A Visualisation Tool for Augmenting Assessment of Ankylosing Spondylitis

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Abstract. Ankylosing Spondylitis (AS) is a chronic condition which requires clinical assessment to inform the management of AS, the intent being to alleviate the symptoms and to improve the health of the suffering person. An integral part of the current assessment is the measurements taken of a number of subjective and objective factors that affect the person’s health status. There is growing awareness that the protocols and means of taking the measurements are both inaccurate and inconsistent. This paper addresses how such assessments may be augmented by utilizing 3-dimensional visualisation technology to collect and present data of this multifaceted condition. The final goal of the research is to provide a relevant tool for AS that can be used in both clinical and home settings. It is designed to directly support the therapeutic regime, to enhance assessment, to provide meaningful feedback to both AS sufferers and clinicians alike and to facilitate the collection of objective evidence relating to the condition.

Keywords. ankylosing spondylitis, assessment, 3-D visualisation, avatar

1. Introduction

Ankylosing Spondylitis (AS) is a painful, incurable rheumatic disease, which mainly affects the spine [1]. Most sufferers are treated by a combination of pharmaceutical and physical therapy regimes; the latter often includes exercise as part of the treatment. The assessment process is integral to the treatment and provides key information related to the person’s condition and helps determine whether or not pharmaceutical or surgical intervention is required. The on-going treatment requires scheduled assessments, which comprise measurements and an opportunity to monitor the condition.

2. Materials and Methods

2.1. An Assessment Model

Terms such as ‘assessment’ are deceptively simple; they are frequently used by clinicians but the meaning is often subtly different even within the same profession and consequently the semantics are variable. As the aim is to augment ‘assessment’, we...
feel it necessary to clarify what we mean by the term to avoid misunderstanding and to identify the scope of our research. We created a simple model.

Figure 1 presents what is essentially a computational model of assessment with input (discover), process (learn), and output (perform) phases. The discover phase involves obtaining subjective and objective detail pertaining to the person’s condition. The learn phase includes documenting findings, making sense of the inputs, making clinical judgments and planning accordingly. Although presented serially, these steps are often interdependent and iterative. It is called the learn phase, because either the assessment is of a new patient, or new information enables comparison of their current status with what is already known. The perform phase is the one where feedback is given to the patient about their condition, reports are passed to other clinicians and treatment is either explained or, in the case of exercises, shown and these ‘outputs’ then become the criteria used for measuring progress at the next assessment.

The tool under development has within its scope all three phases of this assessment model but not all of the steps. In particular, the tool will not automatically make sense of the inputs, make clinical decisions nor determine plans autonomously; nevertheless the aim is that it should support the relevant user in these actions. Originally attention was focused upon how virtual reality (VR)/visualization [2] could support AS treatment. There were examples of VR being used for pain management/relief of stress and even for exercise, although none to our knowledge had focused on AS specifically or on ‘evaluation’. The refined focus therefore concentrates on the assessment, which addresses AS holistically and evaluates it using a variety of measures.

2.2. Current Measurement in AS

AS has a relatively long history of applied clinical metrics; e.g., some of the present gold standards were published back in 1994. Current measurements try to encompass the multidimensional impact of AS, e.g., five core evaluative domains have been recommended by the Assessment in AS International Working Group [3], amongst which our focus, i.e., the Bath Ankylosing Spondylitis Functional Index (BASFI) [4] is deemed valuable for assessing functional ability.

In the AS discover phase, both subjective and objective measures are taken. As AS has multiple symptoms and often co-morbidity is present too, the measurements are provided both by the patient (mainly subjective) and the clinicians (mainly objective). In the UK, a typical assessment includes an interview and completion of forms capturing the demographic details and data from measurements provided by BASFI (for ‘function’), Bath Ankylosing Spondylitis Disease Activity Index (BASDAI, for pain and fatigue) and Bath Ankylosing Spondylitis Metrology Index (BASMI, for

![Figure 1. A simplified assessment model](image-url)
range of movement). These indices are constructed from Visual Analogue Scales (VAS), which attempt to measure a characteristic or attitude that is believed to range across a continuum of values and cannot easily be directly measured. A VAS is essentially a subjective patient report (albeit with the clinician’s deriving numerical scores from the patient’s mark). By contrast, BASMI requires clinicians to use various types of measuring device (varying from tape measures, to rulers, to specialist measuring apparatus) to obtain ‘objective’ measures.

The on-going assessment of an AS patient is by means of scheduled, periodic reviews and, in the UK, these can be quarterly, six monthly or annually; the elapsed time being related to the patient’s condition, and/or to the clinic’s resource constraints. The trend is towards longer periods between assessments and this is deemed to be unsatisfactory by AS groups and clinicians alike who believe that infrequent assessments may result in the earlier onset of advanced disability.

2.3. Towards Augmented Assessment

Here though, we highlight the use of the visualisation and evaluation tool, Salford AS Visualised Interventions (SASVI), for aspects of ‘discover’ and ‘perform’ phases of the assessment. In particular the BASFI questions are addressed for the former, and the potential for ‘feedback’, to both clinician and patient, is considered for the latter. Although the intention is to develop the research and make the evaluation tool appropriate for patients within their homes, and thereby remove many of the process problems of infrequent assessment, it will be some time before this becomes feasible.

The BASFI is regarded highly for functional assessment and became our focus. There are ten questions in the BASFI, the first eight of which are straightforward. Question 9, however, relates to a broad range of activities related to gardening, sport and physiotherapy exercises and it does not distinguish between their relative merits. We therefore specialise question 9 to a set of AS approved exercises as these are seen as being particularly valuable to AS patients [5]. Question 10, “please indicate your level of ability for doing a full day’s activities at home or at work during the last week”, is ruled to be out of scope because it is too imprecise and primarily affects to be a summary of how the individual performed in general throughout a whole day. Each question is presented with a 10 cm VAS with endpoints of ‘easy’ and ‘impossible’. The patient marks the line, the physiotherapist turns it into a number and by simple arithmetic returns a score for the BASFI. Our concern is not primarily to critique the scale or to determine its value as an aggregated score, but rather to see whether each question can be represented by the tool to augment the assessment.

2.4. The Avatar Production Workflow

In part because we began initially to assess VR applications for AS, but also because we considered the current forms of representation and measurement to be unsatisfactory, we examined the use of a 3-Dimensional (3-D) avatar as an alternative to the 2-Dimensional (2-D) VAS. This has clear advantage with a 3-D measure capturing 3-D functionality. Furthermore, it also extends the present forms by enabling dynamic recreation and representation of functional and exercise-related activities.

For example, question 2, asks “indicate your level of ability for bending forward from the waist to pick up a pen from the floor without an aid”. Leaving to one side whether or not this is a good thing to do without bending the knees, it is much easier
and natural for an assessor if the avatar enacts the function enabling direct assessment by simple comparison, rather than by transferring the degree of difficulty to a 2-D scale. Our first step then was to map the appropriate questions and the set of approved exercises to a 3-D avatar. The following software were used: 1) Motion capture system, Qualisys®, captured the motions of the health volunteer via markers while completing the tasks from the questionnaire one by one; 2) Autodesk® 3ds Max®, was used to create the virtual 3-D person—3-D avatar, which will serve as the main visualisation assist; 3) Autodesk® MotionBuilder®, is where the previously created avatar and captured motion data are merged. A video output is available from this stage.

3. Results

3.1. BASFI Questions Transferred to Avatar

The selected questions from BASFI were successfully transferred to the 3-D avatar. For example, question 2, was presented progressively by the avatar shown in Figure 2. It is possible to run the complete action and simply pause it at the point which the avatar corresponds to the patient’s own performance to obviate the use of an intermediate analogue scale. This approach only requires the markers, the movement tracking software and the specialist cameras when the initial training actions are produced.

3.2. Progress Measurement and Meaningful Feedback

BASFI is considered to be an example of Patient Reported Outcome Measures or PROMs. The fact that PROMs are subjective does not diminish their importance and more research will be commissioned [6]. However, like many PROMs the direction of the information is uni-directional, i.e., flowing from the patient to the clinician, and often the end result/score, here computed by the clinician, is relatively abstract, clinician-oriented and/or simply opaque to have much meaning for the patient.

However, it is possible in the foreseeable future to envisage that the avatar within SASVI is driven by movement data taken directly from the patients themselves providing a new ‘what you see is what you measure’ feature. Rather than depending on patients’ understanding of a scale and score, or their recall of their functional activities in the last week, the actual assessment becomes a visual diary, captured and stored for future analysis, replay, reflection and comparisons. The avatar’s performance is a faithful visual analogue scale that accurately shows the extent of the patient’s progress, as well as the capability of presenting other facets of the condition at that time.

Furthermore, we believe that SASVI can add objectivity by removing inconsistencies...
that arise due to differences in subjective reporting, imprecise protocols and differences in the use of measurement devices. A clear advantage of this approach is that the means to provide meaningful feedback directly to the patient with minimal mediation. So awkward questions regarding the current BASFI score system such as, “Does a reduction of 20% from 8 to 6 in BASFI have as much significance as a reduction of two points from 6 to 4, or 4 to 2?” [7] are left for arcane study.

4. Discussion

The existing 2-D instruments have been found helpful by clinicians and do represent the present state of knowledge in encapsulated form [8]. Undoubtedly a debt is owed to those who have introduced measurement where none has previously existed. However, it is also clear that the current gold standards can be improved upon in ways simply not possible before. The assessment model given earlier recognises the importance of measurement in the process but also recognises that assessment as a whole is complex and comprises much more. Currently the physiotherapist is being asked to collect data and to conduct the measurements in ways that are disproportionate in time and effort with respect to the other steps and arguably at the expense of more important clinical functions that only they can perform. SASVI has the potential to augment and improve the current assessment of AS and to give meaningful feedback to the long suffering patient. The current visualisation software is used in a laboratory setting with the 3-D avatar simulating selected questions from BASFI. Two focus groups comprising physiotherapists with expertise in AS are being used for usability testing and formative evaluation of SASVI prior to any clinical trial being performed.

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References