VIRTUAL EXERCISE TRAINING SOFTWARE SYSTEM

L. Vu[1], H. Kim[2], E. Benson[3], W.E. Amonette[4], J. Barrera[4], J. Perera[5], S. Rajulu[5], A. Hanson[5]
[1]Geologics, Houston, TX, [2]Leidos, Houston, TX, [3]MEI Technologies Inc., TX, [4]University of Houston - Clear Lake, Houston, TX, [5]NASA Johnson Space Center, Houston, TX.

INTRODUCTION

The purpose of this study was to develop and evaluate a virtual exercise training software system (VETSS) capable of providing real-time instruction and exercise feedback during exploration missions. A resistive exercise instructional system was developed using a Microsoft Kinect depth-camera device, which provides markerless 3-D whole-body motion capture at a small form factor and minimal setup effort. It was hypothesized that subjects using the newly developed instructional software tool would perform the deadlift exercise with more optimal kinematics and consistent technique than those without the instructional software. Following a comprehensive evaluation in the laboratory, the system was deployed for testing and refinement in the NASA Extreme Environment Mission Operations (NEEMO) analog.

METHODS

To test the hypothesis, 16 subjects with no deadlift training experience volunteered for the project. The subjects participated in 4 total sessions, separated by 1 - 2 weeks. All subjects completed an initial training session where standardized exercise instructions were provided from a strength specialist. In the second session, a one-repetition maximum (1-RM) was determined and baseline or reference kinematic data were recorded. Subsequently, the subjects were randomly assigned to an experimental group using the VETSS (EXP) or a control group (CON) that exercised without software or verbal feedback. In sessions three and four, 3 x 5 repetitions of deadlifts were performed with 80% of the established 1-RM. During these two sessions, kinematic data were recorded using an 8-camera motion capture system with a whole body retro-reflective marker set. A representation of the VETSS instruction screen is shown in Fig 1.

During the NEEMO mission, four crewmembers participated in evaluation of the tool. Prior to submerging, subjects completed training on exercise technique (front squat, deadlift, Romanian deadlift, timed bicep curl) with adjustable weight dumbbells. Baseline data were recorded for each subject; these data were used to train individual coaching 'avatars'. Crewmembers were scheduled two at a time, with one serving as the exerciser and the other as the software operator.

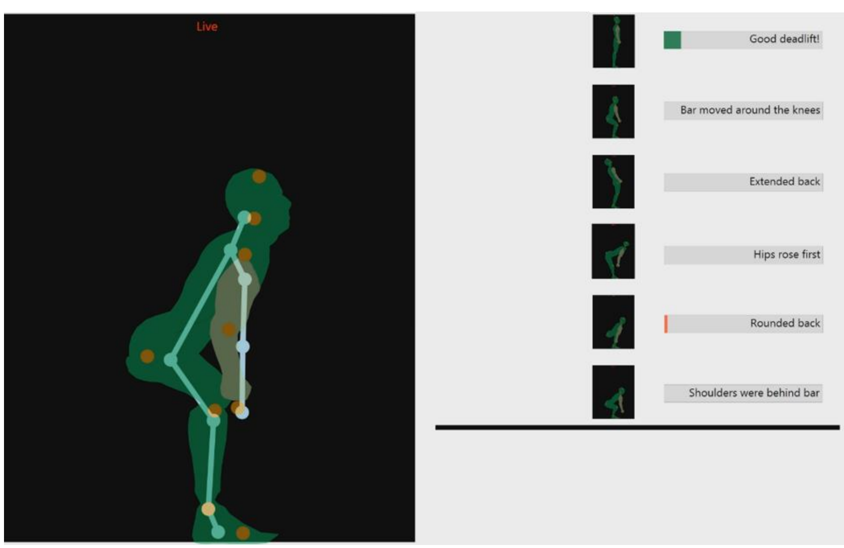

Figure 1: VETSS interface. Green figure or avatar shows model movement parameters and stick figure indicates real-time subject positioning.

RESULTS

Tool Development Results

When exercising with VETSS, hip angles were more similar to reference (effect sizes (*d*) ranged from 0.09 – 0.16) compared to exercise with no corrective feedback (CON; *d* ranged from 0.22 – 0.94). Moderate to large effect sizes for knee flexion angles were observed in both the CON (*d* ranged from 0.15 – 0.94) and EXP groups (*d* ranged from 0.26 – 0.68) when compared to reference data. Reduction peak spine angle (SAp) is critical for injury reduction during the deadlift. CON experienced greater SAp and greater deviations from the reference SAp compared to EXP. From these data we conclude that exercise using the VETSS may improve hip kinematics and reduce spinal flexion; however, it does not seem to improve knee flexion kinematics. Deadlift exercise with the VETSS may provide corrective feedback, helping to prevent more severe spinal flexion and improving the consistency of hip kinematics.

NEEMO Results

Crewmembers successfully operated the software tool and completed 8 data collection sessions. In comparison to the baseline data, all crewmembers showed substantially improved joint range of motion (knee flexion, torso flexion, and hip flexion angles) and improved consistency during the deadlift exercise by the second day with the software. Moderate and slight improvements in joint range of motion and consistency were observed during the goblet squat and Romanian deadlift exercises, respectively. Elbow flexion and extension cadence during the bicep curl exercise showed good agreement the baseline data for all crewmembers. Crewmember operation of the VETSS and exercise consistency was improved over the course of the mission. This proof of concepts program shows promising outcomes; with future refinements the VETSS would be a valuable adjunctive software tool as part of an autonomous exercise system for exploration missions.