

## Implications for an Exercise Prescription Authoring Notation

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### Abstract

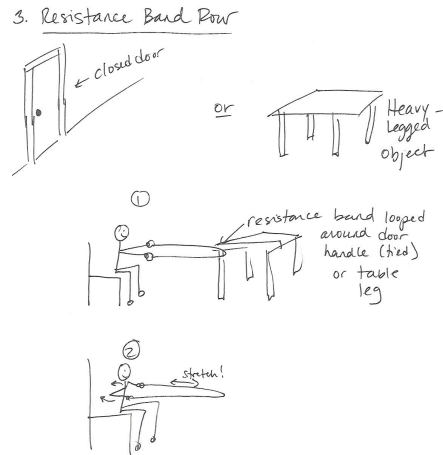
Communicating dynamic motion content, such as exercise, with a static medium, such as paper, is difficult. The technology exists for presenting 3D animated exercise content to patients, however, the tools for allowing exercise domain experts to effectively author the content do not exist. We conducted two formative studies with exercise science domain experts to discover the requirements for an exercise prescription authoring notation. Based on our findings, we implemented a software prototype and performed a think-aloud study to understand its strengths and weaknesses. The results of our studies have implications for any software solution aimed at the authoring of physical activity content.

**Keywords:** exercise science, exercise prescription, content authoring, motion capture animation, user-centered design

### 1 Introduction

According to the Bureau of Labor Statistics, there were nearly 400,000 physical therapists and fitness professionals in the U.S. in 2006 [1]. Consumers of their services seek guidance for various reasons, ranging from general exercise to injury rehabilitation, and they are typically not exercise domain experts. Unfortunately, the services of physical therapists, athletic trainers, and personal trainers can be quite expensive if the client desires supervision every single time they exercise. Although full supervision may be advisable in cases of extreme injury, in most cases, the experts provide exercises for the novices to perform *on their own*. Consider, for example, that among the most successful strategies to reduce fall risk in aging adults are clinician prescribed, home-based, individualized programs with a physical activity component [3, 4].

Paper printouts are commonly used as a communication artifact, but may not adequately convey information about the dynamic performance of an exercise because paper is a static medium (Figure 1). Web sites are also often used to disseminate information about exercise and sometimes provide animations or videos of the exercises. While videos



**Figure 1. Drawing from the paper and pencil study. Dynamic exercise content contains rich information that must be conveyed to the user.**

may be more effective than static illustrations they can only offer the recorded point of view. Additionally, websites are generally not intended to allow a clinician to customize the content to meet the specific needs of an individual client.

Hence, there exists a need for tools that exercise domain experts can use to efficiently author interactive, individualized, and kinematically correct exercise regimens for their clients. Further, incorporating the ability to evaluate the client over time can provide invaluable information for the clinician. We present a series of studies that we conducted to inform the design of an exercise authoring and viewing environment that conveys exercise via interactive 3D animations. The studies include: **(CS)** Case Study, **(PPS)** Paper and Pencil Study, and **(TAS)** Think-aloud Study.

We have identified several similarities between exercise prescription authoring and computer programming, including parameterization and reusable abstraction. We present our findings, rooted in support from each of the studies, and discuss implications for any notation designed to assist clinicians in specifying physical activity content for their clients.

## 2 Related Work

While we are aware of no similar studies, we drew upon ideas from several fields to guide our research, including video games, computer animation, choreography, and natural programming.

Recently, several popular applications presenting exercise content have surfaced, namely *Yourselves! Fitness* and *Wii Fit* [11, 8]. Both offer dynamic content with the benefit of user interactivity, allowing for user-selected exercises and camera views. These products do not provide mechanisms for clinicians to customize the exercise regimens, making them unsuitable for use as in-home, targeted rehabilitation tools. However, some clinics report using *Wii Sports* as a rehabilitation modality with positive results [5]. Most of the research on these systems focuses on the effective presentation of motion to the user, rather than providing the clinician with control of the content [12].

Fitness video games contrast sharply with the existing content creation systems used by clinicians, which are mostly targeted toward the creation of static media. These systems make a much larger array of targeted exercises available to the clinician than are available in fitness games, but the content is much less interactive. Visual Health Information (VHI) is one of the leading providers of content of this type, offering both paper cards to be composed on a copy machine and, more recently, an electronic version of the cards. VHI has also added animations to their library, however, these animations are not interactive [15].

Computer animation research has explored methods for creating animated motion for many years and the techniques generally fall into three categories: keyframe animation, physical simulation, and motion capture animation [10]. We chose to use motion capture for our system because the motion can be recorded directly from an expert performing exercises with correct form. A motion sequence can then be used as a component in a library from which a clinician can compose a larger exercise regimen.

Labanotation has been used by choreographers for many years to represent movement symbolically [6]. Much like music notation, this notation is designed for experts, and is very low level. While a low-level motion description is not desirable for our purposes, it may have implications for editing a particular captured motion sequence. In related work, Calvert has investigated software tools to aid in choreography [2]. However, he focused on the construction of motion, usually via keyframe animation or procedural techniques, while our focus is on composition and customization of an exercise regimen using pre-generated motion data.

To better understand our target ‘authoring’ audience, we drew upon the natural programming approach, which seeks to discover the natural tendencies of users in order to maintain a close mapping between the user’s mental plan and

the notation used to express the plan. Such a mapping is desirable for our system since it is intended for end users with no programming experience but a large body of domain specific knowledge. Myers notes that in natural programming, attention must be paid to the metaphor on which the language is based, as well as how abstraction, terminology, and other constructs, such as iteration, should be represented [7]. Thus, we designed the paper and pencil study to be similar in format to the studies conducted by Pane [9].

## 3 Methods

We performed three studies to understand the exercise prescription process and inform the design of a prototype system. Our first study was a single case, holistic, exploratory Case Study (**CS**) intended to answer the question: **What are the information needs of clinicians and their clients during the exercise prescription process?** We performed three observations made in a clinic over a three week period. First, we observed the examination of a patient (P) visiting an athletic trainer (T1) for the first time and we conducted a semi-structured interview with T1. Our second observation was of the meeting between T1 and a junior trainer (T2) where they discussed the diagnosis and a plan for treatment. Finally, we observed T2 during a training session with P where T2 demonstrated the exercises to P. During this observation, P had an opportunity to perform the exercises and ask T2 questions.

Next, we designed a lab study to further investigate the exercise prescription process with an emphasis on the language and structure used by clinicians to communicate exercise prescriptions when the client is not present. We chose to use a Paper and Pencil Study (**PPS**) because we hoped to learn more about the language, sketches, and spatial organization used when describing an exercise regimen. We performed the study with 10 participants affiliated with the fitness or rehabilitation fields ranging in age from 25 to 56, with a combined total of 78 years of experience in prescrib-

1	Devise a prescription based on a patient history
2	Describe when the client should exercise
3	Describe a specific exercise in detail
4	Describe the materials that a client would get
5	Describe the motion in a video clip (2 questions)
7	Describe when modifications/progressions should be used and how they are described
8	Describe how sensation cues should be conveyed
9	Describe when the client should cease an exercise
10	Provide further comments

**Table 1. Tasks performed during the Pencil and Paper Study (abbreviated descriptions)**

1	View the playback of an example regimen
2	Implement a short exercise regimen
3	Delete an exercise
4	Rearrange the exercise regimen in time
5	Edit the parameters of an exercise
6	Edit the description of an exercise
7	Edit the default parameters for an exercise
8	Add prompts to the regimen
9	Save and load a protocol
10	View the playback of the new regimen

**Table 2. Tasks performed during the Think-Aloud Study (abbreviated descriptions)**

ing exercise regimens and 97.5 years of experience teaching exercise/fitness courses. The participants included five males and five females, with two physical therapists, two athletic trainers, three fitness instructors, two graduate students in sports medicine, and the owner of a fitness club.

Participants were asked to answer a set of 10 questions using words and/or drawings, taking about an hour for each participant. Tasks included devising a prescription based on a brief patient history and describing the motion shown in a short video of an exercise (Table 1). To ensure quality of responses, a researcher from the exercise science department was present for all but one study and one member of the research team was present for all studies.

The **CS** and **PPS** informed the design of a prototype solution for authoring exercise prescriptions with three different interaction metaphors, discussed in more detail in Section 6. We conducted a Think-Aloud Study (**TAS**) to better understand the tradeoffs between the three metaphors and identify usability problems with the prototype. Participants were first presented with a short tutorial for the system. Next, they were given with 10 tasks to complete with each of the three prototype implementations related to creating, modifying, saving, and viewing exercise prescriptions (Table 2). After each task, participants completed a questionnaire to solicit comments and collect suggestions for changes to the system. Each study was performed in a lab setting with one participant and one researcher present and recorded with screen capture software and a microphone. Thus far, we have had four participants in the **TAS**, three of whom were participants in the previous studies (**CS** and/or **PPS**). The three males and one female ranged in age from 25 to 38, with a combined total of 27 years of teaching experience and 26 years of prescribing experience.

## 4 Analysis

For each study, we used an open coding approach to group related observations and develop an initial code set [13]. For the **CS**, we applied a grounded theory approach to the creation of hypotheses, forming them after

performing observations. After formation of hypotheses, we considered rival hypotheses to improve internal validity. To improve reliability, we collected multiple sources of evidence, including observations, interviews, and artifacts, according to a case study protocol.

For the **PPS**, we analyzed each question with an independent set of codes. For each question, we developed a code set and two coders then independently coded a subset of the data. We used the Jaccard index to compute agreement since we allowed multiple codes to be assigned to an answer. After iterating over the code set until reaching agreement of 88% or better on all coded questions, the code set was fixed and one researcher coded the remaining data.

For the **TAS**, we have examined the statements made during each session, as well as answers provided on the written questionnaire. We present the most salient quotes from these sources in Section 6 along with a qualitative analysis of the data.

## 5 Findings

Our most informative lesson from the studies is that communication is the most important component of exercise prescription. As stated by T2 during the **CS**,

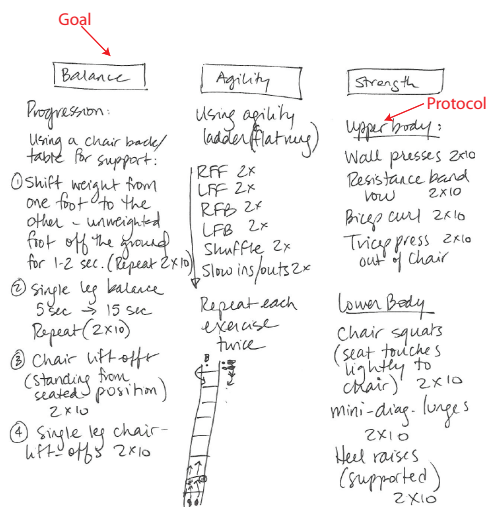
*... our entire job is based on communication.  
If they don't understand, there is no point.*

Communication is extremely important because most of the time spent exercising is done in the absence of the trainer. In order to avoid injury and effect progress for the client, not only must the clinician communicate *what* to do but *how* to do it. In this section, we present our findings about the exercise prescription process from the first two formative studies (**CS**, **PPS**), along with their practical implications, with a focus on support for communication.

### 5.1 Prescription Organization

Many of the clinicians prefaced a prescription with important information. In Observation 2 of the **CS**, the first piece of information that T1 communicated to T2 was a list of “risk factors” of P. Additionally, risk factors were among the information present on the document that T1 and T2 referred to throughout the observation. After describing the results of the examination from Observation 1, T1 began to identify the goals of the rehabilitation in terms of muscle groups to strengthen. It is worth noting that T1 and T2 used simple linear lists as their primary organizational structure.

In Question 1 of the **PPS**, participants were given a brief patient history for a fictional client, detailing risk factors and goals. We then asked them to provide an “exercise prescription” for this person (Figure 2). We left this question open ended in an effort to discover the important aspects of the contents and organization of an exercise prescription.



**Figure 2. Portion of an exercise prescription as organized by a PPS participant. Note the goals at the top with a list of exercises following each goal. The strength exercises are organized into protocols and cues are provided in the balance goal, along with a progression.**

50% of our participants started a prescription with a list of goals and/or risk factors. Presumably, this information was used by the participants to help guide them in choosing the specific exercises for the regimen. 90% of our participants organized their prescribed exercises in a list, leading us to believe that lists may be the preferred organizational method for exercise prescriptions. We were also able to observe how the exercises were *ordered* by the participants. In 50% of the responses, participants specified no ordering. 40% of the participants provided an explicit ordering of execution, and in one case, the order of the exercises in the list was determined as a post-process.

**Practical Implications:** A clinician’s prescription is guided by *goals* and/or *risk factors*. A prescription authoring notation must include mechanisms for recording goals and risk factors for the specific regimen being designed. These should be accessible for reference at any time during the process. In addition, ordering of exercises is important, however, the best order may not be known prior to the completion of the prescription. An authoring notation should provide a mechanism for specifying exercises in order, but should allow for reordering as well.

## 5.2 Reusable Abstractions

It became clear from our **CS** observations that abstractions were important in specifying exercise regimens. During Observation 2, T1 and T2 discussed which “protocols” would be prescribed to P. In particular, P would be put on

“modified lower extremity,” “modified trunk,” and “balance progression” protocols. This implies that clinicians create reusable abstractions called protocols that consist of a collection of exercises. However, during Observation 3, T1 explained the regimen to P and the protocol terms were *rarely* used. When communicating with the client, the goal is to explicitly describe each exercise in its entirety. No steps were skipped because the emphasis had shifted from efficiency to completeness.

In Question 1 of the **PPS**, where participants were asked to devise an exercise prescription based on a fictional patient history, 50% of the responses, participants used some form of abstraction. Figure 2 shows an example prescription that includes a list organization with grouping by various abstractions. In some cases, the abstraction was a grouping of exercises by targeted body part, such as “lower extremity,” while in others, the abstraction was based on a goal, such as “core strengthening” or “balance.” Participants also used abstractions representing the beginning and ending exercises, termed “warmup” and “cooldown.”

**Practical Implications:** Notations for specifying exercise regimens should provide mechanisms for abstracting groups of exercises into protocols. As in traditional programming, abstractions provide several advantages for the clinicians, such as: **1)** Time savings, **2)** Management of complexity, and **3)** Interchangeability. Efficiency is necessary so that the clinician can spend adequate time on assessment and demonstration, while still being able to take the next appointment on time. A clinician may attend to a large number of people on a regular basis, many with the same injury and/or goals, and the use of protocol abstractions helps to manage complexity. Finally, modifications to protocols are inevitable, therefore, care must be taken to allow clinicians to easily change protocols, as well as swap protocols in a regimen.

## 5.3 Cues

Physical cues are present in nearly every aspect of exercise prescription communication. Cues are the mechanism by which the clinician communicates *form* and the *sensation* that should (or should not) accompany correct form. Understanding and remembering the cues is crucial for the client to be able to monitor the correctness of their performance, so both visual and verbal cues are used in training.

Posture cues typically refer to body parts and were generally described in terms that the client could understand. During Observation 1 of the **CS**, T1 used an anatomical model of a human knee to clarify to P the details of the diagnosis and treatment. While clinicians try to use terms that are familiar to the client, they sometimes prefer physical “pointing” to eliminate all ambiguity. For example, rather than saying “you should feel this exercise in your quadriceps,” the trainer might say, “you should feel this here” and

Code	Description	Example
Equipment	Reference to equipment necessary for the exercise	“Stand in a corner with a chair in front of you”
Posture	Description of proper form for an exercise	“Suck in your abdomen”
Rhythm	Direction on how to time the movement of the exercise	“Slow and controlled”
Sensation	Description of what the client should be <i>feeling</i>	“Feel the work in your quads”
Resting	Reference to when or how long the client should rest	“Take a break”

Table 3. Codes applied to Questions 3 and 5 in the PPS.



Figure 3. Depiction of bad (red glowing) and good (green glowing) sensations for a squat exercise.

point to their own or the client’s quadriceps. Even when the participants were asked to describe an exercise on paper during the PPS, several of them began verbalizing the instructions and pointing at themselves.

To better understand the use of cues, we considered Questions 3 and 5 from the PPS. We coded these two questions based on a set of codes we devised to describe cues (Table 3). In Question 3, we asked the participant to describe how they would inform a client how to correctly perform a particular exercise from his or her prescription. 50% of the responses contained posture cues, 60% contained sensation cues, 40% contained rhythm cues, and 50% contained equipment cues. In Question 5, we asked participants to watch a short video of two exercises and summarize what a virtual agent should do to reproduce the motion. 90% of the responses contained posture cues, 90% contained sensation cues, and 50% contained rhythm cues. Since no equipment was used in the video for Question 5, no responses included equipment cues. Cues often contained specifications of angles, positions, and weight distributions. Angles were sometimes described in degrees, while others used the positions of the clock hands. Descriptions of position and weight distribution also came in many forms.

**Practical Implications:** Clinicians need a notation that facilitates providing cues to be presented through text, audio, or visuals (e.g. arrows or highlighting). While it is clear that a mechanism for each form must be provided, further study is needed to determine the most appropriate notations for specifying cues and their presentation to the viewer. For example, in a 3D animated sequence, “pointing” can be accomplished using secondary objects, such as an arrow or a finger icon. Another alternative suggested by a participant is to simply highlight the body part of interest with a contrasting color (Figure 3).

## 5.4 Parameterization of Exercises

According to J.H. Wilmore, an exercise prescription “...is based on the individual’s exercise capacity and includes a definition of the *type*, *frequency*, *duration*, and *intensity* of exercise” [16]. *Type* describes the kind of movement to be performed and *frequency* describes how often exercises sessions should occur. *Duration* represents how long the exercise should last, while *intensity* describes how much energy should be used. In this section, we examine how participants parameterized exercises along these dimensions.

In the CS, a paper handout with pictures and descriptions of the exercise was notably absent from the artifacts. When asked about this, T1 indicated that the clinic had purchased software to produce these handouts, but had stopped using it, stating, “It doesn’t allow me to modify anything. ...We started using it, but there were so many limitations that we stopped.” T1 indicated repeatedly that the diagrams and descriptions found in the software needed adjustment. To illustrate, T1 showed an exercise that used a piece of equipment that, according to T1, was no longer on the market. While descriptions and illustrations may be useful for representing the *type* dimensions, T1 desired the ability to adjust the motion itself.

During Observation 3, T2’s emphasis was on form, which was described in terms of posture and rhythm (Table 3). Posture parameterization is exemplified by a description such as “feet shoulder width apart.” An example of rhythm parameterization is describing the down motion

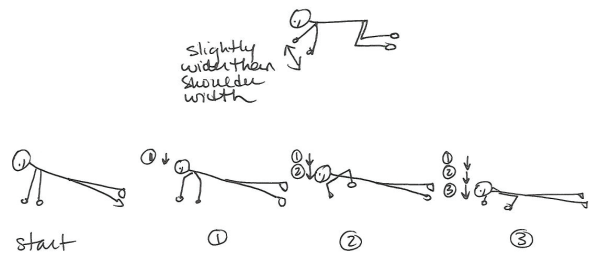


Figure 4. The top illustration taken from the PPS shows a parameterization of the pushup hand width. The bottom image shows a parameterization of the duration for a pushup depicted as a 3-count tempo on the downward motion.



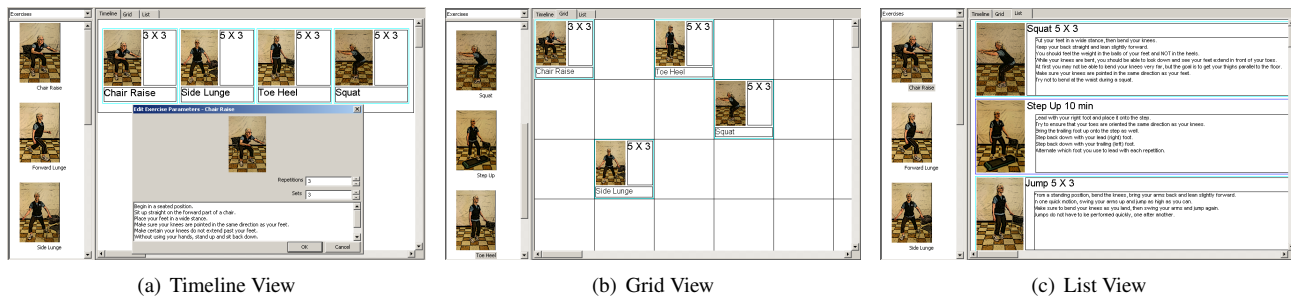


Figure 5. Our prototype included three views with slightly different interaction metaphors. Figure 5(a) also shows the dialog which allows the user to modify parameters and descriptions.

as “down on 2 counts.” Duration of exercises were typically described in terms of repetitions and sets, where repetitions describe how many times an exercise should be performed before taking a rest and sets describe how many cycles of repetition and rest the client should do.

In Question 1 of the PPS, 60% of the participants parameterized exercises by repetitions and sets, while 40% parameterized some exercises by total wall-clock time. Several participants depicted a parameterization of the exercise posture or form with an illustration (Figure 4). Parameterization facilitates the creation of progressions and modifications, which are variations of an exercise regimen to make it more or less challenging. These changes can be as simple as modifying repetitions and sets or may require a significant modification to the actual movement performed. 50% of the participants used progressions for the patient.

**Practical Implications:** An exercise prescription notation requires flexible parameterized components at many levels. Certain parameterizations, such as sets and repetitions, are quite common and easily provided with textual or numerical representations. However, 3D animation is a dynamic medium, which provides opportunities for additional motion parameterization. A software solution should strive to allow the clinician to vary kinematic properties, such as “width of stance” or “depth of the squat,” as these are commonly varied in order to customize the prescription for the client and to provide progressions. Additionally, the notation should include provisions for specifying rhythm in several forms, including speeds and counts.

### 5.5 Monitoring and Logging

An important component of any exercise prescription is tracking a client’s progress. During Observation 3 of the CS, T2 presented P with a card to record the number of repetitions and sets completed for each exercise. This information about the progress of the client could prove useful to a clinician trying to adjust a prescription for a recurring client. Additionally, this information provides positive feedback to the client as he/she observes improvements in strength and performance.

**Practical Implications:** Clinicians who repeatedly see a large number of clients can benefit from a software system which helps track clients’ progress. A notation for exercise prescription must include components for inserting various forms of prompts for the clinician to request information from the client. While this information is necessary for the clinician to track, it can also prove to be useful in keeping the client aware of his or her own progress. The notation should also provide mechanisms for creating and displaying progress visualizations to both the client and clinician.

## 6 Exploring Prototype Designs

Based on the lessons from the CS and PPS, we constructed a partial prototype to explore clinicians’ use of software tools for exercise prescription. In particular, we were interested in investigating layouts, interaction, and the use of abstractions. In our prototype, we implemented three different interaction metaphors, shown in Figure 5: 1) Timeline - similar to video production software 2) Grid - similar to VHI paper handouts [15], and 3) List - similar to the written responses from the PPS.

Three of the four TAS participants preferred the list over the other formats because this format allows for a natural placement of description beside the icon representing each exercise. The one participant who preferred the grid over the other formats cited the fact that a longer prescription could be fit onscreen with no scrolling. This participant also used the extra space as a ‘scratch area,’ placing exercises that might or might not become part of the final prescription. Another participant stated, “I could see this [grid] being useful to organize a weekly workout calendar,” while another participant also requested a weekly view.

Based on the heavy use of abstractions in the previous studies, we included basic abstraction mechanisms in our prototype notation. The importance of abstractions was highlighted when a participant indicated,

[Spoken] When you are doing something like this, there is usually a patient standing right over

your shoulder waiting to get it. [Written] Generally most programs need to be created in 4-6 minutes, with some original protocols taking planning time that is longer, maybe half an hour.

During the **TAS**, one of our questions asked how long the participant felt it would take to prepare a prescription with our software, provided a sufficient exercise database. Most participants provided estimates in the range of 10-15 minutes. However, participants were very positive about our representation of abstractions, with one stating, “I really like the editing popup box when you load a protocol ... It allows you to have a custom design that you can modify very quickly.”

All participants in the **TAS** indicated that they would like to adjust the speed of the motion. They typically wanted to specify speed as the number of seconds a single repetition should take. A more advanced form of this specification suggested by a participant is a “tempo,” usually consisting of three numbers, a time for the first phase of the motion, a time to hold a position, and a time to return to the start position. Similarly, participants requested more features to allow them to specify rest periods, stating, “I’d want to assign rest periods based on what the goals were.” However, some parameters will not be adjusted as often as others. During one session, a participant stated, “The most common thing I am going to change is going to be the sets and reps.” Another participant stated, “When you are organizing a program, sometimes you just want to get the exercises in order, because you are already thinking about that kind of strategy, then you can go back and edit the parameters.”

For simplicity, we did not provide a notation component for visual cues (e.g. arrows) or audio cues, instead focusing on textual descriptions for each exercise. In the **TAS**, clinicians were given a simplified viewer for watching the 3D exercise regimen that they had authored. In this viewer, the exercises were performed by a 3D stick figure, with onscreen textual descriptions. Participants indicated that it would be desirable to have the program speak the cues. Some advocated the removal of the textual cues because it might be overwhelming to watch the motion while reading cues. Several participants commented that presentation of the duration information and cues should be displayed in a large font, in close proximity to the actor.

## 7 Discussion and Threats to Validity

We have presented three studies designed to understand the process and language of exercise prescription and discussed the most salient findings from the analysis of the data, including the need for organization, abstraction, cueing, parameterization, and logging capabilities. It is clear that the exercise prescription process has much in common with computer programming. A computer program is a list

of instructions which the computer should perform in the specified order, while an exercise program is a similar structure for a human to perform. The clinician uses abstractions to manage complexity, to promote reusability and increase efficiency, just as the programmer does. The instructions of the program, the exercises, are parameterized in several ways, as discussed in Section 5.4.

While we have focused primarily on clinicians in this paper, physicians are being encouraged more and more to promote and prescribe exercise. The American College of Sports Medicine has launched the “Exercise is Medicine” initiative to encourage physicians to promote exercise and become educated in exercise prescription [14]. However, without a background in exercise science, most physicians are not equipped to develop exercise prescriptions for their patients without assistance. Thus, a notation for authoring exercise prescriptions must contain mechanisms for aiding in building and debugging the prescription.

Debugging an exercise prescription remains a difficult task to address. Consider that a clinician might make multiple hour long prescriptions per day, and should not be forced to spend an hour watching the 3D agent in order to verify that it is correct. While adjustable playback speed, a time scrubbing slider, or a total time estimate might be helpful, creating bug-free exercise prescriptions remains a challenge. We anticipate that our findings will lead to a notation where we can enforce concepts analogous to type checking, although we have not explored this yet.

There are several interesting differences between exercise prescription and traditional programming. Most notable is that exercise prescription is *time constrained*. As noted by a study participant, the client is typically standing in the clinician’s office waiting to receive their prescription, and with around 5 minutes to complete the task. Also, the creation and addition of new exercises would require a means for generating motion, such as motion capture equipment or a professional animator, both of which are not typically available to clinicians. This contrasts with traditional programming, where the programmer can easily create new procedures.

### 7.1 Threats to Validity

Our **CS** followed a single case design, which inherently has lower external validity than a multiple case design. According to Yin, a single case design is most justified when the case is *representative*, but also when it is *revelatory* or *unique* [17]. While obtaining patients to observe was difficult due to patient privacy rights, to the best of our knowledge, no one has conducted a case study like ours. However, in order to elicit T1’s participation, we had to provide background about our research. During Observation 1, it was not unusual for the topic at hand to drift into potential features for a software system, rather than a “normal”

clinician-client interaction. Another threat to construct validity is that observations occurred within set time periods.

In the **PPS**, the patient history that we provided detailed a client with many risk factors. One participant from an early study expressed worry exercise might be too harmful, given the large number of risk factors. After this, we decreased the number of health problems mentioned in the patient history to avoid this reaction. It is possible that the prescriptions provided during early studies were overly conservative, and not representative of a “typical” prescription.

The largest threat to the validity of the **TAS** is the novelty effect. Some of the participants were unfamiliar with current exercise prescription tools. Those that had experience with prescription software were not used to creating animations, but rather static media. Additionally, it was the only study in which recording devices were used, which may have had an impact on the comfort level of the participants.

## 8 Conclusion and Future Work

In conclusion, we have discussed the need for notations to allow clinicians to create interactive 3D exercise prescriptions and we have presented studies to understand the requirements of such a notation. We have shown that an exercise prescription is a small program written by a clinician that requires organization, abstraction, cueing, parameterization, and logging features. While we have focused primarily on a notation for authoring by the clinician, the system must also include a viewing component which allows a client to interact with the exercise prescription. Our prototype system included a simplified viewer and we leave further exploration of the viewer requirements for future work. Additionally, we plan to include more participants in the **TAS**, then create a more complete prototype and perform a summative evaluation, including measures of errors and time to complete tasks. The end goal of these studies is to develop and deploy a usable system for both clinicians and clients to determine if we can affect exercise adherence and, ultimately, functional independence of the clients.

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