Ergonomic Approach of Modification of Seat Design in the Handloom Industry of Assam

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ABSTRACT

Weaving is a traditional household activity for every women of Assam. With framework of Indian economy and initiatives from different organization this household practice is gradually taking the form of commercial outlook. Work practice has changed but workstation remains same, which increases risk of workstation related musculoskeletal problems as existing workstation is not suitable for long duration of commercial weaving. Objective of the present study is to modify existing seat by the application of ergonomic principles. Seat or plank modification was done on the basis of participatory approach and modified plank was evaluated by subjective assessment method. Among the total number of weavers studied,79% found modified plank was quite comfortable whereas 89% of them felt depth of the seat should be corrected and 60% felt backrest was useful during intermediate rest between task. Modified plank was reported to be qmuite useful and comfortable for long duration of loom usage.

Key words: Handloom, Women weavers, Seat design

INTRODUCTION

Ergonomic issues in workplace are often overlooked at the beginning of a design process, as a result feedback of a poor workstation design are received much later in the form of sick leave, poor performance due to muscular pain resulted production loss. Healthy persons also develop degenerative tissue changes due to stress induced by long enforced posture, misdistribution of tissue pressure and prolonged static loading on the muscles (Chaffin, 1974; Magora, 1970; Van Wely, 1970). Bodily discomforts and pains, tends to be aggravated by tasks on poor workstation leading to increased error rates (Grandjean, 1988; Corlett& Bishop, 1976; Eklund, 1995) and loss of income. Such a situation prevailed in the handloom industries of Assam where weavers suffer from muscular pain due to poor workstation design.

A major workforce in this industry are women who are more prone to health hazards due to multiple overlapping roles in the family as well as in the society, resulting little time for recovery, which gets aggravated with poor occupational set up. Previously women used to spend their leisure time into craft activities as a passion or for domestic needs, but now due to the narrow scope of recruitment under different employment structures, these home based craft activities are taking the shape of commercial outlook under the umbrella of so called "small scale cottage industry". For domestic needs and to perform craft work out of pleasure, there was no time constrain, so they used to take small-breaks in between the task but for commercial work, time plays crucial role. Long duration of improper loam usage for commercial weaving leads to severe muscular pain. Nag et al (2008) in their study at Ahmedabad have reported that male and female workers involved in handloom sectors suffer from back and knee pain which may result from minimal hip support with constrained posture. They also opined poor workstation design aggravates the effect of musculoskeletal disorder among the weavers. This support the needs for ergonomic study in seat design in the handloom industry of Assam where work culture is getting changed but loom structure remains same that is, the weavers spend quality time sitting on a narrow wooden plank for 8-9 hours of work schedule.

Important reason for the development of musculoskeletal problems is when the sitter is forced into constrained and awkward posture during work activities, and when there is no possibilities to get relief or change of posture (van Wely, 1970) which is seen in case of handloom weaving to operate the loom. Many studies have shown strong association between prolonged sitting and increased risk of low back pain (Hartvigsen et al., 2000; Fogleman and Lewis, 2002; Nakazawa et al., 2002; Lis et al, 2007; Mork and Westgaard, 2009; Mark &Westgard, 2009). Risk of low back pain increases manifold times with improper seat design. Seating in case of handloom weaving is task dependent. With financial challenge for the survival of the industry, workers are paid per work basis, as a result weavers spend long hours on plank of the loom in order to finish the task in a single spell.

With long hours of sitting, adequate body support is required; otherwise sitting posture is maintained through muscle effort, by overstretching of the spinal ligaments and strain the disc and surrounding spine structure which is observed in every handlooms of Assam. Kroemer et al 1985 stated prolonged static sitting leads to isometric contraction of back muscles leading to endomuscular pressure restricting blood flow, resulting ischemia which reduces energy requirements of the muscles causing muscle fatigue. This is commonly observed postures among the weavers during continuous weaving when the trunk maintains a straight upright sitting for long hours (Fig 1 D).The intra-discal pressure at the lumbar region is high both in sitting and trunk-bent-forward posture (Wilder et al., 1988; Chaffin et al, 1999; Bernard, 1997) which is commonly seen during motif and beating operation (Fig 1E). Another problem of poor seat design is development of pressure underneath the thigh muscle. Long periods of sitting, especially if front edge of the seat creates pressure, it impairs venous blood flow, increases blood pressure, and cause uncomfortable swelling of feet and lower legs, and even thrombosis in the lower legs. In the existing handlooms, the weavers used to sit on a narrow wooden plank of about 13-15 cm in depth with sharp hard edge in the front, and in almost all the cases their legs dangle in air (Fig- 1 C and F). The situation gets adverse due to gravitational action on leg weights which develop more pressure at the posterior thigh.

Product value of handloom items depend on quality, quality again depends upon the efficiency of the weavers. Strength of handloom industry lies in its uniqueness of innovative designs, which cannot be replicated by the power loom sectors. Each handloom item is different from the other where the artistic quality of the weavers is portrait. There are number of studies showing clear relationships on the influence of environmental factors on quality performance by humans (Sanders McCormick1993; Smith & Jones, 1992). Axelsson, 2000 in his study found that quality deficiency rate was shown to be almost 10 times higher for the worst body postures compared to the best postures. Price of craft items depends upon its aesthetic value which in case of handloom depends on artistic sense of the weavers which gets transformed on fabric in the form of motifs. Weaving on poor loom design leads to discomfort heading towards muscular pain which in turn deteriorates quality performance due to loss of concentration. Ultimate goal, is to design the seat with ergonomic approach to prevent the adverse effects of long hours of seating to perform weaving task so that it can eliminate discomfort and impose fewer risk of performance and makes the task better adapted to the abilities and limitations of the humans.

Fig 1: Showing existing seat design in different handloom industry of Assam **A** and **B.** Forward and Side bending posture to maintain thread breakage **C.** Legs dangling due to fixed seat height **D.** Upright sitting posture for continuous weaving **E.** Forward stretched posture **F.** Narrow width of the plank and sharp hard edge in front of the seat.

METHODS

Survey was carried in different handloom units located in and around Guwahati mainly Kamrup district of Assam; a state of NE India, to find out workstation related problems. To investigate and assess the prevalence of ergonomic issues, clusters of handloom units were visited (both in organized and unorganized sectors) and meetings were conducted between loom owners, weavers and managers. Survey on general working status was carried out among 150 women weavers from 118 handloom clusters under both organized and unorganized weaving pockets.All the looms, chosen for the study undergoes commercial production. Discussion with managing bodies of different government organization, it was found that for the last 10 years with initiatives of Government of India and Assam the home based industry is taking the shape of commercialization. To understand the requirement of commercial workstation, weavers with weaving experience of 2-10 years involved with commercial production was selected for the study group. Personal characteristics of the weavers are given below in Table 1. Subjects were allowed to use work schedule and duration of work-pause of their own practice. Only one worker at a time was interviewed to avoid loss of productive time. Some of the questions were rephrased to find the consistency to the answers of the weavers. The study was conducted in two phases, Phase 1 and Phase 2.Phase 1consist of self-reported exposure assessment through questionnaires and Phase 2 consisted of Design Development and Evaluation phase.

For subjective assessment of the existing and modified plank for Phase 2, 50 women weavers from 3 villages near IIT Guwahati were selected randomly. Influence of modified seat features for pedaling operation in simulated experimental condition was evaluated using subjective measurements after one hour seating. Comfort was evaluated using comfort and discomfort rating scale (Drury CG and Coury BG, 1982).

Table 1: Personal Characteristics of the weavers

Characteristics	**Female weavers (n=150)** **$\overline{X}$ (range)**
Age (yrs)	27 (18-35)
Yrs of involvement	6 (2-10)
Working hours/day	7 (5-10)
Literacy	100%

RESULTS

<u>Phase 1:</u> Self-Reported Exposure Assessment

Pain assessment was done with the help of Borg's Perceived Exertion and Pain scale (Borg G. 1988) in different body parts with the help of Body Map and Standard Nordic questionnaire (Kourinka et al, 1987) along with frequency and severity of pain among 150 women weavers of both organized and unorganized sectors. With the help of body map it was found that 95%

of the weavers reported pain in the neck and back. Of the upper limbs, 78% of them reported of having pain in the shoulder, 85% in the upper and lower arms and 77% in the wrist area. Whereas in the lower limbs 89% of the weavers reported pain in the ankle and foot, 83% in the knees and 87% in the thighs (Fig 2).

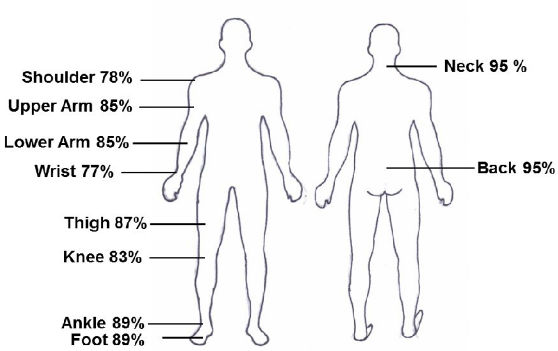

Fig 2: Percentage of pains in different body parts

Neck, back, hand, ankle and foot are the most affected areas where more than 80% weavers reported of having pain "always" followed by shoulder, wrist and knees where 70% and more weavers reported of having "always" pain shown in the following (Fig3). From reported frequency of pains and from pains in different body segments with the help of body map it was found that neck, back, hand and lower leg are mostly affected regions to perform weaving which was further tested with the help of severity of pain sensation. To understand severity of pain, the body is categorized into four segments - neck, back, upper limb and lower limb which helped to understand which body segment is mostly affected. Reporting of the weavers revealed, maximum weavers were having acute pain at back and lower limbs which was due to improper seat design.

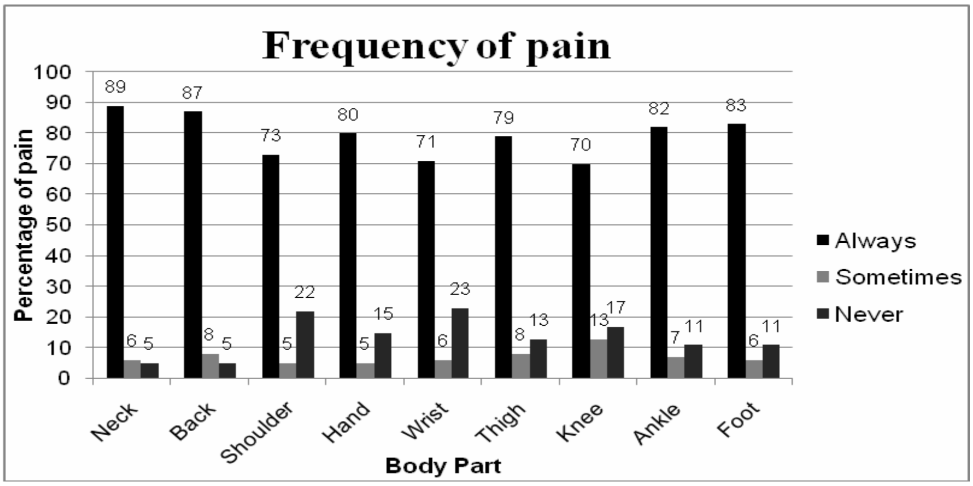

Fig 3: Frequency of Pain

Discussion with different management bodies of both organized and unorganized sectors brings out that with advent of commercialization assistive technological interventions have been introduced in different handloom pockets. With introduction of Jacquard reported incidence of neck pains is gradually reducing among the weavers. Crank for beating and flying shuttle for picking also reduces incidence of upper limb pains among handloom weavers of Assam. But no documented studies on approach of seat design for reduction of back pain have been found till date in the handloom industry of Assam. Keeping this in view, ergonomic principles of seat design have been initiated in the present study, with an objective to reduce adverse effect of long hours of sitting posture for commercial production..

Phase 2: Design Development and Evaluation Phase

Based on the subjective evaluation and feedback from the users and experts, four criteria's were studied for the plank design, adjustable seat height, seat depth, forward tilt at different inclinations and plank with and without back support. To arrive at a comfortable seat design, static anthropometric dimensions followed by dynamic dimensions were considered to execute weaving task (Chakrabarti D., 1997). Three different adjustable seat heights was considered based on popliteal height taking pedal as reference point.25 cm is the height of the pedal from floor where foot rests.0^0, 5^0,10^0,15^0 degree plank angles wasstudiedto derive at the final plank design. Seat depth was decided based on the feedback of the users.3 different seat heights were:

95th percentile

[popliteal height = 44.1]

then (44.1 + 25) cm = 69.1 cm ≈ 70 cm

50th percentile

[popliteal height = 40]

then (40 + 25) cm = 65 cm

5th percentile

[popliteal height = 36.5]

then (36.5 + 25) cm = 61.5 cm ≈ 62 cm

With discussion with the weavers and experts backrest was incorporated with the plank so that weavers can use it whenever required (Fig 5).Rare portion of the plank was set with 3 inclinations to understand which level of inclination is comfortable for pedaling, This is done by placing 3 angles (0^0, 5^0, 10^0, 15^0) made of wood at the base of the plank of the loom seat frame which is shown in CAD drawing (Fig 4).

According to the feedback of the weavers and experts, depth of the plank is increased from 13-15 cm to 24 cm (Fig 9 B to B1) and was found correct by 89% weavers while 87% weavers felt existing plank to be too narrow (Fig 8). 1/4 of the front of the plank was given 0-3 degrees front slope which is again been curved to reduce pressure beneath the thigh muscle while peddling (Fig 9 A to A1). 3/4 of the seat was given a slight backward slope of 2 degrees (Fig 9 A to A1). Adjustable backrest was added to the modified plank design so that weavers can adjust it as per their requirements and can take rest when required (Fig 9 C to C1). From subjective assessment among 50 weavers on simulated loom in the laboratory, it was found that 62% weavers preferred no seat slope, 35% preferred 5^0 forward slope and only 3% of them goes for 10^0 forward slope (Fig 6). Comparing between existing and modified plank it was found 79% weavers felt modified plank to be quite comfortable than the existing one (Fig 7).

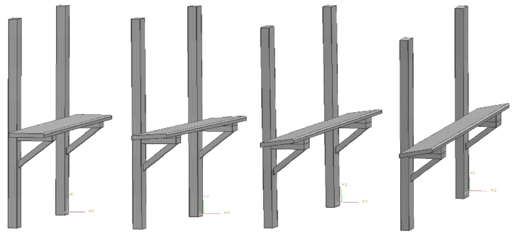

Fig 4: Different plank inclinations

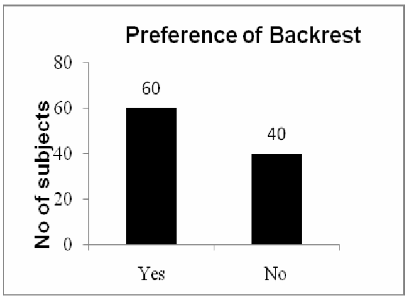

Fig 5: Preference of backrest by weavers

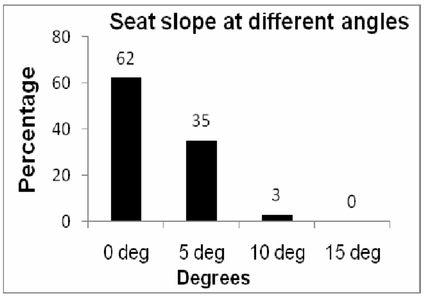

Fig 6:- Preference of seat slope

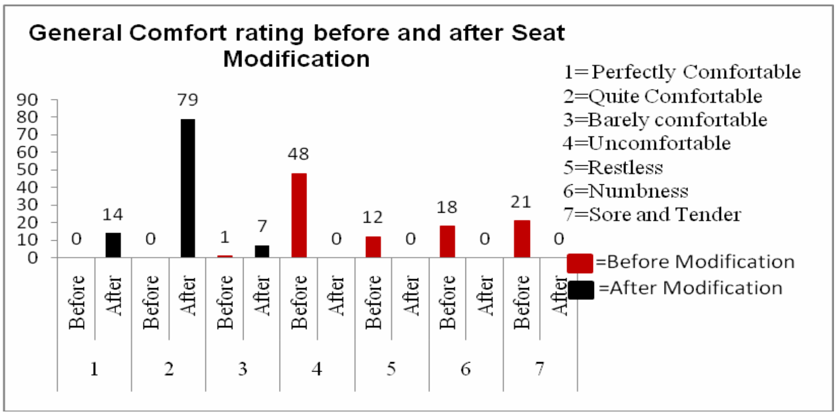

Fig 7: Comfort level of Seat Design

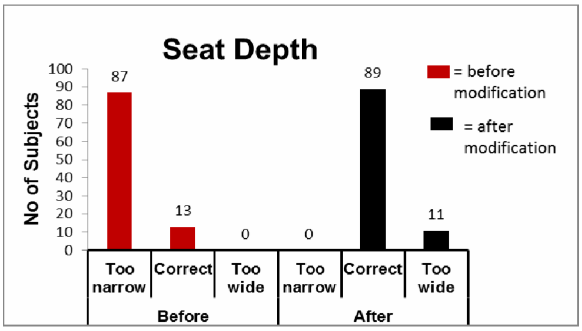

Fig 8: Design evaluation of seat Depth before and after plank modification

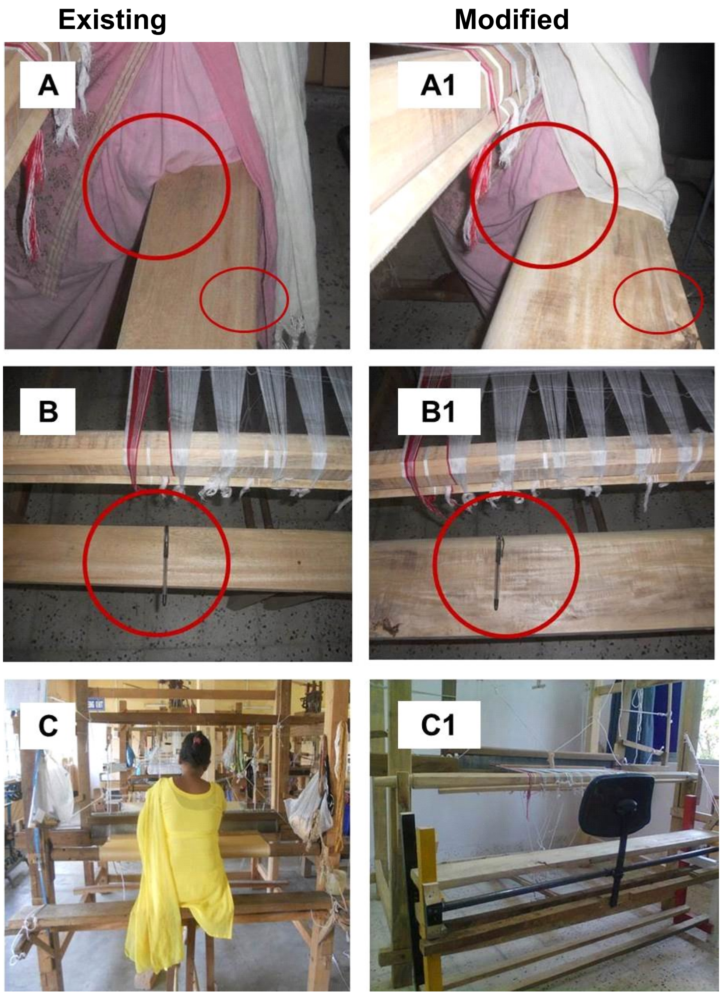

Fig 9: Existing and Modified Plank design

DISCUSSION

The study prevails that high prevalence of back and lower limb pains among the weavers was due to poor ergonomic seat design. Present study concentrates on Kamrup district of Assam which is known for commercial production (Chakravarti et al 2010). However, the study reveals that seating posture cannot be altered in handloom weaving as it is "task defined". Modification of seat might be effective in reducing harmful effect of long hours of sitting for commercial production. Forced forward bend sitting due to beating and inspection task of thread breakage might be attributed to the high incidence of back pain. It was observed that due to minimum body support by the seating surface, weight of the upper body is maintained by isometric contraction of back muscles leading to fatigue and development of back pain. Non-adjustable seat height restraints the weavers due to anthropometric and physiological constraints and increases risk of back and lower limb pains. With raised plank height weavers had to stretch their legs maximally for pedaling which added risk of stress in the lower limbs. Social and psychological factors responsible for development of muscular pain among women weavers were not considered in the present study.

After design intervention of the modified plank it was found with comfort, discomfort rating that most of the weavers felt modified plank quite comfortable. They felt introduction of back-rest was effective after long period of forward bend posture for motif formation or maintaining warp threads or upright sitting during continuous weaving. With modification in the depth and front edge of the plank the weavers reported of absence of numbness and sore and tenderness in the posterior thigh muscles and lower limbs. Large number of women weavers 62% (Fig-6) did not prefer plank inclination due to lack of firm foot support for pedaling as their attire (Meghla Chader) mostly synthetic, increases the risk of slip and fall.

Furthermore, the weavers participated in the study found modified plank good and reported comfort and they believed modified design to be better than the existing one. It indicates that the weavers felt ergonomic intervention has improved their workstation. In this study, seating surface of the weavers was improved considering ergonomic principles in seat design.

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REFERENCES

1. Axelsson JRC (2000). Quality and ergonomics – towards successful integration. Doctoralthesis, Dissertation No 616, Quality and Human Systems Engineering, Linköping University, Linköping.

2. Bernard BP (Ed.) (1997).Musculoskeletal disorders and workplace factors. A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back.National Institute for Occupational Safety and Health (NIOSH), Cincinnati, OH.
3. Borg G (1998).Borg's Perceived Exertion and Pain Scales. Human Kinetics, Champaign, IL 104.
4. Chaff'm, DB (1974). Human strength capability and low back pain.Journal of Occupational Medicine*,* 9: 248-254.
5. Chaffin DB,Andersson, GBJ (1990). Occupational Biomechanics, second ed. Wiley, New York.
6. Chakrabarti D (1997). Indian Anthropometric Dimentions for ergonomic Design Practices, National Institute of Design: 53-60.
7. Chakravorty R,DuttaP and Ghose J (2010).Sericulture and traditional craft of silk weaving in Assam. Indian Journal of Traditional Knowledge, 9 (2): 378-85.
8. Corlett EN, Bishop RP (1976). A technique for assessing postural discomfort. Ergonomics,19 (2): 175–182.
9. Drury CG,Conry BG(1982). A methodology for chair evaluation.Applied Ergonomics, 13: 195-202.
10. EklundJ, (1995). Relationships between ergonomics and quality in assembly work. Applied Ergonomics, 26(1): 15-20.
11. Fogleman M., Lewis RJ (2002). Factors associated with self-reported musculo-skeletal discomfort in visual display terminal (VDT) users. Int. J. Ind. Ergon. 29: 311-318.
12. Grandjean E (1988). Fitting the Task to the Man. Taylor & Frances, London.
13. Hartvigsen J, Leboeuf-Yde C, LingsS, CorderEH(2000). Is sitting-while- at work associated with low back pain? A systematic, critical literature review. Scand. J. Public Health 28(3): 230-239.
14. Kourinka I,Jonsson B, Kilbom A, Vinterberg H, Biering-Sorenson F, Anderation G, and Jorgensen K (1987). Standard Nordic Questionnaire for analysis of Musculo-skeletal symptoms. Applied Ergonomics, 18: 233-237.
15. KraemerJ, Kolditz D, Cnxiwin R (1985). Water and electrolyte content of human intervertebral discs under variable load. Seine. 10: 69-71.
16. Lis AM, Black KM, Korn H, Nordin M (2007). Association between sitting and occupational LBP. Eur. Spine J. 16 (2): 283–298.
17. Magora A(1970).Investigation of the relation between low back pain and occupation.IndusMedSurg*,* 39:504.
18. Mork PJ, Westgaard RH (2009). Back posture and low back muscle activity in female computer workers: a field study. ClinBiomech, 24 (2): 169–175.

19. Nag A, Vyas H, Nag PK (2010). Gender differences, Work stressors and Musculoskeletal Disorders in Weaving Industries. Industrial Health, 48: 339-348.
20. Nakazawa T, Okubo Y,Suwazono Y, Kobayashi E, Komine S, Kato N, Nogawa K (2002). Association between duration of daily VDT use and subjective symptoms. Am. J. Ind. Med. 42: 421–426.
21. Sanders MS,McCormic E J (1993).Human Factors in Engineering and Design.McGraw-Hill, New York.
22. Smith A P, Jones D M (1992). Noise and performance. In A. Smith & D. Jones (Eds.), Handbook of Human PerformanceAcademic Press, San Dieg, Vol 1 pp. 1-28.
23. Van wely P(1970). Design and disease, Applied Ergonomics 1:262-269.
24. Wilder DG, Pope MH, Frymoyer JW, (1988). The biomechanics of lumbar disc herniation and the effect of overload and instability. J. Spinal Disord. 1: 16–32.