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The effects of using computer assisted instruction incorporating data from motion analysis video in order to improve the ability of physical therapy students to perform observational gait analysis.

Shusaku Kanai[1] and Tomoaki Shimada[2]

In clinical practice, physical therapy students (PTS) require not only ADL knowledge but also the ability to assess a patient's problems by observing his or her motion. This is an important problem solving skill and is strongly required by the students. But this ability has not been fully developed in traditional education. The study of Computer Assisted Instruction (CAI) as new teaching material has become increasingly valued in practical curriculum. This study reports the findings of a study that hypothesized the educational benefits of developing new teaching materials incorporating self-directed learning accessible via World Wide Web for improving observational gait analysis. These methods could demonstrate more beneficial educational effects by incorporating not only static models, but also dynamic models developed using the new technology of motion analysis into motion data, along with interactive checking systems. 85 PTS volunteered to participate in this study. The effects showed a significant improvement score between the CAI and control groups. All results of scores and time between before and after the CAI learning were statistically significantly effectiveness. And the final scores strongly associated with the number of login in CAI group.

Key words

Computer Assisted Instruction,
observational gait analysis,
education, physical therapy students,
World Wide Web

Introduction

Recently, rehabilitation has begun to attract much public attention as a major component of the health care insurance system in Japan's ultra-aging society. The goal of rehabilitation for elderly persons or patients is to maintain the patient's activities of daily living (ADL) and to facilitate recovery from disabilities. Assessment of ADL includes measurement of motions, such as "gait", "standing up", "going up stairs", and "taking a bath". Therefore, observational motion analysis for ADL has long been one of the important skills to be learned by rehabilitation co-medical students seeking positions as physical or occupational therapists. However, in order to provide the necessary knowledge for understanding the mechanism of each motion to students, many teachers must be specifically educated. Each motion is a skill that healthy individuals feel is easy to perform in daily life. In contrast, elderly patients may have difficulty in perform-

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ing these characteristic motions in daily life; therefore, the motions are considered to be pathological.

Traditional education methods, such as reading technical journals in turn, distributing data, and watching video aids, have been extensively used to teach ADL and suchlike knowledge1). In clinical practice, however, physical therapy students require not only ADL knowledge but also the ability to assess a patient's problems by observing his or her motion. This is an important problem solving skill and is strongly required by the students. We believe that the basis of motion analysis must be observation ability. Furthermore, basic observation ability requires training for observational gait analysis. However, training for observation ability has not been fully developed in university education2).

In our approach to the above problems, we considered the necessity of combining rehabilitation medicine with instructional technology. While rehabilitation medicine is composed of physical and occupational therapy components, instructional technology is the theory and practice of designing, developing, utilizing, managing, and evaluating processes and resources for learning. The first prerequisite for successful physical therapy education is allowing the students to develop an interest in the subject matter. In the 21st century, advances in information technology (IT) are generating a revolution that is radically transforming medical education systems. As computers become cheaper and more powerful and as computer networks and their accessibility continuously improve, networked computers are becoming a standard learning tool for students. More and more universities are providing all their students with computers and access to IT, which supports the development of various scientific and technological abilities among the students 3). Despite these advances, computer- and IT-based education has not been satisfactorily implemented in rehabilitation co-medical schools (including colleges and universities). Furthermore, research on computer assisted instruction (CAI) for physical therapy students (PTS) has been less numerous than in other fields of medical education. To date, we are only aware of two studies on CAI for PTS4,5).

Therefore, in a pilot study, we considered the possibility of developing new teaching materials, which are able to predict the effects of discovery learning by incorporating a simulated environment and observational gait analysis into a CAI program6). In order to maximize the number of potential students, we selected to embed the educational materials in software that is platform independent. In addition, to increase opportunities for self-learning on the World Wide Web (WWW), we developed a motion analysis education system using CAI for PTS that is available at any time and any place, not just at the school.

Computer aided instruction has become an increasingly valuable part of the practical curriculum for physician7,8) and nurse9,10) educators. Users of CAI believe that it is at least as effective as traditional instruction in helping students to learn specific knowledge and develop problem-solving skills. Lieberman et al11) compared the educational effectiveness of an interactive tutorial with that of an interactive CAI program and determined the effects of personal preference, learning style, and level of training. Both the tutorial and CAI groups demonstrated significant improvement in post-test scores. In a study by Chamberlain et al12), students were encouraged to apply osteopathic principles and practice to a web-based computer assisted clinical case, for which they were required to submit a SOAP (Subjective, Objective, Assessment, Plan) note. Keane et al13) reported that the directors of CAI consider it to be more effective than traditional educational methods since it allows students to learn more quickly. Additional research on co-medical students has reported similar findings that students' overall attitudes toward CAI were positive.

In contrast, little is known about specific aspects of CAI resources, such as learning span, computer specific, display devices, screen design, input design, and technical software, which can be used as educational tools for co-medical students. Keane et al (1991) also identified limitations in terms of the CAI resources used in research. Moreover, this research has been criticized because of the limited number of studies and the low statistical power among existing studies.

The present paper reports the findings of a study that hypothesized the educational benefits of developing new teaching materials incorporating self-directed learning accessible via the WWW. These methods could demonstrate more beneficial educational effects by incorporating not only static models, but also dynamic models developed using the new technology of motion analysis into motion data, along with interactive checking systems. Therefore, we developed CAI materials regarding observational gait analysis because it is thought to be difficult for PTS to initially analyze patients' performance of ADL.

MATERIALS AND METHOD

Subjects

Subjects were 29 university students (age range 20-28, mean age = 21.3 years) in a four-year program, 32 professional school students (age range 20-35, mean age = 28.3 years) in a three-year program, and 24 professional school students (age range 22-38, mean age = 29.6 years) in a four-year program. All students enrolled in departments of physical therapy in Japan volunteered to participate in this study. All students had completed course work addressing anatomy, kinesiology, and basic physical assessment such as observational gait analysis. The experiment used a two-group pretest-posttest design.

Students were randomly assigned into two groups. Forty of the 85 students were assigned to the CAI teaching strategy group. As a control, the remaining 45 students were assigned to the traditional teaching material group. All participants provided informed consent for their participation in this study and were informed that their grade would be unaffected regardless of their participation in this study. Five students did not complete the CAI study; therefore, study results included data from 35 students in the CAI teaching strategy group and 45 students in the traditional teaching material group.

Learning environment

The CAI teaching materials were Hyper Text Markup Language (HTML) text forms maintained on the author's internet server and accessible using a WWW browser. These CAI materials provide three web-based learning environments for individual learning. Individual practice is supported by presenting text, pictures and movies, links to other web-pages, and testing in a common gateway interface (CGI) program. To access the CAI materials, the learner must receive a certified identification number (ID) and password. Information regarding access records were processed according to each learner's ID in a learning records database.

The first page of the CAI materials shows the significance and purpose of this study, which learners are required to read. On the fundamental-knowledge page, the learner can study by reading text or viewing pictures and animations. On the observational gait analysis page, learners can observe gait in videos downloaded from the web server. These gait videos were created in the Windows Media Video format. The two types of videos incorporated into the CAI material were composed of digital video data and a skeleton model with a center of gravity maker measured using the three-dimensional analysis data. On the final question and answer page of the CAI material, students were able to complete a test assessing their observational gait analysis. This test was created using a CGI program in order to elucidate the improvement in students' observation capabilities. In addition, the learners have been banned from putting everyone's head together due to self-directed learning when they answer the questions on the test page.

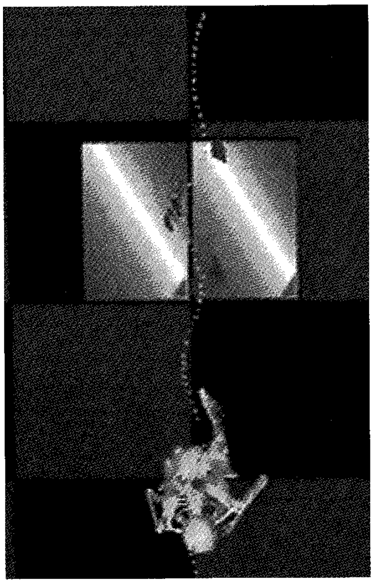
To obtain observational data, digital videos of actual gait were recorded from two angles (frontal plane and sagittal plane) by a digital video camera HC1000 (SONY, Tokyo, Japan). In addition, learners were able to view Stromotion video data, which is a format manufactured to create trajectory video footage revealing the evaluation of a quick movement over space and time. Stromotion video was copied from digital video data recorded on the sagittal plane using Stromotion software (Dartfish Japan, Tokyo, Japan). Therefore, three types of digital video data were prepared. An example of the digital videos is shown in Figs. 1 and 2. For clearer observations, a skeleton model of virtual gait was created using Vicon 512 motion analysis system with six cameras (Oxford Metrics, Oxford, UK) and a force plate (Kistler, Tokyo, Japan) for collecting ground reactive force data. Three angles of the skeleton model video were created (frontal plane, horizontal plane, and sagittal plane) using ARMO software (Gsport, Tokyo, Japan). These videos showed the skeleton model, ground reaction force vectors, and the center of gravity trajectory. An example of the skeleton model video is shown in Figs.3 and 4.

Video recording of gait involved the participation of three subjects who agree to be recorded by video cameras and the Vicon motion capture system for this study. One of the subjects was a normal 28-year-old male (Subject A). The other two subjects were a 72-year-old male (Subject B) with left hemiplegia from a stroke, which had occurred 5 years previously, and an 80-year-old female (Subject C) with right hemiplegia from a stroke, which had occurred 8 years previously. All subjects were able to walk independently and at the required speed for recording.

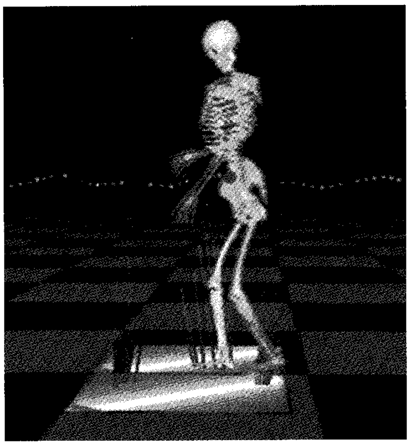
The CGI program contained autonomous functions designed to randomly select ten multiple-choice questions from the test database, check the answers, measure the duration of the test, and measure the frequency of each answer on the question and answer page. On the answer page, true or false responses were indicated by circle or cross icons. Following completion of the test, a ranking of the top five scores was displayed in order to enhance learners' motivation. The test was designed by three experienced and highly trained

Figs. 1. A gait movie in sagittal plane by digital video camera

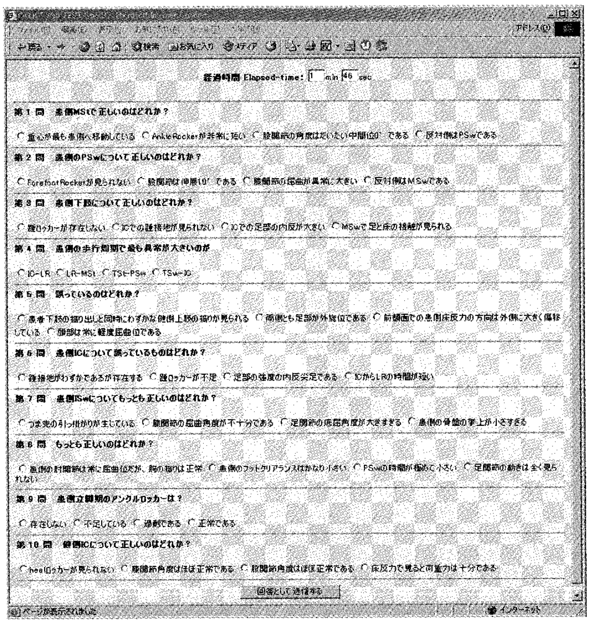
Figs. 2. A gait movie in sagittal plane with Stromotion softwere



Figs. 3. A skeleton model movie horizontal plane with ARMO software



Figs. 4. A skeleton model movie sagittal plane with ARMO software



経過時間 Elapsed-time: 1 min 46 sec

第 1 問　患側MStで正しいのはどれか？

○ 重心が最も患側へ移動している ○ AnkleRockerが非常に短い ○ 股関節の角度はだいたい中間位0°である ○ 反対側はPSwである

第 2 問　患側のPSwについて正しいのはどれか？

○ ForefootRockerが見られない ○ 股関節は伸展10°である ○ 膝関節の屈曲が異常に大きい ○ 反対側はMSwである

第 3 問　患側下肢について正しいのはどれか？

○ 踵ロッカーが存在しない ○ ICでの踵接地が見られない ○ ICでの足部の内反が大きい ○ MSwで足と床の接触が見られる

第 4 問　患側の歩行周期で最も異常が大きいのが

○ IC-LR ○ LR-MSt ○ TSt-PSw ○ TSw-IC

第 5 問　誤っているのはどれか？

○ 患者下肢の振り出しと同時にわずかな健側上肢の振りが見られる ○ 両側とも足部が外旋位である ○ 前額面での患側床反力の方向は外側に大きく偏移している ○ 頭部は常に軽度屈曲位である

第 6 問　患側ICについて誤っているものはどれか？

○ 踵接地がわずかであるが存在する ○ 踵ロッカーが不足 ○ 足部の強度の内反尖足である ○ ICからLRの時間が短い

第 7 問　患側ISwについてもっとも正しいのはどれか？

○ つま先の引っ掛かりが生じている ○ 股関節の屈曲角度が不十分である ○ 足関節の底屈角度が大きすぎる ○ 患側の骨盤の挙上が小さすぎる

第 8 問　もっとも正しいのはどれか？

○ 患側の肘関節は常に屈曲位だが、腕の振りは正常 ○ 患側のフットクリアランスはかなり小さい ○ PSwの時間が極めて小さい ○ 足関節の動きは全く見られない

第 9 問　患側立脚期のアンクルロッカーは？

○ 存在しない ○ 不足している ○ 過剰である ○ 正常である

第 10 問　健側ICについて正しいのはどれか？

○ heelロッカーが見られない ○ 膝関節角度はほぼ正常である ○ 股関節角度はほぼ正常である ○ 床反力で見ると両重力は十分である

回答として送信する

ページが表示されました

Figs. 5. The scene of ten multiple-choice question by Japanese

observers. Each test designer was a physical therapist with more than five years of observational motion analysis and clinical teaching experience. The Japanese ten multiple-choice questions are shown in Fig 5. The CGI programs were written in the Perl programming language for use on a Windows 98 (Microsoft Co, Redmond, USA) or later operating system.

Learning process and data scoring

The teacher distributed individual IDs and passwords to the learners for access to the CAI pages. After learners received an ID and password they were able to study the CAI materials at their own pace. The learners could access the first web page via the Internet at home or at the university. After password authentication, and confirmation of the learning goal, students reviewed the basics of gait analysis with the text and the pictures included on the fundamental-knowledge page. Next, the learners accessed the observational gait analysis page and downloaded videos of abnormal and normal gait. After downloading, the movies can be played on Media Player (Microsoft Co, Redmond, USA). We strongly recommended that each student select the normal gait as the first video to be viewed. Next, the learners accessed the test page and answered the questions. When less than 100% of answers were correct, the correct answers were confirmed and the learners were required to select whether to restudy the fundamental-knowledge page or observe the videos again. In addition, to reduce the effects of test-retest memory, learners were required to wait 20 minutes before taking the test again. If learners correctly answered 100% of the test questions or six weeks had elapsed since the start the CAI program, learning was considered to be complete.

The final score of control group has tested for only once six weeks later since CAI group began learning. And the test was used in exactly the same videos with CAI group.

Statistical analysis

Statistical tests were performed to examine quantitative data collected in this study. Analysis of the effects of this CAI system included a t-test to determine the differences between the CAI and control groups in terms of final scores, and the differences between pre-learning and post-learning scores in the CAI group. A two-way analysis of variance (ANOVA) of the CAI group determined the relationships between the gait video subjects and changes in test scores, and the relationships between the gait video subjects and changes in test duration. Pearson's product-moment correlations were calculated to determine correlations between the number of logins and final scores in the CAI group.

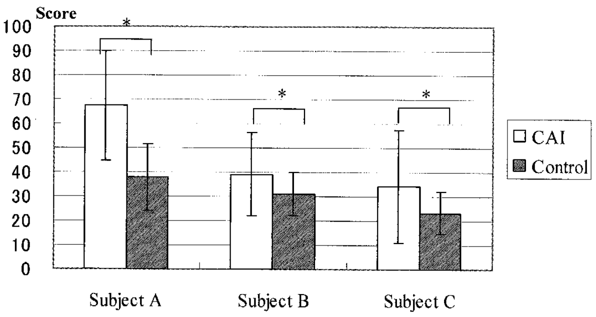
All data analysis was performed using SPSS version 11.0J (SPSS Japan, Tokyo, Japan) software package. Statistical significance was established at the p=0.05 level.

RESULTS

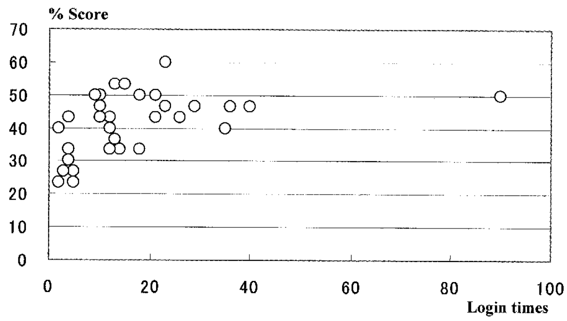
The results of a t-test comparing scores at the completion of the study between the CAI and control groups for the three video subjects is shown in Fig 6. The CAI group scored significantly higher than the control group for videos of subject A (t=7.26, p<0.01), subject B (t = 2.77, p<0.01), and subject C (t = 2.92, p<0.01). Table 1 shows the mean change of scores and test duration in the CAI group for videos of the three subjects. Comparison of pre- and post-learning showed that scores increased significantly (p<0.01), and test duration decreased significantly (p<0.01).

The summary of a two-way repeated measure ANOVA on change in scores is presented in Table 2. Significant differences were observed in test scores for videos of subject A, B, and C (α). A significant main effect (β) was observed between pre- and post-learning scores, indicating that test scores increased following the learning program. Therefore, a post hoc multiple comparison was conducted using Tucky's HSD. It was found that scores for subject A differed significantly from scores for subjects B and C (each p<0.01). However, changes in scores for groups B and C were not significantly different (p=0.39).

In addition, these findings revealed significant interactions ($\beta \times \alpha$) between the differ-



Figs. 6. The completion scores of the CAI and control groups for three subjects of movie materials (*p<0.01)



Figs. 7. The numbers of login and the final scores in CAI groups, were statistically significant (r=0.44, p<0.01)

ence among the test scores for videos of subject A, B, and C and between pre- and post-learning scores. The summary of the two-way repeated measure ANOVA on changes in duration is presented in Table 3. No significant differences were observed between test duration for subject A, B, and C (γ); therefore, a post hoc test was not conducted. A significant main effect (δ) was observed between pre- and post-learning indicating that test duration decreased after the learning program. In addition, the findings revealed significant interactions ($\delta \times \gamma$) between the differences among test scores for videos of subject A, B,

Table 1. The results of the mean of shange scoresand time of three subjects movies in CAI group

Intervention moview	Pre Learning (SD)	Post Learning (SD)	Mean Differences	t	p
Score					
SubjectA	25.1 (9.8)	67.4 (22.5)	3.2	-13.3	.00
SubjectB	25.1 (7.4)	39.1 (17.2)	2.4	-5.9	.00
SubjectC	21.4 (10.1)	34.3 (23.3)	3.5	-3.7	.00
Time					
SubjectA	340.5 (51.2)	171.3 (66.7)	15.3	11.1	.00
SubjectB	280.4 (40.6)	249.7 (48.3)	5.9	5.2	.00
SubjectC	277.1 (31.9)	251.6 (25.2)	6.3	4.0	.00

Table 2. The results of a 2 way ANOVA with repeated measure on changing score

Score	dg	MS	F	p
Between Groups				
α (Subject A/B/C)	2	6510.0	17.6	.000
Error	102	369.5		
Within Groups				
β (Pre-/Post-)	1	27887.6	170.5	.000
$\beta \times \alpha$	2	4863.3	29.7	.000
Error	102	163.6		

Table 3. The results of a 2 way ANOVA with repeated measure on changing time

Score	dg	MS	F	p
Between Groups				
γ (Subject A/B/C)	2	1818.4	.40	.000
Error	102	4512.9		
Within Groups				
δ (Pre-/Post-)	1	296438.6	164.5	.000
$\delta \times \gamma$	2	116301.1	64.5	.000
Error	102	1802.3		

and C and between pre- and post-learning scores.

Pearson's product-moment correlations for the number of logins and the final scores in the CAI group were statistically significant (r=0.44, p<0.01). This characteristic is shown in Fig 7.

DISCUSSION

Though previous studies have indicated many effective uses of CAI, the field of medical education has not adopted this cultural innovation. This is of particular importance for observational gait analysis in physical therapy education.

The paramount importance of observational gait analysis ability has been emphasized previously. In one of our pilot studies on educational tools for observational gait analysis[2)], we created a gait analysis education program for developing the essential movement analysis ability required by physical therapy students. This was created using traditional methods such as tutorial training, reading a standard reference text in turn, and viewing videos. However, the total mean analysis score was significantly higher after the training program. Thus, the originality and ingenuity of educational material for observational gait analysis demonstrated a potential to increase the educational effects of a training program. The CAI-based educational materials developed for the present study were created based on the experience of the pilot research.

Based on our previous experiences, we suggest that CAI be incorporated into Internet technology in order to provide videos based on 3D motion analysis, and CGI programs as new technologies for learners. The present CAI program utilized videos of three subjects based on 3D motion analysis. The results of the t-test indicated that the CAI group improved significant more than the control group. The effects of these video materials are supported by findings published by Douglas et al[14)], Krouse[15)], and Julia et al[16)]. Furthermore, comparison of all scores and durations between before and after the CAI program showed significant improvement. The observed improvement in scores was similar to the outcome of previous studies in which participants completed a multiple-choice test after self-learning using CAI materials[17,18)]. The improvement also demonstrated a beneficial effect for improving gait observation ability. Presently, physical therapists require a high level of observational gait analysis ability and must perform these observations as quickly as possible in practice. Though the CAI program facilitated faster responses to the test questions, ordinary patients are unable to walk repeatedly, as shown in the videos developed for this study; therefore, we must be careful no to assume that the effects of CAI will contribute to assessments conducted in practice.

Studies of CAI and self-learning with Internet technology and motion analysis with digital videos are becoming increasingly common[10, 20)]. However, no studies of CAI for gait analysis using both the Internet and videos have been conducted. In the present study, the results for test scores and test duration demonstrated that our CAI system has educational power; however, results of the two-way analysis of variance showed the effect of statistical interaction. Therefore, further research is required to clarify how to create easy-to-understand videos.

Furthermore, as final scores in the CAI group were strongly associated with the number of logins, we must determine how to encourage self-learning in a CAI program. This finding suggests that the more learners use the materials, the more efficiently they are able to raise their scores. Though continuity and satisfaction with the use of CAI are similar in nature, several studies have not found positive effects for students' satisfaction toward

CAI[20-22]. Students in these studies indicated that CAI was less useful, less stimulating, less satisfying, more frustrating, and generally less enjoyable than other learning strategies. Therefore, user-friendliness is one of the essential factors for developing an effective CAI program. However, students currently have countless opportunities to gain firsthand experience on a computer. Though it may be necessary to investigate the level of satisfaction among students, we were not able to assess this in the present study.

The authors recognize the following limitations of the present study:

Major differences exist between the method of observational gait analysis used in this study and that used in clinical practice. The present CAI program used multiple-choice questions to assess gait; however, in practice, a checklist is used. The well-known observational gait analysis system developed at Rancho Los Amigos Hospital under the direction of Dr. Jacquelin Perry, uses a gait analysis checklist[23], though in many cases, several types of checklist for gait analysis are now commonly used. Therefore, it is necessary to investigate the educational effect of using checklist. This issue must be addressed by future research.

Furthermore, in clinical practice, registered physical therapists (RPT) have to analyze all types of motion to perceive the many patients` disability. Further studies on the motion analysis education will be necessary to add many other ADL motion besides the gait. It may give a clue to elucidating the weak points which both PTS and RPT observe to analyze motion in individual cases.

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