The use of computer touch-screen technology for the collection of patient-reported outcome data in rheumatoid arthritis: comparison with standardized paper questionnaires

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Abstract

Objectives

To investigate the acceptability, feasibility, reliability and score agreement of collecting rheumatoid arthritis (RA) patient-reported outcome (PRO) data using an interactive touch-screen computer system.

Methods

Eighty-seven RA patients completed both the touch-screen and conventional paper-administered set of questionnaires. For this purpose, we have developed a computerized touch-screen system, namely RHEUMATISM (RHEUMA Touch-screen Italian SysteM), to capture PRO data. Variables recorded include the following information: demographic data, VAS scores for pain, patient's and physician's assessment of global activity, and physician's assessment of general health status, 28-joint counts measuring tender and swollen joint, patient self-reported tender joint count, Recent-Onset Arthritis Disability index, and laboratory findings. In a further test-retest study, 35 patients were evaluated.

Results

Although over half the patients had no prior computer experience, nearly all found the touch-screen easy to use. Moreover, 86% of the patients preferred the computer format to the paper format (2%) and 12% of subjects had no preference. The quality of the data collected with the touch-screen system was good, with no missed responses. Agreement between scores obtained with the two modes of administration was very good, with concordance correlation coefficients (CCCs) from 0.887 to 0.972. CCCs were similar in men and in women, in subjects with or without prior computer experience and in subjects below or above age 65. The electronic questionnaire had good test-retest reliability (CCCs from 0.836 to 0.907).

Conclusions

Computer touch-screen questionnaires were well accepted by RA patients, with good data quality, reliability and score agreement.

Key words

Rheumatoid arthritis, patient-reported outcomes, touch-screen computer, electronic data capture, self-administered questionnaires.

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Introduction

Patient-reported outcomes (PRO) are an attractive option in a busy medical practice, as the time burden is transferred from the clinician to the patient. The validity and usefulness of PRO data in evaluating and monitoring patients with rheumatoid arthritis (RA) have been well documented (1-3). Instruments for measuring PRO are easier to administer and less expensive than physician-observed disease activity and process measures. These data have traditionally been collected on paper, but more trials are using electronic means to capture PRO (ePRO) (4). Information technology has wide application in medicine. Computer-assisted administration of outcome measures is an example of a useful application in rheumatology. Electronic data collection improves data quality by providing software safeguard against entry omission and inconsistent response sets, and by completely eliminating data entry errors made by researcher's. Touch-screen technology offers several advantages. Firstly, it permits immediate calculation and printing out of summary information, with the potential to improve physician-patient communication. Secondly, the reduced variability associated with computerized administration of PRO data may reduce sample size requirements in clinical research (5). Thirdly, missing data are less common with computerized technology compared to paper-and-pen used to collect PRO data. This is particularly valuable in quality of life questionnaires, where missing data have been identified as one of the most important problems in analysing this type of information (6). Furthermore, another reason for using ePRO is speedier handling of the data bypassing data entry normally required for transferring paper outcomes to computer database. In order to be able to capture PRO data electronically, computer systems need to be designed for this purpose. Palmblad and Tiplady (7) proposed a set of requirements for designing computer systems for electronic collection of patient diary and questionnaire data in clinical trials. These guidelines are designed to assist both those involved in the specification, design and development of new systems, and those selecting and configuring existing commercial products.

Before introducing computer touch-screen technology into clinical routine, careful comparison of data obtained by paper/pencil and computerized versions of the assessment is crucial, because equivalence of data obtained by the two methods can not be taken for granted (8). The purpose of this study is to describe the application of computer touch-screen system, namely RHEUMATISM (*RHEUMA Touch-screen Italian SysteM*), to capture PRO data in patients with RA. After initial evaluation of acceptability and feasibility, we have compared the computer touch-screen data collection version with paper-based self-completed questionnaires in terms of reliability and agreement between scores in a routine outpatient clinic.

Methods

Patients

Eighty-seven RA patients (58 female and 29 male) agreed to participate. Their mean age was 65 yrs, with a range 34-83 yrs. RA disease duration ranged from 3 to 24 yrs with a mean of 9 yrs. Three patients declined due to lack of time. Seventy-nine patients (90.8%) were treated with DMARDs, namely methotrexate, sulphasalazine, leflunomide, antimalarias, tumor necrosis factor-alpha blokers, including infliximab, etanercept and adalimumab, as well as abatacept; 49 patients (56.3%) were taking corticosteroids (mean 3.1 mg prednisone/day; range 1-25 mg), and all patients received nonsteroidal anthirheumatic drugs on demand. All patients completed the *RHEUMATISM* in the clinic on both touch-screen and paper, randomized to either touch-screen or paper first. Data capture was conducted in a separate quiet room. The length of time required to complete both the computer-administered and paper-administered set of questionnaires were recorded. There was a minimum 60 minutes "washout" period between completion of the first set of PRO variables and commencing the second set. The subject had no access to prior scores when completing the second set

of measures. The wording of the questions of all the computerized outcome measures will be identical to the wording of the questions in the paper format. On completion of the study, the patients indicated the mode of administration (*i.e.* touch-screen, paper, or no preference) that they preferred on an 11-numbered circle/button visual analogue scale (VAS) format. All subjects gave informed consent to participate in the study, which was performed according to the criteria of the Helsinki Declaration and approved by the institutional local research ethics committee.

Key features of touch-screen questionnaires

We have developed a multimedia touch-screen program, called *RHEUMATISM,* to use among RA subjects. The program used an iterative process of discussion among the investigators with the patients' input on screen design and layout, with final development and testing in a convenience sample of rheumatology outpatients. The key features of the *RHEUMATISM* which make it user friendly to use for subjects include (a) presentation of each question individually on one screen with both visual (cartoon) and auditory stimuli, (b) voice-text synchronization which allows subjects to follow the audiovisual playback with relative ease, and (c) replay buttons for the question stem and individual response options so that subjects may listen to these without repeating the entire question. The patients touched their response to each individual question. All questions had to be completed before the computer continued to next screen. The touch-screen computer was designed so that the format of the questions closely matched the format of the questions on the paper form. The software was created using Adobe Director and the Lingo scripting language. The data is stored in a INM V12 Database (Access, Excel compatible and compatible with most databases). The program runs on both Window and Macintosh-based operating system and using the touch-screen technology. Variables recorded in *RHEUMATISM* include the following information on the patient: demographic data, disease duration, patient's 11-numbered button VAS format for pain (Pain 0-10), general health status (GH 0-10), and global activity (PGA 0-10), patient self-reported tender joint count (TJC), and Recent-Onset Arthritis Disability (ROAD) scores (9, 10). In usual clinical care, it is now documented that a numbered circle VAS may be a desiderable alternative to a 10 centimeter horizontal line, yelding similar results and requiring less than half the time to score (11). The touch-screen 11-numbered button VAS questions were "How severe is your arthritis pain today? (0=no pain to 10=unbearable pain)", "How would you describe your general health today? (0=very good to 10=very bad)", "How active is your arthritis today with respect to joint tenderness and swelling? (0=completely inactive to 10 extremely active)". The touch-screen ROAD index used the original questionnaire wording except for an additional option of 'I cannot answer this question'. The ROAD questionnaire is a reliable, valid and responsive tool for measuring physical functioning in patients with early RA, and it is suitable for use in clinical trials and daily clinical practice (9, 10). The computer touch-screen format presents each question of the ROAD as a cartoon and in speech on a 17-inch LCD capacitive touch-screen monitor (Fig. 1). For each item, patients are asked to rate the level of difficulty they experienced over the past week on a 5-point Likert scale ranging from 0 (without any difficulty) to 4 (unable to do). The questions are answered by touching one of the 5 buttons of the Likert scale on the screen. This may be done with a pen or by hand. Programs automatically advanced to the next question after receiving a response. It was not possible to leave one question unanswered. Neither keyboard nor computer mouse are necessary. In addition, there are two squares on the screen that the user could tap on repeat and back. In order to express these scores in a more clinically meaningful format, a simple mathematical normalization procedure was then automatically performed so that all the scores could be expressed in the range 0-10, with 0 representing better status and 10 representing poorer status. Patient self-report TJC was evaluated according to joint list of the "Rheumatoid Arthritis Disease Activity Index" (RADAI) (12). The RADAI joint mannequin list queries pain "to-

Fig. 1. The screen display of the question 4. "Nel corso dell'ultima settimana è stato in grado di svitare il coperchio di un barattolo già aperto in precedenza?" Translation: "Over the past week, were you able to open a jar which had previously been opened?". Answers to question: 0) without any difficulty; 1) with slight difficulty; 2) with some difficulty; 3) with great difficulty; 4) unable to do.

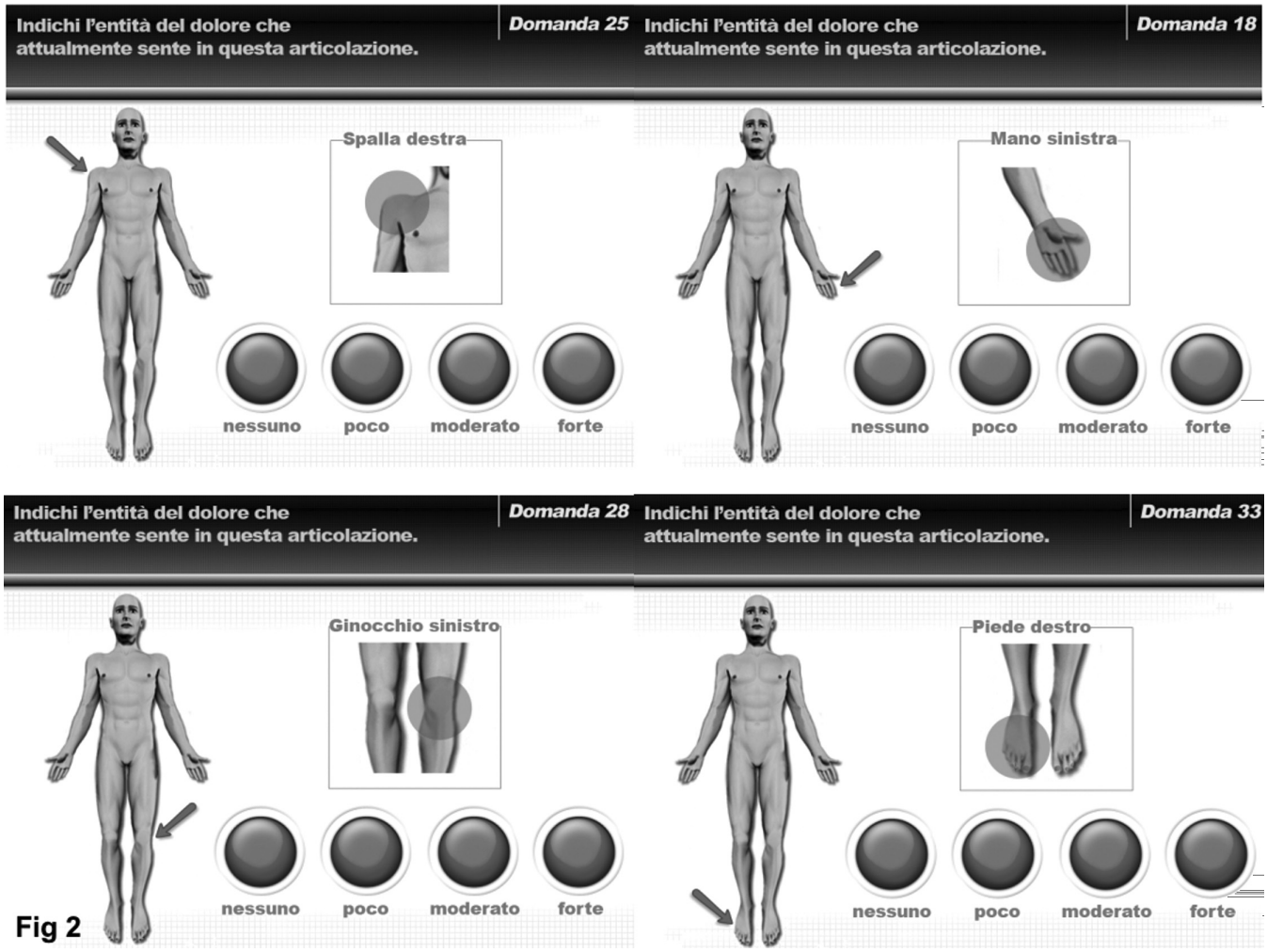

Fig. 2. The screen display of the question 25, 18, 28, 33 on the self-reported tender joint count (TJC). "Indichi l'entità del dolore che attualmente sente in questa articolazione". Translation: "Please, indicate how much joint pain you have at this moment": right shoulder; left hand; left knee; right foot.= Answers to questions: 0) none; 1) mild; 2) moderate; 3) severe.

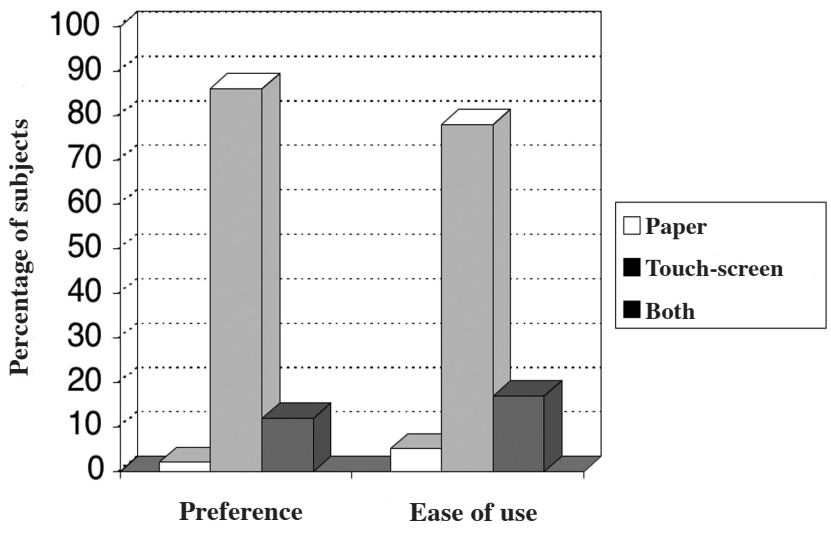

Fig. 3. Patients' preferences with regard to paper and touch-screen computer format of the RHEUMATISM (*RHEUMA Touchscreen Italian SysteM*). In subjects who expressed a preference, there were the majority rated touch screen highly for ease of use.

day" in 16 joints or joint groups including left and right shoulders, elbows, wrists, fingers, hips, knees, ankles, and toes. The TJC weighted the degree of tenderness of each joint on the following scale: 0=none; 1=mild; 2=moderate; 3=severe. The questions are answered by touching one of the 4 buttons of the Likert scale on the screen. The joint patient assessment questionnaire displayed one joint at a time as in Figure 2. The scores range 0 to 48, but are transformed on the scale of 0 to 10. In addition, *RHEUMATISM* comprises a database for data processing and storage of objective measures of disease activity, such a 28-joint count measuring tender joint (TJC28) and swollen joint (SJC28), laboratory findings (erythrocyte sedimenation rate – ESR and C-reactive protein – CRP), the presence

Table I. Mean score (SD), mean score difference (SD), paired *t*-tests and CCCs (CI 95%) of the single-item VAS scores, ROAD questionnaire and patient-reported TJC on first and second administrations of the electronic questionnaires.

	Mean score	Standard deviation	Mean score difference	Standard deviation of difference	Paired *t*-test (*p*-values)	CCCs (95% CI)
VAS GH T1	5.114	2.887	-0.285	1.543	-0.110	0.836
VAS GH T2	5.085	2.501			(0.913)	(0.706 to 0.9121)
VAS Pain T1	4.171	2.925	0.171	1.504	0.674	0.842
VAS Pain T2	4.343	2.448			0.504	(0.720 to 0.914)
VAS PGA T1	4.700	3.123	-0.442	1.336	-1.704	0.876
VAS PGA T2	4.257	2.627			0.061	(0.781 to 0.932)
ROAD T1	3.163	2.554	-0.291	1.173	-1.461	0.881
ROAD T2	2.871	2.397			0.151	(0.780 to 0.937)
TJC T1	2.911	2.285	0.007	0.978	0.044	0.907
TJC T2	2.919	2.263			0.964	(0.828 to 0.952)

VAS GH: 11 numbered button visual analogue scale (VAS) for global general health status; VAS Pain: 11 numbered button VAS for pain; VAS PGA: 11 numbered button VAS for patient global disease activity; ROAD: Recent-Onset Arthritis Disability index; TJC: patient self-reported tender joint count.

Table II. Comparison of paper and computer touch-screen format of the patient reported outcome (PRO) data.

	Mean score	Standard deviation	Mean score defference	Standard deviation of difference	Paired *t*-test *p*-values	CCCs (95% CI)
VAS GH *(Paper)*	54.023	28.179	0.801	10.912	0.688	0.926
VAS GH *(Touch-screen)*	54.828	28.727			(0.493)	(0.881 to 0.950)
VAS Pain *(Paper)*	4.695	2.808	-0.120	1.363	-0.825	0.887
VAS Pain *(Touch-screen)*	4.575	2.971			0.411	(0.834 - 0.925)
VAS PGA *(Paper)*	5.259	2.936	-0.109	1.352	-0.753	0.893
VAS PGA *(Touch-screen)*	5.149	2.931			0.453	(0.841 - 0.928)
ROAD *(Paper)*	3.239	2.331	-0.075	0.565	-1.252	0.972
ROAD *(Touch-screen)*	3.163	2.492			0.214	(0.958 - 0.981)
TJC *(Paper)*	3.362	2.292	0.002	0.869	0.024	0.928
TJC *(Touch-screen)*	3.364	2.290			0.980	(0.891 - 0.952)

See Table I for abbreviations.

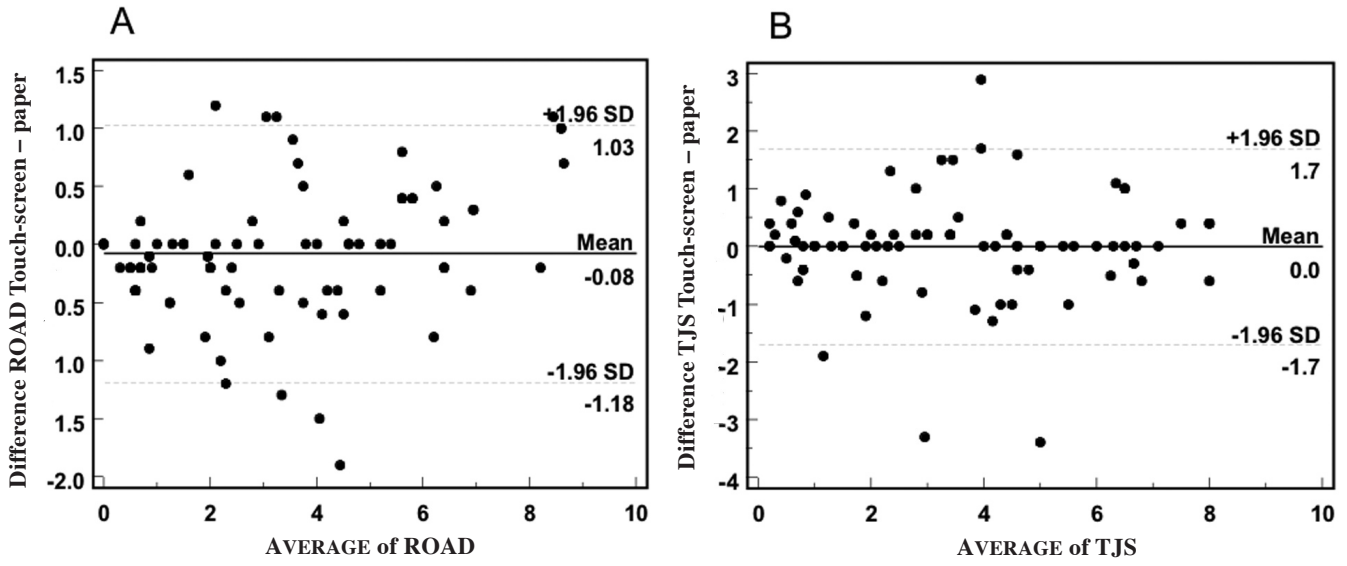

Fig. 4. Agreement between scores obtained by the touch-screen and paper versions illustrated by Bland-Altman plots for (A) Recent-Onset Arthritis Disability (ROAD) index (panel A: 95% limits of agreement –0.69 to 0.74; mean difference –0.03) and (B) patient self-reported tender joint count (TJC) (panel B: 95% limits of agreement –0.69 to 0.74; mean difference –0.04).

of rheumatoid factor, and subjective indicators, such as physician's assessment of global activity (PhGA) on an 11-numbered button VAS format. The following composite indices of disease activity may be calculated automatically by the electronic application and are then displayed to the rheumatologist: Disease Activity Score including 28 joints (DAS28) (13), Simplified Disease Activity Index (SDAI) (14), Clinical Disease Activity Index (CDAI) (15) and Patient-Reported Outcomes CLinical ARthritis Activity (PRO-CLARA) index. The PRO-CLARA is a short and easy to complete self-administered index measure combining a patient's physical function (by ROAD, range 0-10) (9, 10), current disease activity as measured by patient self-reported TJC (range 0-10), and perception of global health status (by GH, range 0-10) into a single measure of disease activity (16). The score ranges 0 to 10, with higher values indicating more activity. The final result is easily to calculate by addition, followed by a division by 3. After completing the questionnaire, the computer automatically analysed and summarised the various indices in a table that includes the patient's previous data and provided a printed copy of the results. This allows the physician to quickly assess patient response to the current treatment. The system was previously tested during a pilot study of 21 patients with various rheumatic diseases to establish its acceptability and performance. All clinical assessments are performed by two trained rheumatologists. Consensus meeting concerning joint assessment are part of the routine quality control program at regular intervals in order to avoid high internal variations among the physicians. For the purpose of this study, however, no formal agreement analysis between the physicians was performed.

Statistical analyses

We assessed overall patient acceptability, preference and ease of use of touch-screen and paper by calculating the proportions in each of the preference categories. We also recorded whether patients had rarely or never used a computer before. We used the Fisher's exact test for categorical variables. To examine the effect of the mode of administration on the time for completion of the two versions, we used the two-sample Student's *t*-test. To check for a significant systematic difference in test-retest administration, paired *t*-tests and concordance correlation coefficients (CCCs) with 95% confidence intervals (CI) for the mean values were used. As elaborated by Lin (17), the CCC is more appropriate than other indices for measuring agreement when the variable of interest is continuous. Test-retest reliability embraces the concept that the repeated administration of a measurement tool in stable subjects will yield the same results. After a one-week interval, patients were asked by the same data collector to repeat all the touch-screen computerized outcome measures, without access to any previous ratings. Because it was possible for a patient's condition to change over a one-week interval, a global rating of change questionnaire was concurrently administered to the subjects. The so-called "transition questionnaire" investigated the current health status compared to that one of the first questionnaire (Question: Compared to when you completed the questionnaire regarding your health status a week ago, how is your health now?). The possible response options were "much better", "slightly better", "no change," "slightly worse," or "much worse". Subjects who reported no change were considered stable and those who reported a change were eliminated from this analysis. In this study, test-retest reliability was analysed in a group of 35 patients who reported no change in their arthritis. To assess agreement between scores of the touch-screen computer method and paper versions we calculated the Student's *t*-test (for paired samples) and CCCs with 95% CI. The agreements between scores were also illustrated by Bland and Altman plots. Relations between composite indices scores were all esamined by Pearson's correlation coefficients. The level of statistical significante was set to <0.05 (two-sided). Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS Inc., Windows release 11.0; Chicago, Illinois, USA), and MedCalc®, version 9.5.1 for Windows XP.

Results

Patients' acceptance and preference

No technical difficulties were experienced and all 87 participants were able to complete it without any aid. The majority of subjects (86%) preferred the computer format to the paper format (2%) and 12% of subjects had no preference. In subjects who expressed a preference, the majority rated touch screen highly for ease of use (Fig. 3). Fifty-two (59.7%) gave a rating of 8 or more out of 10 to the touch-screen version and 19 (21.8%) to the paper. The ratings for touch screen were significantly higher (Student's *t*-test significance = 0.001). We also asked subjects more specifically about 3 features of the two formats. Ninety-two percent of subjects felt that the combination of cartoon, writing and voice of the computer format was informative and helpful, 6% were undecided and 2% were irritated. Seventy-nine percent stated that it is informative and helpful that the touch-screen computer format presents only one question at a time, while 21% had no preference. Fifty-nine (67.8%) of the participants reported had rarely or never used a computer before. Compared with the 28 patients with more computer experience, they were older (mean age of 67 yrs compared with 59 yrs, two-sample Student's *t*-test significance 0.004), and took slightly longer to complete the assessment (a mean total completion time of 8.6 min compared with 7.1 min; two-sample Student's *t*-test significance 0.001). Patients' preference for mode of administration was not related to sex or order of presentation.

Feasibility

The mean time spent completing the questionnaires on touch-screen was 7.3 min (ranging from 6.1 to 11.6 min) and on paper was 7.9 min (ranging from 6.5 to 13.2 min). The difference was significant (Student's *t*-test = 0.006). There was a significant age effect, with older patients being slower both on the touch-screen and on paper (p=0.02, and 0.005, respectively).

Test-retest reliability

The times for completion of the questionnaires were similar to those for the touch screen in the cross-over study (mean time on first administration, 7.1 minutes, with 95% CI from 6.8 to 7.5 minutes). Patients were slightly quicker on the second presentation (mean time 6.7 minutes, with 95% CI 6.3 to 7.0 minutes), and older patients took longer to complete the task. The mean time between the two administrations was 5 days (range, 4 to 7 days). Table I lists the mean score, mean score difference, paired *t*-tests, CCCs and CI 95% for the mean values of the single-item VAS, ROAD questionnaire and patient self-reported TJC scores on first and second administrations of the electronic questionnaires. The coefficients of agreement between the scores on the first and second administrations were very good. All ROAD items showed very good agreement (CCCs >0.810, range of 0.815 to 0.949) (data not shown).

Score agreement

There was good comparability of the touch-screen and paper scores (Table II). There were no significant differences between the mean touch-screen and paper VAS scores for pain, GH, or PGA (Student's *t*-test significance = 0.411, 0.493 and 0.453, respectively) and the CCCs were 0.887, 0.926, and 0.893, respectively. Based on the mean ROAD score difference, there was no significant difference between the paper and the touch-screen computer version (Student's *t*-test significance = 0.214). Agreement, assessed by CCC, was very good (CCC=0.972; 95% CI 0.958 to 0.981). Touch-screen and paper patient self-reported of TJC distributions were also not significantly different (Student's *t*-test significance=0.869). The CCC was 0.928 (95% CI 0.891 to 0.952). The difference between the two formats was plotted against the paper format as the gold standard in Figure 4 to further illustrate the differences between formats by subscale in individuals. According to Bland and Altman analysis, there was no systematic error in both ROAD and patient-reported TJC scores. There was highly significant intercorrelation between paper and touch-screen PRO measures (all $p<0.0001$) (Table III). If agreement between formats was assessed stratifying by prior computer use, age and sex, we found that CCCs between the paper and the touch-screen computer format were similar (Table IV).

Discussion

The primary aim of this study was to determine if touch-screen computer technology was an acceptable and feasible method to collect information in a routine out-RA patient clinic. The results clearly indicate a high level of acceptability and feasibility. This interface is a particularly attractive one, as it is easily used by a wider range of patients than keyboard or mouse options. Experience indicates that this may be important if non-computer skilled persons or senior citizens are using the computerized version of the RHEUMATISM questionnaire. The quality of the numerical PRO data collected with this electronic touch-screen version was excellent, with no missing or problematic responses.

The introduction of the RHEUMATISM system into our clinic resulted in 100% compliance with completion of all the items of the questionnaire. These findings are similar to those of Velikova *et al*. (18) and Wilson *et al*. (19), who reported that their patient cohort achieved full compliance in their answers to their electronic health-related quality of life (HRQL) questionnaires. The electronic system was well accepted by the patients. Despite the fact that 67.8% patients ad no prior experience of computers, 86% reported the touch-screen technology easy to operate. The main reason for this was that they believed the former could be completed more quickly. The novelty of the computer system and the use of cartoon images and voice-text syncronization interface may have made the audiovisual playback for subjects with lack of computer literacy. Patients' preference for mode of administration was not related to sex or age. Similarly, a study of Greenwood *et al*. (20) revealed that, although 62% of the participants reported having rarely or never used a computer before, the majority (64%) of RA patients using the touch-screen found it highly acceptable and it rated significantly higher for ease of use.

The literature supports the efficacy of this method of collecting patient self-reported information in other medical settings. Newell *et al*. (21) and Allenby *et al*. (22) demonstrated that, although 59% and 55% of cancer patients have not used a computer before, and 52% and 54%, respectively were aged 60 years or older, the majority preferred the touch-screen, indicating that patient age and previous computer experience are not a barrier in using this technique of data collection.

Overall, the entire cohort of RA patients were quicker on the touch-screen, and there was also a significant age effect, with older patients being slower both on the touch screen and on paper (p=0.02, and 0.005, respectively). The shorter time to complete questionnaires electronically as opposed to pen and paper versions has been established (23). The high level of agreement found between touch-screen and paper scores demonstrated that where the same wording is used, touch-screen questionnaires can produce comparable results to a traditional paper version. The test–retest reliability of patient reported measures was satisfactory when we considering the CCCs. Similarly, good reliability and equivalence between touch-screen and paper versions of other established questionnaires has also been demonstrated in rheumatology clinic. Greenwood *et al*. (20) demonstrated good reliability and equivalence between touch-screen and paper Rheumatoid Arthritis Quality of Life Questionnaire (RAQoL) scores. Similar results were reported by Bishoff-Ferrari *et al*. (24) for the computerized version of the WOMAC 3.1. Wilson *et al*. (19) used an electronic version of the SF-36 to assess patients with systemic lupus erythematosus and vasculitis. Thumboo *et al*. (5) had shown that computerized versions of the EQ-5D, Health Utilities Index (HUI) and Family Functioning Measure (FFM) in rheumatology outpatients resulted in reduced variability in the mean scores with potential reductions in cost and recruitment time for clinical trials and cohort studies.

Table III. Correlation (r, Pearson correlation coefficients) between patient reported outcome (PRO) measures in paper and computer touch-screen format.

	VAS GH *(Paper)*	VAS GH *(Touch-screen)*	VAS Pain *(Paper)*	VAS Pain *(Touch-screen)*	VAS PGA *(Paper)*	VAS PGA *(Touch-screen)*	ROAD *(Paper)*	ROAD *(Touch-screen)*	TJC *(Paper)*	TJC *(Touch-screen)*
VAS GH *(Paper)*	-------	0.927	0.645	0.637	0.617	0.694	0.698	0.666	0.603	0.599
VAS GH *(Touch-screen)*			0.615	0.633	0.578	0.678	0.727	0.685	0.620	0.621
VAS Pain *(Paper)*				0.890	0.877	0.842	0.739	0.713	0.631	0.624
VAS Pain *(Touch-screen)*					0.810	0.847	0.748	0.729	0.635	0.598
VAS PGA *(Paper)*						0.894	0.692	0.672	0.597	0.590
VAS PGA *(Touch-screen)*							0.809	0.782	0.668	0.696
ROAD *(Paper)*								0.975	0.732	0.741
ROAD *(Touch-screen)*									0.730	0.750
TJC *(Paper)*										0.928
TJC *(Touch-screen)*										-------

See Table I for abbreviations
$p<0.0001$, two-sided, for all correlations.

Table IV. Agreement between formats, assessed stratifying by prior computer use, sex and age.

	Previous experience of computer use		Sex		Age	
	Yes CCC (95% IC)	No CCC (95% IC)	Male CCC (95% IC)	Female CCC (95% IC)	< 65 years CCC (95% IC)	> 65 years CCC (95% IC)
VAS Pain	0.918 (0.903 to 0.924)	0.902 (0.888 to 0.913)	0.902 (0.889 to 0.917)	0.918 (0.901 to 0.928)	0.915 (0.900 to 0.928)	0.906 (0.894 to 0.919)
VAS GH	0.901 (0.888 to 0.914)	0.887 (0.868 to 0.901)	0.889 (0.879 to 0.911)	0.897 (0.873 to 0.909)	0.904 (0.887 to 0.919)	0.889 (0.868 to 0.903)
VAS PGA	0.872 (0.858 to 0.889)	0.852 (0.844 to 0.865)	0.849 (0.833 to 0.859)	0.873 (0.851 to 0.882)	0.869 (0.850 to 0.886)	0.853 (0.840 to 0.862)
ROAD	0.978 (0.961 to 0.986)	0.950 (0.939 to 0.966)	0.954 (0.941 to 0.966)	0.882 (0.951 to 0.993)	0.976 (0.951 to 0.987)	0.951 (0.939 to 0.968)
TJC	0.935 (0.917 to 0.951)	0.919 (0.901 to 0.939)	0.922 (0.909 to 0.937)	0.934 (0.919 to 0.949)	0.931 (0.919 to 0.946)	0.926 (0.911 to 0.937)

See Table I for abbreviations.

Acceptability and reliability have been demonstrated for touch-screen questionnaires in other areas of medicine (18, 23).

Although the physician-performed joint evaluation is regarded as the gold standard in the assessment of patient with RA, joint counts are time-consuming and they are generally performed only by trained clinicians participating in clinical trials (25). Rheumatologists in a busy practice setting infrequently do joint counts (26). A patient questionnaire certainly is not regarded as a substitute for a joint examination since confirmation and interpretation of any questionnaire data on examination is required for decisions in patient management (27). However, a quantitative physician joint examination, supplemented by a patient-reported joint count, may be adequate for most patient care, and certainly preferable to no quantitative data at all, which is usually the case in contemporary care (28). Our results demonstrated that touch-screen administration of the joint assessment questionnaire would be acceptable to the majority of patients with a high level of agreement with the paper format. The validity of the patient-reported TJC on touch-screen was also supported by the significant correlation with other self-reported measures such as ratings of pain, physical disability and disease activity. Several studies have shown that patient-reported joint counts correlate well with physical assessments, with less, robust correlation for joint swelling than joint tenderness (2).

Individual patients may differ with regard to acceptance of new technology. Our work has specifically explored the use of touch-screen technology in clinic patients with RA where gender, age and lack of familiarity with computers are important factors to be considered in the design and evaluation of electronic questionnaires. The use of computer touch-screen technology for the collection of the PRO data in the rheumatologic setting is an acceptable, and in many cases, a preferable option to paper, regardless of age, sex and previous experience of computers.

A major advantage of the computerized questionnaires is the ability to collect good-quality data without missing or problematic responses. Problems with missing data were detected in many of

the paper questionnaires. In their review, Streiner and Norman (6) found that 5% to 10% of returned paper questionnaires were reported as unusable because of omitted, illegible, or invalid responses. Our computer program was designed to allow only complete responses, thus overcoming the problem of missing data. Patients could alter a response on the touch screen by returning to the previous question, but they could not skip a question. This restriction was incorporated because we wanted the electronic version to be as close as possible to the original paper questionnaire. With the electronic questionnaires, both data entry and editing were eliminated and data were transferred directly to the final computer database, allowing immediate printing out and use of the results. These benefits of computerized collection of questionnaire data have been emphasized by other researchers (18, 20, 29, 30).

Our study has some limitations. First of all, the small sample size may have limited our ability to demonstrate the equivalence of the mean PRO data scores obtained using computerized or paper administration. Nevertheless, the results of this pilot study are encouraging and do support the usefulness of further studies to confirm these observations. Secondly, there is the question of the relatively short washout period of 60 minutes between administration of the computer and paper versions. This may have allowed a memory effect to contribute to agreement between methods of administration. However, subjects did not have access to their scores from the first test when completing the second and, as 7 tests were administered in each version with a total of 33 questions, it was thought unlikely that the subjects would recall their scores from the final test. Bellamy *et al*. (31) in comparing paper and computer versions of the WOMAC VA3.0 used a 10-minute washout period, whereas Bent *et al*. (32) in measuring the agreement between computer and paper-administerd versions of BASFI and the Quebec Scale for low back pain, used a 40 minute washout period. Finally, the generalizability of our findings to other PRO instruments and to alphabet-based and other pictogram-based languages needs further investigation.

In conclusion, our results indicated that routine capture of PRO data in individual RA patients is feasible in clinical settings using computer touch-screen technology. This application could improve the quality of data collection in clinical trials by computer-based direct data harvesting and contributes to patients' empowerment. In addition it could simplify its use both in the research setting and in daily clinical practice.

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