Yonsei Medical Journal
Vol. 44, No. 5, pp. 892 - 904, 2003

Development and Validation of a Computerized Exercise Intervention Program for Patients with Type 2 Diabetes Mellitus in Korea

Ji-Soo Yoo[1], Ae-Ran Hwang[1], Hyun-Chul Lee[2], and Chun-Ja Kim[3]

[1]Yonsei University College of Nursing, Seoul, Korea;
[2]Department of Internal Medicine, Yonsei University College of Medicine, Seoul, Korea;
[3]University of Alabama at Birmingham School of Nursing, #0G10B Nursing Building, 1701 University Boulevard Birmingham, AL 35294-1210, USA.

This study was designed to develop and validate a computerized exercise intervention program using the transtheoretical model (TTM) for Korean patients with type 2 diabetes mellitus (DM). This computerized program was web-based and developed by designing a flow chart. An expert group (n=24), who validated the content of the computerized program, produced a mean score for the evaluation scale of 4.25 (SD .56). Of the patients (n=28) with type 2 DM who participated in clinical validity testing of the program, the mean score for the satisfaction scale was 4.82 (SD .12). In the validation of the program, significant differences between baseline and after-intervention were observed in the stage of readiness for exercise ($Z=-3.78$, $p<0.001$), physical activity ($Z=-2.33$, $p<0.05$), blood glucose profiles [FBS ($Z=-2.84$, $p<0.01$), pc 2hr. glucose ($Z=-2.33$, $p<0.05$), HbA_1c ($Z=-2.77$, $p<0.01$)], and VO2max ($Z=-2.52$, $p<0.01$). The study confirmed that the computerized program could be used to construct a database and continue to provide follow-up intervention for patients in all stages.

Key Words: Exercise, computer programs, psychological theory, diabetes mellitus

INTRODUCTION

The number of people with DM in the Korean population is about 2 million, or 10% of the adult population.[1] The three major therapies for DM control and management are diet, exercise and medication. It has been well established that regular exercise is the most helpful intervention for amelioration of blood glucose profiles[2-10] (ex. fast glucose sugar [FBS], after meal [pc] 2hr. glucose and glycohemoglobin [HbA_1c]) and blood lipid profiles,[2-4,6-9] for improvement of cardiopulmonary function[5-9,11] (ex. maximum oxygen uptake [VO_2max], and anaerobic threshold [AT]), for amelioration of fat composition,[8-10,12] for promotion of psychosocial well-being,[7-9] and for early prevention of complications in patients with type 2 DM.[11,13] Furthermore it has been shown that regular exercise prevents or delays patients (n= 530) with impaired glucose tolerance.[14] Another study reported that regular exercise is effective for patients with chronic disease such as hypertension, heart failure, and cognitive disorders, as well as DM.[15]

However, the effects of exercise, which so benefit health, will vanish within 2 to 3 months if exercise is stopped.[16] The participant compliance rate in prescribed exercise programs has been reported to drop to 50% within 3 - 6 months in epidemiological and clinical studies.[17-19] It has been reported that the maintenance of exercise programs on a regular basis is a key problem in applying exercise programs because the benefits of exercise do not persist without continued and regular participation.[20]

The transtheoretical model (TTM) integrates

Received March 12, 2003
Accepted July 11, 2003

This work was supported by grant No. (R01-2001-000-00139-0) from the Basic Research Program of Korea Science & Engineering Foundation (KOSEF).

Reprint address: requests to Dr. Ji-Soo Yoo, Yonsei University College of Nursing, 134 Shinchon-dong, Seodaemun-gu, Seoul 120-752, Korea. Tel: 82-2-361-8142, Fax: 82-2-392-5440, E-mail: yoojs48@yumc.yonsei.ac.kr

current behavioral status with a person's intention to maintain or change his or her pattern of behavior.[21] The core of this model is five stages of motivational readiness for change. They start from pre-contemplation (individuals do not intend to change their behavior) and progress through contemplation, preparation, action and then maintenance (the exercise behavior is maintained for more than six months). Interventions based on TTM utilize the concept of matching intervention to the individual's stage of readiness for exercise and have been shown to be more effective than not tailoring exercise to motivational readiness.[22] For example, interventions targeted to pre-contemplators may focus on enhancing particular aspects of knowledge, and those targeted to individuals in the action stage may focus on social support and injury prevention. Whereas other programs are appropriate only to people who already have an intention to exercise, the stage-based intervention programs can be applied to the total population, including people in the pre-contemplation and contemplation stages. Previous research[23-31] has also demonstrated that a stage-matched intervention program is more effective than any other routine care. However, there is a need to construct programs that can be computerized in order to cumulate and update exercise data more systematically. Such programs also need to provide consistent interventions because health providers such as doctors, nurses or other exercise professionals are too busy to provide exercise interventions for patients in clinical settings.

Thus, it is important to develop a computerized exercise program that will effectively decrease time spent in waiting and gathering for repeated baseline and attrition information on patients. It should also allow health providers to share up-to-date exercise data with patients as well as with each other. The purpose of this study was to develop a computerized exercise program and evaluate the program by testing it firstly for content validity with an expert group and then for clinical validity with type 2 DM patients. For clinical validation of the computerized program we hypothesized that follow-up data after the intervention, compared to baseline data, would show greater exercise physiological outcomes (more advanced stages of readiness for exercise, higher level of physical activity, and higher VO_2max) and improved blood glucose profiles (greater reductions in FBS;, pc 2hr. glucose;, and HbA_1c).

MATERIALS AND METHODS

Method

Phase 1: Develop the conceptual framework for the program

We developed the conceptual framework of the computerized exercise intervention program based on TTM. A design of a data flow chart was made for the input and output components for a web screen using algorithm contents developed by Kim.[32]

Phase 2: Construct the preliminary program

We constructed the preliminary program contents based on the conceptual framework. When the preliminary program screens were completed, a web-site scope was set-up and designed by an expert group consisting of a clinical team, including a program content professional, web designer and programmer, and a consultation team, including a diabetes specialist doctor, diabetic faculty and exercise faculty. The system was constructed on a www site. We used window NT 4.0 for the web server operation system, SQL server 7.0 by Microsoft for the database management system, the NAMO editor, Dream Weaver, Home Site for HTML text, Photoshop 6.0, Illustrator 9.0, and Flash 4.0 for web design on the web page.

Phase 3: Establish the content validity of the preliminary program

The expert group (n=24) participated in simulation of the computerized exercise intervention program for content validity. The content validity of the web-based programs was measured using a 16-item evaluation scale. The expert group indicated their agreement on clearness, precise/property, relevance, consistency, sufficiency, efficiency, ease of use, design/technology and recommendations. The scale used was a 5-point Likert scale ranging from 1 (not at all important) to 5

(extremely important). The instrument has a reported Cronbach's alpha of 0.91.[33]

Phase 4: Establish the clinical validity of the preliminary program

Type 2 diabetic patients (n=30) participated in the computerized exercise intervention program operated by two program providers for clinical validity. A prospective, single group, pretest-posttest design was used for validation of the computerized program. Inclusion criteria for this study were: FBS 100-240 mg/dl, HbA_1c 6.0-10.0%, DM history < 21-year with no chronic complications such as severe retinopathy, nephropathy or neuropathy, no problems with EKG or BP, and not on insulin. Each participant gave informed consent. These participants were recruited among patients seen between May 1, 2002 and September 30, 2002 at the outpatient clinic of Yonsei Medical Center, Korea. During this study, two participants were excluded as one moved and one was injured, leaving a final total of twenty-eight with a mean age of 56.11 years (SD 6.35 years; range 39-62 years). Immediately after the intervention, a 13-item patient satisfaction scale and exercise related measurements were used for clinical validation of the program. Participants indicated their satisfaction with clearness, precise/property, relevance, consistency, sufficiency, efficiency, ease of to use, design/technology and recommendation.[34] The scale used was a 5-point Likert scale ranging from 1 (not at all satisfied) to 5 (extremely satisfied). Cronbach's alpha in this study was 0.97. Exercise related measurements included self-report assessment of stage of readiness for exercise, physical activity, maximum oxygen uptake, and blood glucose profiles.

Phase 5: Develop the final computerized exercise intervention program

We revised the preliminary program according to results of content and clinical validity and developed the final computerized exercise intervention program. The site map is shown in detail in Table 1.

Intervention procedures

The computerized exercise intervention program comprised preplanned counseling and coaching that were matched to the participant's degree of motivational readiness for exercise by targeting deficiencies in assessment responses in the participant's use of constructs from the TTM. The contents were based on exercise adoption and maintenance literature and focused on the processes of change used by individuals in different stages of exercise. All participants were assessed for their present stage of exercise through the assessment tool for stage of readiness for exercise, after which they participated in the computerized exercise intervention program. They were also encouraged to participate in their household, leisure or job physical activities. The definition, goal, objectives, main resources and methods were designed to match each stage. The main strategies of feedback response to the patient's need and questions were: to set-up an individual exercise program consisted of goal, type, time, intensity, frequency and special precaution; to prevent and cope with any emergency situation arising during exercise and precaution for DM; to learn and complete the exercise time schedule and physical activity including regular exercise log consisting of date, place, type, time, intensity, glucose level of pre and post exercise, feeling, other comments and symptoms; to prevent and cope with any emergency situation arising during exercise and precaution for DM. Feedback was re-assessment of the stage of readiness for exercise and then move on to the next stage. The following exercise protocol was designed for diabetes patients[35]; (1) Mode was brisk walking, jogging, climbing or running on a treadmill or track; (2) Frequency was three to five days each week; (3) Duration totaled 40 minutes consisting of 5 minutes of warming up, 30 minutes of aerobic exercise, and 5 minutes of cooling down; (4) Intensity such that each participant aerobically exercised at a workload that produced a heart rate corresponding to 40-75% of the individual participant's heart rate reserve (HRR) method and/or VO_2peak achieved on the graded exercise test (GXT) at baseline; (5) Progression so that as cardiovascular and muscular adaptations occurred in response to training, heart rate and blood pressure decreased in response to a given workload. When participants had exercised at least for the first 2 - 3 weeks, they

were asked to exercise at the exercise lab to ensure their intensity during exercise. Exercise frequency, intensity and duration were monitored by diaries and kcal-pedometer which was provided to participants The participant's energy consumption was measured continuously during each session using a kcal-pedometer to assure that participant's step and energy consumption remained within the prescribed range The participants maintained an exercise log weekly, indicating the length of exercise time and their energy consumption by pedometer. Each week, the participants also reported whether or not they had any problems. The rate of exercise adherence was calculated as the number of sessions performed divided by the number of sessions prescribed. The rate of exercise adherence in this study was 78.5%.

Measurements

Participants completed a questionnaire, including questions about demographics, on entry into the study and again immediately after the intervention. The repeated measures included: self-report assessment of stage of readiness for exercise, physical activity, maximum oxygen uptake, and blood glucose profiles.

The stage of exercise behavior scale (SEBC) requires the participant to choose which of five statements best describes their current exercise pattern and performance (defined as at least 20 min/session, 3 times weekly, with at least the intensity of a brisk walk). Each of the statements corresponds to one of the stages of change from pre-contemplation to maintenance: "I currently do not engage in physical exercise and I am not thinking about starting" (pre-contemplation), "I currently do not engage in physical exercise but I am thinking about starting" (contemplation), "I currently engage in some physical exercise but not regularly" (preparation), "I currently engage in regular physical exercise but I have only begun to do so within the last 6 months" (action), and "I currently engage in regular physical exercise and I have done so for longer than 6 months" (maintenance). Each stage was assigned a numeric value on a five-point scale, with 1 representing the lowest level of readiness to change (pre-contemplation) and 5 representing the highest readiness to change (maintenance). Concurrent validity for the scale has been demonstrated with a 7-day physical activity recall questionnaire.[23] A (index of reliability of 0.78 (n=20) over a 2-week period has been reported.[36]

The activity assessment questionnaire (AAQ) is a 7-day physical activity recall adapted for adults from the Northern Ireland Children's Health and Fitness Survey.[37] The AAQ requires respondents to recall their exercise starting with the same day 7 days ago. Time markers such as morning, lunch-time, etc. were used to increase accuracy of recall. For each activity listed, respondents completed a section asking frequency, duration and intensity of their physical activities. A physical activity energy score was calculated from time spent in various activities and standard metabolic values (METs) for those types of activities. METs were set at less than 3.5 for light activities, 3.6 to 5.5 for moderate activities, 5.6 to 7.5 for hard, and over 7.5 for very hard activities. Each MET was assigned a numeric value on a four-point scale, with 1 representing the lowest level of physical activity (light activities) and 4 representing the highest physical activity (very hard activities). The level of physical activity analyzed in this study was energy expenditure from household, job or leisure time expressed in METs.[37]

VO_2max was directly measured by the sub-maximal exercise stress test using Protocol No. 018307-001, Protocol Bruce 645, Oxycon Delta (accuracy, failure < 1%), Treadmill LE 200C by JAEGER Co., Germany. Blood glucose profiles were measured by BIOSEN 5030autoCal, EKF-diagnostic co., Germany (accuracy, failure < 1.5% @ 12 mmol/l) for FBS, and pc 2hrs glucose; and NycoCard READER II, Axis-Shield UK (accuracy, failure < 5%) for HbA_1c.

Statistical analysis

Descriptive statistics were used to analyze demographics, stage of readiness for exercise, physical activity, VO_2max, and blood glucose profiles. Chi-square for categorical variables and Wilcoxon-signed ranks test for continuous variables were used to analyze differences between baseline and follow-up data. Cronbach's alpha was used to analyze reliability of the patient satisfaction and

program evaluation scales.

RESULTS AND DISCUSSION

Construction of the conceptual framework and preliminary program

We developed the conceptual framework based on TTM. The clinical team, including a program content professional, web designer and programmer, set up and designed a web site scope. The program content professional modified the printed algorithm contents developed by Kim[32] and completed the input and output components for each web screen. The web designer and programmer made each web screen according to the design of a data flow chart. We considered the simplicity and sufficiency of the web contents of each screen. Initial screens included introduction, contents, manual and help, Q & A board, link sites and program start. When the start button was clicked, general information, evaluation instruments, screening instruments, graded exercise test, exercise prescription, stage-matched intervention programs, glossary and related materials were presented in that order. The web-site scope was designed so that whoever used the program, nurses, doctors or exercise specialists, would be able to provide and manage the exercise intervention program consistently. The preliminary web site was validated by two consultations. On six occasions the clinical team found errors or problems in the program. Each time we revised the preliminary program. Content was input and revised for set-up and construction of the database for content of the program. When we input the content, we took care not to use <p> tag but input html in the screening concept, design and technology of the system. When content needed to be deleted we deleted it in reverse order.

Content validity of the preliminary program

An expert group (n=24), which consisted of professionals or experts in diabetes, exercise and informatics, participated in testing the content validity of the computerized exercise intervention program. The demographic characteristics of the expert group showed that the majority of the participants were women (75.0%) and most were in their thirties. The education level of 79.2% of the participants was graduate school. Occupations included diabetes nurses professionals (29.2%), diabetes doctors (20.8%), informatics professionals such as web designer and programmer (20.8%), exercise professionals (16.7%), and faculty related to diabetes, exercise or informatics (12.5%). Of these participants, 45.8% worked in their clinical (expert) field, 42.6% worked in educational departments, 33.4% in clinical settings and 16.7% in departments related to informatics. After they had simulated this intervention program, they evaluated it using a 16-item evaluation scale including clearness, precise/property, relevance, consistency, sufficiency, efficiency, ease of use, design/technology and recommendations (Table 1). The mean score for the evaluation was 4.25 (SD .56). The highest items (range 1-5) were precise/property: "The contents of program are properly arranged by goal" (4.50), "The program provides appropriate content and stage-matched intervention for each client" (4.50), and efficiency: "The program is efficient for patients with DM in detail and practical aid" (4.46). Whereas the lowest items were ease of use: "Explanation and guides for the program are easy to use" (4.04), and design/technology: "I am satisfied with the comprehensiveness of the screen organization" (4.08). The time for simulation of this intervention by the expert group was 40 to 90 minutes.

Clinical validity of the preliminary program

To test the clinical validity of the computerized exercise intervention program 28 Korean patients with type 2 DM participated. The demographic characteristics showed that the majority of participants were women (64.3%) and 57.1% were in their fifties. Most of the participants (76.7%) had a history of DM of less than 10 years. For DM management, medication only was the treatment for 21.4% of the participants, while 17.9% used medication along with diet. For stage of readiness for exercise, 14.3% were in the preparation and maintenance stages, 14.3% in the action stage, 46.4% in the pre-contemplation stage and 25.0% in the contemplation stage. After the intervention the

Table 1. Program Satisfaction Score by the Expert Group

Attrition	Question	Mean ± SD
Clearness	The Program is described the Goal clearly.	4.29 ± .75
Precision/ Propriety	The contents of program are arranged properly by goal.	4.42 ± .72
	The program provides proper content and stage-matched intervention for each client.	4.50 ± .66
Sufficiency	The program gives sufficient information to clients.	4.13 ± .68
Reliance	The program provides content and information by professionals on exercise and DM.	4.38 ± .71
	The program is reliant in providing information on where to make contact and who is responsible for the program.	4.21 ± .78
Consistence	The program manages the data of patients with DM consistently.	4.25 ± .68
	The program accepts opinion of patients via the Q&A Board.	4.17 ± .70
Efficiency	The program is efficient for patient with DM in detail and practical aid.	4.46 ± .72
	Link sites and materials given are useful for understanding related information.	4.25 ± .61
Simplicity (easy to use)	Explanation and guide of the program is easy to use.	4.04 ± .75
Design/ Technique	I am satisfied with the amount and format of the print screen.	4.17 ± .64
	I am satisfied with the loading speed of the web screen.	4.13 ± .68
	I am satisfied with the comprehensiveness of the design of the program.	4.13 ± .68
	I am satisfied with the comprehensiveness of the screen organization.	4.08 ± .72
Recommendation	I strongly recommend this program to other DM and exercise experts and professionals.	4.33 ± .64
Total Mean Score		4.25 ± .56

participants completed a 13-item patient satisfaction scale including clearness, precise/property, relevance, consistency, efficiency, ease of use, and recommendations. The converted mean score for evaluation was 4.82 (SD .12) (Table 2). The highest items (range 1-5) were precise/property: "The program provided appropriate content and stage-matched interventions to each client" (5.0), "The contents of program are properly arranged by goal" (4.93), efficiency: "The program is efficient for patients with DM in detail and practical aid" (5.00), and reliance: "The program provided content and information by professionals on exercise and DM" (5.00), "Where to make contact and responsibility of those in charge of the program is reliant" (5.00). Whereas the lowest item was consistency: "The program accepted the opinion of patients via the Q&A Board" (4.39). The time required for providing this intervention to each participant took between 50 - 105 minutes on the first visit, 20 - 50 minutes in pre-contemplation and contemplation stages, and 60 minutes in preparation, action and maintenance stages at the repeat visit. These findings showed that participants did not connect to this web-based program because it was providing by their health providers. Most of the feedback or opinions from the participants came during telephone or face-to-face counseling but not over the internet because most of them could not use the internet.

The findings for validation of the computerized intervention showed that significant differences were detected between baseline and after-intervention in the following: stage of readiness for exercise ($Z=-3.78$, $p<0.001$), level of physical activity ($Z=-2.33$, $p<0.05$), VO_2max ($Z=-2.52$, $p<0.01$), and blood glucose profiles [FBS ($Z=-2.84$, $p<0.01$), pc 2hr. glucose ($Z=-2.33$, $p<0.05$), and HbA_1c ($Z=-2.77$, $p<0.01$)] (Table 3). The stage of readiness for exercise after the intervention (3.39 ± 1.23) increased significantly compared to baseline (2.18 ± 1.44). The number of changes in stage of readiness for exercise from baseline to after-intervention were: in the pre-contemplation (PC) stage, 13 (46.4%) to 3 (10.7%); in the contemplation (C) stage, 7 (25.0%) to 3 (10.7%); in the preparation

Table 2. Program Satisfaction Score by DM Patients

Attrition	Question	Mean ± SD
Clearness	I can clearly understand the goals of this Program.	4.86 ± .36
Precision/ Propriety	The contents of program are arranged properly by goal.	4.93 ± .26
	The program is provided proper content and stage-matched intervention to me.	5.00 ± .00
Reliance	The program provides content and information by professionals in exercise and DM.	5.00 ± .00
	The program is reliant in providing information on where to make contact and who is responsible for the program.	5.00 ± .00
Consistence	I can get consistent and regular interventions.	4.89 ± .32
	I can know the trends in exercise information.	4.54 ± .51
	The program accepts opinions of patients via the Q&A Board.	4.39 ± .49
Efficiency	The program is efficient for me with DM in detail and practical aid.	5.00 ± .00
	Link sites and materials given are useful for understanding related information.	4.64 ± .49
	My exercise life styles (ex) attitude, knowledge and adoption) are improved practically.	4.79 ± .42
Simplicity (easy to use)	I can get the materials related exercise information rapidly and easily.	4.96 ± .19
Recommendation	I recommend this program strongly to other DM and exercise experts and professionals.	4.71 ± .54
Total Mean Score		4.82 ± .12

Table 3. Differences of Stage of Readiness for Exercise, Physical Activity, Maximum Oxygen Uptake and Blood Glucose Profiles between Pre-Test and Post-Test

	Pre-test M ± SD	Post-test M ± SD	Z	*p*
Stage of readiness for exercise	2.18 ± 1.44	3.39 ± 1.23	-3.78	0.00
Level of physical activity	2.14 ± .45	2.32 ± .48	-2.24	0.03
Maximum Oxygen Uptake (VO_2max)	23.60 ± 3.91	24.06 ± 3.75	-2.52	0.01
Blood glucose profiles				
FBS Fast Glucose Sugar	162.00 ± 46.47	147.86 ± 47.82	-2.84	0.01
PC 2hr. Glucose	251.21 ± 71.61	225.11 ± 69.16	-2.33	0.02
HbA_{1C}	7.99 ± 1.22	7.69 ± 1.11	-2.77	0.01

(P) stage, 1 (3.6%) to 5 (17.9%); in the action (A) stage, 4 (14.3%) to 13 (46.4%); and in the maintenance (M) stage, 3 (10.7%) to 4 (14.3%). We also found that the shifts in change for stage of readiness for exercise after-intervention were that 19 (67.9%) advanced by at least one stage and 9 (32.1%) maintained their initial stage. The findings of this study showed that the intervention resulted in an increase in stage of readiness for exercise. This finding is similar to results where significant differences in stage were found between a control group and those who received a stage-based intervention in primary care settings.[24-28] The level of physical activity increased significantly after the program (M=2.32, SD=0.48) compared to before (M=2.14, SD=0.45). This finding is similar to the results of other studies.[36,37] We also found significant increases in both stage of change and physical activity levels when physical activity was measured by walking and accelerometer scores.[35] Significant differences in VO_2max were found between baseline and after-

intervention. The findings of this study are similar to those of Shimokate, et al.[13] and Na, et al.[5] which showed significant differences in cardiopulmonary fitness, including VO_2max, between intervention and control conditions in patients with DM. Few studies have measured cardiopulmonary function such as VO_2max as an objective measure of fitness and physical activity.[23] Significant differences in FBS, pc 2hrs glucose and HbA_1c were found between baseline and after-intervention. Those findings are similar to those of Agurs[12] who found decreases in HbA_1c in patients with type 2 DM after 12 weeks of aerobic exercise. In a moderate circuit exercise study 4 for patients with type 2 DM, HbA_1c decreased significantly compared to a control group.

Development of the final computerized exercise intervention program

We revised the preliminary program according to results of content and clinical validity and developed the final computerized exercise intervention program. The site map is shown in detail in Table 4. The web-site address for this intervention was http://211.181.217.88/dangnyo/. The web site was validated by content and clinical validities. The following components were revised according to results of contents validity. First, we deleted a large quantity of contents that are provided by other sites and are connected with diabetes, exercise and research issues related to linked sites because the preliminary program had huge contents. Second, the administrator site was separated from the main web site because program operators can handle data easily. Finally, we revised the outcome data to be calculated automatically when the original data is input. The following components were revised according to results of clinical validity. First, we encouraged intermittent exercise (more than 30 minutes per day, more than 8 minutes per session) among those who were too busy to do exercise. Second, we recommended commencement of exercise of

Table 4. Site Map for Computerized Exercise Intervention Program

Attrition	Menu
Introduction	Program/developers/manufacturer
Contents	Stage (I)/Stage (II)/Stage 2/Stage 3/Stage 4/Stage 5/Glossary
Manual/help	Attrition menu explanation/ Method for Printing sheets for Graded exercise test (GXT)
Bulletin board	Q&A/Return to manager via e-mail
Linked sites	Exercise/Medical/Research sites link
Programs	General information/Evaluation instrument/Screening test/GXT/Exercise prescription/ Intervention program/appendix materials
General Information	Demographic characteristics/Disease related characteristics/Physical activity and exercise related characteristics/Medical History/Physical symptom/Diet habits and preferences
Evaluation Instrument	Evaluation for stage of exercise in present/Evaluation for compatibility exercise
Screening Test	Medical test (glucose/cardiovascular/kidney/complication)/body composition/general guidelines
Graded Exercise Test	Type/Method/Pre-exercise Screening (Glucose/Blood pressure/Diet/Medication/History taking)/ Electro-cardiogram (EKG) test/Pulmonary function test/Comprehensive comments
Exercise Prescription	Exercise prescription Record/Exercise prescription and guidelines
Intervention Program	Stage (I)/ Stage (II)/Stage 2/Stage 3/Stage 4/Stage 5/Glossary
Materials	Exercise intensity and Heart rate exchange table/Exercise exchange table/Energy content of consumption/Cautions during exercise/Short-form exercise log/Exercise record sheet/ Stretching Exercise/Muscle Strength Exercise

initial intensity to those who quit doing exercise for more than one week. Finally, telephone contact was made with those who couldn't use e-mail or internet.

The site-map of the final computerized exercise intervention program consisted of .introduction of program and contents, manual and help materials, link sites, general information, assessment tool, screening instrument, exercise test and prescription, five stage-matched interventions and Q&A board (Table 4). The main page included an e-mail address and search function for patient information (Fig. 1). General information consisted of demographics, disease-related characteristics, physical activity and exercise habits, medical history, signs and symptoms, and lifestyle habits and preferences, including questions on diet. The assessment tool page included assessment of stage of readiness for exercise (Fig. 2) and the physical activity readiness questionnaire (PAR-Q) as to whether patients were compatible for doing exercise or not (Fig. 3). The pre-screening page was made up of medical information, including findings for glucose level, cardiovascular system, kidney and complication test, body composition test, including percentage of fat and lean body mass, and routine test guidelines. The exercise stress test page was composed of general information from the patient, exercise stress test method and protocol, results and comprehensive interpretation of tests. The individualized exercise prescription page consisted of a summary of general and medical information, results of body composition and exercise stress tests, exercise prescription and instruction in detail (Fig. 4). The five stage-matched intervention page included an intervention program according to each stage and a glossary (Fig. 5). The material page provided exercise intensity and heart rate conversion tables, exercise exchange tables, energy consumption for each type of exercise or physical exercise, precautions during exercise, short-form exercise log, exercise recording book, stretching exercises and muscle strengthening exercises. The manual and help page provided help on how to print out the sheets for the exercise stress test and explanations of the top menu. The Q & A board provided answers to various questions. The page for participant management consisted of search function and list of all participants. The page for program evaluation and satisfaction scales consisted of provider and respondent questionnaires.

When interpreting and generalizing the results of this study, some limitations need to be considered. If individuals are categorized into stage of readiness for exercise, the sample size becomes

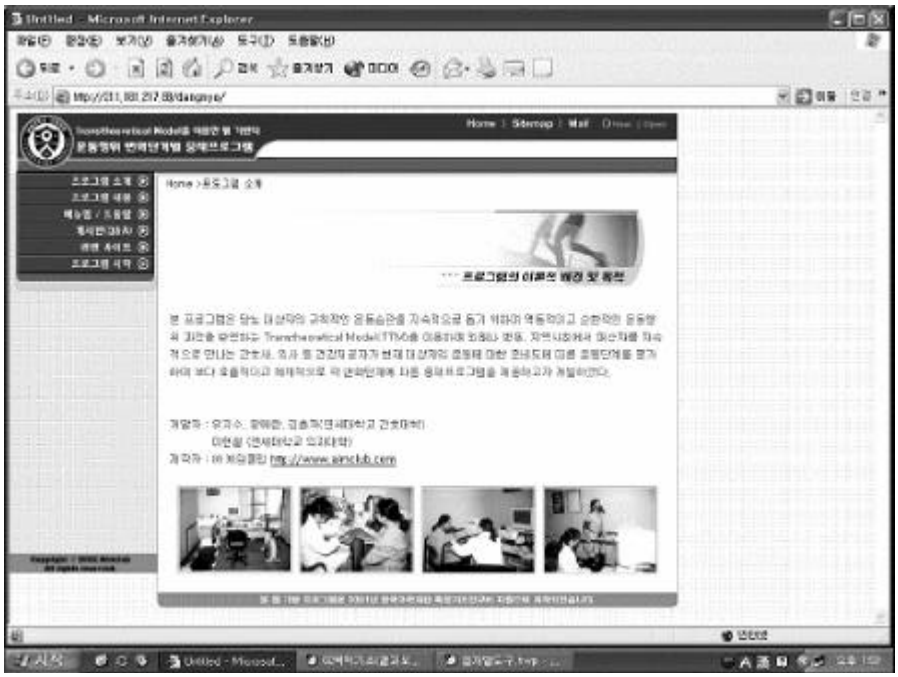

Fig. 1. Main page: Introduction of the computerized program.

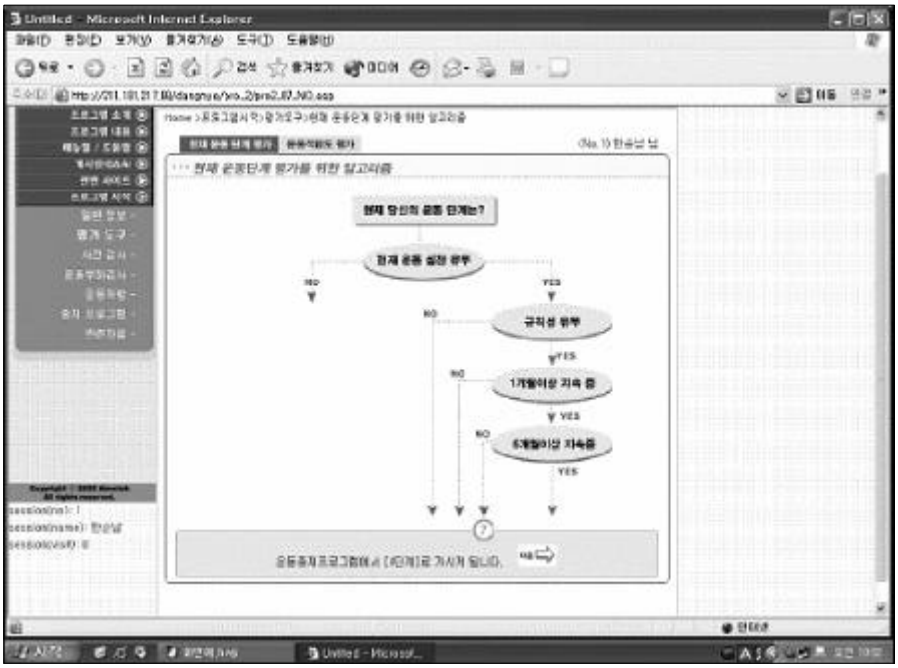

Fig. 2. Evaluation page: Assessment of current "stage of readiness for exercise".

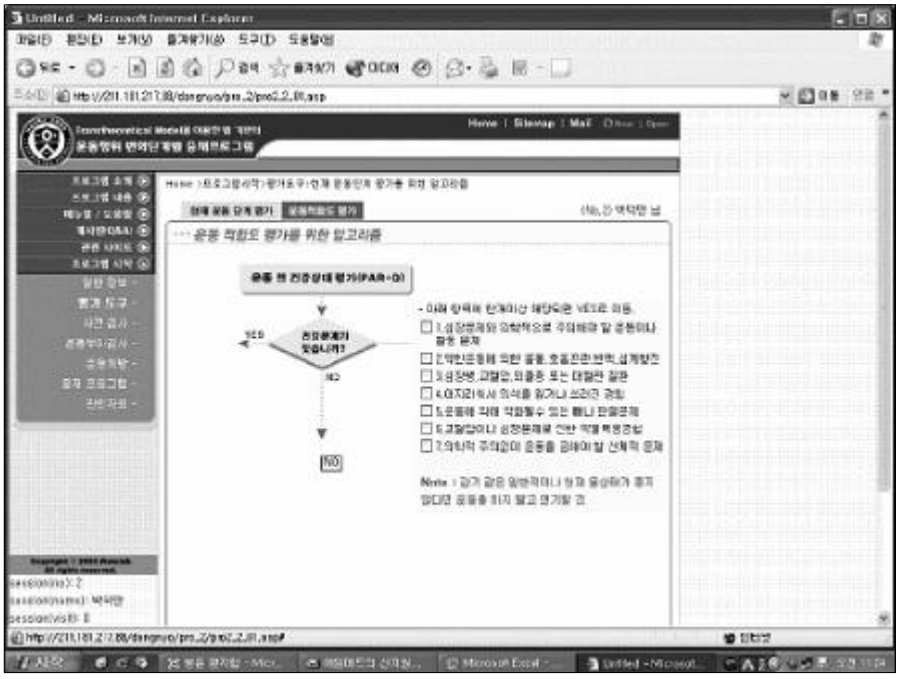

Fig. 3. Pre-screening page before intervention: Assessment of 7-item current physical activity including regular exercise readiness questionnaire (PAR-Q), glucose level, complication or contra-indication of doing exercise and degree of exercise ability.

too small to conduct meaningful analyses. Because there are five categories in the TTM, testing requires a large number of participants. Also, we did not use a control group for validation of the computerized intervention in this study because we focused on development of the program. Finally, the age range of diabetic patients who participated in this study was too wide. So, we recommend that this program be applied in clinical settings after being tested in larger populations to confirm its effectiveness. Nevertheless, this study was significant because the compu-

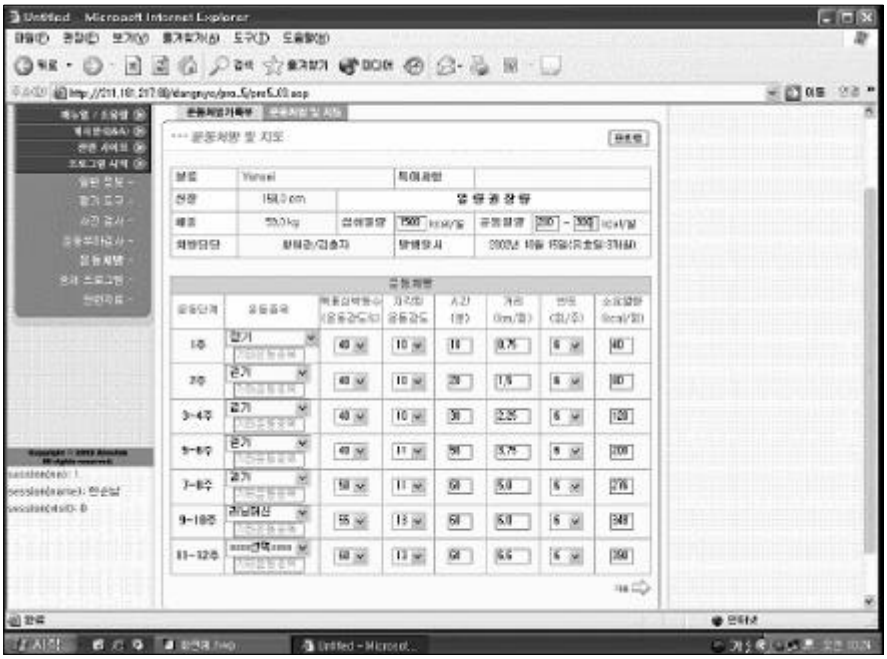

Fig. 4. Exercise counseling and coaching page: An individualized exercise prescription consists of exercise type, intensity, rating of perceived exertion (RPE), time per session, distance per session, frequency (the number of session per week), and energy consumption (kcal per session) at each stage.

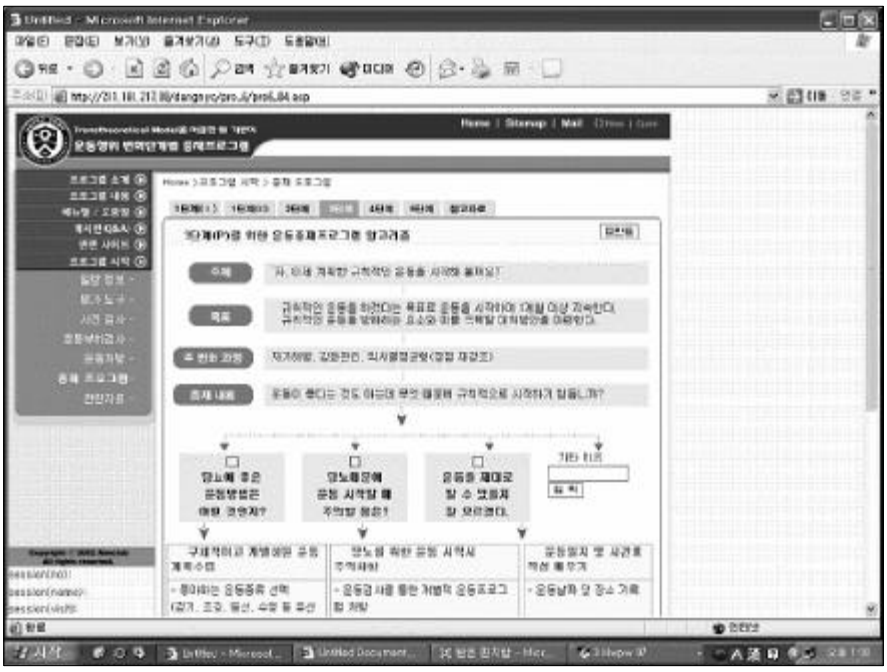

Fig. 5. An example of an intervention program page: This page was the example for the preparation stage. The preparation stage defined what action was intended to be taken in the near future, usually within one month. Goal was adopting the exercise and objectives were to keep regular exercise for more than one month and to be aware of the main roadblocks of adopting exercise and to prepare how to overcome them. Main resources were the processes of change required to commit to being active (self-liberation), the self-reward for being active (reinforcement management), along with empathizing and re-encouraging the benefits of exercise (decisional balance). Feedback was re-assessment of the current "stage of readiness for exercise" and then move on to the next stage. A more detailed description is given in the methods section.

terized intervention we developed could be used to construct a database and continue to provide follow-up intervention for patients in all stages. Future research should examine the influence of this method for delivering interventions in a variety of settings and with large populations of subjects who need regular physical activity or exercise.

ACKNOWLEDGEMENTS

The authors appreciate H. Y. Yoo, J. Y. Kwak and Dr. H. J. Kim in Yonsei Diabetic Center in

Seoul, Korea for their assistance with this research.

REFERENCES

1. Huo KB. Prevention and treatment of diabetes mellitus. Annual lecture book. Seoul: Yonsei diabetic center; 1999.
2. Kim CH. Effects of 2 weeks exercise on glucose and lipid metabolism in NIDDM Patients. The 4th Korean Diabetes Association Spring Conference; 1989. p.54.
3. Lee HR. Effects of exercise therapy on glucose and lipid metabolism in type 2 DM patients. Educational Graduate School Yonsei Unversity; 1990.
4. Honkola A, Forsen T, Eriksson J. Resistance training improves the metabolic profile in individuals with type 2 diabetes. Acta Diabetol 1997;34:245-8.
5. Na CS, Choi KS, Hwang SK. An effect of exercise therapy on blood glucose, cardiopulmonary fitness of patients with type 2 DM. J Korean Sports Med 1993; 11:210-21.
6. Jun JM. The effects of programmed jogging on metabolism and cardio-pulmonary function in type II DM patients. Korean J Nursing Query 1994;3:19-42.
7. Kim CJ. The effects of exercise therapy applied in an efficacy expectation-promoting program on self-efficacy and metabolism in NIDDM Patients. J Korean Academy of Nursing 1998;28:132-42.
8. Hwang AR, Yoo JS, Lee HC, Hwang SG, Kim, CJ. The effects of exercise therapy applied in an efficacy expectation-promoting program on self-efficacy, cardiopulmonary function, and metabolism in type 2 diabetes mellitus patients. J Korean Biological Nursing Science 2000;2:64-75.
9. Hwang AR, Yoo JS, Kim CJ. The effects of planned exercise program on metabolism, cardiopulmonary function and exercise compliance in type 2 diabetes mellitus patients. J Korean Academy of Nursing 2001; 31:20-30.
10. Loreto CD, Fanelli C, Lucidi P, Murdolo G, Cicco AD, Parlanti N, et al. Validation of a counseling strategy to promote the adoption and the maintenance of physical activity by type 2 diabetic subjects. Diabetes Care 2003; 26:403-8.
11. Lehmann R, Vokac A, Niedermann K. Loss of abdominal fat and improvement of the cardiovascular risk profile by regular moderate exercise training in patients with NIDDM. Diagetologia 1995;38:1313-9.
12. Agurs TD, Kumanyika SK, Ten HR. A randomized controlled trial of weight reduction and exercise for diabetes management in older African-American subjects. Diabetes Care 1997;20:1503-11.
13. Shimokate H, Muller DC, Fleg JL. Age as an independent determinant of glucose tolerance. Diabetes 1991; 40:44-51.
14. Pan X, Li G, Hu Y. Effect of dietary and/or exercise intervention on incidence of diabetes in 530 subjects with impaired glucose tolerance from 1986-1992. Chin J Intern Med 1995;34:108-12.
15. Petrella RJ. Exercise for older patients with chronic disease. Phys Sports Med 1999;27:79-104.
16. Hwang AR. Health promotion using exercise. Seoul: Public Health Korean Nursing Assoc.; 1998.
17. Dishman RK. Compliance: adherence in health related exercise. Health Psychol 1982;1:237-67.
18. McAuley E, Courneya KS, Rudolph DL, Lox CL. Enhancing exercise adherence in middle-aged males and females. Prev Med 1994;23:498-506.
19. Lee JK. A study on construction of exercise prediction model for low back pain patients. Doctoral dissertation. Department of Nursing Graduate School, Yonsei University; 1997.
20. Korean Academy of Clinical Exercise Professionals (KACEP) Health & Sports Medicine: DM Management and Exercise; 2000. p.3.
21. Prochaska JO, DiClemente CC. Stages and processes of self-change of smoking: toward an integrative model of change. J Consult Clin Psychol 1983;51:390-5.
22. Marcus BH, Simkin LR. The stages of exercise behavior. J Sports Med Phys Fitness 1993;63:60-6.
23. Bock BC, Marcus BH, Pinto BM. Maintenance of physical activity following an individualized motivationally tailored intervention. Ann Behav Med 2001; 23:79-87.
24. Lewis BS, Lynch WD. The effect of physician advice on exercise behavior. Prev Med 1993;22:110-21.
25. Long BJ, Calfas KJ, Wooten W. A multi-site field test of the acceptability of physical activity counseling in primary care: project PACE. Am J Prev Med 1996;12: 73-81.
26. Calfas KJ, Long BJ, Sallis JF, Wooten WJ, Pratt M, Patrick K. A controlled trial of physical counseling to promote the adoption of physical activity. Prev Med 1996;26:225-33.
27. Calfas KJ, Sallis JF, Oldenburg B, French M. Mediators of change in physical activity following an intervention in primary care: PACE. Prev Med 1997;26:297-304.
28. Marcus BH, Goldstein MG, Jette A, Silverman LS, Pinto BM, Milan F, et al. Training physicians to conduct physical activity counseling. Prev Med 1997;26:382-8.
29. Marcus BH, Simkin LK, Rossi JS, Pinto BM. Longitudinal shifts in employees' stages and processes of exercise behavior change. Am J Health Promotion 1996; 10:195-200.
30. Marcus BH, Emmons KM, Simkin SL, Linnan LA, Taylor ER, Bock BC, et al. Evaluation of motivationally tailored versus standard self-helped physical activity interventions at the workplace. Am J Health Promotion 1998;12:246-53.
31. King AC, Pruitt LA, Phillips W, Oka R. Comparative effects of two physical activity programs on measured perceived physical functioning and other health-related quality of life outcomes in older adults. J Gerontol 2000; 55:M74-83.

32. Kim CJ. Development of an exercise intervention program based on stage of exercise using the transtheoretical model in patients with type 2 diabetes mellitus. J Korean Academy of Fundamental Nursing 2002; 9:123-32.
33. Chung YC, Park HA. Development of an evaluation system scale for health information based on internet. J Korean Medical Informatics 2000;6:53-66.
34. Chin JP, Diehl VA, Norman KL. Development of an instrument measuring user satisfaction of the human computer interface. In Proceeding of CHI '88. ACM Press; 1988. p.213-21.
35. Marcus BH, Banspach SW, Lefebvre RC, Rossi JS, Carleton RA, Abrams DB. Using the stages of change model to increase the adoption of physical activity among community participants. Am J Health Promotion 1992;6:424-9.
36. Riddoch CJ, Murphy N, Nichols A, Van WA, Cran G. Report of the Northern Ireland health survey. Belfast: Queen's University; 1990.
37. American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription 6th ed. Philadelphia: Lea & Febiger; 2000.