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Determination of The Highest Permissible Spinal Shrinkage

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Abstract: The main aim of this study was to establish the highest permissible spinal shrinkage when under any working conditions. The spinal lengths of human subjects were measured in the morning while the strain at failure during compression was obtained from the literature. The study calculated the permissible spinal shrinkage to be 0.021m and thus suggested that this shrinkage should not be exceeded if back pain attributable to workloads is to be largely controlled.

Key words: Spinal Shrinkage, Spine, Workloads, Back Pain, Occupational Injury

INTRODUCTION

Low back pain is one of the leading causes of occupational injury and disability in both developed and developing countries (Mazloum, Adel 2006; Ismaila, S.O. 2006). also observed that spinal disorders at the lumbar vertebrae have caused excruciating pain to many industrial workers, permanent disability to some and heavy losses to industries. Similarly,(Johannig, E., 2000) reported that work related back pain as a result of injury or repeated activities accounted for about 53percent of self reported injuries. Also, (Yamamoto, S., 1997) reported that in 1996, the number of Low back pain cases in Japan accounted for 60percent of officially recognized cases of occupational diseases. Moreover,(Johannig, E., 2000) and (Byrns, G., *et al*, 2002) noted that the prevalence of low back pain was highest between the ages of 32 and 55 years and there was no significant in gender differences.

The high incidence of low back pain and its associated cost as compared to other musculoskeletal disorders (Webster, B.S., S.H. Snook, 1994) prompted a lot of studies channeled towards reducing the risk of low back pain or disorders. Work related factors such as load lifting and body posture contributes to low back pain(Mazloum, Adel 2006).

But load on the spine as a result of work undertaken has been confirmed to be responsible for spinal shrinkage(Ismaila, S.O., O.E. Charles-Owaba, 2006; Reilly, T., D. Chana, 1994; Deursen van, L.L.,*et al,* 2005). It was noted by (Wallace, P., T. Reilly, 1993). that changes in stature during physical activity reflect the alterations in spinal column length due to loading (Reilly, T., D. Chana, 1994). observed that spinal shrinkage reflects the creep behaviour of the intervertebral and vertebral end-plate compression when loaded while (Au, G., J. Cook, S.M. MGill, 2001). confirmed that twisting task demonstrated significant spinal shrinkage compared to lateral bend and flexion tasks. Spinal shrinkage during a seated break and standing break during simulated nursing tasks was studied by (Beynon, C., T. Reilly, 2001). They concluded that spinal shrinkage was significantly less during the seated trial than the standing trial and suggested a seated break during nursing shift to reduce the potential of suffering back problems resulting from spinal loading (Bourne, N.D., T. Reilly, 1991). opined that spinal loading during weight lifting results in a loss of stature (spinal shrinkage). Spinal shrinkage during work in a sitting posture compared to work in a standing posture was investigated by (Leivseth, G., B. Drerup, 1997). and they opined that the major gain in stature occurred in the lumbar spine. The spine may be prone to injuries if the load or its frequency exceeds the tissue threshold or tolerance. In fact, (Mc Gill, S.M., 1997). noted that failure of spinal tissues may be as a result of a sub-maximal load through fatigue. (Kumar, S., A. Mital, 1992). observed that though pain is a physiological mechanism for ensuring safety but every injury is a mechanical disorderliness or disturbance of normality associated with such episodes. They stated that if biomechanical safety can be maintained for spinal segments and elements, the problem of low back pain could be largely controlled.

Moreover, (Chaffin, D.B., G.B.J. Anderson, 1991). confirmed that greater workloads increase mechanical stress (and thus strain) to the cause of low back.

Though, previous studies confirmed that spinal shrinkage was a as result of load on the spine based on the kind of work undertaken, there was the need to determine the limit of this shrinkage to provide a basis for the determination of what constitutes a safe workload for workers. In fact, (Ismaila, S.O., O.E. Charles-Owaba, 2006). suggested the need to determine a limit of spinal shrinkage to provide a basis to determine safe workloads for humans. This study was actually conceived to determine this limit of spinal shrinkage.

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MATERIALS AND METHODS

Experimental samples consisted of 84 male subjects randomly chosen from three locations namely a building site, a factory and a market place. The ages of the subjects were between 18 and 57 years with a mean of 36.6 years and a standard deviation of 8.32years.

The spinal lengths were measured in the morning before the start of work with a meter rule from the first thoracic (T_1) to the lumbar (L_5). The subjects were asked to stand erect while the measurements were read from the meter rule. (Eckstein, F., *et al*, 2005). determine patellar cartilage deformation after knee bends as 0.059, squatting as 0.047, walking as 0.028, running 0.05, cycling as 0.045 and high impact loading as 0.07. Similarly, (Barker, M.K., B.B. Seedhom, 2001) established that elastic strain of knee articular cartilage varied exponentially and was between 0.18 and 0.36 for a compressive modulus of less than 3.1MN/m^2. However, for stiffer specimens with compressive modulus of 16.8 MN/m^2, they obtained the strains to be between 0.05 and 0.13. None of these studies on strains of human cartilages (articular or costal) except (Kenedi, R.M., *et al,* 1966). to the authors' knowledge were yet to determine the strains at fracture or the yield point. (Kenedi, R.M., *et al,* 1966). confirmed that the Young Modulus of Elasticity in the linear region of the stress curve of the human articular cartilage to be 16 MN/m^2. Failure of the cartilage in tension occurred at a strain of 0.08.

In order to determine the highest permissible spinal shrinkage, the Stress-Strain curve by (Kenedi, R.M., *et al,* 1966) was used to obtain a strain at which failure may occur on the cartilage during compression. (Figure 1). The articular cartilage (at the spine) had an initial Young Modulus of Elasticity of 2.4MN/m^2 while that of the costal cartilage was 7.8 MN/m^2, under the same loading condition, the costal being more rigid should sustain a greater stress than the articular. However, the articular cartilage should sustain a higher strain since strain is inversely proportional to stiffness (Young Modulus of Elasticity). The lesser strain seems adequate for proper design. Therefore, the strain of the costal cartilage at failure (at yield point) during compression was used to determine the highest permissible spinal shrinkage.

From Figure 1, the cartilage fails during compression at a strain value of 0.04. This strain was therefore used to establish the highest permissible spinal shrinkage.

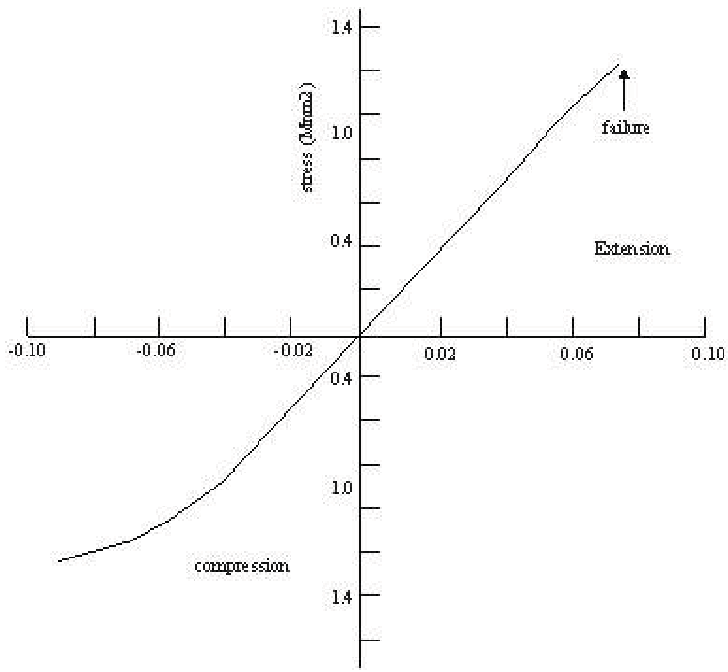

Fig. 1: Stress-Strain Curve Of Human Costal Cartilage. Source: (Kenedi, R.M., *et al,* 1966).

Determination of Maximum Permissible Spinal Shrinkage:

$$\text{Strain} = \frac{\text{Change in Length}}{\text{Original Length}}$$

In this particular case,

$$\text{The Strain at the Spine, } \varepsilon = \frac{\text{Spinal Shrinkage, } x}{\text{Spine Length, } L}$$

From the study, the average spine length, L was 0.0523m and the strain was obtained as 0.04.
Therefore, Spinal Shrinkage, $x = \varepsilon \times L = 0.04 \times 0.0523$
$= 0.021\text{m}$

RESULTS AND DISCUSSION

The value of 0.021m obtained for the maximum permissible spinal shrinkage compare favourably with a value of 0.025m obtained as the highest spinal shrinkage by (Ismaila, S.O., O.E. Charles-Owaba, 2006) for workers who engaged in lifting. Alan Hedge of Cornell University in 1990 also reported that the spine could shrink approximately 0.022m.

Though discs may fail when compressed in flexion (Adams, M.A., W.C. Hutton, 1982). but it could also be as a result of cascade initiated by the failure of the endplate (cartilage at the spine) as noted by (Adams, M.A., B. Freeman, 2000). More importantly, the vertebral endplate appears to be the tissue most likely to experience initial failure (Brown, T., R.J. Hansen, 1957). If the issue of this cartilaginous endplate is adequately addressed, then the issue of slipped discs or spinal pain as a result of exceeding its threshold can be taken care of. It is expected that human beings should not be given a job that may necessitate compression of the spinal shrinkage to be more than 0.021m as this may result in spinal compression fractures of the endplate. The fact that one did not notice or experience serious pain after exceeding the stated spinal shrinkage may not be an indication that a problem has not occurred. The symptoms of spinal fractures may vary between individuals. In fact, (Haines, Cynthia, 2005) noted that it might not be everyone that may feel a clear-cut spinal pain when a fracture occurs. In some cases, there is virtually no pain involved such that as fractures occur gradually, the pain may be relatively mild and unnoticeable. For some, it may result in chronic back ache in the injured area and in some gradual curving of the spine may be an indication that multiple fractures have occurred. Additional load even after initial fracture has occurred and no pain was noticed may result in more fractures and chronic pain in the affected area.

Conclusion: On the basis of the current investigation, the main conclusion that can be drawn is that any work embarked upon should give a spinal shrinkage of not more than 0.021m. If this is adhered to strictly, the issue of back pain due to workloads may be controlled in the workplace. Though the present study was based on the reasoning of the authors that the data of costal cartilage should govern the design, further work may need to done when data on articular cartilage of the spine is available.

REFERENCES

Mazloum, Adel, Nozad, Hojjatollah, Kumashiro, Masaharu, 2006. Occupational Low Back Pain Among Workers in Some Small-Sized Factories in Ardabil, Iran. Industrial Health, 44: 135-139.

Ismaila, S.O. 2006. Post Work Height Shrinkage Based Model for Predicting a Safe Weight of Lift. PhD Thesis, University of Ibadan, Ibadan Oyo State, Nigeria.

Johannig, E., 2000. Evaluation and Management of Occupational Low Back Disorders. Am J Ind Med., 37: 94-111.

Yamamoto, S., 1997. A New Trend in the Study of Low Back Pain in Workplaces. Industrial Health, 35(2): 173-185.

Byrns, G., J. Agrew, B. Curbow, 2002. Attriburions, Stress, and Work related low back pain. App Occup Environ Hyg, 17: 752-64.

Webster, B.S., S.H. Snook, 1994. The cost of 1989 worker's compensation low back pain claims. Spine, 19: 1111-1116.

Ismaila, S.O., O.E. Charles-Owaba, 2006. Effects of Type of Work and Age on Spinal Shrinkage. Journal of Applied Science, Engineering and Technology, 6(1): 8-15.

Reily, T., K.A. Freeman, 2006. Effects of loading on Spinal Shrinkage in Males of Different Age Groups. Applied Ergonomics, 37(3): 306-310.

Deursen van, L.L., D.L. Deursen van, C.J. Snijders, H.J. Wilke, 2005. Relationship between Everyday Activities and Spinal Shrinkage as a Parameter of Functional Load of the Human Spine. Spine, 18: 1504-1515.

Wallace, P., T. Reilly, 1993. Spinal and Metabolic loading during simulations of golf play. J Sports Science 11, 6: 511-515.

Reilly, T., D. Chana, 1994. Spinal shrinkage in fast bowling. Ergonomics, 37(1): 127-132.

Au, G., J. Cook, S.M. MGill, 2001. Spinal shrinkage during repetitive controlled torsional, flexion and lateral bend motion exertions. Ergonomics, 44(4): 373-381.

Beynon, C., T. Reilly, 2001. Spinal shrinkage during a seated break and standing break during simulated nursing tasks. Applied Ergonomics, 32(6): 617-622.

Bourne, N.D., T. Reilly, 1991. Effect of a Weightlifting belt on Spinal shrinkage. British J. Sports Medicine, 25(4): 209-212.

Leivseth, G., B. Drerup, 1997. Spinal shrinkage during work in a sitting posture compared to work in a standing posture. Clinical Biomechanics, 1234(7-8): 409-418.

Mc Gill, S.M., 1997. The biomechanics of low back injury: implications on current practise in industry and the clinic. Journal of Biomechanics, 30: 465-475.

Kumar, S., A. Mital, 1992. Margin of Safety for the Human Back: A parableconsensus based on Published Studies. Ergonomics, 35(7/8): 769-781.

Chaffin, D.B., G.B.J. Anderson, 1991. Occupational Biomechanics. John Wiley and Sons. New York (2nd ed).

Eckstein, F., B. Lemberger, C. Gatzke, M. Hudelmaier, C. Glaser, K.H. Englmeier, M. Reiser, 2005. In vivo cartilage deformation after different types of activity and its dependence on physical training status. Ann Rheum Dis., 64(2): 29-5.

Barker, M.K., B.B. Seedhom, 2001. The relationship of the compressive modulus of articular cartilage with its deformation response to cyclic loading: does cartilage optimize its modulus so as to minimize the strains arising in it due to the prevalent loading regime? Rheumatology, 40: 274-284.

Kenedi, R.M., T. Gibson, C.H. Daily, M. Abraham, 1966. Mechanics of Human skin and cartilage. Proc Fed Am Soc Exp Biol., 25: 108-1087.

Adams, M.A., W.C. Hutton, 1982. The effect of posture on the role of the apophyseal joints in resisting compressive force. J Bone Joint Surg, 62B: 358-362

Adams, M.A., B. Freeman, H.P. Morrison, I.W. Nelson, P. Dolan, 2000. Mechanical initiation of intervertebral disc degeneration, Spine, 25: 1625-1636.

Brown, T., R.J. Hansen, A.J. Yorra, 1957. Some Mechanical Tests on the Lumbosacral Spine with Particular Reference to the Intervertebral Disc J Bone Joint Surg, 39A: 1135-1164.

Haines, Cynthia, 2005. Your Guide to Spinal Compression Fractures from. www.webmd.com\content\article\111\110111.htm.Accessed on August, 16: 2006.