A New Concept for Adaptive Sports in Amputee Rehabilitation

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ABSTRACT

We designed an adaptive motor sports program for community dwelling amputees to determine its safety and efficacy. Participants were recruited from a community amputee support group and were asked to respond to a series of questions pertaining to driving and daily living challenges. The program was a one day event which consisted of four components: 1) Training on a skills course using an adapted car focusing on high speed braking using hand controls; 2) Handling and maneuvering drills using a car with an adapted steering wheel; 3) Driving simulator with adapted steering wheel and hand controls; and 4) Adapted stock car racing around a short track with hand controls, adapted steering wheel and a professional driver in the passenger seat with a steering wheel and speed controls. Finally, participants completed the Psychological Impact of Assistive Devices Scale (PIADS) to assess the effects of the program on functional independence, well-being, and quality of life. All participants reported a positive impact following the event and PIADS showed highly positive results in participants' competence, adaptability, and self-esteem scores with the greatest impact on the adaptability score. This is the first report of the effects of an adaptive motor sports program on amputees. We showed that using appropriate safety measures, training and assistive technology, amputees can participate in adaptive motor sports with profound effects. This provides a unique perspective to addressing psychological issues, including decreased self-esteem. Further study is needed to better understand adaptive motor sports in rehabilitation following amputation.

INTRODUCTION

Suffering an amputation presents multiple problems for an individual, their family and friends. Psychological issues can be difficult to address and individuals can feel isolated leading to depression. During Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF), many service members have suffered traumatic amputation during a time in their life when they were in peak physical and mental condition. During military service they are embedded in teams and involved in combat leading to periods of heightened mental awareness. They rely on this level of stimulation and identify themselves by their unique skill sets as soldiers. Following traumatic amputation these individuals are transferred to top-level military hospitals and participate in rehabilitation programs allowing them to transition to the next phase of their lives. Upon retirement from military service and transition to their communities, many will lose that feeling of being part of a team, which can lead to loneliness. In addition, they may become depressed due to their belief that they can no longer participate in activities that will stimulate them or that they will enjoy.

Furthermore, amputation does not occur to a particular subset of the population; rather individuals following amputation can be an extremely diverse group due varying etiology such as trauma, cancer, infection and vascular problems. Due to this diverse population the rehabilitation care team needs to gain an understanding of each patient's potential functional level.

Individuals following amputation at a low functional level often have to relearn how to perform daily activities with or without a prosthesis, and they tend to become more dependent on others, leading many amputees to experience decreased self-esteem[1]. Others may return to a high functional level. Regardless, the rehabilitation care team must assess the functional and recreational goals of the patient to guide the treatment plan with the mission of creating an environment where there is no limit to what an amputee can accomplish.

Participation in varying activities has a profound effect on an amputee's life. It has been shown that involvement in adaptive sports increases the quality of life for persons with disabilities by increasing self-esteem[2]. Furthermore, it has been demonstrated that those who participate in these sports have a higher level of confidence and more motivation to complete daily activities[3].

In 2009, the Veteran's Health Administration (VHA) created a national Amputation System of Care (ASoC) to provide our veterans with high quality, specialized medical and rehabilitation care to optimize function upon return to home from service. The ASoC aims to ensure that all veteran amputees receive high quality rehabilitation care to enable them to accomplish their goals at home, at work and in the community. Many interventions to prevent depression and loneliness offered to our veterans through the ASoC include physician visits,

medications, therapeutic modalities (such as physical and occupational therapy), assistive devices and adaptive equipment, individual and group therapy sessions, peer support and peer visitation, case management and interactive web-based information and resources. The ASoC also goes beyond traditional methods to include recreational activities such as wall climbing, kayaking, golf, paratriathlon, wheelchair sports and summer and winter competitions through the VA Adaptive Sports Program.

To our knowledge, an area that has not yet been broached by the ASoC is adaptive motor sports (e.g. stock car racing). This study assesses the effect of an adaptive motor sports program on community dwelling amputees to understand how the assistive technology and rehabilitation engineering used can affect functional independence, well being, and quality of life. Furthermore, this study evaluates if the adaptive technology allows participants to more readily participate in other activities.

METHODS

Participants were recruited from an amputee support group affiliated with an academic medical center in a large metropolitan area. Eight members of the amputee support group, ranging in age from 29 to 65 years old, were selected to participate in the one-day event. Upon arrival at the short track speedway, five male and three female participants provided surveys with basic demographic information including driving history and challenges associated with daily living. Then they signed informed consent documentation and were oriented to two adapted vehicles that were used for the one day event.

The first vehicle was a standard 4-door sedan with hand control modifications to be used during training sessions on the street course. The second vehicle was a stock race car with modifications to allow persons with disabilities to safely enter/exit and control the car. These modifications include: a removable outer body panel exposing a door opening in the frame, and a custom designed seat base that moves fore and aft and swivels out into the door opening for transfer into the car. Due to the variety of special needs to drive for individuals with disability there are multiple options for control including: conventional steering wheel and a left foot gas pedal; manual hand controls (a fold up pedal blocker plate is used with manual hand controls to prevent inadvertent leg interference with the pedals); and electric gas and brake controller. All drivers electrically operate the automatic transmission.

Figure 1: Participant has entered the seat base and used the rotator unit on his right leg prosthesis to create space to swivel into the car

The steering column is easily modified to adjust for driver's needs. The steering gear box is modified for easier steering and there is a tandem vacuum booster master cylinder to make it easier to stop the car. Both the steering and the brake systems have automatically activating back up systems in case of OEM failures such as fluid loss, vacuum loss or electrical issues. Lastly, on the passenger side of the vehicle there is dual steering, brake and gas with switch controls for turning off the engine and activating the back up systems.

The one day event consisted of training, simulation and racing components:

Training:

- Led by driver training specialists, participants were instructed in anti-lock braking systems and introduced to the training vehicle.
- On the street course, each driver demonstrated competency in high speed braking using hand controls and performed handling and maneuvering drills using an adapted steering wheel.

Simulation:

- Each participant trained using the VXP driving simulator equipped with a MOMO Force Feedback Racing wheel and iRacing hand controls and software. The iRacing software offers a wide variety of scenarios preparing the driver both mentally and physically by teaching and testing reaction time, accident avoidance, hand eye coordination and many other necessary driving skills.

Racing:

- Finally, each driver participated in adapted stock car racing around a short track with hand controls, an adapted steering wheel and accompanied by a professional race car driver in the passenger seat with a steering wheel and acceleration and deceleration control.

Following the event, participants were given the Psychological Impact of Assistive Devices Scale (PIADS) to assess the effects of the adaptive motor sports program on functional independence, well being, and quality of life. PIADS is a 26-question survey designed to examine the psychosocial impact of different assistive technologies. Each question is a word or phrase used to describe the affect of the assistive technology on the participant's personal traits and emotions. Participants ranked each question on a scale of -3 to 3. A negative score indicates a decrease in the particular trait or emotion while a positive score denotes an increase in the trait or emotion. Each survey was then scored using the PIADS scoring sheet. Finally, the individual scores were averaged for each of the three categories.

RESULTS

All participants were able to complete all components of the event. Each person was able to successfully learn how to use the adaptive technology on the simulator and effectively apply that to the actual short track experience. Additionally, all participants reported enjoying the experience and described feelings of exhilaration, accomplishment and teamwork based on the event. The PIADS showed highly positive results in participants' competence, adaptability and self esteem. As table 1 illustrates, the event had a positive impact on individuals at each level of amputation along all metrics evaluated using PIADS with the upper extremity level showing the highest scores in all three categories.

Table 1: PIADS results by level of amputation

Amputation Level	Competence	Adaptability	Self-Esteem
Transradial	2.50	3.00	2.88
Hip disarticulation	1.42	2.33	1.25
Transfemoral	2.20	2.61	1.84
Transtibial	1.69	2.20	1.81

Figure 3 reveals a strongly positive response from the event in all three categories of the PIADS indicating all participants experienced an increased level of that trait or emotion.

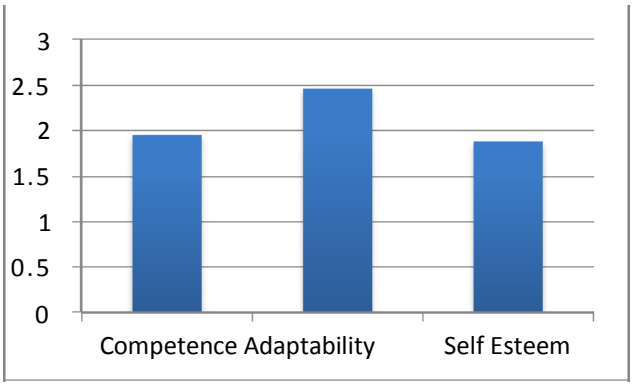

Figure 3: Average PIADS results for all participants by category

DISCUSSION

This is the first description of an adaptive motor sports rehabilitation program for amputees. This event utilized rehabilitation engineering and assistive technology to allow persons with disabilities the opportunity to overcome obstacles and push the limits of their potential. Our experience demonstrates a safe and effective method of rehabilitation for amputees that can improve their competence, adaptability and self esteem. Furthermore, the design of this event using a training program, a driving simulator, and a racetrack experience, is one that can be duplicated and improved upon.

This experience provides a unique perspective to addressing psychological issues using rehabilitation engineering and assistive technology for adaptive sports. It allows the participants to try something new, fun and challenging while in a safe environment. Our goal is to introduce our amputee patients to programs that allow them to overcome barriers and return their locus of control.

Further development of adaptive sports is needed to address the goals of our diverse amputee patient population.

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