplored. Therefore, there was a need to develop a predictive model/method which can be used to identify/assess the risk factors for the development of wrist disorders. Based on the need, a study was planned to develop a conceptual model where the impact of both physical and psychosocial factors can be predicted with their weightage.

Conceptual models provide abstract ideas about interacting components within a system. Thus a conceptual model can be effective in understanding the interaction of different variables for wrist disorder risk.

Methodology

The methodology consists of three parts:

- The extraction of risk components and identifying the interaction among risk factors
- Associating various design elements with their physical effect or risk
- Development of the conceptual model

At the beginning of the study, two separate questionnaires were circulated to two different groups of people. In the first group, a questionnaire survey was conducted approximately among 100 subjects diagnosed with any wrist disorder by physicians. The questionnaire contained information about their workplace's physical and psychosocial environment. The presence of risk factors, intensity, and duration of exposure was enquired in the questionnaire on a five-point Likert-like scale. Following were the inclusion and exclusion criteria for the subject selection.

Inclusion Criteria

- A physician should diagnose the disorder;
- Any job, including homemaking, was considered;
- All the genders were considered;
- Only adult subjects were considered.

Exclusion Criteria

- The presence of any particular disease that may cause wrist disorders secondarily, e.g., diabetes mellitus or renal diseases.
- Presence of wrist problems due to some accidents, e.g., fracture of wrist bones, etc.

For the second group, another survey with 50 subjects

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participated. All subjects used to perform hand and wrist-intensive activities in their daily life. The questionnaire was developed to understand the impact of the design element on the physical efforts on a five-point Likert-like scale.

Statistical Analysis

The Principal Component Analysis (PCA) was carried out to extract the combined risk factors. This was done for both physical and psychosocial risk factors. K-mean cluster analysis was done to isolate the design element clusters for each physical effect or risk factor.

Development of the Conceptual Model

Five combined physical risk components were extracted with their cumulative variability from the first part of the survey, whereas for psychosocial risk factors, the extracted components were four. All the combined components consisted of constituent risk factors and their weightage to the combined components. Any risk factors with weightage less than 0.3 were automatically excluded.

From the second survey, six design clusters were isolated and elated to six physical risk factors. The physical risk factors are repetitive wrist movement, wrist posture, repetitive finger movement, finger posture, forceful exertion by hand, and vibration on hand.

Combining the data from the two surveys, the model was developed, which is divided into three parts.

Results

The newly developed model is divided into three major parts. There are mainly five physical risk components: the repetition component (0.24), the force component (0.31), the finger posture component (0.18), the vibration component (0.21), and the wrist flexion component (0.12). It was observed that the impact of psychosocial factors is indirect. Therefore, this component's variability is not presented in the result. The extracted components are: the stress component, the job satisfaction component, the work environment component, and the reward component. The repetition component is related to design element clusters 1 to 4, whereas design element cluster 5 is related to the force component. Likewise, design element clusters 4, 6, and 2 are linked to the finger posture, vibration, and wrist flexion components, respectively. The details of these clusters were provided in a later part.

Constituent risk factors of all the physical risks are present in the second part of the model. The repetition component consists of repetitive wrist movement, duration and intensity, sustained wrist position, repetitive finger movement, and sustained finger position.

The force component comprises two risk factors: intensity and duration of forceful exertion by hand. The finger posture component consists of the duration of finger flexion and finger extension. Like force, the vibration component also consists of the duration and intensity of vibration on the hands. As the name suggests, the wrist flexion component has a constituent risk factor of wrist flexion duration.

Details of different element clusters are presented in the third part of the model. Design elements from three different types of interfaces are present in each cluster. These are the interfaces from small digital devices, bigger digital devices, and manual or non-digital. The clusters were related to a particular physical effect or risk factor.

Discussion

The proposed conceptual model is effective in both research and practical purposes in ergonomics and design aspects of wrist disorders. The proposed model is useful in understanding the interaction of different risk variables in the present context. In this model, five combined physical risk components and four psychosocial risk components are present. All the combined components have integral risk factors with their weightage. For e.g., the highest component for physical risk is the repetition component consisting of wrist repetitive movement intensity and duration, repetitive movement duration of fingers, and static postures of wrist and fingers. Digital devise operation includes all these activities.[3,4] However, the past epidemiological studies failed to show significant relation between these types of activities with wrist disorder development.[5,6] The probable reason may be that, in earlier days, such activities were comparatively less from current days. Hence, not been explored or reported as similarly as in the recent context. Thus in the present context, the significance of their interacting effect together can be assumed. This is represented through the repetition component in the model.

All the combined components also have their weightage individually in terms of variability. In an environment or system where more than one type of risk component is present, this weightage can help to identify the optimum modification points. This model can be used at the very beginning of the design process. Providing optimum modification points to reduce the risk of wrist disorders is this model's main attraction.

The impact of psychosocial factors on the development and progression of wrist disorders also can be predicted clearly from this model. The mode of action of psychosocial factors is indirect effects on the neuroendocrine-musculoskeletal feedback system of the body.[7,8] The direct weightage and variability, thus, are inappropriate in this case.

One of the significant limitations of this model is that it requires some contextual knowledge to apply effectively. The model provides a generalized idea about different interacting risk factors of wrist disorders and their relation with interface design elements. However, this conceptual model does not provide any idea about the approximate risk of wrist disorders influenced by different work and activity-related risk factors. Thus, a predictive method is needed to understand the chances of wrist disorder from a particular activity or group of activities.

Conclusion

The developed model will help understand the interaction of physical risk factors in current working conditions. The type of psychosocial aspects that can affect the incidence and progression of wrist disorders can be identified from the model. It can aid in visualizing the effect of any design element on the chances of wrist disorders. Also, this will provide a list of probable candidates best suited for modification. Thus, the model can help to optimize the risk of wrist disorders at the early conceptual phase of interface design. In summary, it can be noted that the model can be used in ergonomics and design for both theoretical and practical purposes concerning wrist disorders. However, a predictive method is needed to calculate the approximate risk of wrist disorders. In the next phase of the study, such a method is developed.

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