User-Chair Fit Index (UCFI): An Ergonomic Evaluation Tool for User-Chair Compatibility

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Abstract. VDT work is associated with a high degree of postural constraint, thus, requires maximum flexibility to be built into the workstation setup so as to compensate for the lack of flexibility in the job design. In workstations where static postures are unavoidable, like a VDT workplace, the risk can be reduced by designing to accommodate the limitations of human anatomy. Work chair has a major role to play in the comfort/discomfort experienced at the workplace. User-Chair Fit Index (UCFI) is an ergonomic tool developed on the lines of the Likert Summated Rating Scale for checking the aptness of the work chair by assessing the fit between user and work chair. UCFI, initially, was developed with 36 items, and was evaluated by a panel of 50 experts i.e. 25 engineers and 25 furniture designers for its appropriateness in measuring the desired construct. The tool with 36 items was administered for pilot study on 200 VDT operators working in IT industry. The item correlation and item differences were computed for item analysis and after dropping items with low t-values, final set of 26 items was selected, which was given to 1000 male respondents in the age group of 25–35 years, working in the IT industry, selected randomly. The final data used for the standardization of the tool was derived from 839 respondents, after eliminating the incomplete response sets. The tool was validated to ensure its dependability in recognizing the fit between the user and work chair in the VDT workplace. The reliability estimates and validity indicate that the scale was highly reliable and valid for identifying the user-chair fit in the VDT workstation. z-Score norms were developed for interpretation of the raw scores.

Keywords: Ergonomics · Furniture · Likert scale

1 Introduction

Most of the work in the modern work world is performed in a well established workstation where the workers are required to sit for many hours at a stretch, working on video display terminals (VDTs) or any other related devices. VDTs support the activities of almost every occupation, but the requirements vary with the peculiar nature of work being performed. VDT work, particularly, is one of the most significant examples of static work where the workers are required to perform repetitive wrist movements sitting in a static posture for prolonged hours. The loads experienced during static work are deduced from the angular relationship between different body parts, distribution of masses, length of time for which the posture is held and bodily responses of the person maintaining the posture. These factors determine the stability of

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posture, muscle loads and joint torques, fatigue levels and recovery times and hazards related to work posture.

Working on VDTs is considered to be a highly repetitive static task and leads the worker to attain static or awkward postures for prolonged periods of time, sometimes struggling to feel comfortable while working. Bridger [6] suggested that health risks increase when postures are static and when tasks are highly repetitive. The work on VDTs places a set of unique demands in terms of visual, postural and temporal requirements. In terms of postural requirements, it should be well considered that all work supplies and set up is under the optimum reach of the worker so that they are not required to attain awkward postures to remain stable. As VDT work is a highly constrained job in terms of posture, it requires maximum flexibility to be built into the workstation setup, say, in terms of adjustable furniture etc., to compensate for the lack of flexibility in the job design. According to National Occupational Health and Safety Commission, Australia [3], constrained postures which are often troublesome are forward flexion of the neck; twisting of the neck; elevation of the shoulders; twisting of the trunk; forward reaching of the upper arm; abduction of the upper arm; ulnar deviation of the hand; and extension of the wrist.

The time for which such postures must be held is crucial in determining the need for correction. It is important to prevent poor posture by giving attention to furniture and equipment and its proper arrangement and adjustment. Ergonomic improvements can have a beneficial effect on productivity and alleviate the sources of injury and discomfort at work.

Ergonomic furniture is the contemporary approach to workstation design. The furniture in the workspace should be designed to facilitate task performance, minimize fatigue and injury by fitting equipment to the body size, strength and range of motion of the user. The design of the chair and other furniture pieces in the workstation play a significant role in determining the level of comfort/discomfort experienced by the worker. Lefler [7] suggested that working in an office typically involves spending a great deal of time sitting in an office chair - a position that adds stress to the structures in the spine. Therefore, to avoid developing or compounding back problems, it is important to have an office chair designed ergonomically, that supports the lower back and promotes good posture.

Office furnishings should have adjustable components that enable the user to modify the workstation to accommodate different physical dimensions and the requirements of the job. Ergonomically designed furniture aids in reducing pain and injury, increase productivity, improve morale, and decrease worker's complaints of discomfort.

The selection of work furniture and equipment should be task specific in order to eliminate static or awkward posture; repetitive movements; poor access or inadequate clearance and improper ZCR; difficult to read displays; and confusing controls. Office workstations must be designed carefully to meet the operator's needs determined by the postural, visual and temporal requirements arising out of the worker-work interface. The design objectives should support operators so that operational objectives can be achieved. The major goals to consider in human-centred design include enhancing human abilities and overcoming human limitations.

Miller [2] suggests that a chair should move the way the body moves. In the best of all possible worlds, the body is free to position itself spontaneously, constrained only by gravity. A person seated at work should be able to move freely and unselfconsciously from computer-related tasks to more relaxed or interactive postures. The work chair should follow along, providing optimal support whether the body is in motion or at rest.

Work guidelines for VDT workers suggest that seat back and height should be adjustable; forearms approximately horizontal; minimal extension, flexion or deviation of wrists; screen height and angle should allow comfortable head position and sufficient space in front of keyboard to support hands/wrists during pauses in keying. The major aspects of work chair design suggested by Bridger [6] include dynamic sitting, proper swivel system, appropriately designed lumbar supports, forward tilts, footrests for short users, free space underneath the seat to allow for a knee flexing by 90° or more, proper backrest, properly positioned armrests and comfortable upholstery.

Various studies have been conducted to assess the design features of the work chair and ergonomic designs have been developed. It is important to consider various aspects of chair design which determine the aptness of the chair for the work being performed and the user-chair fit. Because one size does not fit all, it is important that the chairs are designed with as much flexibility to allow different users to use it in the most comfortable manner and also allow for dynamic sitting. A well-designed chair allows the user to maintain the equilibrium of the posture. The major features of chair that need to be considered well during designing include seat height, seat slope, seat depth, backrest, armrest, footrest, lumbar support, headrest, castors and other adjustability controls.

Various studies have been conducted to identify the risk factors in different work setups. Triano and Selby [8] suggested that it is important to develop a job description based on the forces present in a particular work environment; the time spent performing the task and the biomechanics (which define human motions and seated posture in an office chair) used in the task. Diverse actions need to be taken to assure the safety of the workers from injuries. It is important to assess the fit between the worker, work and various other features of the workspace. A chair becomes ergonomic when it suits a worker's body dimensions, particular workstation, and the tasks that must be performed there.

2 Scale Construction Technique

User-Chair Fit Index (UCFI) is an ergonomic tool designed to assess the level of fit between the user and the work chair in any office setup especially in VDT workstations. It was developed on the lines of the Likert Summated Rating Scale for checking the aptness of the work chair by assessing the fit between user and chair. It assesses the comfort/discomfort experienced by the operators while sitting on the work chair during the performance of work implying the fit between user and work chair.

The User-Chair Fit Index (UCFI) initially, was developed with 36 items. The pattern was so developed as to be comprehendible. Items were kept short, limited to single construct and comprised simple terminology keeping in mind that the set of items is optimized and the items are easy to grasp. The items were created primarily from an in – depth study of literature and later on through brainstorming with experts (engineers and furniture designers). The tool with 36 items was evaluated by a panel of

50 experts i.e. 25 engineers and 25 furniture designers for its appropriateness in measuring the desired construct. The specific goals were to understand the reactions to alternative ways of phrasing scale items; reword items to improve clarity; eliminate redundant items; and obtain feedback on the length, format, and clarity of the instructions and initial draft. On the basis of insights from the experts, directions were simplified and confusing items were eliminated or reworded. The tool was then provided with a five-point scale i.e. 1 (Strongly Disagree) to 5 (Strongly Agree).

The tool with 36 items was administered for pilot study on 200 VDT operators working in IT industry for at least 6 months in continuation. The item correlation and item differences were computed for item analysis. A set of 26 items was finally selected on the basis of correlation and t-values obtained from item analysis. These statements had item correlation value higher than 0.8 and also high item discrimination (with t-values ranging from 4.68 to 11.85). The items with very low t-values were dropped and the final scale of 26 items was obtained. The final 26 items selected for UCFI are presented in Table 1.

Table 1. Items in UCFI.

Statement
1. My work chair allows me to change posture easily
2. My work chair swivels easily
3. My work chair has easily adjustable heights
4. My work chair has a good footrest
5. There is a proper clearance for legs underneath the seat
6. The backrest in my work chair is good enough to keep my trunk stable
7. The backrest of my work chair reclines independent of the seat pan
8. My work chair has a well designed lumbar pad
9. I do not slide forward when seated during work
10. I do not feel pressure under the thighs when seated during work
11. My forearms are properly supported by the armrest when I sit erect
12. The armrest does not obstruct me when I use any of the devices (mouse/keyboard) on the work desk
13. My work chair provides proper support to the neck while I maintain gaze on the monitor
14. The seat does not slope backwards while I approach the work desk
15. I can get in the chair easily
16. I can get out of the chair easily
17. I don’t find difficulty in finding the controls of my work chair
18. I don’t find difficulty in controlling the chair while adjusting
19. The lumbar support in my work chair helps me to sit up straight
20. I can keep my feet on floor while reclining
21. The elbow rests do not make me feel locked in
22. The padding on the seat pan is adequate
23. The padding on the backrest is adequate
24. My work chair feels stable
25. I can tuck the feet easily under the seat when I want to
26. The castors in my work chair are properly positioned

The final scale with 26 items was given to 1000 respondents in the age group of 25–35 years working in IT industry for at least three years. The data collected from 1000 respondents was checked for its completeness which led to the dropping of number of respondents from 1000 to 839. The final data used for the standardization of the tool was derived from 839 respondents.

2.1 Scoring

In the final version of User-Chair Fit Index (UCFI), item responses were to be elicited on a Likert-type Scale that range from 1 (Strongly Disagree) to 5 (Strongly Agree). Table 2 describes the scoring pattern for the scale.

Table 2. Scoring pattern.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

2.2 Reliability of the Scale

After item analysis the scale was subjected to test of reliability to find out its consistency in providing results after repeated use. The reliability was found by estimating the correlation coefficient (Cronbach's alpha) of scores.

Test-Retest method. The respondents were supposed to give their responses on the scale at an interval of 6 months, while using the same chair. The reliability of the scale was then estimated by the correlation (Cronbach's alpha) between the two sets of scores obtained at an interval of 6 months.

Split-Halves method. The Split-Halves method was used to calculate the reliability estimate of the scale. The scale items were divided into two sections (the even-numbered items and the odd-numbered items) and scores were calculated for each half. The reliability of the scale was estimated by the correlation (Cronbach's alpha) between the two score sets (Table 3).

Table 3. Reliability estimate of User-Chair Fit Index (UCFI).

Sr. no.	Method	Reliability
1	Test - Retest	0.98
2	Split-Halves	0.96

2.3 Validity of the Scale

The tool was validated to ensure its dependability in recognizing the fit between the user and work chair in the VDT workplace. A number of measures were adopted to establish the content and construct validity viz., creation of items after thorough literature, scanning and brainstorming with experts. The Panel was requested to comment on appropriateness of the items to the concept that help in suitably modifying the scale without affecting the meaning of desired aspects to be enquired in the item. The User-Chair Fit Index (UCFI) may be useful in assessing the comfort provided by the work chair to the operator as a measure of user-chair fit.

The reliability estimates and validity indicate that the scale was highly reliable and valid for identifying the user-chair fit in the office setup especially in the VDT workstation.

3 Scoring, Norms and Interpretation

The scale was designed for assess the fit between user and the work chair. The level of fit can be assessed by cumulative scores of any single dimension or the total scale. Weighted score is assigned for each response opted and the scores obtained by individual respondent on 26 items are added.

When the raw scores are converted into z-Scores, the level of fit between the user and work chair in the VDT workplace can be identified, which can further be used to conclude if there is a need to take actions to make the work chair comfortable for the operator. Higher the score greater will be the fit between user and work chair; and lower the score, lower will be the user-chair fit indicating that actions need to be taken in order to make the work chair comfortable for the operators.

If the level of fit is below moderate i.e. if it is low, very low or extremely low, it will indicate that the work chair needs to be replaced with an ergonomically designed chair to make sure that the worker is comfortable using the work chair. Table 4 shows the z-score norms for UCFI, and Table 5 indicates the interpretation of z-scores for identifying the level of fit between user and work chair.

Table 4. z-Score norms for User-Chair Fit Index (UCFI).

Raw score	z-score	Raw score	z-Score	Raw score	z-Score	Raw score	z-Score
80	−1.14	**93**	−0.55	**106**	+0.04	**119**	+0.64
81	−1.09	**94**	−0.50	**107**	+0.09	**120**	+0.68
82	−1.05	**95**	−0.45	**108**	+0.14	**121**	+0.73
83	−1.00	**96**	−0.41	**109**	+0.18	**122**	+0.77
84	−0.96	**97**	−0.36	**110**	+0.23	**123**	+0.82
85	−0.91	**98**	−0.31	**111**	+0.27	**124**	+0.86
86	−0.85	**99**	−0.27	**112**	+0.31	**125**	+0.91
87	0.82	**100**	−0.23	**113**	+0.36	**126**	+0.96
88	−0.77	**101**	−0.18	**114**	+0.41	**127**	+1.00
89	−0.73	**102**	−0.14	**115**	+0.45	**128**	+1.05
90	−0.68	**103**	−0.09	**116**	+0.50	**129**	+1.09
91	−0.59	**104**	−0.04	**117**	+0.55	**130**	+1.14
92	−0.59	**105**	0.00	**118**	+0.59		

Table 5. Norms for interpretation of z-score and level of user-chair fit.

Sr. no.	Range of raw scores	Range of z-Scores	Grade	Level of fit
1.	128 and above	+1.05 and above	A	Extremely high
2.	119–127	+0.64 to +1.00	B	Very high
3.	110–118	+0.23 to +0.59	C	High
4.	101–109	−0.18 to +0.18	D	Moderate
5.	92–100	−0.59 to −0.23	E	Low
6.	83–91	−1.00 to −0.64	F	Very low
7.	82 and below	−1.05 and below	G	Extremely low

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