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ERGONOMICS IN BED DESIGN

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Abstract

This study investigated how spine support affects sleep in healthy subjects, finding that the relationship between bedding and sleep quality is affected by individual anthropometry and sleep posture. In particular, results indicate that a sagging sleep system negatively affects sleep quality for people sleeping in a prone or lateral posture.

Introduction

Although the domains of both sleep research and ergonomics are rapidly expanding, it is surprising to learn how little research is at hand that combines the knowledge of both disciplines. A key issue in the design of current, state of the art sleep systems (i.e. mattress and supporting structure) is how the optimization of bed design affects the manifestation of sleep in healthyhuman beings. Whereas some research is available on the influence of the mechanical characteristics of mattresses and supporting structures on spinal alignment (Lahm and Iaizzo 2002, DeVochtet al. 2006), very few ergonomists perform actual sleep registrationsto test whether their findings have an effect on how people sleep. Additionally, the available research that looks at sleep quality on different bedding systems remains very vague on the actual bed properties, using terms such as soft, firm, medium-firm, (un)comfortable, etc. without further specification (Bader and Engdal 2000, Lee and Park 2006, Jacobson et al. 2008, 2010). This lack of quantification makes itDifficult to compare and interpret results.

The main function of sleep systems is to support the human body in a way that allows the muscles and intervertebral discs to recover from nearly continuous loading by day (Nachemson and Elfstro¨m 1970).

The main function of sleep systems is to support the human body in a way that allows the muscles and intervertebral discs to recover from nearly continuous loading by day (Nachemson and Elfstro¨m 1970). This recovery can beachieved when the shape of the spine is in its natural physiological shape, yet with a slightlyflattened lumbar lordosis due to the changed working axis of gravity (Dolan et al. 1988). In general, the mechanical characteristics of a sleep system should account for two anthropometrical aspects: body contours and weight distribution. Since both of these factors are highly individual, the allocation of an appropriate sleep system to a specific person should be done on a personalized basis(Haex 2004). Furthermore, the body contours that are in contact with the mattress surface are dependent on the adopted sleep posture.

Because healthy sleep requires the presence of several major posture changes throughout the night (De Konincket al. 1992, Coenen 2006), the ideal sleep system should be able to cope with these variable loading conditions; for instance, by changing its characteristics according to the adopted posture at any moment during the night (Verhaertet al. 2009). The objective assessment of a sleep system's support qualities is generally done by evaluating either contact pressure or spinal alignment.

Methods

Altogether, 17 subjects (nine males, eight females; age 24.3+7.1 years) were recruited through advertisement. Inclusion criteria were a regular sleep–wake schedule and a good general health condition. According to the Pittsburgh Sleep Quality Index (Buysseet al. 1989) and a sleep diary, all subjects were normal sleepers and did not suffer from insomnia. Exclusion criteria were medical problems that can interfere with normal sleep, e.g. intake of sleep medication, antidepressants, any form of back pain. All subjects signed an informed consent. The study was approved by the Ethics Committee of the Vrije Universiteit Brussel.

Procedure

Prior to the actual sleep experiments, the subjects underwent an anthropometric screening. The purpose of this screening was to determine the sleep system170 V. Verhaertet al. Downloaded by [K.U.Leuven - Tijdschriften] at 01:30 03 September 2012 configuration for each of the subjects that best matched their individual body dimensions and to objectively validate the effect of both experimental conditions on spinal alignment. In order to provide both a personalized and a sagging support for a variety of people, sleep systems with an adjustable stiffness distribution were used (Dyna Sleep; Custom8, Leuven, Belgium). The mattress core of these systems consists of pocket springs and comprises 10 comfort zones. Eight of these comfort zones can be separately adjusted in stiffness by applying a vertical displacement of the zones' spring bases, effectively creating positive or negative preloads.

The reference condition consists of an individualized sleep system configuration that minimizes spinal deformation in a lateral sleep posture (i.e. when the spine approximates a straight line in the frontal plane).

A lateral posture was considered because it is the most commonly adopted sleep posture in the Western world (approximately 60% of time in bed is spent in a lateral sleep posture) (Haex 2004). Furthermore, this corresponds to how most modern sleep systems with comfort zones are designed at present (Coenen 2006).

The induction consists of a configuration with arelatively high stiffness of the shoulder zone and a relatively low stiffness of the waist and hip zones compared to the reference condition. This simulates a homogeneous sleep system that is worn down and suffers from sagging of the most load-bearing zones.Subjects were blinded from the experimental conditions to eliminate expectation effects. A night in the sleep laboratory consists of approximately 8 h in bed: subjects entered the sleep laboratory at 19.00; bedtime was between 22.30 and 23.30; subjects were awakened at 07.00 hours. In theevening, they were allowed to engage in recreational activities, such as watching television, reading and conversation. No caffeinated drinks or heavy meals were allowed. Subjects completed the sleepiness, stateof arousal and mood scales at 22.15 and 07.20 hours.

Measurements and analysis

Anthropometric screeningDuring anthropometric screening, the following series of measurements was conducted. First, a set of 29 × 1-D body measurements was collected by means of a calliper and a tape measure. Height, width and circumference were measured on the following anatomical sites: acromion; shoulder; breast; waist; pelvis;hip; crotch. An additional depth measure was taken on the acromion, shoulder, breast, waist and pelvis sites.

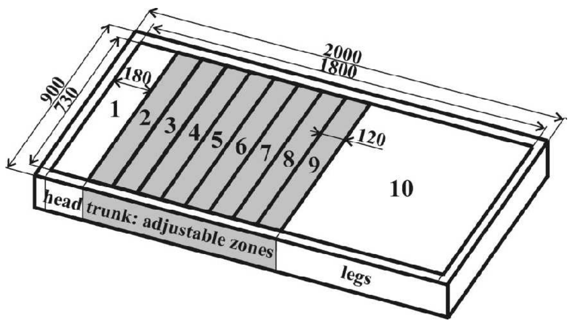

Figure1. Dimensions (mm) and locations of the sleep

System's stiffness zones

Objective and subjective sleep measuresThe subjects underwent three full night polysomnographic recordings (DREAM; Medatec, Brussels, Belgium). Electrodes were attached according to the standardised 10–20 system of electrode placement (Jasper 1958) at the F3, C3, O1, F4, C4 and O2 positions, together with electrooculography, sub mentalelectromyography and electrocardiography. Furthermore, video frames and chest orientation were recorded in order to determine the adopted sleep postures during the night.

Statistical analysis

First, all grouped data were tested for normality using Lilliefors' adaptation of the Kolmogorov Smirnov test (Lilliefors 1967). Normal distributions were analysed using parametric repeated measures ANOVA. For non-normaldistributions, non-parametric Friedman ANOVA was performed. Subjective data were analyzedusing non-parametric Friedman ANOVA because of the ordinal nature of the subjective scales. Unsupervised cluster analysis based on the k-means algorithm (Mac Queen 1967) was performed to partition the data on sleep postures into different categories. The amountof clusters was determined by means of clustersilhouettes (Rousseeuw 1987). The squared Euclidean distance was used as distance measure to perform the k-means clustering and to calculate silhouette values. Both experimental condition (personalized vs. saggingsupport) and the amount of time spent in each posture (cluster A vs. cluster B) were considered as independent factors in the statistical analysis of the results of the sleep experiments.

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