Human-Bed Interaction: A Methodology and Tool to Measure Postural Behavior during Sleep of the Air Force Military

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Abstract. The behavioral and postural habits and sleep rhythm of air force military change depending on the specialty work at the airbase or other types of events but we did not find anything in the literature to analyze and evaluate this behavior through sleep disorders. Perhaps this is related to the fact that the evaluation of this behavior is complex and the observation of these postural behaviors in the environmental context is needed. However the observation methodology based on ISEE software [9] allows the classification and registration of postural behaviors for long periods of time and can be applied in this context. This paper presents a study whose objective was to research the human interaction with postural behaviors during sleep in the residences' bedrooms of male air force military during the periods in which the subjects were asleep, awake, out of bed, doing activities, using a pillow in different time periods and with ecological validation with observation method and Visual Analogical Scale (VAS). A sample of 8666 observations, which corresponds to 240 sleep-hours of 12 air force military, was classified into six (6) Interaction Categories (IC). The results show that 50,2% of the participants presented the Lateral position (25,38% on the left and 24,86% on the right) as the most common postural behavior during sleep and 94,1% used only one pillow under their head. In the IC´s, the most common interactions were sleep period using the pillow with 66,47%, followed by category Out of bed with 25,32% and followed the category the activities and using the pillow with 6,95%. Findings of this study allow suggesting what graphical interface designers must seek as new strategies and solutions for behavior change in posture in bed, exploring other peripheral equipment for sleep position; or, at least, to improve the posture of the participants when using the number and the placement of the pillow in bed and if these Ergonomic changes can influence the reduction in back pain indications.

Keywords: sleeping position, air force military product interaction, health care professionals procedures, back pain, ISEE.

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1 Introduction

Video analysis has been used in many areas, especially in the sociology field that traditionally uses observation theory techniques ([15]; [21]; [26]; [19]). Posture, according to Silva et al. [20], is considered to be the biomechanical alignment and the spatial arrangement of body parts in relation to their segments. The risk of back pain is due to a multi-factorial nature, being that poor posture is one of these factors ([20]; [27]; [11]). Many young adults have occasional sleep disorders and the pain may be one of the factors that cause them. However, in some cases, these problems can become chronic, causing serious consequences in their behavior and their quality of life [18]. The risk of back pain is due to a multi-factorial nature, being that poor posture is one of these factors ([20]; [27]; [11]). Posture, according Silva et al. [20], is considered to be the biomechanical alignment and the spatial arrangement of body parts in relation to their segments.

Back pain (BP) is one of the most common forms of chronic pain and is a significant cause of disability and cost in society ([17]; [1]; [28]). Chronic BP substantially influences the capacity to work and has been associated with the inability to obtain or maintain employment and lost productivity ([22]; [24]).

Musculoskeletal back pain, are the most common reasons for medical evacuation in military with return to occupation being uncertain. BP is also a common reason for long-term Soldier disability ([4]; [3]; [16]).

The behavioral and postural habits and sleep rhythm of air force military change depending on the specialty work at the airbase or other types of events but we did not find anything in the literature to analyze and evaluate this behavior through sleep disorders. Perhaps this is related to the fact that the evaluation of this behavior is complex and the observation of these postural behaviors in the environmental context is needed. However the observation methodology based on ISEE software [9] allows the classification and registration of postural behaviors for long periods of time and can be applied in this context.

The complexity of some newer product interactions in complex context systems demands a higher level of user performance and involves risk that may possibly negatively impact the user's safety and health. For this reason, the evaluation or design of new products used in complex systems requires extensive knowledge of human interaction, including the operation and vulnerabilities of the whole system. Therefore, taking this into consideration, the use of video analysis increases the capability to collect more detailed information on human activity during the interaction of the user with a product-environment system. With this data comes increased understanding of user strategies and awareness of possible safety and health issues as well as system dysfunctions [19].

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In a general way, the data regarding the sleep analysis is collected in simulated laboratory conditions. Although these kinds of studies interfere with the tasks and with the natural behaviors in the sleep period, they have some advantage such as: an accurate control of variables, a high potential to collect physiological measures and the accuracy of data collected, mainly the quantitative data ([5]; [7]; [10]).

Handrick & Kleiner [13] argue that the main element for a good ergonomic analysis of the activity is to adopt a systemic approach of activity through the analysis of all possibilities of interactions in a real context.

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Recently, with the technological advances of digital video equipment and computers, associated with low costs, video analysis is being routinely used in human behavior research. Video analysis usage makes multiple revisions possible, thereby allowing the collection of detailed information that would be impossible to collect in field studies involving only the researcher's visual memory. In this case, the use of a single source of observation (visual memory) may cause losses due to memory lapses and potential interpretation difficulties. It is, however, important to point out that for the ergonomist, the exclusive use of video analysis is not a substitute for traditional tool usage in ergonomic analysis. In addition, some aspects, such as user interpersonal relations, environmental issues, and macro-ergonomic data, are also important in analyzing product quality [19]. In order to minimize the difficulty in applying these experimental methods in real context, researchers combine some objective with subjective techniques, which generally are qualitative such as questionnaires, interviews and direct/indirect activity observation. Usually, this approach is also related to the interpretation and evaluation of the comfort or discomfort that is experienced through users testimony and the understanding of the real activity through self-report ([9]; [2]; [8]; [25]). In this context, the main objective of this study is apply systematic observations of the motor behaviors with the equipment of residence bedrooms in the Portuguese air force through digital video recording using a methodology proposed by Rebelo, Filgueiras & Soares [19], to understand the human interaction with postural behaviors during sleep of male air force military during the periods in which the subjects were asleep, awake, out of bed, doing activities, using a pillow, in different time periods and with ecological validity.

This knowledge will allow to: a) understand the possible origin of incidence of back pain referred in the day-by-day activities; and, b) elaborate more specific recommendations to the changes in postural behaviors and products' development. However, for this paper we will only present the results for interaction patterns during the use of a set of specific Interaction Category - IC [19].

2 Methodology

This paper presents a part of a larger study which aims to analyze the relationship between the perception of Back Pain and the sleeping position and is based on the

observation of the human interaction (with Visual Display Terminals [VDTs]) with postural behaviors in bed during the night period (10 hours/night) in the residences' bedrooms of male air force military. We used the same group of equipment and the same model of bed, in order to analyze if there are similar patterns of interaction between users. This study started on the 2nd of September 2013 and finished on the 3rd of October 2013.

Study Site and Residence Bedrooms' Properties. Data was collected from the Portuguese air force military. Twelve soldiers aged between 18 and 25 years, of different categories (1st Corporal, 2nd Corporal or Soldier), residing in dormitories of the air base were selected. The bedrooms were in dormitories with 2 beds in each bedroom with the same type of bed, mattress and pillow.

The Subjects and Night Activities. 134 soldiers (112 male and 22 female), aged between 18 and 25 years, belonged to the air base nº5 of the Portuguese air force when the research began . These, 66 soldiers answered a questionnaire about the perception of pain in the spine according to the Visual Analogue Scale (VAS) and, 12 male (mean=22.17 years old+ 1.749) were volunteers in this study. The soldiers worked in the area of: mechanical aviation material (n = 6), hospitality services and sustenance (n = 2), car driver (n = 1), mechanical, electrical and flight instrument work (n = 1), weaponry and equipment mechanics (n = 1), health service (n = 1). Participants were informed about the study's objective through a group meeting and an individual approach on the day before each video recording. All video collection was authorized by the participants through a consent form. Finally, participants were instructed to perform their tasks as usual and to not change their schedule due to the presence of the cameras.

Recording Procedure and Features. The participants' interactions with the bedroom equipment were video recorded on a normal rest period day and were assessed using: a) one infrared digital camera (Wireless AEE Weather-proof -

2,5 GHz – color); b) one multiplexer video recorder (ACH MPEG-4 Realtime DVR) and c) DVD recorder HD (LG recorder). All devices' lights were turned off or hidden and participants were informed about the placement of all cameras. However, they did not know the real video recording time.

The digital video cameras turned on automatically from 11:00 p.m. to 9:00 a.m. and during the periods in which the subjects were asleep, awake, out of bed, doing activities, using a pillow, they were filmed using one plan (frontal superior) considering the best visualization of the participant and activity (Fig. 1).

In order to ensure similar interaction times in the bedroom and to not interfere in the evening activity and sleep period, all volunteers were filmed during three days during ten hours continuously (starting at 11:00 p.m.). After the filming period for each participant, a quick analysis of the video was done in order to select the best two days, according to the following criteria:

- Longer stay of soldiers in the bed (preferred > 6 hours);
- More than 60% of the video had a good visualization of the postural behaviors during sleep times.

Fig. 1. Images of the first plan (Frontal superior) of the bed Observations

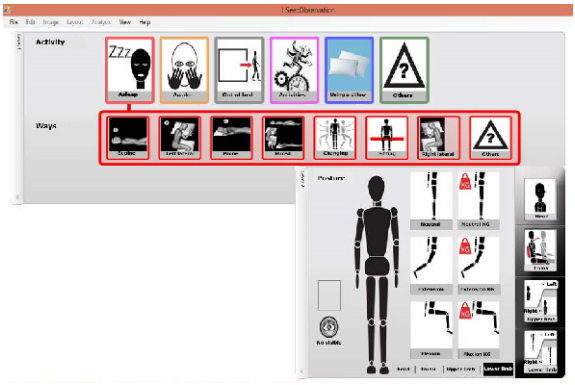


Fig. 2. Functional areas of the ISEE software interface

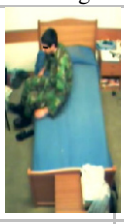
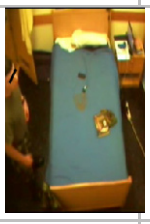
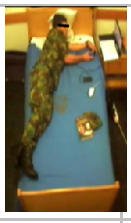
Categories of behaviors					
Base categories			Interaction´s categories		Others
					
Asleep	Awake	Out of bed	Activities	Using a pillow	Other non specific

Fig. 3. Level 1 - Six categories of behaviors

The data, collected through video using a methodology proposed by Rebelo, Filgueiras & Soares [19], analyzed the postural behavior in real situations in bed and was done using software developed for this purpose (Fig. 2). The fundamental aspect of this analysis was the definition of interaction categories of behavior that will be quantified later. Following of the analysis of the results of the previous phases and of the observation of the collected videos, the categories were defined.

Six (6) categories of behaviors were defined, that represent the night activity or posture behaviors in this residences' bedrooms, divided into three base categories, two interaction categories and one other non specific category (Fig. 2, 3 and 4).

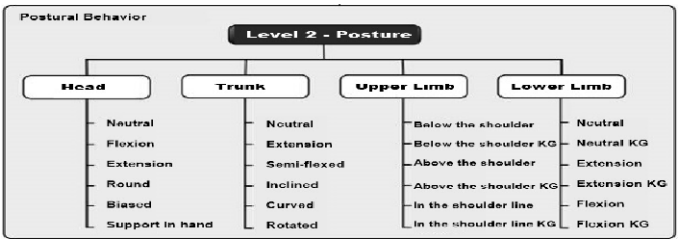


Fig. 4. Level 2 - Postural Behaviors

Table 1 to 6 show the codes and description for ICs "asleep", "awake", "out of bed", "activities", "using a pillow" and "others" groups.

Table 1. Categories, ways and description for asleep group

Category	Ways	Description
Asleep		Period of time when the participant did not have any activity associated to the bed.
	Supine	They were in the supine sleep position with their back in contact with the mattress.
	Prone	They were in the prone sleep position with their frontal trunk in contact with the mattress.
	Left lateral decubitus	They were in the left lateral sleep position with their trunk and hip left side in contact at mattress.
	Right lateral decubitus	They were in the right lateral sleep position with their trunk and hip right side in contact at mattress.
	Mixed position	They were at least two different sleep position at same time with their trunk, hip and shoulder in different contact at mattress.
	Position change	They were a change at sleep position.
	Sitting	They were in the sitting sleep position with their back in contact at pillow and your hip in contact at mattress.
	Other	Any posture activity that represent some kind of specific Category which was not anticipated.

Table 2. Categories, ways and description for awake group

Category	Ways	Description
Awake		Period of time when the participant had activity associated to the bed.
	Supine	They were in the supine sleep position with their back in contact with the mattress.
	Prone	They were in the prone sleep position with their frontal trunk in contact with the mattress.
	Left lateral decubitus	They were in the left lateral sleep position with their trunk and left side hip in contact with the mattress.
	Right lateral decubitus	They were in the right lateral sleep position with their trunk and right side hip in contact with the mattress.
	Mixed position	They were in at least two different sleep position at the same time with their trunk, hip and shoulder in different contact with the mattress.
	Position change	There was a change in sleep position.
	Sitting	They were in the sitting sleep position with their back in contact with the pillow and their hip in contact with the mattress.
	Other	Any posture activity that represents some kind of specific Category which was not anticipated.

Table 3. Categories, ways and description for out of bed group

Category	Ways	Description
Out of bed		Period of time in which the participants are not in bed.
	Standing	They are standing.
	Getting out of bed	They are getting out of bed.
	walking	They are walking.
	out of the picture	They are absent from the picture.
	Other	Any activity that represents some kind of specific Category which was not anticipated.

Table 4. Categories, ways and description for activity group

Category	Ways	Description
Activity		It includes all the activity/action behaviors of a specific task, which interacts with other categories.
	Personal communication	The category "Personal communication" must be activated whenever the participant observes a facial articulation characteristic of an oral or gestural communication, for a period of time greater than or equal to 2 seconds.
	Using the computer	The category "using the computer" should be considerd whenever there is contact of the participant with a computer system.
	Reading	The category "reading" where the position of the participant's head is facing a readable medium (eg., paper, book), for a period of time greater than or equal to two seconds.

Table 4. (*continued*)

	Eating / Drinking	The category " eating / drinking " records all behavior related to eating or handling liquids (drink) or solids (food) for a period of time greater than or equal to 2 seconds.
	Using mobile devices (phone or tablet)	The category "using mobile devices" must be activated whenever the participant observes a set of actions relating to the handling of equipment (eg., tablet, mobile phone), for a period of time greater than or equal to 2 seconds.
	In housekeeping	The category of "housekeeping" aims to identify all the situations in which the participant was engaged in activities for the organization, cleaning or adjusting their bed or bedroom (eg., organizing or reposition equipment, making the bed), for a period of time greater than or equal to 2 seconds.
	Watching TV	The category "watching tv" where the position of the participant's head is turned to the television screen, for a period of time greater than or equal to 2 seconds.
	Other	Any activity that means some kind of specific Category which was not anticipated.

Table 5. Categories, ways and description for using a pillow group

Category	Ways	Description
Using a pillow	Under the head	The category "Under the head" must be activated whenever the participant used one pillow under the head.
	Between the legs	The category "between the legs" must be activated whenever the participant uses one pillow between the legs.
	Between the arms	The category "between the arms" must be activated whenever the participant used one pillow between the arms.
	Mixed	The category "mixed" must be activated whenever the participant used two or more pillows at the same time in some place of the body (head, leg, arm, feet and/or trunk).
	On the trunk	The category "on the trunk" must be activated whenever the participant used one pillow under the trunk.
	Between the feet	The category "between the feet" must be activated whenever the participant used one pillow between the feet.
	Without support	The category "without support" must be activated whenever the participant did not use any pillow.
	Other	Any activity that means some kind of specific Categorys which was not anticipated.

Table 6. Categories, ways and description for others group

Category	Ways	Description
Others	Other	Any posture activity that represent some kind of specific Category which was not anticipated.

As mentioned, the analysis was done using software developed for this purpose. It allows classifying the IC (through video analysis) in levels. According to Filgueiras, Rebelo & Moreira da Silva [9], although the system allows the observation and register of categories in a continuous time, the high number of categories for this analysis represents a cognitive overload to the observer and may contribute to a significant increase in classification errors.

Thus, the classification of systematic activity sequences was done using samples controlled by the software (10 seconds of analysis for each 100 seconds of activity). Each one of these activity sequences represents an "event" which remained in looping (10 seconds) until all ICs were registered (Fig. 5).

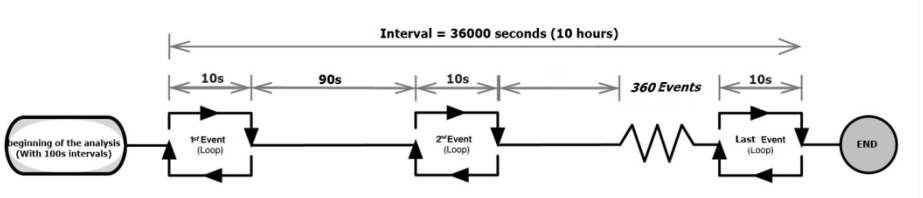


Fig. 5. Flowchart with the systematic observation stages used by the software

3 Results

A sample of 8666 observations, which corresponds to 240 sleep-hours of 12 air force military participants, was classified into six (6) ICs. The results can be seen in Fig. 6, 7 and 8.

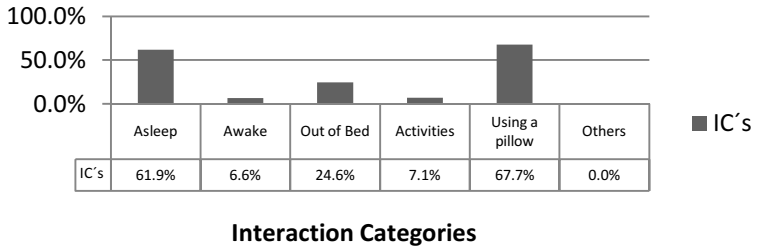


Fig. 6. Results for ICs groups

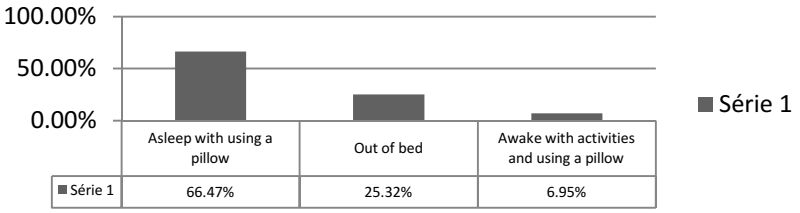


Fig. 7. Results for IC and their interactions

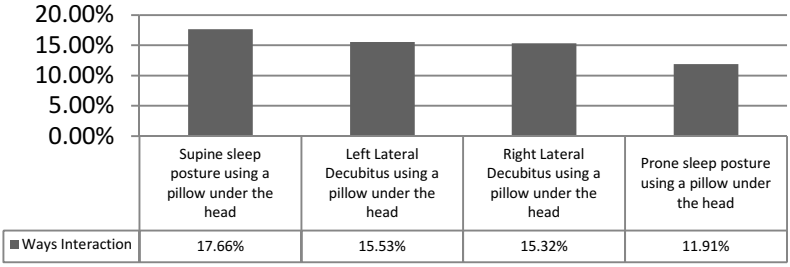


Fig. 8. Results for ways interaction

The results show that 50,2% of the participants presented the Lateral position (25,38% on the left and 24,86% on the right) as the most common postural behavior during sleep and 94,1% used only one pillow under their head.

In the IC´s, the most common interactions were sleep period using the pillow with 66,47%, followed by category Out of bed with 25,32% and followed the category the activities and using the pillow with 6,95%.

The category Asleep and Using a pillow are the most common IC´s with 60.42% of all classifications. In the ICs of most interaction, Supine using a pillow under the head occurs 17,66%, Left Lateral Decubitus using a pillow under the head corresponds to 15,53%, Right Lateral Decubitus using a pillow under the head occurs 15,32% and Prone using a pillow under the head occurs 11,91%.

4 Conclusion

The ICs of Asleep and Awake are the largest periods of the postural behaviors in bed during rest period. The influence of the sleep position on the physiological damage in the rest of the period with or without activities in bed is not very known [6]. The results obtained with this method of analysis of postural behaviors for long periods of continuous time are important to understand their influence on musculoskeletal conditions. This data can be associated to the increase of the musculoskeletal problems, which can be found among young adults of the Portuguese air force when these remain in bad postures for long periods of time in bed.

While held image capture, participants answered a questionnaire about the perception of pain in the spine according Visual Analogue Scale (VAS). The

questionnaire´s result presented: 100% of air force military answered complaints back pain; 33.3% referred to the evening and wake up whose the pain was more intense; 50% of participants reported that pain disrupts sleep and; The bigger indication of median of pain was in the Lumbar region (3,25+ 2.094).

Finally, this ISEE methodology was considered efficient for the proposed objectives and the findings suggest new challenges for future research. Findings of this study allow suggesting what graphical interface designers must seek as new strategies and solutions for behavior change in posture in bed, exploring other peripheral equipment for sleep position; or, at least, to improve the posture of the participants when using the number and the ideal placement of pillows in the bed and if these Ergonomic changes can influence the reduction in back pain indications.

This data is essential for health care professionals, in particular the rehabilitation professionals, who can use this information to enable a reduction factor of complaints of back pain and obtain tools to measure postural Behavior. However, the ISEE software methodology defines the categories of observation, called categories of interactions, and the software to quantify them [9]. This software is essential to analyze the data. Without it, it would be necessary to directly observe the video with notes on paper or a computer record of every change without the application of categories for the purpose and with a loss of important information.

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