最後に，ナースステーション内の音環境がスタッフに与える心理的な影響について考察する．看護師の静かさに対する満足度は 55dB 前後で不満に変わるとされる[8]が，今回の調査では，高い騒音レベルや，耳につきやすい周波数成分が多いナースステーション内の音環境により，看護師やスタッフにとって不満を感じやすい音環境であることが予測された．また，今回騒音レベルが高かった測定点は調剤業務が中心に行われる場所であり，この場所では特に慎重な作業が求められるといえる．よって，場所によっては，音環境がストレスになりうることが考えられるため，スタッフ自身が集中力を高めて，ミスを犯さないように十分注意が必要である．また，今回のナースステーションの音環境調査からも，看護師は多忙で常に業務に追われている様子が見受けられ，職業上のストレスもあると推察された．以上のことから，ナースステーションの音環境は検討すべき課題と考える．しかし，単純に騒音レベルが低い環境がよいというわけではなく，特にモニターのアラーム音など重要な情報をもつ音や音声の伝達に支障をきたさない音環境の検討が重要と考える．

今後の課題として，病院，病棟，曜日，時間帯により音環境はかなり異なると考えられることから，他の病院や病棟の音環境の測定や今回測定した以外の時間帯や曜日での測定などが挙げられる．

また，今回は等価騒音レベルを用いて分析を行うことで，30 分ごとの音環境実態を明らかにし，ナースステーション内の環境の時間的変化を捉えることができたと考える．さらに，今後は全時間のデータを分析すれば，より正確な騒音レベルや周波数の推移を明らかにすることができると考えられる．また，今回の結果との比較により，分析法が適当であったかも評価できると考える．

今後，タイムスタディにおいて音環境を調査する際には，ナースステーションの環境の一日の流れや測定点周囲の環境を把握し，慎重に測定点を選定した上で測定を実施する必要があると考える．

E．結論

ナースステーション内の音環境が，不快感を与えるなど医療スタッフになんらかの悪影響を与える可能性を見出した．等価騒音レベルの変動にはナースステーション内の人数の変動が関係していることも見出された．ナースステーションの音環境を改善し，スタッフにとってより快適な職場環境をつくる必要性があることが示唆された．

本研究結果は無人タイムスタディを行う基礎資料となり得る．

F. 文献

厚生労働省(1997)．厚生白書，厚生統計出版会，東京．

豊増美喜，大橋徹，内之浦祐樹(2004)．病院待合室の音環境に関する研究，日本建築学会環境系論文集，584，9-16．

後藤翙(1979)．騒音・振動，産業情報サービス，東京．

渡辺敏，廣瀬稔，稲毛博(1985)．医療機器による騒音について，医器学，55，401-403．

日本工業規格(1999)．JIS Z 8731：環境騒音の表示・測定方法，日本規格協会，東京．

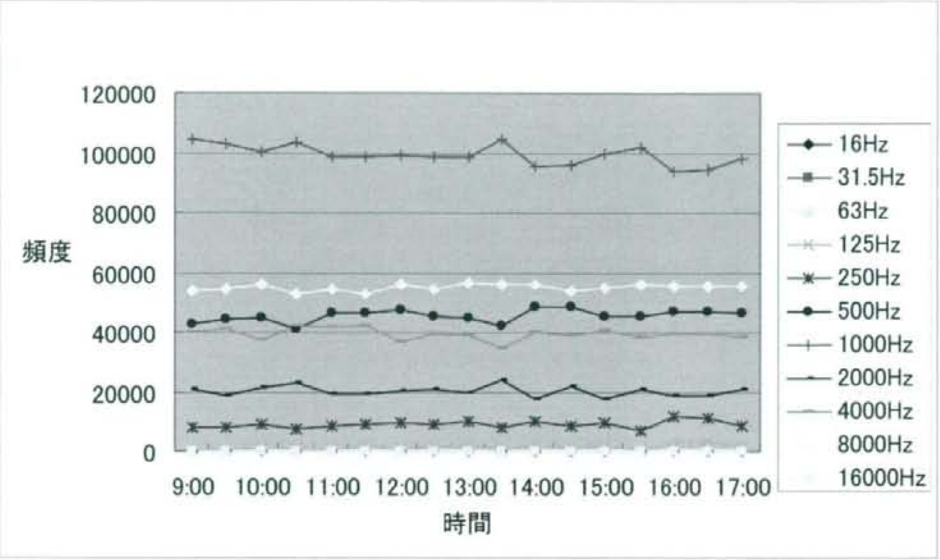


図 3-1　A 病棟測定点 1 におけるオクターブバンド別頻度の推移

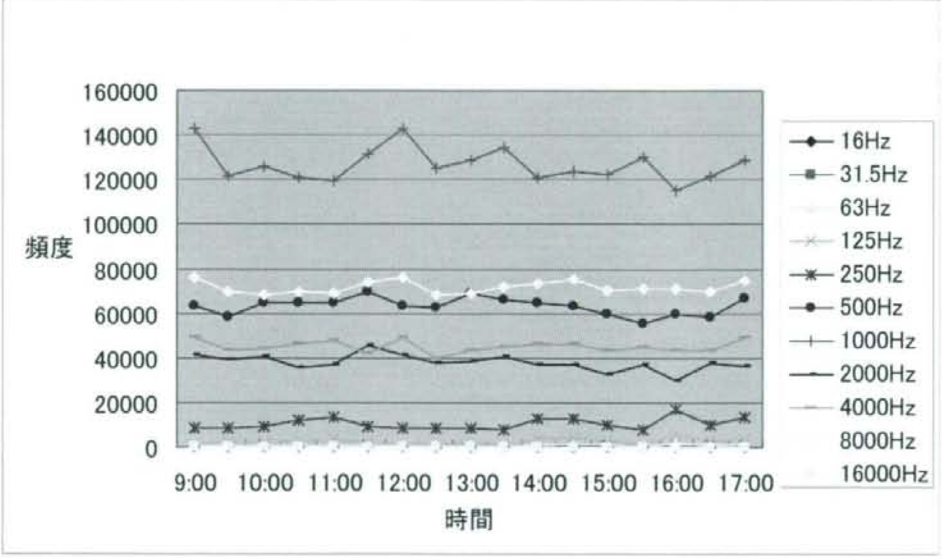


図 3-2　A 病棟測定点 2 におけるオクターブバンド別頻度の推移

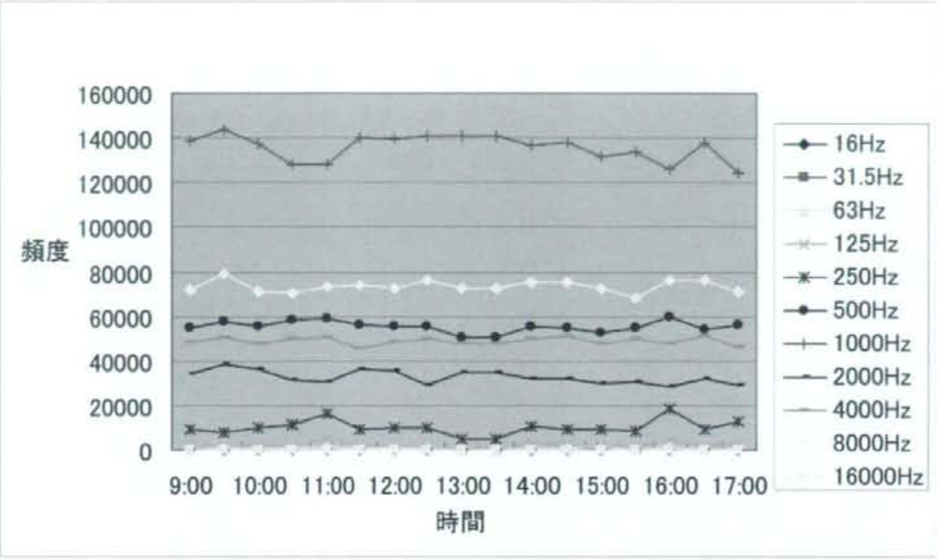


図 3-3　A 病棟測定点 3 におけるオクターブバンド別頻度の推移

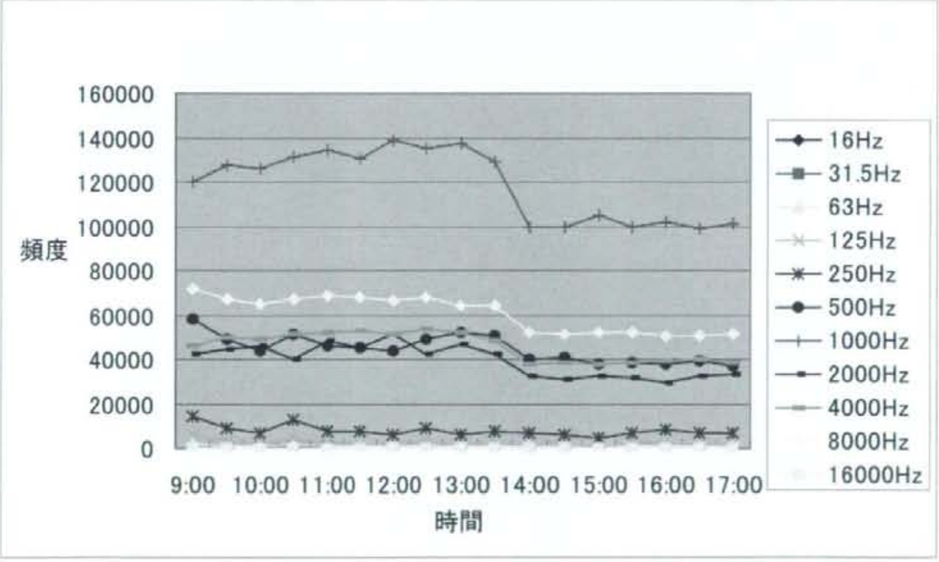


図 3-4　B 病棟測定点 1 におけるオクターブバンド別頻度の推移

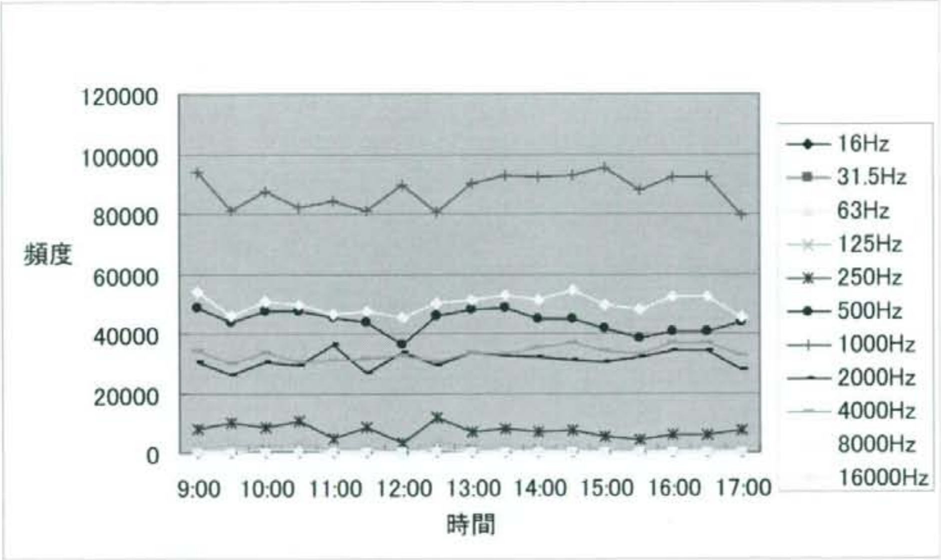


図 3-5　B 病棟測定点 2 におけるオクターブバンド別頻度の推移

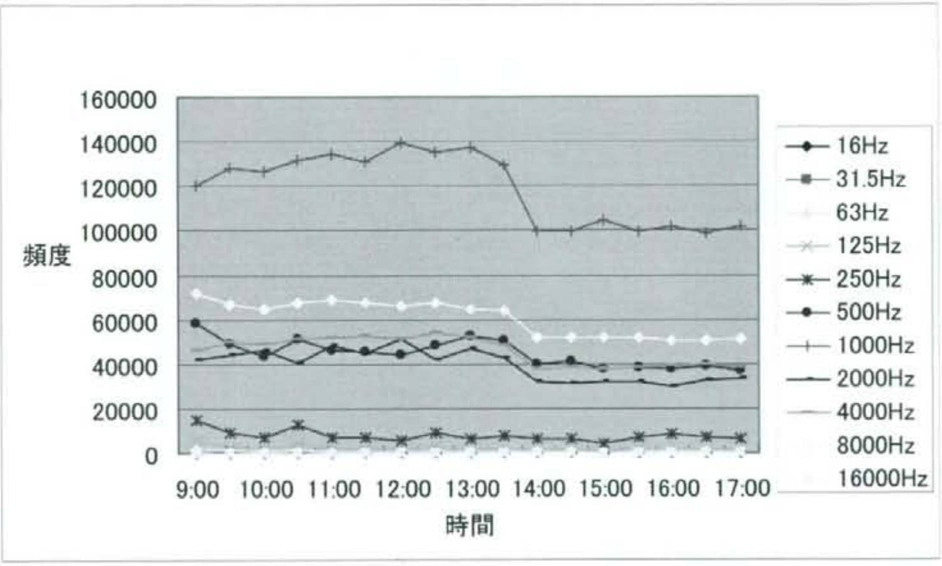


図 3-6　B 病棟測定点 3 におけるオクターブバンド別頻度の推移

Ⅲ. 研究成果の刊行に関する一覧表

別紙4

研究成果の刊行に関する一覧表レイアウト

書籍

著者氏名	論文タイトル名	書籍全体の編集者名	書籍名	出版社名	出版地	出版年	ページ
Yasushi Matsumuraa, Shigeki Kuwatab, Yuichiro Yamamotoa, Kazunori Izumic, Yasushi Okada, Michihiro Hazumic, Sachiko Yoshimotoa, Takahiro Minenoa, Munetoshi Nagahamaa,Ayumi Fujiia, Hiroshi Takedaa	Template-based Data Entry for General Description in Medical Recordsand Data Transfer to Data Warehouse for Analysis		MEDINFO 2007	IOS Press		2007	412-416

雑誌

発表者氏名	論文タイトル名	発表誌名	巻号	ページ	出版年
Shima Okada, Yuko Ohno	Investigation into Using Difference Images to Monitor Sleeping Patients	IT Healthcare	3(2)	85-95	2008
Naomi Shiki, Yuko Ohno, Ayumi Fujii, Taizo Murata, Yasushi Matsumura	Unified Modeling Language (UML) for Hospital-based Cancer Registration Processes	Asian Pacific Journal of Cancer Prevention	9(4)	789-796	2008
志岐直美、大野ゆう子、清水佐知子、伊藤ゆり、井岡亜希子、津熊秀明	がん医療均てん化指標としてのがん患者受療動態と地域別生存率に関する研究	ITヘルスケア	3(1)	58-61	2008
Anna Tsutsui, Yuko Ohno, Junichi Hara, Yuri Ito, Hideaki Tsukuma	Trends of Centralization of Childhood Cancer Treatment Between 1975 and 2002 in Osaka, Japan	Japanese Journal of Clinical Oncology	39(2)	127-131	2009
Numasaki, H., Ohno, Y., Ishii, A., Kasahara, S., Fujimoto, H., Harauchi, H., Inamura, K., Monden, M., Sakon, M.	Workflow Analysis of Medical staffs in Surgical Wards Based on the Time-Motion Study Data.	Japan Hospitals	27	75-80	2008
小澤壯治，日月裕司，田中乙雄，篠田雅幸，宇田川晴司，松原久裕，馬場秀夫，竹内裕也，小山恒男，室圭，宇野隆，手島昭樹，沼崎穂高，山名秀明，小西敏郎.	食道癌全国登録の再開にあたり一問題点と解決法一	癌と化学療法	35(9)	1497-1499	2008

発表者氏名	論文タイトル名	発表誌名	巻号	ページ	出版年
Numasaki, H., Teshima, T., Shibuya, H., Nishio, M., Ikeda, H., Ito, H., Sekiguchi, K., Kamikonya, N., Koizumi, M., Tago, M., Nagata, Y., Masaki, H., Nishimura, T., Yamada, S., Japanese Society of Therapeutic Radiology and Oncology Database Committee.	National Structure of Radiation Oncology in Japan with Special Reference to Designated Cancer Care Hospital.	International Journal of Clinical Oncology			in press
Q. Zhang, Y. Matsumura, T. Teratani, S. Yoshimoto, T. Mineno, K. Nakagawa,M. Nagahama, S. Kuwata, H. Takeda	The Application of an Institutional Clinical Data Warehouse to the Assessment of Adverse Drug Reactions (ADRs) Evaluation of Aminoglycoside and Cephalosporin Associated Nephrotoxicity	Methods Inf Med	5	516-522	2007
Yufeng Chen, Yasushi Matsumura, Katsuhiko Nakagawa, Shanmei Ji, Hirohiko Nakano, Tadamasa Teratani, Qiyan Zhang, Takahiro Mineno, Hiroshi Takeda	Analysis of Yearly Variations in Drug Expenditure for One Patient Using DataWarehouse in a Hospital	J Med Syst	31	17-24	2007
近藤礎，田墨恵子，椛桂子，松村菜津子，竹上学，黒川信夫，金倉譲，野口眞三郎，水木満佐央	オーダリングシステム型外来化学療法部の現状と問題点	Japanese Journal Cancer Chemotherapy	34(8)	1264-1266	2007
Takashi Uno, Minako Sumi, Yoshitomo Ishihara, Hodaka Numasaki, Michihide Mitsumori, Teruki Teshima	Changes in Patterns of Care for Limited-Stage Small-Cell Lung Cancer: Results of the 99-01 Patterns of Care Study — a Nationwide Survey in Japan	International Journal of Radiation Oncology Biology Physics	71(2)	414-419	2008
Takafumi Toita, Takeshi Kodaira, Atsunori Shinoda, Takashi Uno, Yuichi Akino, Michihide Mitsumori, Teruki Teshima	Patterns of Radiotherapy Practice for Patients with Cervical Cancer (1999–2001): Patterns of Care Study in Japan	International Journal of Radiation Oncology Biology Physics	70(3)	788-794	2008
Teruki Teshima, Hodaka Numasaki, Hitoshi Shibuya, Masamichi Nishio, Hiroshi Ikeda, Hisao Ito, Kenji Sekiguchi, Norihiko Kamikonya, Masahiko Koizumi, Masao Tago, Yasushi Nagata, Hidekazu Masaki, Tetsuo Nishimura, Shogo Yamada, Japanese Society of Therapeutic Radiology and Oncology Database Committee	JAPANESE STRUCTURE SURVEY OF RADIATION ONCOLOGY IN 2005 BASED ON INSTITUTIONAL STRATIFICATION OF PATTERNS OF CARE STUDY	International Journal of Radiation Oncology Biology Physics	72(1)	144-152	2008

発表者氏名	論文タイトル名	発表誌名	巻号	ページ	出版年
手島昭樹，山本時裕	米国に学ぶ医学物理士の養成・活用法	原子力eye	54(10)	16-20	2008
手島昭樹，日本PCS作業部会	PCS（Patterns of Care Study）による日米間の放射線治療の比較	Cancer Frontier	10	143-150	2008
Kazuhiko Ogawa, Katsumasa Nakamura, Tomonari Sasaki, Hiroshi Onishi, Masahiko Koizumi, Yoshiyuki Shiooyama, Masayuki Araya, Nomutaka Mukkumoto, Michihide Mitsumori, Teruki Teshima, the Japanese Patterns of Care Study Working Subgroup of Prostate Cancer	External Beam Radiotherapy for Clinically Localized HormonereFractory Prostate Cancer: Clinical Significance of Nadir Prostate-specific Antigen Value within 12 Months	International Journal of Radiation Oncology Biology Physics	In press	1-7	2008
門田守人	外科医からみた医療制度の問題点	外科	70(7)	699-705	2008
門田守人	外科からの提言	医学のあゆみ	225(3)	260-263	2008
門田守人	アプローチ	最新医学	63(6)	1035-1040	2008
検見崎兼治，大野ゆう子，岡田志麻，清水佐知子，王媛媛，筒井杏奈	睡眠時体動検出の自動化を目指した差分処理手法の検討	ITヘルスケア	3(1)	30-33	2008
持丸祐子，大野ゆう子，沼先穂高，手島昭樹，JASTROデータベース委員会，伊藤ゆり，津熊秀明	がん拠点病院が備えるべき集学的治療環境指標の研究	ITヘルスケア	3(1)	54-57	2008

Ⅳ. 研究成果の刊行物・別刷

Original

Investigation into Using Difference Images to Monitor Sleeping Patients

Shima Okada[1), Yuko Ohno[1), GOYAHAN[1), Wang Yen-Yen[1),
Kumi Kato[2), Ikuko Mouri[2), Masako Taniike[2)

1) Osaka University, Graduate School of Medicine, Health Sciences
2) Osaka University, Graduate School of Medicine, Molecular Research Center for Child Mental Development

From the standpoint of ensuring the safety of patients in hospitals, a system that keeps watch over sleeping patients is necessary. In an actual clinical site, depending on a patient's age and medical condition, accidents may occur due to sensors and wires attached to the bed. So there is the need now for technology that monitors patients in an unrestricted state and which is completely detached from sensors. In this paper, we propose a technique that monitors patients using difference video image processing that it was considered realizable at bedside. Detecting unusual movements of a patient is especially critical for this technique. Therefore this technique was focused on the movement amount about subject. As a verification experiment, substantial amount of movement of a healthy subject was calculated at outside the clinical site. From this experiment, it was confirmed the soundness of using difference images to determine substantial movement amount. Then next test was conducted in a clinical site on trial. To verify the possibility of clinical application, it was examined the relation between substantial amount of movement about sleeping patient and the sleep state. For this testing, using difference images we measured body movements of pediatric patient during his sleep stage. At the same time, polysomnogram (PSG) was measured to read sleep stage. We picked up the patient without obstructive sleep apnea syndrome (AHI<1). The results showed that a relationship could be seen between body movements as measured by difference images and the transition periods of sleep stages measured by PSG. From these results, it is considered that substantial movement amount we propose was proper value at clinical testing. Results suggest the possibility of clinical application for monitoring patients during their sleep. In addition to not restricting the patient, this technique has the benefit of not requiring sensors or wires attached to beds. The patient is thus completely free of contact with this system.

Key Words
Body Movement Detection, Difference Image, Sleeping Patient Monitoring

1. Introduction

It is said that he method that monitoring of patient's movement in non-restrictive and non-contact ways in the bed has been needed[1-2]. Because in an actual bedside, depending on a patient's age and medical condition, accidents may occur due to sensors and wires being attached to the bed. Furthermore, due to patients' vomiting or incontinence in bed, cleanliness is becoming increasing important for a monitoring system. These considerations demonstrate a growing need for technology that monitors patients in non-restrictive ways. In additionally, it is also needed the ways in completely detached from sensors.

Systems developed in recent years that are useful for managing physiological conditions by measuring the breathing rate and heartbeat rate of sleeping patients using

1 16 2008 Recieved, 3 17 2008 Accepted
1-7 Yamadaoka Suita city Ohsaka Pref
Department of Mathematical Health Science, Course of Health Science, Graduate School of Medicine, Osaka University
Shima Okada

highly-sensitive pressure sensors placed on the bed[5-7]. Furthermore simple method had been developed. The method is that body temperature monitor to evaluate body movement during sleep[8-9]. These technologies are extremely useful as monitoring systems because they do not restrict the patient movement during sleep. However, the problems involved due to sensors and wires being attached to the bed are not resolved.

The method called videosomnography can be used as a non-contact, non-restrictive means of measuring sleep conditions[10] For this method, the analyst visually examines and notes the appearance of body movement manually from the recorded video of the patient's sleep. This method evaluates an entire night's sleep. However, because one data set extends up to 10 hours, it has the problem of requiring a lot of time for processing.

To address these problems, a system that measures the number of human breath and body movement using a CCD camera and infrared camera is being developed. By carrying out difference processing of video[11-12], it is possible to detect the number of the subject's body movement and breath. The technique of difference processing of video is older method[13]. However, Nakajima et al. recently applied this technique for medical engineering area.

Difference processing of video image detects the movement of a subject by calculating differences in sequential images. To detecting movements of patients in a non-restrictive state and being completely detached from sensors. Additionally, this technique does not store the originally recorded video. Instead, it stores the images obtained after difference processing. Therefore, video images of the subject are not left behind, and it is possible to protect the patient's privacy.

In this paper, we propose a sleeping patient monitoring technique in a clinical site using difference processing of video image and then determined its possibility of clinical application. Previous research on difference processing mentioned above[11-12] emphasized on counting breath and body movement. However, from the standpoint of a system that monitors the patient's condition, it is critical to have information such as what kind and how big of a movement a patient makes in his or her bed according to sleep state. Therefore this technique was focused on the movement amount about subject. To make a system specialized for monitoring patients in hospitals, we propose a method that estimates the center location of the moving subject from difference images, and from this value, estimates the amount of substantial movement inside the image in order to detect unusual movements from the patient. As the first step of research, the testing was carried out on a healthy subject outside the clinical site. Next, to show the possibility of clinical application in a bedside, it was performed recording video image and analysis of body movement of pediatric patient by difference processing.

2. Measuring Method

Measurements were done on video of subjects to carry out difference processing. Video recording was done using a digital video camera recorder. Infrared recording was used in the darkness after the patient had fallen asleep. The video camera was affixed against the wall of the room, and recorded the entire body of the subject within its frame when the patient was sleeping. The infrared video camera was set up on subject's head side, and taking a picture of the entire bed. To throw up the positional relation between infrared video camera and subject, Fig 1 indicated a view showing positional relation and one video scene. The recorded video was transferred directly to a PC's hard drive using an IEEE 1394 connection between the PC and the video camera.

Figure 1

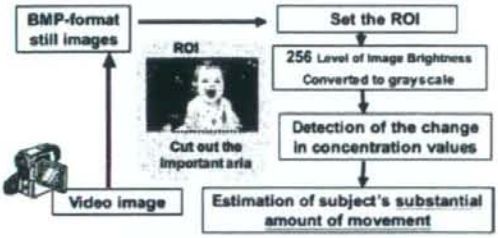
a) The positional relation between infrared video camera and subject and 2)one video scene.

3. Method of Image Processing

(1) Summary of Difference Processing

Difference processing of images was carried out using image processing. The flow of image processing is shown in Figure 2. The video images were transformed to still images, the movements of the subject were captured continuously, and we built an application to detect changes in the movements. The developmental environment of the application was Windows 2000 for the operating system and Microsoft Visual C++ Version 6.0 for the building of the application. Video output from the video camera was converted to BMP-format still images and analyzed. The size of the converted still images was 320 pixels (width)×240 pixels (height).

Figure 2



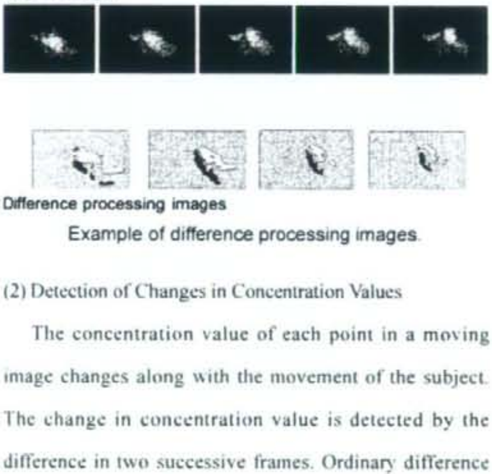
Flow of Image Processing

Next, the BMP-format still images were read successively, and the region of interest (ROI) was specified for high-speed processing. The ROI carves out the necessary region from the overall image for processing. By eliminating excess noise and decreasing the image size, ROI processing makes high-speed processing possible. After ROI processing, the image was converted to grayscale, and changes in concentration values between frames were detected using difference processing. From these values, the coordinate position of the subject in the image and substantial amount of movement were estimated.

About difference processing, it is one of the most important features for patient's privacy to store the images obtained after difference processing. Fig 3 show the example of difference processing images. It could not be identified an individual difference processing images.

Figure 3

Original images



Example of difference processing images.

(2) Detection of Changes in Concentration Values

The concentration value of each point in a moving image changes along with the movement of the subject. The change in concentration value is detected by the difference in two successive frames. Ordinary difference image method was adopted. For one frame of still image, the temporal differentiation of concentration values of all pixels is calculated, and the change in concentration value of each pixel is detected. The size of a static image was N(1,...,n) pixels along the x-axis, and M(1,...,m) pixels along the y-axis, for a total of N×M pixels. The size of still images used in this paper was 320 pixels (width) × 240 pixels (height), so N = 320 and M = 240.

The matrix of the concentration values in a frame at time t is represented as **D(t)**. Matrix **D(t)** and the temporal differentiation matrix $\dot{\mathbf{D}}(t)$ can be expressed by the following equation (1) and (2).

$$\mathbf{D}(t)=\begin{pmatrix} d(t)_{11} & \cdots & d(t)_{1n} \\ \vdots & \ddots & \vdots \\ d(t)_{m1} & \cdots & d(t)_{mn} \end{pmatrix} \quad (1)$$

$$\dot{\mathbf{D}}(t)=\begin{pmatrix} \dot{d}(t)_{11} & \cdots & \dot{d}(t)_{1n} \\ \vdots & \ddots & \vdots \\ \dot{d}(t)_{m1} & \cdots & \dot{d}(t)_{mn} \end{pmatrix} \quad (2)$$

Next, using temporal differentiation of concentration value for each point and the constant ε, the following three expressed. The change in concentration value of a pixel at coordinate (x,y) can be expressed as dxy(t). Based on the condition of dxy(t) below, the following three states can be expressed. The constant ε used in the conditions represents the threshold of error.

i) Increase in concentration value

$$\left|\dot{d}_{xy}(t)\right| > \varepsilon \quad \text{and} \quad \dot{d}_{xy}(t) < 0$$

ii) Decrease in concentration value

$$\left|\dot{d}_{xy}(t)\right| > \varepsilon \quad \text{and} \quad \dot{d}_{xy}(t) > 0$$

iii) No change in concentration value

$$\left|\dot{d}_{xy}(t)\right| \le \varepsilon$$

(3) Estimation of Substantial Amount of Movement within Image

To estimate the substantial amount of movement, the method of estimating is described here, from the changes in concentration values, the center coordinate of the subject. In difference images, when a subject moves, the coordinate before the movement has a decrease in concentration value and an increase after the movement. Thus, first we calculate the average coordinate position (p_x, p_y) of all pixels that had a increase in concentration value (i) as shown in Section (2) above, and also the average coordinate position (n_x, n_y) of all pixels that had a decrease in concentration value (ii).

Next, taking (p_x, p_y) as the center coordinate of the aggregate of pixels that had an increase in concentration value, and (n_x, n_y) as the center coordinate of the aggregate of pixels that had a decrease in concentration value, the center coordinate of the moving subject can be expressed by calculating the center coordinate of (p_x, p_y) and (n_x, n_y). Each axis value of the center location (x,y) of the moving subject is calculated as follow expression (3) and (4).

$$x=\frac{p_x+n_x}{2} \quad (3)$$

$$y=\frac{p_y+n_y}{2} \quad (4)$$

Next, the method of estimating the substantial amount of movement is described. The substantial movement amount L(t) is calculated as the value corresponding to the distance of movement within the image from the change in the center coordinate (x,y) of the moving subject at time t. Please note that the image used for processing is expressed in two dimensions, so distortions occur for distance, speed, and amount of movement, which are values of the subject's movement in three-dimensional space. Therefore in this paper, the subject's amount of movement is called the "substantial amount of movement".

$$L(t)=\sqrt{\{(x(t+1)-x(t)\}^2+\{(y(t+1)-y(t)\}^2)}$$

4. Verification Experiment

(1) Methods of Experiment

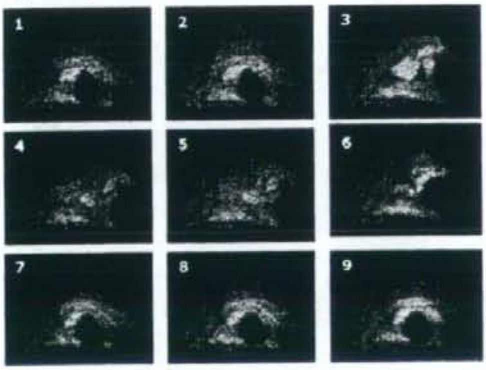
To verify the substantial amount of movement of subjects using difference processing of video images, we had a subject perform three different movements whose movement sizes differ. A healthy male (172cm, 73kg 30years old) lying on a futon, performed the following three movements: tossing and turning, getting up, and getting into a supine position in bed after being out of bed. For these three movements, substantial amount of movement were calculated.

(2) Results of Experiment

The actual tossing-and-turning movement of the subject is shown in Figure 4a). The sitting-up movement is shown in Figure 4b). And the movement from out of bed to a supine position in bed is shown in Figure 4c). Finally, the calculated substantial movement amounts for these three actions are shown in Figure 5. Please note that for the coordinates, the upper-left hand corner of the still image is (0, 0) and the lower-right hand corner is (320, 240).

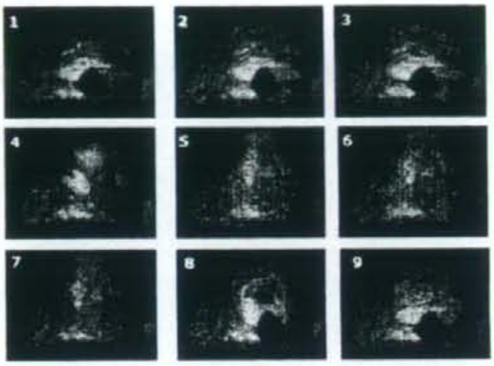
Actual Movements Images of the Subject.

Figure 4a)



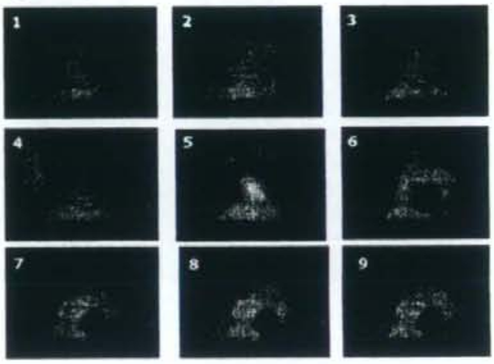
tossing-and-turning movement

Figure 4b)



sitting-up movement

Figure 4c)



out of bed to a supine position

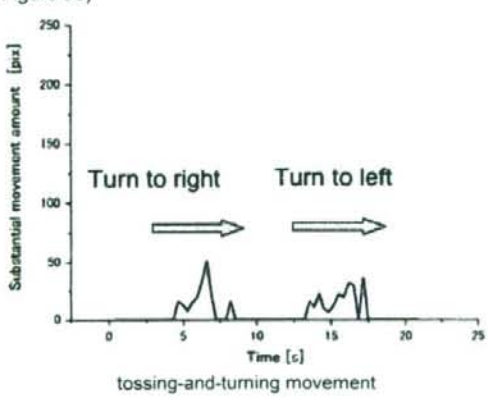
(3) Discussion

From the still images shown in Figure 4a), it is confirmed that the subject tossed and turned during sleep by turning rightward from a supine position, lying still for a while, and then returning to the original position by rolling leftward. From the still images shown in Figure 4b), it could be seen that the subject raised his upper body from a supine position, sat still for a while, then returned to his original supine position. From the still images shown in Figure 4c), it could be seen that from a position away from the bed, the subject entered the bed from the left side of the image and fell asleep in a supine position.

Next, the validity of the substantial movement amount is investigated from the results of shown in Figure 5. Looking at Fig 5a), for the tossing-and-turning action, after measurement begins, the substantial movement amount increased at the time the subject rolled rightward from a supine position. The significant movement amount became 0 after some stillness. Afterwards, when the subject rolled leftward to return to his original position, the substantial movement amount again increased. Similarly, for the sitting-up action in Fig 5b), substantial movement amount increased at the time the subject sat up, and become 0 when there was stillness for some duration. Afterwards, when the subject returned to his original position, it could be seen that the substantial movement amount increased. For the action of getting into bed and assuming a supine position in Fig 5c), initially the substantial movement amount was 0, indicating no movement for the initial duration. Then, an increase in substantial movement amount could be seen, which matched the increase in substantial movement amount for the action of assuming a supine position.

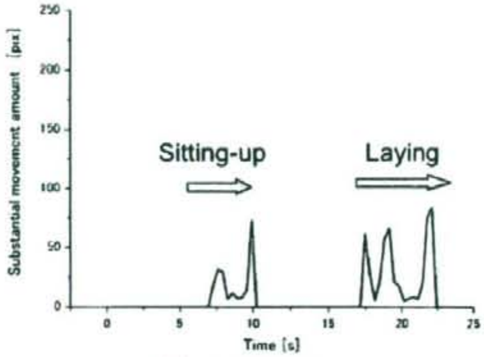
Substantial Movement Amount.

Figure 5a)



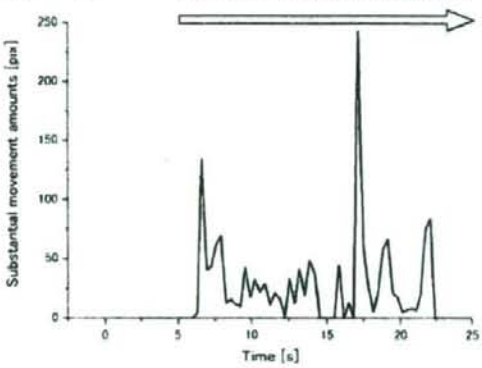
tossing-and-turning movement

Figure 5b)



sitting-up movement

Figure 5c)



out of bed to a supine position

Comparing the substantial movement amount, the tossing-and-turning movement showed the least substantial movement amount. The sitting-up movement and the getting-into-supine-position movement both showed great substantial movement amount. Considering the size of the movement, the results were appropriate. From this finding, we judged that the technique was sufficient for use in a clinical site, to figure out how big of a movement a patient makes and performed clinical testing next.

5. Clinical Testing

As mentioned in the preceding this paper. in the case of monitoring the sleeping patient. consider, the bedside accidents have to be considered. In particular, pediatric inpatients need to be taken of how they are wake or sleep or tending to wake. Because they have the characteristic like following things. Hospitalization experiences are easily produce panic for a child. And many bedside accidents occur caused by child's hypersensitivity during waking state. Therefore, it is important to show the pedeatric inpatient's sleep state. To show the possibility of clinical application in a bedside, analysis of substantial amount of movement of pediatric patient with sleep-wake cycle was performed by difference image.

(1) Methods of Clinical Testing

To verify the possibility of clinical application, the relation between substantial amount of movement about sleeping patient and the sleep-wake cycle was examined. It was performed polysomnogram (PSG) readings and measurements of body movement using difference images on pediatric patients who visited Osaka University Hospital from April to September 2007.

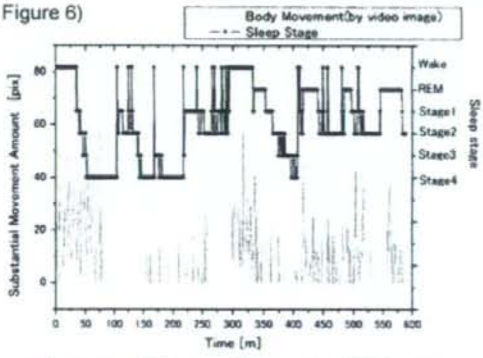
It was confirmed that substantial movement amount measured from difference images fluctuated depending on the sleep condition. Subjects were selected subjects from patient diagnosed without any sleep disorders and removed those who slept together with parents or had duplicate diagnoses. One subject was ended up (114 cm. 18.4 kg 4years old).

For measuring body movement using difference images in a clinical site, sufficient ethical consideration is required. The clinical testing here was performed after receiving approval from Osaka University Hospital's ethics committee and permission from each patient with written informed consent Institutional Review Board.

(2) Results of Clinical Testing

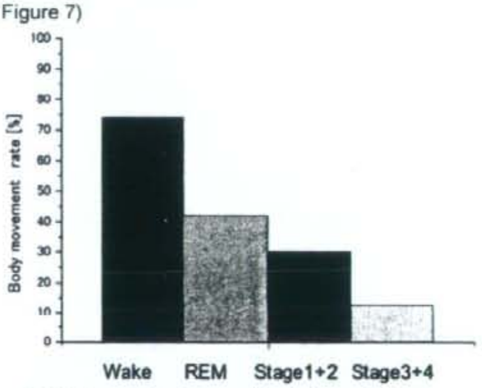
The sleep stage evaluated by PSG and the substantial movement amount from difference images of a subject are shown in Figure 6. Also, the rate of body movement according to image differences for each stage of sleep (Wake, REM, Stage 1+2, Stage 3+4) is shown in Figure 7, and the average substantial movement amount for each stage of sleep is shown in Figure 8.

Figure 6)



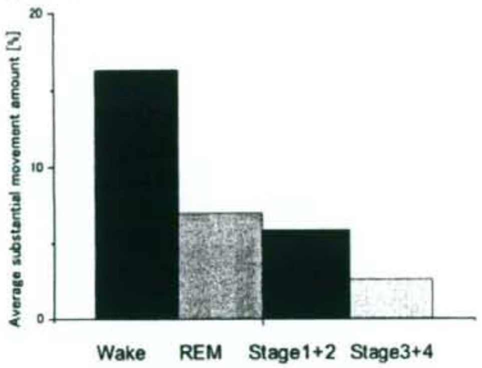
The stages of Sleep as Measured by PSGand the Substantial Movement Amount from Difference Images.

Figure 7)



Body Movement rate according to Image Differences for Each Sleep Stage.

Figure 8)



Average Substantial Movement Amount for Each Sleep Stage.

(3) Discussion

From the results shown in Figure 6, it could be seen that the transition to different sleep stages was accompanied by changes in substantial movement amounts as calculated from difference images. It could be seen increases and decreases of substantial movement amount being tied to the sleep-wake cycle. An intimate relationship between body movement and the sleep-wake rhythm is known[14] . Therefore it could be said the substantial movement amounts change along with the transition of sleep stage. Conventionally, sleep condition is evaluated by sleep stage. However, sleep stage is a qualitative variable - the value of Electroencephalogram (EEG), Electromyogram (EMG) and Electro-oculogram (EOG) is synthesized and judged according to Rechtschaffen and Kales's sleep scale[15] . Therefore to analyze the relation between sleep in physiologic meaning and substantial movement amount more in detail, it might be necessary to compare EEG with substantial movement amount.

As shown in Figure 7, the rate of body movement for each stage of sleep was as follows: Wake > REM > Stage 1+2 > Stage 3+4. According to Oswald[16] after the Wake stage, the amount of body movement is the greatest in REM sleep stage, followed by Stage 3+4. In other words, body movement was greatly reduced in SWS[17]. Our results conformed to this finding. Also, from the results shown in Figure 8, it could be seen that body movement in the Wake stage were large, followed by the REM stage. In the Wake stage, the consciousness level is naturally high and large body movement occur[18]. In the REM stage, large tosses and turns occur as a person shifts to the sleep stage[18]. Therefore, there was possibility of evaluation not just the number of body movement using difference processing, but also their movement sizes.

As above stated, in this method, it could be confirmed the relation between sleep-wake cycle and substantial movement amount. This method could be applied in not only monitoring sleeping patients, but as simple sleep state screening. However, in this testing it was only one clinical example. So to verify the availability of this method, it is necessary to study more clinical cases in the future works.

6. Conclusion

In this paper, from the standpoint of the ensuring patient safety in hospitals, it was considered the necessity of a system that watches over sleeping patients, and we proposed a monitoring technique using difference processing of video image that had possibilities to implement in an actual clinical site. This technique places great importance on detecting unusual movements of patients, and calculates the substantial movement amounts of patients. Furthermore, to test the effectiveness of this technique in a clinical site, the sleep stage and substantial amount of movement was measured for pediatric patient. The results showed a relationship between body movement as determined by difference processing and the sleep stage. Thus the results indicated that this technique had prospects of sleeping patient monitoring. In additional to not restraining the patient. this technique has the benefit of not requiring sensors or wires attached to beds. The patient is thus completely free of contact with this system. and it is also possible to protect the patient's privacy. By widening the camera's field of vision. it is possible to monitor not only movement while the patient is sleeping. but also during daytime.

However, a problem of this technique is that because it uses two-dimensional images distortions might occur between x direction and y direction. To address this problem, to obtain near-3D visualization by positioning another camera to record images. However. this has the disadvantages of more complex processing and higher costs. Because this research is especially concerned about detecting unusual movements of patients. such rigorous detection of position movement of the patient is not being considered.

In the future. we plan to apply this technique to clinical site through cooperation with sleep research. In addition. there are several studies about video image analysis for sleep apnea syndrome (SAS) [19]. We also plan to construct a SAS patient monitoring system apply the method of difference images.

References

1) Eric J. Manders, Benoit M. Dawant, Data Acquisition for an Intelligent Bedside Monitoring System. the 18th annual international conference of the IEEE Engineering in Medicine and Biology Society. Technical Report. 1996.
2) Ying Zhang, Christine Tsien Silvers and Adrienne G. Randolph, Real-Time Evaluation of Patient Monitoring Algorithms for Critical Care at the Bedside, Proceedings of the 29th Annual International Conference of the IEEE EMBS, 2784-2786, 2007.
3) Kajiro Watanabe. Takeshi Watanabe and Haeumi Watanabe et al., Nonivasive Measurement of Heartbeat. Respiration. Snoring and Body Movements of a Subject in Bed via a Pneumatic Method. IEEE Transaction of Biomedical Engineering. 52-12,2100-2107. 2005.
4) Takashi Watanabe. Kajiro Watanabe, Noncontact Method for Sleep Stage Estimation. IEEE Trans. Bio-Medical Engineering, 51-10. 1735-1748. 2004.
5) Allihanka. J.. Vashtoranta, K.. Static sensitive bed a new method for recording body movement during sleep. Electroencephaloger.Clin.Neurophysiol., 46. 731-734. 1979.
6) Allihanka, J., Vashtoranta, K., A new method for long-term monitoring of balistcardiogram. heart rate and respiration, Am.J.Physiology, 240. 384-392, 1988.
7) Tomek I, Ballistocardiography: principles. simulation. applications. Adv Cardiovasc Phys 2: 119-157, 1975.
8) T.Tamura, J. Zhou and H. mizukami et al, A system for monitoring temuperature distribution in bed and its application to assesment ob body movement. Physiol. Meas., 14. 33-41, 1993.
9) Tamura T., Togawa T. and Murata M. A bed temperature monitoring system for assessing body movement during sleep. Clin. Phys. Phsiol. Measu., 9. 139-145, 1988.
10) Erika E. Gaylor. Melissa M. Burnham, Beth L. Goodlin-Jones et al., A Longitudinal Follow-Up Study of Young Children's SleepPatterns Using a Developmental

Classification System,Behav Sleep Med.,3(1),44-61,2005.

11) K.Nakajima, A.Osa, S. Kasaoka et al., Evaluation of physical activity during bed rest with sequential image processing, after acute myocardial infraction, The Institute of Electronics, Information and Communication engineers, MbE95-61, 109-113, 1995.

12) K.Nakajima, Y. Matsumoto and T. Tamura, Development of real-time image sequence analysis for evaluating posture change and respiratory rate of the subject in bed, Physiol. Meas., 22, 21-28, 2001.

13) H. Miike, Ktogawa, T. yamada et al., Measuring surface shape from specula reflection image sequence-Quantitative evaluation of surface defect of plastic moldings, Jpn. J. Appl. Phys.2, Lett.,34, 1625-1628, 1995

14) Jacobson A., Muscle tonus in human subject during sleep and dreaming, Exp Neurol., 10, 418-424, 1964.

15) A Rechtschaffen and A Kales; A Manual of Standardized Terminology, Techniques and Scoring System for Sleep Stage of Human Subjects; Public Health Service U.S. Government Printing Office, Washington D.C, 1968.

16) Oswald I, Melancholia and barbiturates: a controlled EEG and eye-movement study of sleep, Br J Psychiatry 109, 66-78, 1963.

17) Wilde-Frenz J. and Schulz H., Rate and distribution of body movement during sleep in humans, Percept Mot Skills, 56, 275-283, 1983.

18) Gardner R. and Grossman WL., Normal motor patterns in sleep in man, Advances in sleep research, 2 New York, Spectrum, 66-107, 1975.

19) H.Aoki, Y.Takemura, K.Mimura, M.Nakajima, Development of Non-restrictive Sensing System for Sleeping Person Using Fiber Grating Vision Sensor, Proceedings of the 2001 International Symposium on Micromechatronics and Human Science, 155-160,2001

差分画像を用いた就寝中の患者見守り方法の検討

岡田志麻[1]，大野ゆう子[1]，高亜罕[1]，王媛媛[1]，加藤久美[2]，毛利育子[2]，谷池雅子[2]

[1] 大阪大学大学院医学系研究科保健学専攻
[2] 大阪大学大学院医学系研究科子どものこころの分子統御機構研究センター

病院における患者の安全確保という観点から，就寝中の患者の様子を見守るシステムの必要性が考えられる．実際の臨床現場において，患者の年齢，病状，状態によっては，センサによるベッドやベッド付近の配線によって事故が起こる可能性があるため，患者をセンサ類から完全に切り離した無拘束状態での見守り技術が必要となってくる．そこで，本論文では，実際の臨床現場において，実現可能と考えられる動画像の差分処理を用いた患者見守り方法を提案した．本手法では特に患者の動作の大きさを検出することが重要と考え，まず，検証実験として，臨床現場の外で健常被験者1名に対し，被験者の移動相当量の算出を行った．これにより，差分画像による移動相当量の妥当性が確認できたため，さらに臨床現場での有用性の検討を行った．有用性を示すため，移動相当量と睡眠状態との関連を検討した．臨床実験では，小児の患者１名を対象とし，就寝時の睡眠ステージと差分画像による体動計測を同時に行った．この結果，差分画像による体動と睡眠ステージの推移の間に関係が見られ，就寝時の見守りとして有用であることが示唆された．この手法の利点としては，患者が全くの無拘束であることに加え，センサによるベッドやベッド付近の配線が必要ないため患者に対して完全に非接触であり，差分画像を残し，元画像を破棄することで患者のプライバシーも守ることも可能である．

和文キーワード
体動検出，差分画像，見守り，睡眠

2008年1月16日受付；2008年3月17日受理

連絡先：〒565-0871　大阪府吹田市山田丘1-7
大阪大学大学院医学系研究科保健学専攻
総合ヘルスプロモーション講座
岡田　志麻
Tel:06-6879-2526　Fax:06-6879-2524
E-mail:shima@sahs.med.osaka-u.ac.jp